Solvent and Other Product Use

SNAP CODE: **060000**

SOURCE ACTIVITY TITLE: **SOLVENT AND OTHER PRODUCT USE**
Introduction

NOSE CODE: **107.various**

NFR CODE: **various**

1 ACTIVITIES INCLUDED

All activities in which organic solvents are used and are emitted, are included in this chapter. In this chapter a general method for estimating the overall solvent use in a country is described. For more detailed methods the chapters on source-specific solvent use (060100 - 0600409) should be consulted.

2 CONTRIBUTION TO TOTAL EMISSIONS

Solvent use is a major contributor to NMVOC emissions. On a European scale its contribution is roughly a quarter of the total anthropogenic NMVOC emission. Per country its contribution to anthropogenic NMVOC emissions varies between 15% and 30%.

Allegedly, solvent use contributes also to the emissions of some heavy metals (Cd, Cu, Pb and Zn), but no quantification can be given at this stage.

3 GENERAL

3.1 Description

Most solvents are part of a final product, e.g. paint, and will sooner or later evaporate. This evaporation of solvent is a major source of NMVOC emission in any country, thus inventorying of this source is of great importance.

A small fraction of the solvents will end up in waste or as emission to water and may finally also contribute to air pollution by evaporation from these compartments.

Estimating emissions from solvent use can be done in two ways: either by estimating the amount of (pure) solvents consumed or by estimating the amount of solvent containing products consumed (taking account of their solvent content).

For the first method you need to inventory all relevant solvents, at least those together representing more than 90% of the total NMVOC emission. The sum of all these solvents equals the NMVOC emission. This method is the detailed methodology of this chapter.

For the second method you need to inventory all relevant source categories, at least those together contributing more than 90% to the total NMVOC emission. To estimate these source categories they have to be defined first. In the SNAP system this defining of categories has already been done (see chapters 060100 - 060409), but several countries have their own categorisation. To get data for each source category two ways are possible: either collecting all relevant consumption data or (only to be applied when no consumption data are available) using a per capita emission for each category. The first way is used in most 060… chapters, the other way is described in this chapter as the simpler methodology.

3.2 Definitions

Solvent content:	percentage of a product that consists of organic solvent
Water-borne:	the solvent in the product is water
Solvent-borne:	the solvent in the product is an organic solvent

3.3 Techniques

Many different process and other techniques use solvent products. It is not within the remit of this chapter to describe these techniques in detail, but many are described in other chapters within SNAP Group 6.

3.4 Emissions

The use of solvents, like other products, has three stages in which emissions occur: during production, during the actual use and during the disposal. The methodology in this chapter only deals with stage two. Stage one is dealt with in the chapters on production processes and stage three is covered by chapters on waste treatment and disposal.

3.5 Controls

NMVOC emissions can be decreased by lowering the solvent content of a product or replace the solvent by another non-NMVOC substance (e.g. water-borne paint instead of solvent-borne paint). The harmfulness of a solvent containing product can be decreased by replacing the solvent by another solvent.

In industry the emission caused by the use of solvents can be decreased by using closed circuits with abatement technologies, e.g. activated carbon, instead of open application.

4 SIMPLER METHODOLOGY

The NMVOC emission from solvent use is calculated based on per capita data for several source categories. The categories most used for this purpose are:

- paint, all applications
- industrial degreasing
- dry cleaning
- glues & adhesives
- graphic arts (ink)
- chemical industry (e.g. pharmaceutics)

- household products (e.g. toiletries)
- rubber and plastics industry
- vegetable oil extraction
- leather industry
- pesticides
- other solvent use

To get the emission for a source category in your country for which you do not have any information, you only have to select a per capita factor, which resembles the situation in your country as close as possible, and multiply the factor by the inhabitants of your country.

To get the total emission due to solvent use in your country you can take the per capita factor for the total of all source categories from a country resembling yours and multiply it by the inhabitants from your country.

5 DETAILED METHODOLOGY

This method is based on a mass balance per solvent. The sum of all solvent mass balances equals the NMVOC emission due to solvent use. In formula the solvent mass balance is:

consumption = production + import - export - destruction/disposal - hold-up (1)

Note that solvent used as feedstock is not included in the consumption. Destruction and disposal of solvents is a way of lowering one’s emissions due to solvent use. The amount of solvents disposed is small, but increasing in most countries. Hold-up is the difference in the amount in stock in the beginning and at the end of the year of inventory.

For each solvent the NMVOC emission can be calculated by multiplying the consumption by the fraction emitted; in formula:

NMVOC component emission = consumption * fraction emitted (2)

When no other information is available the fraction emitted in formula (2) can be set to 1.0. Veldt [20] estimated that this assumption will lead to an error of less than 10%. Formula (3) shows how the total NMVOC emission due to solvent use can be calculated.

Total NMVOC emission = sum of all individual NMVOC component emissions (3)

In making a solvent mass balance you have to be very careful not to double count certain NMVOC components. A lot of solvents consist of a mixture of NMVOC components, e.g. white spirit consists of several alkanes (paraffins), alkenes (olefins) and aromatics representing dozens of individual compounds. Before setting up a mass balance you have to decide whether you will inventory groups of NMVOC components, e.g. alkanes, chlorinated hydrocarbons, cellosolves, etc. or individual compounds, e.g. methylbenzene (toluene), 1,1,1-trichloroethane, etc.

6 RELEVANT ACTIVITY STATISTICS

6.1 Simpler methodology

- Data on population per country
- Data on per capita emission factors (see Tables 8.1.1 and 8.1.2)

6.2 Detailed methodology

- A list of the most important solvents, covering at least 90% of all solvent emissions
- Per solvent: data on import, export, disposal and destruction, feedstock, hold-up and production of the solvent and the solvent containing products
- Data on solvent content of products

7 POINT SOURCE CRITERIA

As a default approach solvent use can be considered as an area source. If information is available, large plants in some industrial branches can be distinguished as point sources (see also 060… chapters).

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Simpler methodology

Table 8.1.1 lists the per capita NMVOC emission factors per source category reported by several industrialised countries. The table was originally made by Veldt [20] and has been updated and expanded.

Table 8.1.1: Reported NMVOC emissions for some source categories[1] (in kg/cap./year).

Country	year	paint	industrial degreasing	graphic arts	glues & adhesives	household products	total	lit.
Australia	1990	3.7	1.6[2]	0.80		1.3	11.0	21
Australia	1990	5.0	1.6[2]				9.9	27
Austria	1987	5.3		0.60	1.45			13
Austria	1990						17.1	32
Canada	1985	4.8					12.7	20
Canada	1985	4.8					17.1	28
Canada	1990	6.5					22.8	28
Czech Rep.	1995						14.6	31
Finland	1988	5.55		1.8		0.7	9.6	20
Finland	1991	3.7	2.7[3]	0.4	0.17	0.27	12.3	23
France	1985	4.8	0.84	0.47	0.26	1.1	10.4	17
W. Germany	1986	6.8	2.0	1.5	1.1	±2	18.8	10
Italy	‘84-’86	4.5	0.75	0.60	1.0	0.8	12.9	16
Japan	1983	6.4	0.74	1.15	0.29		10.4	20
Netherlands	1981	6.6	0.85	1.2	0.20	1.6	15.3	18
Netherlands	1989	5.05						22
Netherlands	1990	4.5	0.40	0.76		1.5	10.0	20
Netherlands	1992	4.6	0.73	0.99	0.05	1.75	11.3	18
Norway	1976						15.1	1-4
Norway	1992	4.5		0.36			7.5	20
Norway	‘88-’92	2.5 - 5.0					10.1	1-4
Poland	1989	4.45						20
Slovak Rep.	1990	6.2[5]	1.3[3]			1.6	9.0	30
Slovak Rep.	1993	3.6[5]	0.64[3]			1.6	5.8	30
Sweden	1988	4.7	1.4	0.82		2.6	12.1	15
Switzerland	1990						22.1	29
UK	1988?	4.8	0.81	0.68	1.02	3.3	13.7	9
UK	‘91-’92						11.4[4]	26
USA	1985						17.5	20
USA	1989	8.6	2.8	1.3	1.3	1.5	21.3	24
USA	1990	9.5	2.7	2.5			22.9	25
USA	1990	7.6	2.7	1.3	2.7	3.9	21.6	28
W. Europe	1988						15.2	20
W. Europe	1990	5.3	1.0	0.86	0.84	1.1	14.4	19
Europe[6]	*>1990*	*4.5±0.4*	*0.85±0.3*	*0.65±0.25*	*0.6±0.45*	*1.8±0.45*	*12±3.4*	

1) the definition of the categories varies per country and per report, especially for the category household products

2) the sum of the US EPA emission factors for cold cleaning in manufacturing and automobile repair

3) includes industrial and dry cleaning

4) in the report the NMVOC emission from solvent use is constant for 1970-1994; the per capita NMVOC emission from solvent use decreases due to the increase in inhabitants in the UK (1970: 11.8; 1980: 11.7; 1990: 11.5 kg/capita/year)

5) including (application of) glues

6) default European per-capita factors (average of country data)

Table 8.1.2 lists the percentages of source categories as are found in several European countries. With Table 8.1.2 you can estimate which percentage of the total NMVOC emission due to solvent use is covered by your known source categories, so that you can estimate which percentage for the unknown source categories should be added to get the total NMVOC emission.

Table 8.1.2. Reported source category subdivisions in country studies (wt.% of total NMVOC emissions).

Source category	France	West Germany	Italy	Country the Netherlands	Sweden	the UK	Western Europe	Europe[3]
Paint	46.1	39.6	35.2	40.4	36.1	35.6	36.7	40±4
Household prod.	10.6	9.2	3.5	15.5	18.5	21.6	8.2	15±5
Chem. industry	14.0	10.8	13.7	12.4	4.7	5.5	11.8	
Industr. degreasing	8.1	10.8	5.8	6.4	10.5	5.8	6.9	8±2.5
Graphic arts	4.5	8.2	8.0	8.8	6.3	5.6	5.9	7±1.7
Glues & Adhesives	2.5	5.8	8.0	0.4	[1]	7.9	5.8	
Rubber & plastics	7.5	3.5	2.3	3.5	4.3	0.9[2]	[1]	
Dry cleaning	3.1	2.0	4.7	0.9	1.5	1.5	2.1	
Pesticides	2.7	0.5	2.1	[1]	1.4	5.3	[1]	
Veg. oil extraction	0.5	1.4	2.0	[1]	[1]	1.4	2.2	
Leather	[1]	[1]	[1]	0.2	0.5	0.3	[1]	
Other solvent use	0.5	8.2	14.8	11.7	16.3	8.7	20.5	
Year	1985	1986	‘84-‘86	1990	1988	1988?	1990	
Reference	17	10	16	18	15	9	19	

1) included in other solvent use
2) rubber industry only
3) default European percentages

8.2 Detailed methodology

The following information is needed:

- a list with the most important compounds or groups, e.g. those groups used in Table 9.1
- a list with solvent content per source category (see chapters 060100-060408)
- a list with solvent composition per product or source category (see Table 9.1)
- production, import, export and waste disposal statistics from the national statistics office

9 SPECIES PROFILES

9.1 Simpler methodology

Table 9.1.1 gives an idea of the NMVOC profile for solvent use. All profiles are overall profiles for solvent use as a whole (category 060000), for profiles per source category see the relevant (060...) chapters.

This table was just as Table 8.1.1 originally made by Veldt [20] and has been updated and expanded.

Table 9.1.1: Reported NMVOC composition per country (wt.% of total NMVOC emissions).

Country	year	alkanes	aromatics	alcohols	esters	cello-solves[7]	ketones	ClHCs	other	lit.
Australia	1990	36.5	27.9	10.4	4.9	5.6	3.7	8.6	2.4	21
Austria	1987	29.5	11.3[1]	18.8	8.1	4.4	16.7[2]	10.7	0.5[3]	13
Finland	1991	26.1	18.0	34.4	7.4	4.4	6.5	3.3	0.0	23
France	1985	26.1	14.6	27.5	5.6[5]	-	9.8	14.5	1.9	17
W.Germany	1986	20[4]	20[4]	15.7	9.6	4.2	8.9	15.6	6.0[3]	10
Italy	'84-'86	15.1	24.0	14.8	9.9	4.3	13.8	15.4	2.7	16
Sweden	1988	12.4	13.7	29.8	8.8	4.8	2.6	9.6	18.3[6]	15
W. Europe	1990	27.3	18.7	16.3	10.2	5.3	11.8	10.1	0.3	19
UK	1988?	30.5	18.9	14.2	4.1	1.9	5.9	8.9	15.6[6]	9
USA	1989	30.9	8.7	17.9	14.7[5]	-	11.1	12.8	3.8	24
Europe8		23±7	18±4	22±8	8±2.5	4±1	8±4	11±4.5		

1) methylbenzene (toluene) and dimethylbenzenes (xylenes)
2) propanone (acetone)
3) includes chlorofluorocarbons (CFCs)
4) corrected for aromatics in alkanes
5) includes cellosolves
6) including unknowns (67% of 'other' is unknowns in Sweden and 98% in the UK)
7) cellosolves are glycol ethers and glycol ethanoates (acetates)
8) default European percentages

10 UNCERTAINTY ESTIMATES

10.1 Simpler methodology

The uncertainty of the resulting overall (per capita) emission for a country will be a factor 1.25 to 2.

The more the activity in a source category of your country resembles that of the country, which per capita factor is chosen, the lower the uncertainty.

10.2 Detailed methodology

The uncertainty differs per solvent. In the more products a solvent is present the higher the uncertainty. Compounds like methylbenzene (toluene) or butanone (methylethylketon; MEK) are difficult to inventory, others like most chlorinated hydrocarbons are easier.

The overall uncertainty is estimated to be 1.25 to 2, depending on completeness of mass balance data and quality of the production, import, export, disposal, destruction and hold-up data.

11 WEAKEST ASPECTS/PRIORITY AREA FOR IMPROVEMENT IN CURRENT METHODOLOGY

11.1 Simpler methodology

- more data on southern and eastern European countries would improve the estimates for those countries
- background data on source category activities of countries for the selection of per capita factors (with the information on the size of activities you can select the country resembling your country's situation for a certain source category the best)
- more data for small(er) source categories, e.g. leather industry

11.2 Detailed methodology

- a representative list with all important solvents (representing at least 90% of all emissions)
- (per country) data on solvent content of products
- consistent national statistics on import, export, production and waste disposal
- definition of compounds or compound groups to be inventoried

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Depending on source category: population density or certain industries can be used to distribute the emissions spatially. The default distribution method is using population density.

13 TEMPORAL DISAGGREGATION CRITERIA

Temporal variation does occur, but data to make a temporal disaggregation profile is not available. A complicating factor is that the temporal disaggregation differs per source category.

14 ADDITIONAL COMMENTS

The methods described in this chapter are "default" methods. The use of one of them should be limited to cases where it is not possible to set up an emission database on solvent use according to the methodologies in the chapters 060101 - 060409.

15 SUPPLEMENTARY DOCUMENTS

For the detailed method national trade statistics; for the simple method none.

16 VERIFICATION PROCEDURES

The simpler and detailed methodologies can be used to verify one another.

17 REFERENCES

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18 BIBLIOGRAPHY

For application of solvents:

- Kirk-Othmer

For information per source category:

- All sorts of weekly and monthly magazines, like Farbe und Lack, EuroCoat, Rubber Statistical Bulletin, Chemical and Engineering News, European Chemical News, etc.

19 RELEASE VERSION, DATE AND SOURCE

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20 POINT OF ENQUIRY

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ADDITIONAL NOTE ON SOLVENT USE

The following additional note may prove useful when preparing emission inventories from the solvent use sector.

The NMVOC emission from solvent use can be calculated using consumption (or production) statistics for several categories. The user categories which are often most suitable for this purpose are:

- paint, all applications
- industrial degreasing and dry cleaning
- glues & adhesives
- graphic arts (ink)
- rubber & plastics industry

Two user categories, which also contribute substantially, are hard to inventorise, namely:

- chemical industry (e.g. pharmaceutics)
- household products (e.g. toiletries)

In the other group 6 chapters solvent content and/or emission factors for several user (sub)categories are given. Multiplying the user category consumption with the solvent content or emission factor gives the NMVOC emission for that user category.

When the emissions from all known user categories are calculated, the emission for the unknown user categories has to be estimated. This can be done by using the percentages that the unknown user categories contribute to the total NMVOC in countries, which have a complete inventory. For the U.K., West Germany, Italy, Sweden, France, the Netherlands and Western Europe relatively complete inventories are available (see [9], [10], [16], [15], [17], [18] and [19]); Table 4 gives the subdivision in user categories for these countries.

To provide an idea of the size of some user categories table 1 lists solvent emissions per user category reported by several industrialised countries. The table was originally made by Veldt [20] and has been updated and expanded by Bloos. The table can also be used to estimate a per capita emission for the user categories mentioned.

Table 1: Reported solvent emissions for some user categories (in kg/cap./year)

Country	year	paint	industrial degreasing	graphic arts	glues & adhesives	household products	total
Australia	1990						11.0
Austria	1987	5.3		0.60	1.45		
Canada	1985	4.8					12.7
Finland	1991	3.7	2.7^1	0.4	0.17	0.27	12.3
France	1985	4.8	0.84	0.47	0.26	1.1	10.4
W. Germany	1986	6.8	2.0	1.5	1.1	±2	18.8
Italy	‘84-’86	4.55	0.75	0.60	1.0	0.8	12.9
Japan	1983	6.4	0.74	1.15	0.29		10.4
Netherlands	1990	4.5	0.40	0.76		1.5	10.0
Norway	<1992	4.5		0.36			7.5
Poland	1989	4.45					
Sweden	1988	4.7	1.4	0.82		2.6	12.1
U.K.	1988?	4.8	0.81	0.68	1.02	3.3	13.7
USA	1989	8.6	2.8	1.3	1.3	1.5	21.3
W. Europe	1990	5.3	1.0	0.86	0.84	1.1	14.4

1 includes industrial and dry cleaning

Table 2 gives an idea of the NMVOC profile for solvent use. All profiles are for the complete solvent use category, for profiles per user category see the relevant chapters for group 6. As for table 1, this table was originally made by Veldt [20] and updated by Bloos.

Table 2: Reported solvent emissions per substance group (wt.% of total solvent emissions)

Country	year	alkanes	aromatics	alcohols	esters	cellosolves	ketones	ClHCs	other
Australia	1990	36.5	27.9	10.4	4.9	5.6	3.7	8.6	2.4
Austria	1987	29.5	11.3^1	18.8	8.1	4.4	16.7^2	10.7	0.5^3
Finland	1991	26.1	18.0	34.4	7.4	4.4	6.5	3.3	0.0
France	1985	26.1	14.6	27.5	5.6^5	^{5}	9.8	14.5	1.9
Germany	1986	20^4	20^4	15.7	9.6	4.2	8.9	15.6	6.0^3
Italy	‘84-’86	15.1	24.0	14.8	9.9	4.3	13.8	15.4	2.7
Sweden	1988	12.4	13.7	29.8	8.8	4.8	2.6	9.6	18.3^6
W. Europe	1990	27.3	18.7	16.3	10.2	5.3	11.8	10.1	0.3
USA	1989	30.9	8.7	17.9	14.7^5	^{5}	11.1	12.8	3.8

1 toluene and xylene
2 acetone (propanone)
3 includes CFCs
4 corrected for aromatics in alkanes
5 esters include cellosolves
6 includes unknowns

Table 3, also originally by Veldt [20] and updated by Bloos, gives the NMVOC profile for the user category paint applications.

Table 3: Reported solvent emissions from paint applications per substance group (wt.%)

Country	year	alkanes	aromatics	alcohols	esters	cellosolves	ketones	ClHC	other
Finland	1991	28.3	32.1	13.1	13.1	11.4	1.8	0.2	-
France	1985	29.6	18.4	28.8	8^{1}	-	14.6	0.6	-
Germany	1986	11^{2}	23^{2}	17.8	17.8	11.5	10.4	6.9	1.6
Italy	‘84-’86	13.4	42.1	11.5	11.5	7.7	11.5	1.5	0.8
Sweden	1988	15.6	26.4	24.0	23.6	8.4	2.0	-	-
W. Europe	1990	29.7	24.1	11.5	17.7	6.9	9.9	0.0	0.2
U.K.^{3}	recent	11.4	49.5	13.8	6.3	4.8	12.5	0.5	1.2
USA	1989	17.1	15.9	16.0	29.8^{1}	-	16.5	2.9	1.8

1 includes cellosolves
2 corrected for aromatics in alkanes
3 industrial paint

Table 4 lists the percentages of user categories as found in several European countries. With table 4 it is possible to estimate which percentage of the total NMVOC emission due to solvent use is covered by known user categories, in order to determine which percentage for unknown user categories should be added to provide the total NMVOC emission.

Table 4: Reported user category subdivisions in country studies

			Country				
user category	**France**	**Germany**	**Italy**	**Netherlands**	**Sweden**	**U.K.**	**W. Europe**
Paint	46.1	39.6	35.2	40.4	36.1	35.6	36.7
Household prod	10.6	9.2	3.5	15.5	18.5	21.6	8.2
Chem. ind.	14.0	10.8	13.7	12.4	4.7	5.5	11.8
Other solv. use	0.5	8.2	14.8	11.7	16.3	8.7	20.5
Ind. degreasing	8.1	10.8	5.8	6.4	10.5	5.8	6.9
Graphic arts	4.5	8.2	8.0	8.8	6.3	5.6	5.9
Glues & Adh.	2.5	5.8	8.0	0.4	^{1}	7.9	5.8
Rubber & plastic	7.5	3.5	2.3	3.5	4.3	0.9	^{1}
Dry cleaning	3.1	2.0	4.7	0.9	1.5	1.5	2.1
Pesticides	2.7	0.5	2.1	^{1}	1.4	5.3	^{1}
Veg. oil extr.	0.5	1.4	2.0	^{1}	^{1}	1.4	2.2
Leather	^{1}	^{1}	^{1}	0.2	0.5	0.3	^{1}

1 included in other solvent use
2 rubber industry only

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SNAP CODES:
060101
060102
060103
060104
060105
060106
060107
060108
060109

SOURCE ACTIVITY TITLES:
PAINT APPLICATION
Manufacture of automobiles
Car repairing
Construction and buildings (except item 060107)
Domestic use (except item 060107)
Coil coating
Boat building
Wood
Other industrial paint application
Other non industrial paint application

NOSE CODE:
107.01.01
107.07.02
107.07.03
107.07.04
107.07.05
107.07.06
107.07.07
107.07.08
107.07.09

NFR CODE: **3 A**

1 ACTIVITIES INCLUDED

This chapter deals with the use of paints within the industrial and domestic sectors as described by the source activity titles. Traditionally the term paint has often been used to describe pigmented coating materials only, thus excluding clear coatings such as lacquers and varnishes. However here the term paint is taken to include all materials applied as a continuous layer to a surface with the exception of glues and adhesives which are covered under SNAP 060405 (Application of glues and adhesives). Inks, which are coatings applied in a non continuous manner to a surface in order to form an image, are excluded by the definition given above.

Application of coatings during the manufacture of a number of other industrial products are covered by other SNAP codes:

060306	Pharmaceutical products manufacturing
060311	Adhesive, magnetic tapes, films and photographs manufacturing
060312	Textile finishing
060313	Leather tanning

The SNAP codes dealt with by this chapter are described below:

Activity 060101 "Paint application: manufacture of automobiles" refers to the coating of automobiles as part of their manufacture; it includes corrosion protection at point of manufacture; however it does not include the use of vehicle refinishing coatings (SNAP code 060102) or the application of aftermarket sealants, covered in the chapyer on underseal treatment of vehicles (SNAP code 060407). The application of sealants as part of the manufacturing process is covered here. Note that in some countries, only those paints manufactured for coating of high volume production vehicles (i.e. cars and light vans) are classified as automobile manufacture paints.

Activity 060102 "Paint application: car repairing" refers to the coating of road vehicles carried out as part of vehicle repair, conservation or decoration outside of manufacturing sites, or any use of refinishing type coatings where this is carried out as part of an original manufacturing process. In some countries, specialist paints which are used for coating small volume vehicles such as heavy goods vehicles and buses are classified as vehicle refinishing paints.

Activity 060103 "Paint application: construction and buildings" refers to the use of paints for architectural application by construction enterprises and professional painters.

Activity 060104 "Paint application: domestic use" refers to the use of paints for architectural applications by private consumers. Other domestic solvent use should not be included. However, it is sometimes difficult to distinguish between solvents used for thinning paints and solvents used for cleaning. See chapter B648 for further guidance.

Activity 060105 "Paint application: coil coating" refers to the coating of coiled steel, aluminium or copper alloy strips as a continuous process.

Activity 060106 "Paint application: boat building" refers to all paints for the hulls, interiors and superstructures of both new and old ships and boats. Strictly speaking this sector should include paints for both marine and river craft although there may be differences between the classification of coatings in different countries.

Activity 060107 "Paint application: wood" refers to all paints for wood and wooden products but excluding the use of wood preservatives and creosote (see chapter for SNAP 060406)
Activity 060108 "Other industrial paint application" refers to all industrially applied paints for metal, plastic, paper, and glass substrates which are not covered by any of the other SNAP codes described here.

Activity 060109 "Other non industrial paint application" refers to the use of high performance protective and/or non corrosive paints applied to structural steel, concrete and other substrates and any other non industrial coatings which are not covered by any of the other SNAP codes described here. The sector includes coatings for offshore drilling rigs, production platforms and similar structures as well as road marking paints and non decorative floor paints.

2 CONTRIBUTION TO TOTAL EMISSIONS

Table 2.1: Contribution to total emissions of the CORINAIR90 inventory (*up to 25 countries*)

Source-activity	**SNAP-code**	**Contribution to total emissions [%] including emissions from nature)**							
		SO_2	NO_x	NMVOC[1]	CH_4	CO	CO_2	N_2O	NH_3
Manufacture of Automobiles	060101	-	-	0.8	-	0	-	-	-
Construction and Buildings	060103	-	-	2.4	-	-	-	-	-
Domestic Use	060104	-	-	1.4	-	-	-	-	-
Other Industrial Paint Application[*]	060102 060105 060106 060107 060108 060109	-	-	4.5	-	-	-	-	-

0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)
- = no emissions are reported
1 = contributions estimated (some countries reported total emissions to SNAP level 060100)
[*] = SNAP90 code 060102

According to OECD estimates for the year 1980, paint application accounts for 15.8% of all stationary emissions of NMVOC and 26.1% of all stationary anthropogenic emissions in the whole OECD (OECD, 1990).

Table 2.2: Contribution of paint application to NMVOC emissions in different OECD regions

Country, region	**Contributions to total stationary emissions**	**Contribution to stationary anthropogenic emissions**
OECD Europe	18.1%	32.4%
Canada	7.6%	13.2%
USA	15.3%	24.2%
Total OECD	15.8%	26.1%

Source: OECD, 1990

The use of paints is generally not considered relevant for emissions of heavy metals and persistent organic pollutants. Chlorinated solvents such as trichloroethylene and 1,1,1-trichloroethane are used in certain paint types in some countries although not in large quantities. Pigments which are compounds of metals such as lead, cadmium, chromium and zinc may be used in paints and could presumably be emitted to air, particularly where spraying is used as an application method. The European Atmospheric Emission Inventory of Heavy Metals and Persistent Organic Pollutants for 1990 includes emissions of copper from paint use in Spain (8% of total).

3 GENERAL

3.1 Description

This chapter covers the use of paints by industry, and by the commercial and domestic sectors. Most paints contain organic solvent which must be removed by evaporation after the paint has been applied to a surface in order for the paint to dry or ‘cure’. Unless captured and either recovered or destroyed, these solvents can be considered to be emitted to atmosphere. Some organic solvent may be added to coatings before application and will also be emitted. Further solvent is used for cleaning coating equipment and is also emitted.

The proportion of organic solvent in paints can vary considerably. Traditional solventborne paints contain approximately 50% organic solvents and 50% solids. In addition, more solvent may be added to dilute the paint further before application. High solids and waterborne paints both contain less organic solvent - typically less than 30% while powder coatings and solvent free liquid coatings contain no solvent at all.

Paints are applied using a variety of methods:

- spreading e.g. by brush, roller or paint pad;
- spraying, including air assisted and airless spraying, electrostatic spraying;
- flow coating, e.g. dipping, curtain coating, and roller coating;
- electrodeposition.

After application of the paint the surface is air or heat dried ***(stoved)*** to remove the volatile solvents from the coated surface.

3.2 Definitions

Paint: Traditionally a material containing pigment which is applied to a surface in order to form a film with protective, decorative and/or particular technical properties. Stains, which contain transparent pigments, are strictly speaking paints. In this chapter, the term paint should be understood to include unpigmented (clear) coatings such as lacquers and varnishes as well.

Varnish: Correctly speaking an unpigmented material which forms a hard glossy clear film and which cures by means of a chemical reaction as well as evaporation of the solvent. In practice the term is often used interchangeable with lacquer.

Lacquer: Correctly speaking an unpigmented material which forms a hard glossy clear film and which dries by evaporation of solvent alone i.e. where no chemical reactions occur. In practice the term is often used interchangeable with varnish.

Electrocoating: a process in which resins are electrolytically deposited on a substrate. The substrate is immersed in a water-borne resin system. A current is applied, with the substrate acting as either anode or cathode depending upon the resin system used. Resin in the vicinity of the substrate is destabilised and deposited.

3.3 Techniques

Depending on the product requirements and the material being coated, a surface may have one or more layers of coating applied. For example, a first coat may be applied to cover surface imperfections or to assure adhesion of the subsequent coatings, intermediate coats might provide the required colour texture and a final coat provide protection, durability and gloss. Coatings can be applied by a variety of methods such as brushing, rolling, spraying, dipping and flow coating; following application the surface is air and/or heat dried to remove the volatile solvents from the coated surface.

Activity 060101. Paint application: manufacture of automobiles

Surface coating of an automobile body is a multi-step operation carried out on an assembly line conveyor system. Although finishing processes vary from plant to plant, they have some common characteristics and generally four major steps can be recognised:

- metal pre-treatments;
- application and curing of primer coatings;
- application and curing of primer surfacer coatings;
- application and curing of topcoats.

Various auxillary operations such as sealant application and repair operations may also be carried out.

Pretreatments include the removal of rust using mineral acids and oils and other surface contamination using alkalis, followed by phosphating. The purpose of this is to modify the surface of the metal car body in order to improve the subsequent adhesion of the primer coating and also to increase the corrosion resistance of the metal. No NMVOC emissions have been reported for these processes. Primers can be applied by dipping, spraying or electrodeposition. Virtually all primers are now applied by the latter method. Primer surfacers and topcoats are applied by spraying which may be manual or automatic. It is increasingly common for metallic finishes to be applied using a basecoat plus clearcoat rather than a single topcoat with both colour and gloss properties. This process requires an extra coat of paint, and generally leads to higher emission rates (powder coating is currently being developed in order to avoid emission increases). All automotive coatings require stoving, at temperatures up to a maximum of about 200°C.

The application and curing of the primer, primer surfacer and topcoat account for 50 to 80% of the NMVOC emitted from assembly plants. Final topcoat repair, cleanup, and miscellaneous sources such as the coating of small component parts and application of sealants, accounts for the remaining 20% to 50%.

Activity 060102 Paint application: Car repairing

Paints used for car repairs are often termed automotive or vehicle refinish paints. These products are commonly used to repair damaged bodywork although occasionally they can be used for purely cosmetic reasons. Typically a small area only will be repainted and spraying is always used to apply the coating. Because refinish paints are applied to a fully finished vehicle, fitted with fabric, plastic and rubber components, curing temperatures must be relatively low, a constraint which does not apply to original automotive coatings. Because of this, different technologies are used for the two types of paint.

It should be noted that refinish paints may be used by vehicle manufacturers to repair imperfections in original coatings. The use of such paints should be included under SNAP code 060102.

Activity 060103 Paint application: construction and buildings

Activity 060104 Paint application: domestic use

These two SNAP codes both refer to the use of paints for the interiors and exteriors of buildings. These paints are often referred to as decorative or architectural coatings and their use is covered by two SNAP codes, 060103 (construction and buildings) and 060104 (domestic use). The former refers to paint supplied to professional decorators and used by painting contractors, local authorities, government departments, industrial and commercial companies etc. and is often called trade decorative paint. The latter refers to paint sold to the general public as ‘do-it-yourself’ paint and is also known as retail decorative paint. There are only small differences in the formulations of these two types of paint and application methods are similar in both cases, although spray application may be used to a greater extent by professional decorators. Application by brush or roller are the preferred options.

It is possible to distinguish the main following applications of paints for the whole architectural sector:

- interior walls, ceilings and floors;
- exterior walls and floors;
- interior wood substrates: e.g. floors, furniture, doors, window frames;
- exterior wood substrates: e.g. fences, garden sheds, gable boards, garden furniture, wooden chalets;
- interior metallic substrates: e.g. radiators, tanks;
- exterior metallic substrates: e.g. fences, portals, garden furniture;

In addition, paints will fulfil a range of functions (e.g. undercoat or topcoat) and provide different finishes ranging from matt to gloss. The composition of the paint is very dependent upon the substrate being painted, the function and the finish required.

Activity 060105 Paint application: coil coating

Coil coating is the application of paints to continuous metal strip (generally steel, although aluminium and copper alloys are also painted) and is generally carried out on a large scale. The painted metals are used in the manufacture of kitchenware such as non-stick pans, white goods such as refrigerators and for building cladding. Roller coating is used to apply the paint which is then cured at high temperatures.

Activity 060106 Paint application: boat building

Paints for marine applications have some severe challenges to meet, in particular the need for excellent corrosion protection and anti-fouling properties. The formulation will depend upon the area being coated (e.g. hull or superstructure) and whether the paint is an original coating or a refinish paint. Marine paints are invariably applied as systems since all of the properties required cannot be met by a single paint. Paints are commonly applied by spraying although brushing is also used.

Activity 060107 Paint application: wood

Wood may be colour coated, stained or varnished. Application of paint is by roller or curtain coating (applicable only to flat stock) or spraying. Paints can be stoved or air dried with air drying frequently being carried out as an uncontained process. Fugitive emissions are therefore significant from many wood painting processes.

Activity 060108 Other industrial paint application

Paints supplied by industrial activities other than those already described are sometimes referred to as the general industrial sector. Products painted include agricultural, construction, and earthmoving equipment (‘ACE’), aircraft, cans and drums, caravans, domestic appliances, electrical components, freight containers, machine tools, military vehicles, motor vehicle components including engines, office equipment, paper and plastics, and toys. The scale of operation varies considerably, from large operations employing automated roller coating to smallscale manual spraying of paint. Processes may be enclosed or open air and both air dried and stoved coatings are used.

Activity 060109 Other non industrial paint application

This sector consists of the application of high performance protective and/or non corrosive paints to buildings, roads and other large structures. Most paint is applied in-situ by brushing, rolling or spraying, although some shop application of structural steel may occur.

3.4 Emissions

The most important pollutant released from painting activities is NMVOC. Particulate matter can also be emitted where spraying is used as an application technique, however many spraying operations are carried out in spray booths fitted with some type of particulate arrestment device. As mentioned earlier, heavy metal compounds, used as pigments, could be emitted to air, however, no emission factors are available.

NMVOC emissions result from the use of organic solvents in paints. The evaporation of the solvent is essential for the proper curing of the paint, however, it is possible to reduce the quantity of solvent needed either by substituting water or by applying the paint at a low(er) solvent content. Powder paints and solvent free liquid paints do not contain solvent and so NMVOC emissions are avoided. In the case of powder paints there is the potential for emissions of particulate matter.

A number of factors affect the mass of NMVOC emitted per unit of coated product. These include:

NMVOC (solvent) content of coatings:	emissions can therefore be reduced by decreasing the organic solvent content of a paint.
Volume solids content of coating:	since generally a given thickness or depth of solids needs to be applied to a surface, increasing the volume solids content of a paint means that a smaller volume of paint is required per unit of coated surface.
Paint usage:	Paint usage will be dependent upon the film thickness and the area painted. The extent to which these can be modified is fairly limited since they will be dictated by the design and function of the coated article. Decreases in paint usage might be possible in some cases through process improvements or improved process control.
Transfer efficiency	this is the percentage of solids in paint applied which remains on the surface of a coated article, and is thus an indication of the amount of paint wastage. Increasing the transfer efficiency means less paint wastage and therefore less needless NMVOC emission.

It should be noted that the first two factors are sometimes but not always connected i.e. it is possible to decrease the NMVOC content of a paint without increasing the solids content by substituting water for organic solvent.

Industrial painting processes can be fully enclosed and automated. Examples include coil coating, application of automotive electrocoat primers and coating of some metal and wooden substrates. These processes are, to a large extent, enclosed and emissions can be easily captured and treated by end-of-pipe technology. Many other painting processes are carried out manually, but are still to a greater or lesser extent enclosed, usually by special ‘booths’.

Again, the emissions can be captured and treated by end-of-pipe technology, although the economics of doing so are generally less favourable than in the previous case. Examples of these processes include vehicle repairing, the application of some automotive paints and the painting of many metal and wooden objects. Finally, some industrial painting processes are uncontained, for example the in-situ painting of ships and immovable structures.

Solvent is emitted from the moment the paint is applied. Some paints require stoving (heating in an oven) in order to cure fully, others are air dried. Emissions of solvent from ovens can be vented to control devices whereas air drying is often allowed to proceed in uncontained areas.

All painting activities lead to at least some fugitive emissions. The extent varies; for coil coating a figure of 5% has been reported (ERM), while emissions from the in-situ painting of ships are effectively 100% fugitive.

3.5 Controls

The best - and in some cases the only - way to control NMVOC emissions from paint application is to alter the process in such a way that no products containing solvent have to be used, or by reformulating the product in order to minimise the solvent content (see Table 3.1). Where for practical reasons prevention is not (yet) possible, “add-on” or “end-of-pipe” abatement technology should be used.

Paint technology is developing rapidly: increasingly more low-solvent coatings become available as a result of intensive research. Low-solvent and solvent-free paint can be divided into several categories. Table 3.1 gives a brief review of alternative paints with typical solvent content.

Table 3.1: Solvent content of alternative paints

Category	Mean solvent content (%)
Waterborne paint	< 20
Powder paint	0
High-solid paint (1 pack alkyds)	< 30
Low-solvent (1 pack radiation cure)[a]	0 - 3
Low-solvent (2 pack epoxy)[b]	< 10
Low-solvent (2 pack polyurethane paint)[b]	< 10
Conventional solvent paint	40 - 70

Source: ECE - VOC Task Force, 1990

a): setting of paint by IR or UV radiation

b): setting of paint by chemical reaction between binder (base-component) and hardener

The solvent content on application may be higher due to the use of ‘thinners’. It should be noted that some types of alternative paint still contain a low percentage of solvents. This is the case for waterborne and high-solid coatings. However, the content of organic solvents in these coatings is less than 30%. Powder and solvent-free liquid coatings do not contain organic solvents. When considering the effectiveness of changing to different coatings, it is important to consider the coverage efficiency, since this varies from paint to paint, as well as the solvent content.

Control options on exhaust air are the following:

- adsorption onto a solid surface;
- absorption by a liquid;
- membrane separation;
- condensation;
- incineration;
- biological treatment.

Typical ranges of efficiencies for different control options are given in Table 3.2. More precise values can be given for each type of coating operation.

Table 3.2: Control efficiencies for surface coating operations

Control option	**Reduction[a] (%)**
Replace with waterborne coatings	60 - 95
Replace with low solvent coatings	40 - 80
Replace with powder coatings	92 - 98
Add afterburners/incinerators	upto 95

Source: EPA, 1985. a): expressed as % of total uncontrolled emission load

Improvements in the transfer efficiency (fraction of the solids in the total consumed coating which remains in the part) decrease the amount of coating which must be used to achieve a given film thickness, reducing emissions of NMVOC to the ambient air. With brush and roller painting the loss of paint is small; however, uneven coating may lead to higher paint consumption. With spray painting, on the other hand, only part of the paint is effectively used since a proportion of the paint is sprayed around the products. Spray losses are determined by the product’s shape and the spray equipment used. Transfer efficiency for typical air atomised spraying ranges from 30 to 50 per cent. Electrostatic spray is most efficient for low viscosity paints. Charged paint particles are attracted to an oppositely charged surface. Spray guns, spinning discs or bell shaped atomisers can be used to atomise the paint. Typical transfer efficiencies are in the range from 60 to 95%. High volume, low pressure (HVLP) air atomised spray guns have recently been introduced and are designed to reduce paint wastage caused by overspray. They have been reported to be cost effective compared with conventional air atomised spray guns with paint usage reduced by 20% (Aspinwalls/NERA).

Activity 060101 Paint application: manufacture of automobiles

With particular reference to car coating operations, three significant actions can be taken to reduce emissions:

i) installation of abatement equipment;
ii) modification of the spraying process, the oven and air supply systems
iii) reformulation of coating.

With regard to item i), only two technologies have actually been proven on a large scale in commercial installations:

- adsorption onto a solid surface;
- incineration

The latter can be used either as the final step after adsorption or as a “combined” collection and destruction process.

With regard to item iii), opportunities exist for changes in coating formulations as follows:

- coating solvent content: water-borne, high solids, powder coatings;
- steel body part versus pre-coloured plastic parts.

Water-borne paints and low-solvent lines are already in use in some automobile painting lines. For special parts (e.g. fuel tanks, shock-absorbers) powder paints are also already in use.

The potential for reducing solvent vapour emissions from car painting processes by means of different control options is given in Table 3.3. The reductions achieved by each technique will depend on the order in which they are applied; the following data refers to sequential application of the control techniques in the order listed.

Table 3.3: Potential Reductions in NMVOC emissions from car painting processes

Control Option	Reduction(%)
Incinerators on paint ovens	6 - 7
Improved application efficiency	5- 10
Low solvent paints	28 - 39
Water based paints	<6
Application of abatement equipment on spray booths	62 - 69
Solvent management	39 - 41

Emission limit values are established by different legislations; they can be used to estimate actual emissions, as an alternative to the above mentioned approach, based on uncontrolled emission factors and control system efficiencies. Emission rates are related to vehicle surface are, for instance, in the French legislation, an emission standard of 0.14 kg/m^2 is in effect from 03.01.1987 for new plants, from 01.01.1991 for existing plants, whereas a circular dated 11.06.1987, referring to the act of 19.07.1986 establishes a figure of 0.105 kg/m^2 solvent emitted per car painted as the first minimum objective to be achieved within 5 years.

The following values of emission factors expressed in kg/m^2 have been drawn from national information and from the proposal for an EC Directive on solvent emissions.

Table 3.4: Emission rates in use or proposed in different legislation

Country	(kg/m^2 of car body)	Date of entry into force	Notes
Germany	0.060	3/1/86 (new), 3/1/91 (exist.)	Uniform paint + lacquer[1]
	0.120	3/1/86 (new), 2/1/91 (exist)	Metallized paint + lacquer[1]
	0.035	May 91 ?	New plants
	0.045	May 91 ?	Existing plants
Italy	0.060	note 2	Existing plants
	0.120	note 2	Single application solid coat (existing plants)
	0.090	July 93	Double application or metallic coat new plants (existing plants[3])
Sweden	0.126	92	Actual average emission rate
	0.030	97/8[4]	
UK	0.120	October 1996	Clear over base systems
	0.060	October 1996	All other systems
	0.060	April 2001	All systems
EU	0.045	00?	>5000 monocoque cars per 12 months new plant
	0.060	07?	>5000 monocoque cars per 12 months existing plant
	0.090	00?	<5000 monocoque cars per 12 months new plant
	0.090	07?	<5000 monocoque cars per 12 months existing plant

1) The limit does not cover refinishing and waxing
2) 1992 for applications using highly toxic solvents, 1994 for applications using less toxic solvents but emitting greater than twice the guideline limit, 1997 for applications using less toxic solvents and emitting less than twice the guideline limit.
3) Equipped with water based paint, high efficiency electrostatic spraying, incinerators on bake ovens.
4) The two Swedish car companies have applied to have final implementation delayed by three years.

At present, no special regulations refer to NMVOC emissions from van, truck and bus coating processes; however, they should be significantly higher than for passenger cars given the fact that:

- the ratio between the surface coated in spray booths and the total surface (electro-coat) is substantially higher for commercial vehicles than for passenger cars;
- nearly all applications are manual, resulting in a much lower efficiency compared with automatic spraying;
- the automation of the spraying system is difficult due to the low production volume and the variation in shape of the products;
- the colour range is much wider (up to one hundred different colours), which calls for more frequent colour change operations and a large consumption of washing solvents.

The situation is the same for passenger cars with more than six seats.

Activity 060102 Paint application: car repairing

Although it is technically feasible to fit end-of-pipe abatement to vehicle refinishing processes, the use of reformulated products, coupled with improved transfer efficiency is a far more attractive option for process operators. Waterborne and high solids coatings are being developed and the use of high volume low pressure spray guns is increasing.

Activity 060103 Paint application: construction and buildings

Activity 060104 Paint application: domestic use

In the household sector and the commercial painting sector the only means to reduce NMVOC emissions are:

- to reduce the consumption of such products;
- to change the product composition;
- to change the modes of application.

To increase the effectiveness of implementation, additional measures, such as labelling of products and economic incentives for the use of low solvent products, could be taken.

The use of waterborne decorative coatings has increased with time, although the market share varies from country to country. Further progress can be expected, most technological difficulties have been or can be expected to be overcome with time, although currently waterborne paints can be more expensive than traditional alternatives. Some consumer resistance can also be expected.

Activity 060105 Paint application: coil coating

Incineration is currently used by some coil coaters and is likely to remain the most popular choice of abatement system. Due to the enclosed nature of these processes and therefore the high capture and destruction efficiency of incineration, only powder coatings are likely to reduce emissions from the sector further.

Activity 060106 Paint application: boat building

Since marine coatings are generally applied in-situ using spraying techniques, the most obvious options for reducing emissions are improved transfer efficiency (e.g. the use of HVLP spray guns) and reformulation of coatings. Some form of containment or capture of emissions might also be technically feasible in some cases.

Activity 060107 Paint application: wood

This sector covers a wide range of applications and so a variety of abatement options could be adopted. Reformulation of many paint systems may be possible with waterborne, high solid, powder and radiation cured paints all being developed. Where spraying is employed, solvent emissions can be reduced by switching to HVLP spray guns.

Many wood painting operations have significant fugitive emissions. These can be reduced by good solvent management, by the use of low solvent coatings, highly efficient application techniques and by enclosing the process wherever possible so that the air can be extracted through NMVOC abatement equipment.

As concerns the types of coatings, the use of high-solid paints (e.g. UV-cured paints) is the most promising option; powder or waterborne paints are less common, as they require high polymerisation temperatures, not compatible with the wooden support. Oven and spray booths can be equipped with activated carbon systems or combustion devices (both catalytic and thermal). Activated carbons must be avoided for some dangerous and reactive solvents; combustion technologies, on the other hand, are highly efficient with low air flow rates, whereas wood products industry is characterised by very high flow rates. Considerable efforts are being made towards an improvement of transfer efficiencies (common values are 0.15 - 0.5 for automatic systems and 0.1 - 0.2 for manual systems).

Activity 060108 Other industrial paint application

As with painting of wood, this sector covers a wide range of applications and a variety of control techniques are also available to reduce NMVOC emissions. These control techniques normally fall under one of three categories:

- modification in paint formula
- process changes
- add-on controls

At the present time modification in paint formula is the best means to reduce solvent emissions in industrial paints. The use of low solvent or powder coatings may reduce NMVOC emissions by 40 to 100 per cent. However, substitutes for products currently being used may not always be commercially available or fully developed for some applications.

Examples of process changes include:

- improvement of the application processes: electrostatic guns, heated paints (thus allowing higher solids content);
- reduction of the ventilation air flow rate with a better ventilation control, a recirculation system for the ventilation air from manned cabins to unmanned zones;
- the development of the use of pre-painted metal sheets.

Add-on controls include activated carbon adsorption, thermal and catalytic incineration. These technologies may have very high technical efficiencies of 90 to more than 99 per cent, but may only apply to a portion of the emission from the entire facility. Due to the generally high flow rate of waste gases and the low solvent content, add-on controls are often not the most cost effective abatement option and may be technically complex.

Activity 060109 Other non industrial paint application

Most coatings are applied in-situ, and the only abatement options which may be considered for these coatings are improvements in transfer efficiency and reformulation of coatings. Brush and roller application are widely used and since these methods of application have high transfer efficiencies little further can be done. Where spraying is used there is potential for the use of more efficient systems such as high volume low pressure (HVLP) spraying systems. Reformulation options include high solids and waterborne coatings. Due to the high technical specification of paints used in this sector, there may be problems in using waterborne systems in particular. However, very little information is available on the potential for reductions in solvent emissions from this sector.

4 SIMPLER METHODOLOGY

The simpler methodology is to multiply the consumption of paint by an emission factor.

An alternative methodology for activity 060101 is to combine the number of automobiles produced with an appropriate emission factor depending on the quality of the coating, the average area of the vehicles, the type of application systems and any control devices fitted. An alternative methodology for wood painting (060107) is to combine the area of coated product with an appropriate emission factor. Emission factors are available for a number of different types of painted wooden products.

Note. The activity statistics for paint use may not be easily categorised into the SNAP categories. At a simple level, it may only be possible to quote an emission for paint use as a whole on SNAP94 060100 level.

5 DETAILED METHODOLOGY

Realistic estimates for the different coating processes can only be obtained by means of solvent usage data. Plant-wide emissions can be estimated by performing a liquid material balance in uncontrolled plants and in those where NMVOCs are recovered for re-use or sale. This technique is based on the assumption that all solvent purchased replaces NMVOCs which have been emitted. Any identifiable and quantifiable side streams should be subtracted from this total. The general formula for this is:

(solvent purchased) - (quantifiable solvent output) = NMVOC emitted.

The first term encompasses all solvent purchased including thinners, cleaning agents, and the solvent content of any pre-mixed coatings as well as any solvent directly used in coating formulation. From this total, any quantifiable solvent outputs are subtracted. These outputs may include solvent retained in the finished product, reclaimed solvent sold for use outside the plant, and solvent contained in waste streams. Reclaimed solvent which is re-used at the plant is not subtracted.

The advantages of this method are that it is based on data that are usually readily available (e.g. from associations of paint manufacturers and sellers), it reflects actual operations rather than theoretical steady state production and control conditions, and it includes emissions from all sources at the plant. However, care should be taken not to apply this method over too short a time span. Solvent purchases, production, and waste removal occur in their own cycles, which may not coincide exactly.

In cases where control devices destroy potential emissions or a liquid material balance is inappropriate for other reasons, plant-wide emissions can be estimated by summing the emissions calculated for specific areas of the plant.

Estimating NMVOC emissions from a coating operation (application/flash-off area and drying oven) starts with the assumption that the uncontrolled emission level is equal to the quantity of solvent contained in the coating applied. In other words, all the NMVOC in the coating evaporates by the end of the drying process. This quantity should be adjusted downward to account for solvent retained in the finished products in cases where it is quantifiable and significant.

Two factors are necessary to calculate the quantity of solvent applied; the solvent content of the coating and the quantity of coating applied. Coating solvent content can be directly measured; alternative ways of estimating the NMVOC content include the use of either data on coating formulation that are usually available from the plant owner/operator or pre-mixed coating manufacturer or, if these cannot be obtained, approximations based on the information in Table 3.1. The amount of coating applied may be directly metered. If it is not, it must be determined from production data. These should be available from the plant owner/operator. Care should be taken in developing these two factors to assure that they are in compatible units.

Where an estimate of uncontrolled emissions is obtained, the controlled emissions level is computed by applying a control system efficiency factor:

(uncontrolled NMVOC) ´ (1 - control system efficiency) = (NMVOC emitted).

Not all potential emissions are captured and delivered to the control device. The control system efficiency is the product of the efficiencies of the capture device and the control device. Emissions from such sources as process waste water or discarded waste coatings may not be controlled at all. The above equation applies when the solvent is destroyed or disposed of, not when it is reused.

Note: there is a considerable possibility for double counting here, because of the use of cleaning and thining solvents. In general, thinning solvents are not covered elsewhere and need to be included in the total for this sector. Cleaning solvents for metals (specifically those used in metal degreasing) should not be included in sectors covering paint application.

6 RELEVANT ACTIVITY STATISTICS

For the simpler methodology, the total quantity of ‘paint’ which is used for each activity is required; some emission factors are in terms of paint only, others consider paint to include associated diluents and cleaning solvents as well. The choice of emission factors will depend upon the available activity statistics.

The alternative methodology for activity 060101 requires the knowledge of the number of painted vehicles and the average painted area of the vehicles. The alternative methodology for wood painting (060107) requires the knowledge of the number of painted pieces and the average painted area of each piece. The detailed approach can be used where either solvent usage data are available, or, alternatively, the solvent content of the coating and the quantity of coating applied.

In addition, the mass or relative proportion of sales of waterborne and the mass of organic solventborne paint is required.

The detailed approach can be used where either solvent usage data are available or alternatively, the solvent content of the coating and the quantity of coating applied, is known.

7 POINT SOURCE CRITERIA

Within the CORINAIR inventory, vehicle painting units with a production capacity higher than 100,000 vehicles/year (or equivalent) are all considered point sources.

In addition to this, according to the CORINAIR ‘90 methodology, every plant emitting more than 1,000 Mg/year is a point source. In practice, this is likely to include only a very small number of processes possibly including some coil coating (060105) and wood painting (060107) as well as a very small number of other industrial paint application (060108), principally the painting of metal packaging such as cans.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

Table 8.1 - Emission Factors for NMVOCs

Compound	**Sectore**	**Paint type**	**Abatement type**	**Abatement efficiency**	**Fuel type**	**Emission factor**[1]	**Data Quality**	**Country or region**	**Reference**
NMVOC	Car manufacture	All types	Baseline emission factor (uncontrolled)	N/A	N/A	**500 g/kg of paint**[2]	**C**	Unknown	Unknown
NMVOC	Car manufacture	All types	Baseline emission factor (uncontrolled)	N/A	N/A	**675 g/kg of paint**[2]	**C**	UK	Calculated from unpublished UK data
NMVOC	Car manufacture	All types	Solvent management plan / good housekeeping - type controls	30 %	N/A	**473 g/kg of paint**[2]	**D**	UK	Chem Systems Ltd / ERM 1996
NMVOC	Car manufacture	All types	Solvent management plan / good housekeeping - type controls and use of low solvent paints	55 - 60 %	N/A	**270-304 g/kg of paint**[2]	**D**	UK	Chem Systems Ltd / ERM 1996

NMVOC	Vehicle refinishing	All types	Baseline emission factor (uncontrolled)	N/A	N/A	**280 g/kg of paint**	**C**	Unknown	Unknown
NMVOC	Vehicle refinishing	All types	Baseline emission factor (uncontrolled)	N/A	N/A	**600 g/kg of paint (excluding thinners etc)**	**C**	Unknown	Unknown
NMVOC	Vehicle refinishing	All types	Baseline emission factor (uncontrolled)	N/A	N/A	**700 g/kg of paint**[2]	**C**	UK	Calculated from unpublished UK data
NMVOC	Vehicle refinishing	All types	Housekeeping - type controls	5 %	N/A	**665 g/kg of paint**[2]	**D**	UK	Chem Systems Ltd / ERM 1996
NMVOC	Vehicle refinishing	All types	Housekeeping - type controls, enclosed gunwash and HVLP guns	45 %	N/A	**385 g/kg of paint**[2]	**D**	UK	Chem Systems Ltd / ERM 1996
NMVOC	Vehicle refinishing	All types	Housekeeping - type controls, enclosed gunwash and HVLP guns and low solvent paints	60-76 %	N/A	**168-280 g/kg of paint**[2]	**D**	UK	Chem Systems Ltd / ERM 1996

NMVOC	Trade decorative	Solventborne	Baseline emission factor (uncontrolled)	N/A	N/A	**300 g/kg of paint**	**C**	Unknown	Unknown
NMVOC	Retail decorative	Solventborne	Baseline emission factor (uncontrolled)	N/A	N/A	**400 g/kg of paint**	**C**	Unknown	Unknown
NMVOC	Decorative	Solventborne	Baseline emission factor (uncontrolled)	N/A	N/A	**300 g/kg of paint**[2]	**C**	UK	Calculated from unpublished UK data

NMVOC	Decorative	Waterborne	Baseline emission factor (uncontrolled)	N/A	N/A	**33 g/kg of paint**[2]	**D**	UK	Chem Systems Ltd / ERM 1996

NMVOC	Coil coating	All types	Baseline emission factor (uncontrolled)	N/A	N/A	**200 g/kg of paint**[2]	**C**	UK	Calculated from unpublished UK data
NMVOC	Coil coating	All types	Solvent management plan / good housekeeping - type controls and incineration	95 %	N/A	**10 g/kg of paint**[2]	**D**	UK	Chem Systems Ltd / ERM 1996

NMVOC	Boat building	All types	Baseline emission factor (uncontrolled)	N/A	N/A	**750 g/kg of paint**[2]	**C**	UK	Calculated from unpublished UK data
NMVOC	Boat building	All types	Improved transfer efficiency and reformulated coatings	55 %	N/A	**338 g/kg of paint**[2]	**E**	UK	Author’s judgement based on information from industry

NMVOC	Wood coating	All types	Baseline emission factor (uncontrolled)	N/A	N/A	**750 g/kg of paint**[2]	**C**	UK	Calculated from unpublished UK data
NMVOC	Wood coating	All types	Solvent management plan / good housekeeping - type controls and reformulated paints	74 %	N/A	**270 g/kg of paint**[2]	**D**	UK	Chem Systems Ltd / ERM 1996
NMVOC	Wood coating	All types	Solvent management plan / good housekeeping - type controls and add on technology	80 %	N/A	**150 g/kg of paint**[2]	**D**	UK	Chem Systems Ltd / ERM 1996

NMVOC	Other industrial	All types	Baseline emission factor (uncontrolled)	N/A	N/A	**750 g/kg of paint**[2]	**C**	UK	Calculated from unpublished UK data
NMVOC	Other industrial	All types	Housekeeping and improved transfer efficiency	35 %	N/A	**488 g/kg of paint**[2]	**E**	UK	Author’s judgement
NMVOC	Other industrial	All types	Housekeeping, improved transfer efficiency and reformulated paints	66 %	N/A	**250 g/kg of paint**[2]	**E**	UK	Author’s judgement

NMVOC	Other non industrial	All types	Baseline emission factor (uncontrolled)	N/A	N/A	**740 g/kg of paint**[2]	**C**	UK	Calculated from unpublished UK data
NMVOC	Other non industrial	All types	Improved transfer efficiency and reformulated coatings	55 %	N/A	**333 g/kg of paint**[2]	**D**	UK	Author’s judgement based on information from industry

Notes:

1. Unless, otherwise stated emission factors are given in terms of emission per kg of paint including thinners and cleaning solvent.
2. These emission factors were originally expressed in g/litre of paint and have been converted to g/kg by assuming that 1 litre of paint weighs 1 kg in the case of wood paints and 1.2kg in the case of all other paints. This is because it is assumed that wood paints are largely unpigmented.

The above should only be considered as default emission factors, to be used if no better information is available. It may be possible to get better information by consulting, for example, the national product register or trade associations, for the national characteristic solvent content of the different types of coating used in a country.

An alternative methodology for activity 060101 is to combine the number of automobiles produced with an emission factor depending on the quality of coating, the type of application systems and control devices. The emission factor proposed by CORINAIR ‘85 was 10 kg/vehicle (within the range 5-15kg/vehicle). A range of 6-11kg/vehicle has been obtained from a detailed survey made in Italy during years 1991 to 1993, which refers to plants having a production bigger than 100,000 vehicles per year.

More realistic values can be calculated by multiplying the average painted surface area of the vehicle by an emission factor given in terms of the unit painted surface. Table 8.2 summarises the range of emissions observed from small (surface area 65m^2) and large (surface area 117m^2) car painting; these emission factors are for essentially uncontrolled processes.

Table 8.2: Uncontrolled emission factors for car painting

Type of car	Painted surface area m^2	Type of paint	Typical NMVOC emissions	
			kg/car	g/m^2
Small	65	Solid	12.3	189
Small	65	Metallic	14.1	217
Large	117	Solid	31.6	270
Large	117	Metallic	33.2	284

Source: UK Society of Motor Manufacturers & Traders

In order to estimate total emissions, it is therefore necessary to take into account the distribution of production by car size in each country. As the actual average surface for each vehicle category may differ from those given in Table 8.2, the relevant emission factor must be interpolated. Currently small cars have an average surface of about 65 m^2, medium size cars of about 75 m^2, and large cars of about 90 m^2; the production of these types of cars in the different EC-Member States is shown in Table 8.3.

Table 8.3: Breakdown by size of car production in the EC-Member States

Country	Small cars	Medium cars	Large cars
Belgium	10	80	10
France	8.6	41.5	49.9
Germany	0.3	18.7	81
Italy	42.7	32.2	15.1
Netherlands	10	80	10
Spain	40	60	-
United Kingdom	10.6	62.3	27.12

Source: Ziercock, 1993

As concerns the average painted areas of trucks, vans and buses, the following figures are available (IVECO FIAT, 1991):

truck cabins	60-75	m^2/vehicle
truck boxes	80	“ “
truck axles	4-8	“ “
truck chassis	11-25	“ “
vans	120	“ “
bus bodies	220-280	“ “
bus chassis	18-25	“ “

Total NMVOC emissions from existing plants currently amount to:

- 0.12 kg/m^2 on average for vans, trucks and passenger cars with more than 6 seats (but going up to 0.16 kg/m^2 in some cases);
- 0.5 kg/m^2 for buses.

Possible emission limits (yet to be discussed) are:

- 0.07 kg/m^2 (new plants) and 0.09 kg/m^2 (existing plants) from large installations for vans, trucks and passenger cars with more than 6 seats;
- 0.09 kg/m^2 (new plants) and 0.12 kg/m^2 (existing plants) from small installation for vans, trucks and passenger cars with more than 6 seats produced;
- 0.055 kg/m^2 (new plants) and 0.065 kg/m^2 (existing plants) for truck cabins which are not coated in the same facility as the truck chassis;
- 0.25 kg/m^2 (new plants) and 0.35 kg/m^2 (existing plants) from large installations for buses;
- 0.35 kg/m^2 (new plants) and 0.45 kg/m^2 (existing plants) from small installations for buses.

Emissions from the wood products industry (included in activity 060102) can also be estimated using an alternative methodology, in which emission factors are referred to the painted surface of the products. Emission factors depend on products’ quality and application methods; the following values, which represent the current situation of the wood industry in Italy, can be used elsewhere to give an order of magnitude (Federlegno, 1994):

Case A	100 g/m^2
Case B	400 g/m^2
Case C	400 g/m^2
Case D	200-585 g/m^2
Case E	360 g/m^2
Case F	284 g/m^2
Case G	600 g/m^2

Case A: painting on line of flat elements with prevalent use of polyester-based coating products and polyurethane-based finishing products
Case B: painting on line of flat elements with use of polyester-based products both for coating and finishing
Case C: spray painting of kitchens
Case D: spray painting of frames (the lowest value is referred to door frames and staff angles, the highest to furniture frames)
Case E: spray painting of chairs
Case F: spray painting of windows
Case G: spray painting of assembled furniture

Note: it may be difficult to obtain specific activity statistics for these emission factors, nevertheless , they indicate the range of factors that are available.

9 SPECIES PROFILES

The solvents used in surface coatings are a mixture of aromatics, acetates, ethers and alcohols. Estimates of solvent emissions by solvent type reported by selected countries and regions are given in Table 9.1.

Table 9.1. Reported solvent emissions from paint applications per substance group (wt.%).

Country	year	alkanes	aromatics	alcohols	esters	cellosolves	ketones	ClHCs	others
Finland	1991	28.3	32.1	13.1	13.1	11.4	1.8	0.2	-
France	1985	29.6	18.4	28.8	8[1]	-	14.6	0.6	-
W.Germany	1986	11[2]	23[2]	17.8	17.8	11.5	10.4	6.9	1.6
Italy	‘84-’86	13.4	42.1	11.5	11.5	7.7	11.5	1.5	0.8
Netherlands	1989	30.4	28.5	7.1	9.2	8.2	6.1	3.1	7.5
Sweden	1988	15.6	26.4	24.0	23.6	8.4	2.0	-	-
W. Europe	1990	29.7	24.1	11.5	17.7	6.9	9.9	0.0	0.2
USA	1989	17.1	15.9	16.0	29.8[1]	-	16.5	2.9	1.8

Source: Veldt, 1993

[1]) includes cellosolves
[2]) corrected for aromatics in alkanes

A profile of emissions from the use of paints in the UK is given in Table 9.2.

Table 9.2 Speciated profile of the paint industry in the United Kingdom

Species		wt %
Aliphatic hydrocarbons	white spirit	30.0
	SBP solvents	2.1
Aromatic hydrocarbons	toluene	10.0
	xylenes	12.4
	styrene	2.0
	160-180 boiling fraction	9.2
	180-220 boiling fraction	4.2
Alcohols	ethanol	0.6
	2-propanol	0.8
	2 methyl-1-propanol	1.8
	1-butanol	3.6
	2-butanol	1.5
	4-methyl-4-hydroxy-2-pentanone	1.5
	other alcohols	0.8
Esters	n-butyl acetate	2.7
	ethyl acetate	1.7
	other esters	0.7
Ketones	propanone (acetone)	1.8
	2-butanone (methyl ethyl ketone, MEK)	2.2
	4 methyl-2-pentanone (MIBK)	4.1
	cyclohexanone	0.6
	other ketones	0.6
Glycol ethers/acetates (cellosolves)	2-butoxyethanol	1.4
	1-methoxy-2-propanol	0.8
	other glycol ethers & acetates	1.5
Chlorinated		0.4
Other		1.0

Source: Rudd, 1995

Although data from national speciated surveys can be extrapolated to other countries, a comparison of the estimates from different countries given in Tables 9.1 and 9.2 shows that patterns of solvent use in paints can differ significantly. Countries are therefore encouraged to keep extrapolations at a minimum. These data are generally assigned a data quality B.

10 CURRENT UNCERTAINTY ESTIMATES

Due to the wide range of paint applications and the even larger number of paint formulations which are available, there must be considerable scope for uncertainty in emission factors. Due to developments in paint formulation the emission factors may be valid for only a short period. Improved emission factors are therefore required especially for controlled processes.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

Estimating emissions from surface coating operations is very site-specific because of the wide range of coating formulations and the variety of coating techniques in use. The only realistic option that can be generally used to improve emission estimates is to apply the detailed methodology, based on solvent mass balances.

Another aspect is the variation of paint types. This requires good activity data, which may not be present, particularly with the increasing use of alternatives to high solvent paints.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Emissions from industry (activities 060101, 060102 and 060103) can be disaggregated using the relative number of industrial employees as a surrogate pattern for emission distribution. The necessary assumption of uniform NMVOC emission rates for all industry branches is a source of considerable uncertainty. Emission figures for industrial paint application performed in larger installations (i.e. all those referring to the mechanical industry) can be disaggregated through the use of other indicators. Emissions from the domestic use of paints (activity 060104) can be disaggregared according to the population distribution, assuming a constant value of per-capita paint consumption.

In principle, activity 060101, industries could be point sources. Activity 060103 could be distributed according to population, or housing, rather than industrial employment

13 TEMPORAL DISAGGREGATION CRITERIA

Temporal allocation of emissions from industrial and professional paint application (activities 060101, 060102 and 060103) can be derived from monthly production statistics and from information on operating schedule, workshifts, week-end interval etc. For instance, it can be assumed that professional architectural applications, and the relevant emissions, take place only in daylight (this does not apply to the Nordic countries).

Emissions from the domestic use of paints are equally distributed during the day; they can take place both on working days and on holidays. In the absence of specific surveys, a reasonable assumption is that emissions on Saturdays are twice as high as those on the other days of the week (Obermeier et al., 1991). In addition, there is a seasonal aspect. Most painting for 060103/4 can be expected in the spring and summer.

Solvent vaporisation from paints and varnishes generally lasts for some hours from its application. The duration of this process obviously depends on a number of parameters describing drying conditions; a default assumption can be the following (Obermeier et al., 1991);

- for industrial uses, 80% of the solvent is released as soon as it is applied, and 20% in the following hour;
- for architectural uses, 50% of the solvent is released as soon as it is applied, 20% during the following hour, and 10% during each of the following three hours.

14 ADDITIONAL COMMENTS

Frequently, trade balance figures can provide a good overall figure than the use of surrogate statistics, although the level of detail is less.

15 SUPPLEMENTARY DOCUMENTS

No supplementary documents are required.

16 VERIFICATION PROCEDURES

Trade balance (import-export) and production statistics of a country may be compared to total emissions from solvent use. Per-capita emission factors can also be used to verify emission estimates: Available figures show that per-capita emissions from the paint application sector are strikingly uniform (see, for instance, Table 8.1.1 in chapter su060000 ‘Solvent use’).

Available statistics do not generally break down consumptions by individual activities. Some figures are available for France and for the United Kingdom (Akkenabdm 1992; Passant 1993); they can be used to derive per-capita emission factors referring to the individual activities:

- construction and building: France 1.4 kg/cap.y, Netherlands 1.7 kg/cap.y, United Kingdom 0.5 kg/cap.y;
- domestic use: France 0.6 kg/cap.y, Netherlands 1.1 kg/cap.y, United Kingdom 0.5 kg/cap.y.

The alternative approaches proposed for estimating emissions can also be used to check estimates carried out by means of the baseline methodology.

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19 RELEASE VERSION, DATE AND SOURCE

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20 POINT OF ENQUIRY

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SNAP CODE **60201**

SOURCE ACTIVITY TITLE **DEGREASING, DRY CLEANING & ELECTRONICS**
Metal degreasing

NOSE CODE: **107.02.01**

NFR CODE: **3 B**

1 ACTIVITIES INCLUDED

Degreasing is a process for cleaning products from water-insoluble substances as grease, fats, oils, waxes, carbon deposits, fluxes and tars. In most cases the process is applied to metal products, but also plastic, fibreglass, printed circuit boards and other products are treated by the same process. Therefore a wide range of NACE codes is covered. The metal-working industries are the major users of solvent degreasing. Solvent degreasing is also used in industries as printing and production of chemicals, plastics, rubber, textiles, glass, paper, and electric power.

Also repair stations for transportation vehicles use solvent cleaning part of the time.

2 CONTRIBUTION TO TOTAL EMISSIONS.

From the CORINAIR 90 inventory it can be concluded that the contribution of metal degreasing to total non-methane volatile organic compound emissions (including natural sources) for 21 of the 28 CORINAIR countries is about 1.8%.

The OSPARCOM-HELCOM-UNECE emission inventory gives for some specified substances the contributions given in Table 2.1. These substances are:

- tetrachloroethene (PER),
- trichloroethene (TRI),
- 1,1,1-trichloroethane (TCA),
- tetrachloromethane (TCM) and xylenes (XYL).

Table 2.1: Contribution to total emissions of some substances used for metal degreasing (from the OSPARCOM-HELCOM inventory)

Source-activity	SNAP-code	Contribution to total emissions [%]				
		PER	TRI	TCA	TCM	XYL
Metal degreasing	060201	3.3	5.2	1.1	0.1	0.4

In addition, metal degreasing could be a significant source of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), (ETC/AEM-CITEPA-RISOE 1997).

3 GENERAL

3.1 Description

As a result of the wide range of activities for which metal cleaning is used it is very difficult to get a reliable picture of the penetration of the different techniques. Assuming a stationary situation for practical reasons the nation-wide figures can be derived from sales information. The detailed description is more applicable to situations where the applied technology is known.

Metal degreasing by using organic solvents takes place in either open top or closed tanks. Closed tank apparatus offers better opportunities for recycling of solvents. For some applications water based solvents containing tensides, sodium carbonate and alcohol's can be used. Application of these processes will lead to a great reduction of VOC emissions.

3.2 Definitions

Solvent degreasing	Removing fats, oils, wax or soil from surfaces with solvents as petroleum distillates, chlorinated hydrocarbons, ketones and alcohol's.
Good housekeeping	Use covers, let the fluid drip off, avoid spraying technique, recirculate solvents.
Improved equipment	Improved covers, use higher freeboard, cool freeboard.

3.3 Techniques

The following technologies are described:

3.3.1 Cold cleaners

Cold cleaners are mainly applied in maintenance and manufacturing. They are batch loaded, non-boiling solvent degreasers, providing the simplest method of metal cleaning. A distinction can be made between cleaners for maintenance, using petroleum solvents, and production cleaners using more specialised solvents. Cold cleaner operations include spraying, brushing, flushing, and immersion phases. There is a wide range of designs possible. Emissions occur by waste solvent evaporation, solvent carryout, solvent bath evaporation, spray evaporation and agitation.

3.3.2 Open-top vapour systems

Open-top vapour degreasers are batch loaded degreasers where the cleaning effect is achieved by condensation of hot solvent vapour on colder metal parts. Vapour degreasers only use halogenated hydrocarbons as solvents. Vapour degreasers are usually equipped with a water separator which allows the solvent to flow back into the degreaser. The use of good housekeeping can greatly effect the size of the emissions. Sources of emissions are solvent carry-out, exhaust systems, and waste solvent evaporation.

3.3.3 Conveyorised degreasers

Conveyorised degreasers may operate with either cold or vaporised solvent, but are continuously loaded and are in most cases hooded or enclosed. The large workload capacity, and the fact that they are usually enclosed leads to less solvent emitted per amount product than is the case with other technologies.

3.4 Emissions

The most common organic solvents for vapour cleaning are:

- methylene chloride	(MC)
- tetrachloroethylene	(PER)
- trichloroethylene	(TRI)
- 1,1,1-trichloroethane	(TCA)
- xylenes	(XYL)
- trichlorotrifluoroethane	(CFC-113)

The CFC is displaced by HFC's or PFC's. Further details about the calculation of the emissions can be found in the IPCC Manual (see section 17 References).

For batch cold cleaners the primary solvents used are mineral spirits, Stoddard solvents and alcohol’s like propyleneglycol.

3.5 Controls

In general it can be stated that good housekeeping can reduce emissions by about 20% compared to unabated emissions. Using water based technologies wherever possible also reduces the VOC emissions. Regarding the three different types of technologies the following measures can be taken:

Cold cleaners

- Waste solvent loss is the most important emission source. It can be reduced by distillation or incineration of waste solvent. Good housekeeping is for this technology also very important. Bath evaporation can be reduced by using a water layer of 5-10 cm on top of the solvent.

Open-top vapour systems

- Most emissions are due to diffusion and convection for which many abatement measures are available mostly like reducing the opening times, applying carbon adsorption etc.

Conveyorized degreasers

- As these degreasers are usually enclosed no extra primary measures are useful.

4 SIMPLER METHODOLOGY

The simplest way of calculating emissions from degreasing is based on solvent sales statistics, in combination with assumptions about the distribution over the different environmental compartments. This method assumes that a stationary situation is reached where only the solvent losses have to be supplied. Even in situations where it is possible to use the detailed method a comparison with sales to the sector will give a useful check on the information.

5 DETAILED STATE OF THE ART METHODOLOGY

A mass balance over an individual plant taking into account the technologies applied is the best approach for situations where the information about the technology is available.

6 RELEVANT ACTIVITY STATISTICS

Statistics about solvent sales should be used as a basis for the calculations when applying the simple method, and as a check when using the detailed methodology. For applying the detailed methodology an insight in the penetration of the different technologies is necessary. For the cold cleaners who are used in a very wide range of different maintenance- and production processes this will not be feasible in many cases. For the other processes who are more used as a part of a standardised process some information about the production derived from detailed production statistics may be available.

7 POINT SOURCE CRITERIA

Emissions from metal degreasing are either the main source for small activities or a secondary source for big metal producing plants. In both cases the emissions can be regarded as coming from a diffuse source.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

In Table 8.1 solvent loss emission factors are given for degreasing operations [1]. These factors can be used for the simple sales based approach, and for the type dependant information of the detailed approach. If no information about penetration of techniques or sales is available the inhabitant related factors based on a mean west-European situation can be used.

The information given in these tables may be different when applied to individual situations. To give an example of this aspect some measurements from the Czech Republic are given in Table 8.3.

Table 8.1: Solvent loss emission factors for degreasing operations.
(Emission factor rating: C)

Degreasing technique	Activity	Uncontrolled emission factor [(a)]
All (simple method) [(b)]	Solvent used	1000 kg/Mg
Cold cleaner		
Entire unit [(c)]	Units in operation	0.30 Mg/yr/unit
Waste solvent loss		0.165 Mg/yr/unit
Solvent carry out		0.075 Mg/yr/unit
Bath and spray evaporation		0.06 Mg/yr/unit
Entire unit	Surface area and duty cycle [(d)]	0.4 kg/hr/m2
Open top vapour		
Entire unit	Units in operation	9.5 Mg/yr/unit
Entire unit	Surface area and duty cycle [(e)]	0.7 kg/hr/m2
Conveyorized, vapour		
Entire unit	Units in operation	24 Mg/yr/unit
Conveyorized, nonboiling		
Entire unit	Units in operation	47 Mg/yr/unit

(a) 100% nonmethane VOC.
(b) solvent consumption data will provide much more accurate emission estimates than any of the other factors presented.
(c) emissions generally would be higher for manufacturing units and lower for maintenance units.
(d) for trichloroethane degreaser.
(e) for trichloroethane degreaser. Does not include waste solvent losses.

In Table 8.2 inhabitant related emission factors as a first approximation are given for the emissions of non-methane VOC emissions from small cold cleaning degreasing operations. It should be noted that there is significant uncertainty in these emission factors.

Table 8.2: VOC emissions from small cold cleaning degreasing operations
(emission factor rating: C)

Operating period	Per capita emission factor
Annual	1.8 kg [(a)]
Diurnal	5.8 g [(b)]

[(a)] include 25% 1,1,1-trichloroethane, methylene chloride and trichlorotrifluoroethane
[(b)] assumes a 6 day operating week (313 days/yr)

Table 8.3: Examples of measurements on different apparatus are given. (Bretschneider 1997)

Type of equipment	Open top-vapour	Cold cleaner	Conveyorized vapour	Conveyorized nonboiling	Cold cleaner
Solvent used	TCE	Water and propylene glycol	TRI	TRI	TRI
Abatement	adsorption to activated coal	-	adsorption to activated coal	-	-
VOC kg emission/ Cycle	0.062	0.002	0.40	0.15	5.87
VOC kg emission/hr	0.286	0.005	0.27	0.29	2.71
VOC kg emission/ton product	1.20	0.01	1.68	5.84	392

9 SPECIES PROFILES

Emissions from metal degreasing should be related to the solvent use. A profile of the solvents used which may differ from country to country should be used.
No general applicable profile can be given.

10 CURRENT UNCERTAINTY ESTIMATES

The accuracy of the calculated emissions depends on the accuracy of the statistics used. When the sales based methodology is used the accuracy can be estimated to be about C. The overall accuracy of the detailed method will not be much better, the local accuracy may improve to B. The inhabitant related approach will have an accuracy from D to E, dependant on the comparability of the different countries.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The weakest aspect is the lack of sufficiently accurate statistics about solvent use and penetration of techniques.

More details on abatement methods, including efficiencies, should be added.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Metal degreasing is a process that is used in a great number of small plants. Concentrations of these plants in a certain industrial area may be considered as point sources on a regional level. This may improve the local accuracy.

13 TEMPORAL DISAGGREGATION CRITERIA

Metal degreasing is a process that usually is only used during the daytime.

14 ADDITIONAL COMMENTS

15 SUPPLEMENTARY DOCUMENTS

16 VERIFICATION

Verification of the calculated emissions may be done be measurements at the plant level.

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Conducted by:
BSM Gesellschaft fur Betriebsberatung,Dusseldorf
TAUW Infraconsult B.V.

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SNAP CODE: **060202**

SOURCE ACTIVITY TITLE: **DEGREASING, DRY CLEANING & ELECTRONICS**
Dry Cleaning

NOSE CODE: **107.02.02**

NFR CODE: **3 B**

1 ACTIVITIES INCLUDED

Dry Cleaning refers to any process to remove contamination from furs, leather, down leathers, textiles or other objects made of fibres, using organic solvents.

2 CONTRIBUTION TO TOTAL EMISSIONS

The most significant pollutants emitted from dry cleaning are NMVOCs. These include chlorinated solvents (see section 3.4). Heavy metal and POP emissions are unlikely to be significant.

Source-activity	**SNAP-code**	**Contribution to total emissions [%], (including emissions from nature). [Source - CORINAIR90]**							
		SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
Dry cleaning	060202	-	-	0.6	-	-	-	-	-

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

3 GENERAL

3.1 Description

Dry cleaning can be defined as the use of chlorinated organic solvents, principally tetrachloroethene, to clean clothes and other textiles. In general, the process can be divided into four steps:

- cleaning in a solvent bath
- drying with hot air and recovery of solvent
- deodorisation (final drying)
- regeneration of used solvent after the clothes have been cleaned.

Clothes are first cleaned in a solvent bath, followed by drying in hot air. The solvents are regenerated and the dirt and grease from the cleaning process are removed as a waste product.

3.2 Definitions

Dry Cleaning - any process to remove contamination from furs, leather, down leathers, textiles or other objects made of fibres, using organic solvents.

3.3 Techniques

Two main types of machine are in use:

- open-circuit machines - deodorisation of the clothes take place with venting of drying air to atmosphere;
- closed-circuit machines – solvent is condensed from the drying air inside the machine and there is no general venting.

The following table shows the share of machine types for halogenated solvents in operation in some Member States (%), as reported in 1991:

Table 1: Share of Machine Types for Halogenated Solvents in Operation in Some EU Member States (%)

Country	Closed-circuit machines	Open-circuit machines	Open-circuit machines + activated carbon
Belgium	29	65	6
France	50	50	very few (large equipment)
Germany	45	0	55
Italy	50	50	
The Netherlands	30	5	65
Spain	44	53	3
United Kingdom	50	36	14

Source: Jourdan and Rentz, 1991

In the European Union, the dry cleaning sector is essentially made up of small family units, using 1 to 2 machines of 10/12kg capacity.

3.4 Emissions

Emissions arise from evaporative losses of solvent, primarily from the final drying of the clothes, known as deodorisation. Emissions may also arise from the disposal of wastes from the process.

The most widespread solvents used in dry cleaning, accounting for about 90% of the total consumption, are chlorinated solvents like tetrachloroethene (also called tetrachloroethylene or perchloroethylene (PER)), trichloroethene (trichloroethylene), 1,1,1-trichloroethane (methyl chloroform) and cichloromethane (methylene chloride).

To a lesser extent fluorinated solvents, mainly R113 (trichlorotrifluoroethane), and hydrocarbon solvents, are used for dry cleaning. Hydrocarbon solvents are C_{10} to C_{13} aliphatic hydrocarbons with a vapour pressure of less than 0,1 kPa at 20°C. Recent international agreements which address substances responsible for stratospheric ozone depletion have led to a decline in the use of certain solvents (e.g. chlorofluorocarbons and 1,1,1-trichloroethane).

Emissions of organic compounds from dry cleaning vary considerably with the type of process and solvent used. Solvent emissions come out of the cage, the air circulation system and the distillation column, the still boiler, the handling and storage of still residue and filter muck, and out of the pipe fittings, flanges and pumps of the transport system.

Solvent emissions from dry cleaning machines are highly dependent on correct operation and maintenance. Inadequate operating procedures and poor maintenance can result in an excessive loss of solvent, both in the workroom and to the outside atmosphere.

Further sources of emissions are the solvent-laden air discharged from storage tanks during filling and solvents retained on cleaned clothes and waste materials.

3.5 Controls

In general, emission control techniques include:

- Good operating procedures and end of pipe abatement techniques (such as condensation or carbon adsorption), or
- Replacement of machine with one with better performance (e.g. totally enclosed machines rather than open circuit machines)

4 SIMPLER METHODOLOGY

The simpler methodology is to estimate emissions from solvent consumption data. Most of the solvent is recycled, but some is lost to the environment. This needs to be replaced and it can be assumed that the quantity of solvent which is used for replacement is equivalent to the quantity emitted.

Solvent emissions directly from the cleaning machine into the air represent about 80% of the solvent consumption (i.e. 80% of solvent used for the replacement of lost solvent) for an open-circuit equipment and little more than 40% for a closed-circuit machine. The rest of the lost solvent is released to the environment in still residues or retained on cleaned clothes, but for the simpler methodology it can be assumed that this eventually finds its way to the atmosphere (Passant, 1993; UBA, 1989).

Solvent consumption data may be available from the industry and this can be compared with a per capita emission factor. In addition, the proportion of solvent lost directly from the machine can also be estimated.

5 DETAILED METHODOLOGY

The detailed methodology requires a comparison of solvent consumption data (available from the industry) or population, with emission estimates based on technology and solvent dependent emission factors and activity statistics.

It is necessary to estimate the mass of clothes cleaned by different machine types:

- Open-circuit machines for halogenated solvents without carbon filter
- Open-circuit machines for halogenated solvents with carbon filter
- Open-circuit machines for hydrocarbon solvents
- Conventional closed-circuit machines for halogenated solvents
- ‘New generation’ closed-circuit machines for halogenated solvents

6 RELEVANT ACTIVITY STATISTICS

Basic activity statistics are solvent consumption for the simpler methodology and quantity of material cleaned per machine type for the detailed methodology.

7 POINT SOURCE CRITERIA

Not applicable

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

In the absence of better data, the following default emission factors may be used (Jourdan and Rentz (1991), UNECE (1998), De Lauretis (1999)):

Simple Methodology

Emission Source	**Emission Factor (Quality Code)**
All machines	100% of solvent consumed[2] (D)
All machines	0.25 – 0.375 kg/inhabitant year (E)
Open-circuit machines[1]	0.8 kg/kg solvent consumption (D)
Closed-circuit machines[1]	0.4 kg/kg solvent consumption (D)

1 - For emissions into the atmosphere directly from the machine
2 - Solvent consumed (i.e. used to replace what is lost) can be assumed to be equivalent to solvent emitted

Detailed Methodology

Emission Source	**Emission Factor (Quality Code)**
Open-circuit machines for halogenated solvents without carbon filter	125 g/kg material cleaned (C)
Open-circuit machines for halogenated solvents with carbon filter	55 g/kg material cleaned (C)
Open-circuit machines for hydrocarbon solvents	5 g/kg material cleaned (C)
Conventional closed-circuit machines for halogenated solvents	30 g/kg material cleaned (C)
”New generation” closed-circuit machines for halogenated solvents	< 10 g/kg material cleaned (C)

9 SPECIES PROFILES

Perchloroethylene (PER) is the most important solvent in the European dry-cleaning branch, amounting to approximately 90% within the Union, followed by the chlorofluorocarbon R113. All the other solvents are of minor importance. In the United States and Japan flammable petroleum solvents (white spirit) are also used, such as Stoddard or 140-F, which are inexpensive hydrocarbon mixtures similar to kerosene (U.S. EPA, 1985).

Table 2: Share of Different Solvents used for Dry Cleaning in % (1991)

Country	PER	R 113	Others
Belgium	90	7	3
Denmark	90	10	0
France	93	5	2
Germany	90	10	0
Greece	?	?	?
Italy	85	14	1
Ireland	?	?	?
Luxembourg	97	0	3
The Netherlands	95	4	1
Portugal	97	0	3
Spain	95	5	0
United Kingdom	75	25	0
Austria	?	3	?
Finland	?	15	?
Japan	?	4	> 50
Norway	?	20	?
Sweden	?	50	?
Switzerland	?	25	?
United States	?	5	> 20

Source: Jourdan and Rentz, 1991

Small amounts of detergents are normally added to aid cleaning e.g. surface-active agents, solvents (alcohols, petroleum), optical whitener, resin finishing, disinfectant additives and aromatic substances. A profile for C_{10} - C_{13} hydrocarbon solvents in use in the United States is shown in Table 3.

Table 3: Speciated Profile of Emissions from the Dry Cleaning Using Petroleum Solvents (% wt.)

isomers of decane	11.28	methylheptane	4.19
isomers of undecane	7.92	methylnonane	0.91
isomers of dodecane	1.12	methyldecanes	0.43
isomers of tridecane	0.05	methylundecane	0.17
C_9 olefins	0.02	nonadiene	6.49
C_{10} olefins	2.15	pentylcylcohexane	0.24
C_{11} olefins	0.88	nonadiene	5.99
C_{12} olefins	0.12	dimethyloctanes	0.29
isomers of $C_{10}H_{18}$	0.07	dimethylundecane	2.48
isomers of $C_{11}H_{20}$	0.32	methlpropylcyclohexanes	0.21
$C_{10}H_{16}$	0.10	dimethyldecane	0.34
nonane	6.96	dimethylnonanes	0.10
methylcyclohexane	0.02	ethyloctane	4.27
ethylcyclohexane	0.59	ethylhexane	0.95
octanol	0.10	ethylmethylhexane	0.50
trimethylcyclohexanol	0.17	ethylmethylcyclohexanes	5.89
trimethylcyclopentanone	0.15	ethyldimethylcyclohexane	0.35
tetramethlypentanone	0.64	ethylpropylcyclohexanes	0.02
isomers of butylbenzene	2.74	trimethylheptanes	0.55
trimethylbenzene	2.23	trimethylhexene	1.68
isomers of propylbenzene	0.98	trimethyloctanes	1.49
toluene	0.50	trimethyldecane	0.77
ethylbenzene	0.35	tetramethylcyclopentane	0.67
o-xylene	1.56	butylcyclohexane	0.55
cumene (isopropyl benzene)	0.34	methyloctanes	0.55
tert-butylbenzene	0.31	propenylcyclohexane	0.43
ethyltoluene	0.38	methyldecene	0.10
C5-alkylbenzenes	0.10	propylheptenes	0.17
C4-alkylphenols	0.38	diethylmethylcyclohexanes	0.05
C5-alkylphenols	0.17	isopropylmethylcyclohexane	0.10
dimethylbenzylalcohol	0.15	dimethyloctyne	2.11
chlorobenzene	0.26	pentylidenecyclohexane	0.47
octahydroindenes	0.17	octahyrdopentalene	2.01
tetramethyltiorea	0.05	propylcyclohexane	0.45
benzothiazole	0.05	dimethylcyclohexane	0.55
naphtalene	0.35	trimethylcyclohexane	
methyldecalins	0.55	diethylcyclohexane	
decalins	0.60	dimethylheptanes	
m-xylene and p-xylene	2.26		

10 CURRENT UNCERTAINTY ESTIMATES

Uncertainty depends on the methodology. The highest uncertainty, >100%, would result from the use of per capita emission factors alone. Unverified solvent consumption data may also have a similar uncertainty.

The detailed methodology, where comparisons between different estimation techniques are used, should give an accuracy of ± 10% or better.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The weakest aspect of the methodology is the requirement for activity data on market share. This is likely to be difficult.

In addition, dry cleaning, in common with other processes using chlorinated solvents, is continually developing, solvents used will change and the efficiency of machines in use may improve rapidly. There will therefore be a need to review this chapter regularly.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Spatial disaggregation criteria depend on the size of the units: emissions from smaller installations can be reasonably disaggregated according to the population distribution, assuming a constant value of per-capita cleaned material.

As mentioned, the dry cleaning sector in the European Union essentially involves small family units, using 1 to 2 machines of 10/12kg capacity. In some countries, grouping of shops in “chains” may have a certain importance, but most of such groups operate only small units, so that pollution problems will be similar. For the whole Union, there are about 60000 dry cleaning shops. Table 2 shows the number of dry cleaning units in Member States, and the density of these units in relation to population.

Table 4: Main Characteristics of the Dry Cleaning Sector in EU Countries

Country	Number of Dry Cleaning Units	Density of Units in Relation to Population	Number of Machines
Belgium	1500	1/6500	
Denmark	1000	1/5000	
France	8000	1/7000	10000
Germany	10000	1/6000	12000/15000
Greece	3500	1/3000	
Ireland	800	1/4500	
Italy	20000	1/2500	
Luxembourg	50	1/8000	75/100
The Netherlands	660	1/20000	750
Portugal	1000	1/10000	1400
Spain	7500	1/5000	10500
United Kingdom	6500	1/8500	
Total	60510	1/5300	

Source: EEC, 1993

13 TEMPORAL DISAGGREGATION CRITERIA

Temporal allocation of emissions can be derived from monthly consumption statistics and from information on operating schedule, work-shifts, weekend interval etc. If these data are not available then constant operation should be assumed.

14 ADDITIONAL COMMENTS

No additional comments.

15 SUPPLEMENTARY DOCUMENTS

No supplementary documents are required.

16 VERIFICATION PROCEDURES

Verification is through the comparison of results using different methodologies:

- Emissions estimates based on per capita emission factors.
- Emissions based on solvent consumption data from the industry, trade associations etc.
- Emissions based on emission factors per tonnage of material cleaned.

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No additional references.

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107.02.04

NFR CODE: **3 B**

A specific methodology for these activities has not been prepared because the contribution to total national emissions is thought to be currently insignificant, i.e. less than 1% of national emissions of any pollutant.

For general guidance please refer to chapter 060000 Solvent and Other Product Use - Introduction.

If you have information contrary to this please contact the expert panel leaders.

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SOURCE ACTIVITY TITLE: CHEMICAL PRODUCTS MANUFACTURING OR PROCESSING

ACTIVITY	SNAP CODE	NOSE CODE	NFR CODE
Polyester Processing	**060301**	**107.03.01**	**3 C**
Polyvinylchloride Processing	**060302**	**107.03.02**	**3 C**
Rubber Processing	**060305**	**107.03.05**	**3 C**
Pharmaceutical Products Manufacturing	**060306**	**107.03.06**	**3 C**
Paints Manufacturing	**060307**	**107.03.07**	**3 C**
Inks Manufacturing	**060308**	**107.03.08**	**3 C**
Glues Manufacturing	**060309**	**107.03.09**	**3 C**
Adhesive, Magnetic Tapes, Films and Photographs Manufacturing	**060311**	**107.03.11**	**3 C**
Textile Finishing	**060312**	**107.03.13**	**3 C**
Leather Tanning	**060313**	**107.03.14**	**3 C**
Other	**060314**	**107.03.19**	**3 C**

A specific methodology for these activities has not been prepared because the contribution to total national emissions is thought to be currently insignificant, i.e. less than 1% of national emissions of any pollutant.

For general guidance please refer to chapter 060000 Solvent and Other Product Use - Introduction.

If you have information contrary to this please contact the expert panel leaders.

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SNAP CODE: **060303**
060304

SOURCE ACTIVITY TITLE: **CHEMICALS PRODUCTS MANUFACTURING OR PROCESSING**
Polyurethane Foam Processing
Polystyrene Foam Processing

NOSE CODE: **107.03.03**
107.03.04

NFR CODE: **3 C**

1 ACTIVITIES INCLUDED

This chapter deals with the application and subsequent discharge of organic compounds as blowing agents for creating plastic foams (Polyurethane and Polystyrene). These blowing agents need to be liquids which are characterised by a low boiling point. By application of external heat (polystyrene) or due to the reaction heat (polyurethane) the liquid evaporates and helps create the foam, without actually taking part in the reaction. Liquids used are CFC’s (like F11, F12, F22), now being replaced by pentane and butane. Emissions are from the release of these blowing agents during foaming, or subsequently by the long-term release over several years, and are strictly evaporative. The production of the raw materials is included in SNAP code 040500 covering bulk chemical production.

Polyurethane (PUR) and polystyrene (EPS) are used in building construction, for heat insulation, and for packaging material. Characteristic is a high proportion of on-site foaming, i.e. only the production takes place in well defined production plants, the foaming (EPS) and the actual formation (PUR) directly at the site needed, which leads to direct emissions without foreseeable control.

2 CONTRIBUTIONS TO TOTAL EMISSIONS

	PUR	**EPS**	**source**
Baden-Württemberg (Germany)	0.1 %*	1.3 %	(Rentz et al, 1993)
Austria	0.5 %	0.2 %	(Orthofer et al, 1989)

*) long-term emissions not considered

3 GENERAL

3.1 Description

a) Polyurethane

Polyurethane is produced by the exothermic reaction of iso-cyanates with alcohols. About 80 % of the world production is foams (Stoeckhert et al, 1993), which are created by adding blowing agents. For soft polyurethane foams water may be used, which binds with iso-cyanate to form CO_2. Hard polyurethane foams utilise organic liquids as blowing agents (CFC’s, now being replaced by alkanes), which evaporate due to the heat formation of the reaction. Hard foam is known for its good sealing and insulation properties. This also determines its use in refrigeration equipment as well as in the building and construction industry. While prefabricated compounds can be attributed to production sites directly, a considerable proportion of polyurethane foam is produced and applied directly, for example at a construction site. Figures for Germany (Greenpeace, 1991) indicate that this “direct production” is almost as large as prefabrication (7000t CFC’s used, vs. 9500t).

Another aspect of the sealing properties is, that the blowing agent is included into the cells of the structure, and only eventually released. According to German estimation (Rentz et al, 1990), only about 15 - 25 % of the blowing agent applied is released immediately, the rest is stored inside the cells of the foam and released eventually. Again, estimations are available for Germany (Plehn, 1990). The total amount of stored F11 (70000 t) is about 5 times the annual usage of CFC’s for hard foam polyurethane.

b) Polystyrene

Polystyrene foams are primarily used for insulation material and for packaging material. EPS raw beads contain about 6 % pentane which is evaporated in the expansion stages and emitted during pre-expansion and moulding as well as during transport and storage (Achermann, 1992). Moulding is frequently performed in relatively small units (by heating EPS-beads with steam), and therefore relatively difficult to control. For Baden-Württemberg (Rentz et al, 1993), the emissions from EPS foam processing are about 10 times the emissions from polyurethane processing (without long-term emissions).

3.2 Definitions

Blowing agent:	usually liquid substance which evaporates during the process (or releases gas) in order to expend the volume of the substrate (“blow”) into a foam.
PUR:	polyurethane
EPS:	expandable polystyrene

3.3 Techniques

see 3.1.

3.4 Emissions

Emissions are due to evaporation of blowing agents and consist of CFC’s or alkanes (pentane, butane), respectively. All blowing agent used will be emitted eventually into the atmosphere, unless there exists some kind of capturing device. However, it may take years until all of the blowing agent is released from the cells of a PUR foam.

3.5 Controls

Replacement of CFC’s by pentane and butane is reducing CFC emissions at the cost of increasing alkane emissions

Control / combustion of pentane, wherever defined production units are available

Reduction of long-term emissions by controlled destruction of used foam material (like the insulation of refrigerators).

Replacement of plastic foams as packaging materials.

4 SIMPLER METHODOLOGY

Emissions are derived from the production of PUR-foams and EPS foams times blowing agent content (see section 8). Assuming all of the blowing agent is eventually emitted, and constant annual production figures, the annual emissions are equal to the amount of blowing agent applied. In this case, the long-term emissions from foams produced in previous years are simply assumed to be equal to the amount of blowing agent retained in the foam produced in the current year.

5 DETAILED METHODOLOGY

Basically, emissions are determined the same way as for the simpler methodology. A number of parameters need to be taken into account, however:

Release of trapped blowing agents - According to figures presented by Rentz et al, 1993, about 30 % of the emissions due to hard PUR foam take place in the year of its formation, and 20 % in the years thereafter. In case of drastic changes of production, the production statistics of 4 years before the base year of the inventory need to be taken into account for the long-term releases.

Control measures (section 3.5) need to be taken into account for primary production. For EPS foaming, especially the abatement technology used in storage, pre-expansion and moulding has to be assessed (see section 8).

The blowing agent applied needs to be determined.

6 RELEVANT ACTIVITY STATISTICS

Industry statistics (production of PUR and EPS foams).

7 POINT SOURCE CRITERIA

No point sources are to be expected from this sector. Some large chemical plants may, however, include activities described here.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Simpler Methodology

Emissions are equal to the amount of blowing agent applied. Production figures are taken from the respective production statistics, the content of the blowing agent is listed in table 2.

Table 2: Content of blowing agent (%) in material before expansion

	Polyurethane (Rentz et al, 1993)	EPS (Achermann, 1992)
blowing agent content:	12 % (D) *	6 % ©

* figure derived for CFC’s used as a blowing agent. No data are available for pentane as a replacement. Applying the same emission factor, the quality code has to be downgraded to (E).

8.1 Detailed methodology

For EPS foam processing, the application of controls needs to be considered. While no explicit emission factors can be given, a split of the emissions during different parts of the process may help attributing the efficiency of an abatement device (table 3).

Table 3: Relative emissions during different stages of EPS foam processing [6]

Transport/storage of raw beads	8 %
pre - expansion	27 %
Storage	17 %
Moulding	25 %
Final product*	23 %

* Diffuse emissions during use

9 SPECIES PROFILES

Depending on the blowing agent, emissions are F11, F12, F22, butane and pentane. The dominant agent will be pentane in the foreseeable future.

10 UNCERTAINTY ESTIMATES

As the production figures as well as the content of blowing agent can be found quite straightforwardly, the uncertainty is not too high and may be in the range of +/- 30% (see also Rentz et al, 1993), where uncertainty is estimated at +/- 20 %).

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

No information is available on the amount of blowing agent being transferred to other media (soil, water) than air.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Much of the emissions are associated with final distribution of goods (packaging) or building industry (insulation). These emissions are most appropriately attributed to population. Thus disaggregation of emissions should be performed according to population.

13 TEMPORAL DISAGGREGATION CRITERIA

Depending on the specific situation, about half of the emissions may be considered continuous, the other half process - orientated, concentrated on regular working times.

14 ADDITIONAL COMMENTS

15 SUPPLEMENTARY DOCUMENTS

16 VERIFICATION PROCEDURES

The total emissions from the solvent sector (SNAP group 6) may be assessed applying a solvent balance (Import - Export + Production - Destruction) for a country. In many countries good statistics can be obtained which may be more reliable than the data available for individual source activities.

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19 RELEASE VERSION, DATE AND SOURCE

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SNAP CODE: **060310**

SOURCE ACTIVITY TITLE: **CHEMICALS PRODUCTS MANUFACTURING OR PROCESSING**
Asphalt Blowing

NOSE CODE:

NFR CODE: **3 C**

1 ACTIVITIES INCLUDED

Asphalt blowing is used for polymerising and stabilising asphalt to improve its weathering characteristics. Air blown asphalts are used in the production of asphalt roofing products, in the installation of built-up roofs and for the repair of leaky roofs. Air blowing of asphalt may be conducted at oil refineries, asphalt processing plants, and asphalt roofing plants. The emissions from a blowing still are primarily organic particulate with a fairly high concentration of gaseous hydrocarbon and polycyclic organic matter.

2 CONTRIBUTIONS TO TOTAL EMISSIONS

Asphalt blowing emitted the following percentages of anthropogenic emissions:

Table 1: Percent of Total Anthropogenic Emissions in 1990

Region	Particulate	SOx	NOx	CO	VOC
BG					0.1
Canada					0.04
DEw					1.0
ES					0.2
GR					<0.0
United States	0.2	0	0.004	0.001	0.004
CORINAIR					0.1

Emissions of SOx and NOx are most likely related to combustion for process heating (see SNAP Code 030100).

3 GENERAL

3.1 Description

The process involves blowing air through a hot asphalt flux to raise the temperature at which it will soften. Blowing may be done in vertical or horizontal stills. Catalysts may be used to achieve certain properties and to increase the rate of reaction.

3.2 Definitions

Blowing still: A blowing still is a tank fitted near its base with a ‘sparger’, which increases contact between the air and the asphalt.

3.3 Techniques

Asphalt blowing involves the oxidation of hot asphalt flux which is achieved by the bubbling air of the blowing still. Air is forced through holes in the sparger into a tank of hot asphalt flux. The result is an exothermic oxidation reaction, which raises the softening temperature of the asphalt, as well as modifying other characteristics.

The process is highly temperature dependent, as the rate of oxidation increases rapidly with increases in temperature. Since the reaction is exothermic, the temperature rises as blowing proceeds. Temperatures must be kept safely below the flash point of the asphalt. The temperature is therefore kept at an optimum level of 260 ^{o}C during blowing by spraying water onto the asphalt surface. For some crudes auxiliary cooling may also be required.

Inorganic salts such as ferric chloride ($FeCl_3$) may be used as catalysts to achieve the desired properties and/or to increase the rate of reaction, thus decreasing the blowing time. Blowing times may vary in duration from 30 minutes to 12 hours, depending on the desired characteristics of the asphalt (softening point, penetration rate).

Stills may be either vertical or horizontal. Vertical stills are preferred because of the increased asphalt-air contact and consequent reduction in blowing times, as well as lower asphalt losses.

Asphalt blowing can be either a batch process or a continuous operation. Typically, stills at roofing plants and processing plants may be run as batch processes, while refineries may run in both modes, depending on the product demand.

In Canada, the percentage of asphalt produced that was sold for non-asphalt purposes, and was therefore likely to have been blown, ranged from 16.4 to 24.7 % of total reported asphalt sales in the period 1983 to 1991. In the U.S., 14% of total sales was reported for non-paving uses in 1991. (Asphalt Institute 1992)

3.4 Emissions

Asphalt blowing stills are sources of particulate hydrocarbon, gaseous hydrocarbon and carbon monoxide. Emissions of gaseous hydrocarbons are small because of the prior removal of volatile hydrocarbons in the distillation units.

The type of crude and characteristics of the asphalt may influence the emissions. For instance, the US EPA (1980) hypothesizes that uncontrolled emissions are higher for asphalts derived from the more volatile West Coast or Middle East crudes than from the mid-continent crudes. Process parameters influencing emissions include the blowing temperature, air rate, design/configuration of the still, and the type of product desired (e.g. saturant or coating asphalt).

3.5 Controls

Process controls include the following:

1. vertical rather than horizontal stills;
2. asphalts that inherently produce lower emissions;
3. higher flash point asphalts;
4. lower asphalt blowing temperatures.

Thermal afterburners in combination with closed capture systems are used to control combustible emissions from asphalt blowing stills. Although they consume less supplemental fuels, catalytic afterburners cannot be used because the catalyst is subject to rapid poisoning and plugging due to constituents of the fumes from the process.

4 SIMPLER METHODOLOGY

The simplest inventory methodology is to combine total national production statistics with default emission factors to estimate total emissions. Default emission factors for this simplified approach re provided in Table 8.1.

5 DETAILED METHODOLOGY

The detailed methodology would involve procuring production statistics and control information for each plant. The latter information would be used to select the most appropriate emission factor. This would be for the case where asphalt blowing stills are considered to be point sources. If they are considered to be area sources, then the detailed methodology is not applicable. Reference emission factors for comparison with user’s own data are provided in Table 8.2.

6 RELEVANT ACTIVITY STATISTICS

The total weight of asphalt blown is required to estimate emissions from asphalt blowing stills. This information may be available on a national or regional basis from industry; for example, the Asphalt Institute publishes annual asphalt usage statistics for the United States and Canada.

7 POINT SOURCE CRITERIA

Release estimates only for asphalt blowing are difficult to obtain. For a large roofing manufacturing location, the U.S. EPA (1980) reports that about 120,000 Mg/yr. of asphalt would be blown. Emissions for this blowing facility in (Mg), calculated with emission factors from AP-42 (see Table 4) and assuming approximately half saturant and half coating blowing (U.S. EPA 1994) are summarised in Table 2.

Table 2: Calculated Annual Emissions for A Large Blowing Still (Mg)

Saturant Blowing		
Particulates	198	8.4
Total organic compounds	40	0.1
Coating Blowing		
Particulates	720	not available
Total organic compounds	102	5.1

Thus this asphalt blowing operation does not qualify as a point source of criteria pollutants in the CORINAIR 1990 classification, where emissions should be in excess of 1000 Mg in a year for SO_2 or NOx and 1500 Mg per year of NMVOC.

Note that the location of the still may be the most important parameter in determining if it is a point source under the CORINAIR system: stills located at a refinery would likely be inventoried as a point source because the rest of the facility will qualify for this designation. Stills at other locations may qualify depending on total production and/or what other emission sources, such as combustion sources, are present.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Simpler Methodology

A summary of default emission factors for use with the simpler methodology are provided in Table 8.1.

Table 8.1 Default emission factors for asphalt blowing

Pollutant	Emission factor	Units
Particulate matter Total suspended particulate	0.4[1]	kg/Mg
Arsenic	0.5	mg/Mg
Cadmium	0.1	mg/Mg
Chromium	6.0	mg/Mg
Nickel	54.7	mg/Mg
Selenium	0.5	mg/Mg
Polyaromatic hydrocarbons	3.75	kg/Mg

8.2 Detailed Methodology

Tables 8.2a and 8.2b provide reference emission factors for comparison with user's own emission factors.

Table 8.2a Emission Factors for Asphalt Blowing (Passant 1993)

	NMVOC	Data	Data
Asphalt blowing	**Emission Factor**	**Quality**	**Source**
Controlled	27.2 kg/t asphalt	D*	Robinson and Sullivan 1992
Uncontrolled	0.54 kg/t asphalt	D	Robinson and Sullivan 1992

* An estimate based on an engineering calculation derived from a number of relevant facts and assumptions

Emission factors from the U.S. EPA compilation of air pollutant emission factors for asphalt roofing manufacturing plants are summarised in Table 8.2b.

Table 8.2b Emission Factors for Asphalt Blowing (U.S. EPA 1994)

Operation	**Particulates**	**TOC**[a]
	Emission Factor (Data Quality) (kg/Mg asphalt processed)	
Uncontrolled		
Saturant	3.3	0.66 (E)
Coating	12	1.71 (E)
Controlled		
Saturant	0.14	0.0022 (D)
Coating		0.085

[a] total organic compounds , [b] both processes are controlled with after burners

For blowing stills associated with petroleum refineries, the U.S. EPA (1985) cites an uncontrolled VOC emission factor of 30 kg/Mg of asphalt, stating that emissions may be controlled to negligible levels by vapour scrubbing, incineration or both. No quality factor is given.

9 SPECIES PROFILES

Passant (1993) used the general speciation profile summarised in Table 9 for emissions from petroleum refineries to characterise emissions from asphalt blowing.

Table 9: Asphalt Blowing - NMVOC Speciation (Passant 1993)

Compound	% Weight
Ethane	6.0
Propane	18.8
Butanes	30.5
Pentanes	17.2
Hexanes	8.4
Heptanes	9.8
Octanes	7.4
Cycloparaffins	1.9
Benzene	0.1

UN ECE groups: 2% group I; 73% group II; 25% group III.
POCP factor:43

10 UNCERTAINTY ESTIMATES

It is not possible to estimate the accuracy of estimates based on the emission factors summarised in section 8. Based on the low data qualities and the large differences in emission factors, the level of uncertainty is high. The comments received from other panel members suggest that the uncertainty is greater than a factor of 2.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

Quality factors assigned to emission factors for NMVOC and CO are low. It is recommended that improvements be made in the emission factors for these sources through new testing programs for uncontrolled and controlled blowing of asphalt.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

If asphalt blowing is inventoried as an area source, emissions may be disaggregated based on population.

13 TEMPORAL DISAGGREGATION CRITERIA

Asphalt blowing may be expected to occur year round. The U.S. EPA indicates that a typical blowing plant at a roofing manufacturing site may operate 16 hours a day, five days a week. Similar information for asphalt blowing at other facilities was not identified.

14 ADDITIONAL COMMENTS

There is considerable uncertainty on how much asphalt is actually blown. For instance, asphalts used for paving in France may be blown.

15 SUPPLEMENTARY DOCUMENTS

16 VERIFICATION PROCEDURES

Emissions estimates at selected facilities could be verified against plant measurements.

17 REFERENCES

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18 BIBLIOGRAPHY

19 RELEASE VERSION, DATE AND SOURCE

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SOURCE ACTIVITY TITLE: OTHER USE OF SOLVENTS AND RELATED ACTIVITIES

ACTIVITY	SNAP CODE	NOSE CODE	NFR CODE
Glass Wool Enduction	**060401**	**107.04.01**	**3 D**
Mineral Wool Enduction	**060402**	**107.04.02**	**3 D**
Application of Glues and Adhesives	**060405**	**107.04.05**	**3 D**
Domestic Use of Pharmaceutical Products	**060411**	**107.04.11**	**3 D**
Other (Preservation of Seeds,...)	**060412**	**107.04.12**	**3 D**

A specific methodology for these activities has not been prepared because the contribution to total national emissions is thought to be currently insignificant, i.e. less than 1% of national emissions of any pollutant.

For general guidance please refer to chapter 060000 Solvent and Other Product Use - Introduction.

If you have information contrary to this please contact the expert panel leaders.

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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

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

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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.

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19 RELEASE VERSION, DATE AND SOURCE

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AEA Technology Environment
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SNAP CODE: **060404**

SOURCE ACTIVITY TITLE: **OTHER USE OF SOLVENTS & RELATED ACTIVITIES**
Fat, Edible and Non Edible Oil Extraction

NOSE CODE: **107.04.04**

NFR CODE: **3 D**

1 ACTIVITIES INCLUDED

Solvent extraction of edible oils from oilseeds. Drying of leftover seeds before resale as animal feed.

2 CONTRIBUTION TO TOTAL EMISSIONS

Emissions of NMVOC from the solvent extraction and subsequent drying of oilseeds represent between 0 and 0.5% of a country's total NMVOC emission.

For example, in the UK the contribution is 0.34% (Passant, 1993).

3 GENERAL

3.1 Description

The extraction of oil from oil seeds is performed either mechanically or through the use of solvents, or both. Where solvent is used, it is generally recovered and cleaned for reuse. The seed may be subjected to solvent treatment many times before all the oil is extracted. The remaining seed residue is then dried and may be used as an animal feed.

3.2 Definitions

3.3 Techniques

If the oil content of the seed is high, for example olives, the majority of the oil is pressed out mechanically. Where the oil content is lower, or the remaining oil is to be taken from material which has already been pressed, solvent extraction is used.

Hexane has become a preferred solvent for extraction. In extracting oil from seeds, the cleaned and prepared seeds are washed several times in warm solvent. The remaining seed residue is treated with steam to capture the solvent and oil which remains in it.

The oil is separated from the oil-enriched wash solvent and from the steamed out solvent. The solvent is recovered and re-used. The oil is further refined.

3.4 Emissions/Controls

Solvent recovery is an integral part of solvent extraction plant. The economics of a plant may be finely balanced on the proportion of solvent which is recovered. The efficiency of recovery is usually high, but is dictated by economic considerations, and will be limited to recovery plant on which the capital investment can be paid for by reduction in expenditure on new solvent.
Emissions of NMVOC will also arise from the drying of spent oil seeds.

Emissions may be controlled by improving the efficiency of the solvent extraction plant and by adding abatement equipment such as water scrubbers to the drying plant.

4 SIMPLER METHODOLOGY

The simpler methodology is to combine an activity statistic with an appropriate emission factor for solvent extraction and for the drying of spent grain.

5 DETAILED METHODOLOGY

A more detailed methodology would combine activity statistics and emission factors for different vegetable oil types and for the production of different VOC species. It might also consider other stages within the oil extraction process.

6 RELEVANT ACTIVITY STATISTICS

For the simpler methodology, the relevant activity statistics are the quantities of oil extracted and seed used in units of tonnes per year. In addition, the total solvent consumption by the industry is a measure of the solvent required to replace that lost during the recovery process.

For the more detailed methodology, the activity for different oil types and for different NMVOC species are needed. Data on other stages within the oil extraction process could also be used.

7 POINT SOURCE CRITERIA

There are relatively few oil extraction plants in the UNECE area. These could be considered as point sources, if plant specific data are available. Otherwise the activity is a relatively small source of NMVOC and hence should be considered as an area source.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Simpler Methodology

Solvent extraction:

Emission Factor	**Quality Code**	**Reference.**
19 kg VOC. t^{-1} of seed	D	Finelt (1979)
6 kg VOC. t^{-1} of seed	D	Munday (1990)
0.85 kg VOC. t^{-1} of seed	C	Swannell et al. (1991)

Grain Drying:

Emission Factor	**Quality Code**	**Reference**
1.31 kg VOC. t^{-1} of seed	D	US EPA (1985)

8.2 Detailed Methodology

No data available.

9 SPECIES PROFILES

The only solvent identified is hexane (Rentz *et al.*, 1990), and any solvent which fails to be recycled will eventually be emitted. Hexane is therefore suggested as the major species emitted (Data Quality D). Aldehydes and Fatty acids are liberated during steam treatment (Swannell *et al.*, 1991).

10 UNCERTAINTY ESTIMATES

The range of emission factors available suggests that there is considerable variation from plant to plant on the efficiency of the solvent recovery systems, with older plant being considerably less efficient than new plant. If this is not taken into account then the emission estimate may vary by a factor of 20.

There is only one reference emission factor for the drying of seed. This may not be expected to vary as much as the efficiency of solvent recovery plants. Nevertheless an uncertainty estimate of 100% cannot be ruled out.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The weakest aspect of the methodology is the application of general emission factors to different types of plant and different types of feedstock. The methodology would be considerably improved if emission factors could be established for old and modern plants and for the different types of seed e.g. corn, cotton seed, sunflower, rape, soya-bean, peanut.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

(Plants should be considered as point sources if possible.)

13 TEMPORAL DISAGGREGATION CRITERIA

It may be assumed that emissions occur uniformly over diurnal and annual cycles.

14 ADDITIONAL COMMENTS

15 SUPPLEMENTARY DOCUMENTS

Passant N.R., Richardson S.J., Swannell R.P.J., Gibson N., Woodfield M.J., van der Lugt J.P., Wolsink J.H., and Hesselink P.G.M. Emissions of Volatile Organic Compounds (VOCs) from the Food and Drink Industries of the European Community. Atmos. Environ. 27A, 2555-2566, 1993.

16 VERIFICATION PROCEDURES

Emission estimates based on emission factors may be compared with data on the total solvent consumption of this industrial sector. Emission factors should also be verified through measurements if possible.

17 REFERENCES

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SNAP CODE: **060406**

SOURCE ACTIVITY TITLE: **OTHER USE OF SOLVENTS & RELATED ACTIVITIES**
Preservation of Wood

NOSE CODE: **107.04.06**

NFR CODE: **3 D**

1 ACTIVITIES INCLUDED

This chapter considers industrial processes for the impregnation with, or immersion of timber in organic solvent based preservatives, creosote or water based preservatives.

Wood preservatives may be supplied for both industrial and domestic use. This SNAP only covers industrial use and does not include domestic use of wood preservatives, which is covered under SNAP 060408 (Domestic solvent use).

Most of the information currently available on emissions relates to the industrial use of wood preservatives.

This section is not intended to cover the surface coating of timber with paints, varnishes or lacquer (see chapter for SNAP 060100).

2 CONTRIBUTION TO TOTAL EMISSIONS

Table 2.1: Contribution to total emissions of the CORINAIR90 inventory *(11 of 28 countries which report to CORINAIR)*

Source-activity	**SNAP-code**	**Contribution to total emissions [%], (including emissions from nature)**							
		SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
Preservation of Wood	060406	-	-	0.6	-	-	-	-	-

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

The contribution to total NMVOC emissions from the preservation of wood varies significantly from country to country. It has been estimated (Giddings et al 1991) that the total NMVOC emission for the EU was 47.5 kt/a in 1990, varying up to 1% of the total NMVOC emissions from all sources in individual countries.

Wood preservation is likely to be a significant source of some POPs, such as PAHs and PCP. PAH emissions from creosote use are important. Wood preservation is unlikely to be a significant source of emissions of heavy metals to the atmosphere (Table 2.2), although releases of heavy metals to land and water could be important.

Table 2.2: Contribution to total POP and heavy metal emissions of the OSPARCOM-HELCOM-UNECE emission inventory *(up to 39 countries)*

Source-activity	**SNAP-code**	**Contribution to total emissions (including emissions from nature) [%]**										
		As	Cr	Cu	Pb	Cd	Hg	PCBs	PCDD/Fs	PAH	Lindane	PCP
Preservation of Wood	060406	0	0	0	0	0	0	0	0	30	5.5	55

Wood preservation is unlikely to be a significant source of sulphurhexafluoride (SF_6), hydrofluorocarbons (HFCs) or perfluorocarbons (PFCs), (ETC/AEM-CITEPA-RISOE 1997).

3 GENERAL

3.1 Description

Wood is preserved to protect it against fungal and insect attack and also against weathering. There are three main types of preservative: creosote, organic solvent based (often referred to as ‘light organic solvent-based preservatives (LOSP)’) and water borne.

3.1.1 Creosote preservatives

Creosote is an oil prepared from coal tar distillation. Creosote contains a high proportion of aromatic compounds such as PAHs.

Levels of Benzo[a]pyrene in some types of creosote are restricted in the EU to 500 ppm for industrial use (14th amendment to the Marketing and Use Directive - Creosote (96/60/EEC)).

Creosote is the oldest form of wood preservative and is used for external applications such as telegraph poles and railway sleepers. Creosote is gradually being replaced by water borne preservatives.

Creosote may be mixed with petroleum fractions to produce carbolinium. This can be brushed onto the surface of the wood and is mainly for private use.

3.1.2 Water borne preservatives

Water borne preservatives consist of solutions of inorganic salts in water. Copper, chromium and arsenic (CCA) types are the most widely used. These are usually based on copper oxide, chromium trioxide and arsenic pentoxide. In the UK CCA formulations are supplied only to industry.

3.1.3 Organic solvent borne preservatives

These consist of approximately 10% active ingredient including insecticides and fungicides such as dinitrophenol, pentachlorophenol, chloronaphthalenes, chlorobenzenes, lindane, dieldrin, organophosphorous and carbamate compounds, and copper/zinc naphthenates, (Giddings et al 1991). The preservatives also have 90% organic solvent, usually white spirit or other petroleum based hydrocarbons.

3.2 Definitions

Carbolinium - a mix of creosote and petroleum fractions.

CCA - copper, chromium and arsenic water-borne preservatives

Creosote - the oldest form of wood preservative. Creosote is an oil prepared from coal tar distillation; contains a high proportion of aromatics.

NMVOC - non-methane volatile organic compounds.

PAH - polycyclic aromatic hydrocarbons.

PCB polychlorinated biphenyls.

PCDD/F- polychlorinated dibenzo-para-dioxins and polychlorinated dibenzo furans - a series of chlorinated aromatic compounds, commonly known as ‘dioxins’.

PCP - pentachlorophenol

POPs - persistent organic pollutants.

SBP - Specific Boiling Point

Vacuum process - a process for the application of wood preservative, making use of an evacuated chamber.

White spirit - a petroleum fraction intermediate between gasoline and kerosene. White spirit or other petroleum distillates are commonly used as organic solvents in wood preservatives

3.3 Techniques

Wood preservation is a major industry, with 6 million m^3 of timber treated annually in the EU alone (Hein et al. 1994). Wood impregnation may be carried out at large plants, where control of emissions may be practical, or smaller plants, where add-on abatement systems could be prohibitively expensive.

The application of the preservative may be via vacuum processes, dipping, spraying or brushing. Vacuum processes are used widely in the UK, The Netherlands and Denmark, but in other EU Member States dipping, spraying and brushing techniques are more common (Hein et al. 1994).

The vacuum process may vary slightly, depending on the preservative :

3.3.1 Creosote preservatives

Timber is treated in a chamber which may be pressurised with air. The chamber is flooded with hot creosote for 1-3 hours. After draining, a vacuum is applied to draw off excess creosote. The timber is then left to dry in the open air.

3.3.2 Water borne preservatives

These are applied in the same way as creosote.

3.3.3 Organic solvent borne preservatives

Timber is treated in a chamber which is subsequently evacuated. The chamber is flooded with preservative and pressurised for 5 to 20 minutes. After draining the chamber, a final vacuum is applied to draw off excess preservative. The timber is left to dry in the open air.

About 15-25 % of the solvent remains in the wood which leaves the treatment plant. A large part of this residual solvent is likely to evaporate over the life of the product.

The application efficiency of the vacuum process, dipping and brushing is close to 90%. Spraying has a much lower efficiency of around 50% (Giddings et al 1991).

3.4 Emissions

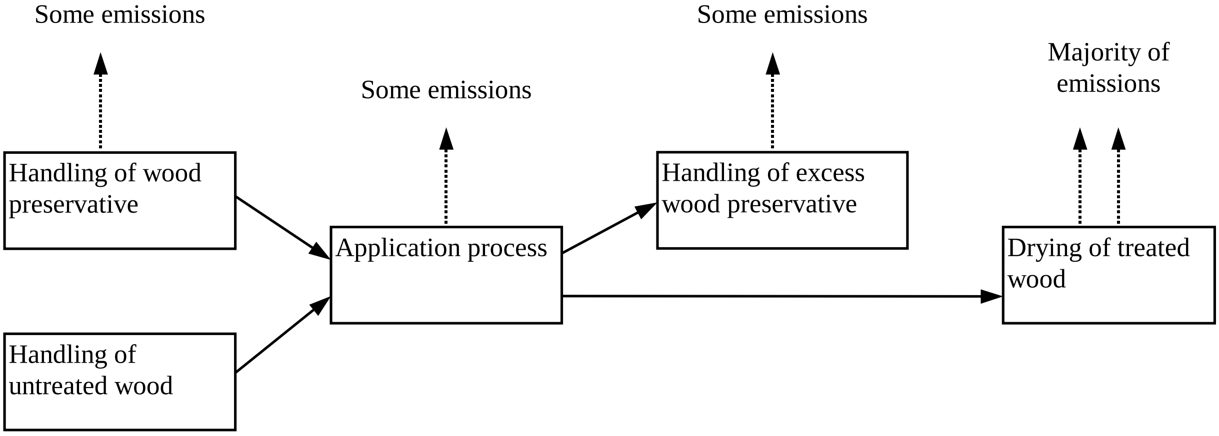
NMVOCs result from the evaporation of organic solvents and the volatile components of creosote.

The evaporation of creosote is likely to be a significant source of PAHs. In addition the use of certain organic solvent-borne wood preservatives is a potential source of other POPs such as lindane and pentachlorophenol.

These emissions may be fugitive (un-captured emissions) or captured and vented via a stack. Stack emissions may be controlled using waste gas cleaning (e.g. carbon adsorption, incineration etc.).

Fugitive emissions can occur throughout the handling, application and drying stages of the processes. Timber impregnation using the closed double vacuum process minimises the fugitive loss from the application process. However, the majority of the emissions occur during the drying process (Chem Systems Ltd / ERM 1996).

Figure 3.1 - Stages in industrial wood preservation process with likely emission sources



3.5 Controls

Emissions from drying can be reduced by enclosing the drying process so that air can be extracted through abatement equipment (e.g. condensation or incineration).

In addition some reduction in emissions from the handling and application process can be made by good solvent management, housekeeping-type controls, measures to reduce spillages, enclosing the process wherever possible, and using alternative low solvent coatings where possible.

A separate abatement option for some processes which use creosote or organic solvent-borne preservative is substitution with water-borne preservatives. This abatement option would be nearly 100 % efficient for NM VOCs, but in many processes organic solvent-borne preservatives are still used where they offer substantial technical advantages (e.g. some organic solvent-borne preservatives give greater durability and are more likely to be used for wood which will be subjected to difficult environments). Many processes are therefore unlikely to substitute the preservatives they use. The applicability of this substitution option will therefore vary between countries.

Where a spraying process is used, a reduction in NMVOC emissions could be achieved (depending on the existing level of abatement) by changing the process to, for example, the vacuum process, which would improve the application efficiency from 50 % to 90 %.

4 SIMPLER METHODOLOGY

The simpler methodology involves the combination of emission factors (e.g. mass of NMVOC emitted per kg of wood preservative used) with activity statistics (e.g. kg of wood preservative used), taking into account the extent of control expected to be present. Equation (1) gives an example of the simple methodology :

Emission = [Baseline emission factor] x [1- abatement efficiency] x [Mass of preservative used] (1)

If preservative consumption data is not available then it can be calculated by using the ‘quantity of wood preserved’ combined with the following assumptions (estimated from Giddings et al 1991) and equation (2) below :

1m^3 of wood requires 75 kg of creosote
1m^3 of wood requires 24 kg of solvent borne preservative
1m^3 of wood is approximately 1 t.

$$\text{Quantity of preservative used} = [\text{Volume of wood impregnated } (m^3)] \times [\text{kg of wood preservative per } m^3] \qquad (2)$$

5 DETAILED METHODOLOGY

The detailed methodology for NMVOC emissions involves a solvent audit of each plant. Estimates for each plant would be combined to give a more accurate estimate of the total emission. This methodology requires knowledge of the quantities of preservative used at a plant. Equation (3) is an example of how to calculate NMVOC emissions from each plant :

$$\text{NMVOC emission from a plant} = [\text{Mass of captured NMVOC emissions treated by abatement or recycled etc}] \times [1 - \text{abatement efficiency}] + [\text{Mass of fugitive (uncaptured) NMVOC emissions}] + [\text{Mass of NMVOC lost to land and water}] \qquad (3)$$

6 RELEVANT ACTIVITY STATISTICS

Simpler methodology

The simpler methodology requires the following activity statistics :

- mass production/consumption by industry of :
    - solvent borne wood preservatives;
    - creosote wood preservatives;

OR :

- mass/volume of wood treated by industry with :
    - solvent borne preservatives;
    - creosote;

In addition the simpler methodology requires some knowledge of the type, efficiency and applicability of existing abatement.

Detailed methodology

The detailed methodology requires the following activity statistics for each plant:

- mass of solvent borne preservatives consumed per year;
- mass of creosote consumed per year;
- mass of NMVOC lost to land, or water;
- mass of fugitive (un-captured) NMVOC emissions;
- mass of captured NMVOC emissions treated for abatement / recycled etc;
- efficiency of abatement equipment.

Given the difference between the use of wood preservatives by industry and for domestic applications, where possible activity statistics should be collected on both. For some countries, national statistics are not easy to obtain and it may be necessary to directly contact plants and trade organisations (e.g. West European Institute for Wood Preservation).

Hein et al. (1994) estimate that the 6.1 million m^3 of timber treated per year in the EU uses the following proportion of preservatives :

70 % water-borne preservatives
20 % organic solvent-borne preservatives
10 % creosote

7 POINT SOURCE CRITERIA

The wood preservation sector is characterised by a large number of relatively small plant. It has been estimated (Giddings et al, 1991) that 1000 installations are involved in the treatment of timber in the EU, resulting in an emission of approximately 47 kt/a. Therefore the average emission per installation is 47 t/a. This is relatively small for a point source and hence this activity can be considered as contributing to an area source. In addition, Giddings et al. (1991) estimate that 68% of plant use less than 25 t/a of solvent.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Simpler Methodology

Table 8.1 - Emission Factors for NMVOCs

Compound	Plant type	Preservative type	Abatement type	Abatement efficiency	Fuel type	Emission factor	Data Quality	Country or region	Reference
NMVOC	All processes[1]	Creosote	Baseline emission factor (uncontrolled)	N/A	N/A	**100-200 g/kg of creosote used [2]**	**D**	EU data	Giddings et al. 1991
NMVOC	All processes	Creosote	Solvent management plan / good housekeeping - type controls	5 %	N/A	**95-190 g/kg of creosote used [3]**	**D**	UK data	Chem Systems Ltd / ERM 1996
NMVOC	All processes	Creosote	Enclosure of drying and other areas and venting through end-of-pipe controls such as condensation or incineration.[6]	60-75 %	N/A	**25-80 g/kg of creosote used [4]**	**D**	UK data	Chem Systems Ltd / ERM 1996
NMVOC	All processes[1]	Organic solvent-borne preservative	Baseline emission factor (uncontrolled)	N/A	N/A	**900 g/kg of preservative used**	**C**	EU data	Giddings et al. 1991
NMVOC	All processes	Organic solvent-borne preservative	Solvent management plan / good housekeeping - type controls	5 %	N/A	**855 g/kg of preservative used**	**D**	UK data	Chem Systems Ltd / ERM 1996
NMVOC	All processes	Organic solvent-borne preservative	Enclosure of drying and other areas and venting through end-of-pipe controls such as condensation or incineration.[6]	60-75 %	N/A	**215-345 g/kg of preservative used[5]**	**D**	UK data	Chem Systems Ltd / ERM 1996

Table 8.1 (continued) - Emission Factors for NMVOCs

Compound	**Plant type**	**Preservative type**	**Abatement type**	**Abatement efficiency**	**Fuel type**	**Emission factor**	**Data Quality**	**Country or region**	**Reference**
NMVOC	All processes[1]	Water-borne preservative	Baseline emission factor (uncontrolled)	N/A	N/A	**0 g/kg of preservative used**	**C**	EU data	Giddings et al. 1991

Footnotes to Table 8.1

[1] Emission factors originally derived for vacuum process, but likely to apply for dipping, spraying or brushing processes as the majority of the emission occurs during drying.

[2] Recommended emission factor 150 g/kg.

[3] Recommended emission factor 145 g/kg.

[4] Recommended emission factor 50 g/kg.

[5] Recommended emission factor 280 g/kg.

[6] Assumes that solvent management plan / good housekeeping-type measures are also used

Table 8.2 - Emission Factors for PAHs

Compound	**Plant type**	**Preservative type**	**Abatement type**	**Abatement efficiency**	**Fuel type**	**Emission factor**	**Data Quality**	**Country or region**	**Reference**
Benzo[a]pyrene	Unknown	Creosote oil	Unknown	Unknown	N/A	**0.5 mg/kg of creosote used**	**E**	W Europe	Berdowski et al. (1995)
Benzo[ghi]perylene	Unknown	Creosote oil	Unknown	Unknown	N/A	**0.25 mg/kg of creosote used**	**E**	W Europe	Berdowski et al. (1995)
Benzo[k]fluoranthene	Unknown	Creosote oil	Unknown	Unknown	N/A	**0.25 mg/kg of creosote used**	**E**	W Europe	Berdowski et al. (1995)
Fluoranthene	Unknown	Creosote oil	Unknown	Unknown	N/A	**97 mg/kg of creosote used**	**E**	W Europe	Berdowski et al. (1995)
Indeno[1,2,3-cd}pyrene	Unknown	Creosote oil	Unknown	Unknown	N/A	**0.25 mg/kg of creosote used**	**E**	W Europe	Berdowski et al. (1995)
Benzo[b]fluoranthene	Unknown	Creosote oil	Unknown	Unknown	N/A	**0.25 mg/kg of creosote used**	**E**	W Europe	Berdowski et al. (1995)

No information is available on emission factors of other PAHs and other POPs.

8.2 Detailed Methodology

Emission factors should be derived through on-site measurements and a solvent audit. Otherwise, those factors listed above may be used.

9 SPECIES PROFILES

White spirit, other petroleum distillates and creosote are the most common solvents used. They are complex mixtures of hydrocarbons, ranging in mass from isomers of hexane to isomers of dodecane, aromatics such as toluene and xylene, and some C6 to C12 alkenes. Typical species profiles for white spirit, other petroleum distillates, and creosote, are given in annex 1.

10 UNCERTAINTY ESTIMATES

There is considerable uncertainty in estimating fugitive emissions of NMVOCs and the quantity that can be captured. Uncertainty in the emission factor estimates for NM VOCs is greater than a factor of 2. There is significantly greater uncertainty in the emission factors for PAHs (a factor of approximately 10).

There is also much uncertainty in the significance of this source with respect to emissions of PAHs and other POPs. Only the more volatile PAHs are likely to be emitted in significant quantities from creosote use. Additional uncertainty arises because of the potential for double counting of these PAH emissions and the NMVOC emissions.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The weakest aspect of the methodology is the accuracy of the emission factors and the lack of field-based emission data.

The recommended emission factors should be improved through on-site measurement, particularly from the controlled (abated) use of creosote and solvent borne preservatives. PAHs and other POPs should be covered by these measurements as well as NMVOCs.

In addition, the issue of evaporation of solvent after the treated wood has left site of the application process should be reviewed.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Emissions from wood impregnation may be considered to be distributed according to population. However, given that industrial wood preservation is unlikely to be an urban business, a significant improvement in the spatial disaggregation would be made if the main territorial units where wood preserving takes place could be identified.

Further information is required on spatial disaggregation for wood preservation processes.

13 TEMPORAL DISAGGREGATION CRITERIA

Unless better information is available, emissions may be considered to occur evenly through out the diurnal and annual cycles.

14 ADDITIONAL COMMENTS

A number of national Trade Associations exist which may be contacted to obtain information on wood preserving in a given country. In addition, further information may be obtained from the West European Institute for Wood Preservation.

15 SUPPLEMENTARY DOCUMENTS

No supplementary documents are required.

16 VERIFICATION PROCEDURES

For the simpler methodology, verification is through the solvent auditing of selected plants and comparison of this data with estimates based on emission factors. For the detailed methodology, inter-comparison of plants and a comparison with data from other countries is recommended.

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ANNEX 1 SPECIES PROFILES DATA

White spirit is commonly used in organic solvent-based wood preservatives.

Table A1 shows a “typical” composition of white spirit (Passant et al. 1996).

Table A1. Composition of white spirit

C - Number	Cycloalkanes	Paraffins	Aromatics
8			2
9	7	15	9
10	16	20	8
11	9	13	
12	2	4	
TOTAL	34	52	19

Rounding errors mean that the totals add up to > 100%.

Other petroleum distillates are also used in organic solvent-based wood preservatives. SBP solvents are petroleum fractions distilled to special boiling point ranges. The compositions of three example products are shown in table A2 (Passant et al. 1996).

Table A2. Composition of SBP solvents

Component	SBP 40/65 (Petroleum ether)	SBP 65/70	SBP 80/110
2-methyl butane	1		
n-pentane	32		
cyclopentane	7		
2,2-dimethyl butane	2		
2,3-dimethyl butane	7	2	
2-methyl pentane	38	20	
3-methyl pentane	11	18	
n-hexane	2	49	3
methylcyclopentane		8	5
cyclohexane		3	16
dimethylpentanes			9
methylhexanes			32
n- heptane			19
dimethylcyclopentane			9
methylcyclohexane			7

As discussed in section 3, creosote contains a high proportion of aromatic compounds, including PAHs. Approximately 10-20 % of the creosote used for wood preservation is made up of NMVOC (Giddings et al, 1991, Chem Systems Ltd / ERM 1996) and reported concentrations of PAHs in creosote vary from 54 % (Burtscher 1997) to 75-85 % (IARC (1985), Wild and Jones (1995)). The following results of a HPLC analysis (Burtscher 1997) indicate an approximate profile for PAHs in creosote oil :

Table A3. HPLC results from analysis of creosote oil

PAH	concentration (wt %)
Naphthalene	9,8
Acenaphthlyene + Fluorene	14,5
Phenanthrene	12,8
Anthracene	1,5
Fluoranthene	7,7
Pyrene	5,2
Benz[a]anthracene	0,7
Chrysene	0,4
Benzo[a]pyrene	370 ppm
Others	< 0,1

SNAP CODE: **060407**
060409

SOURCE ACTIVITY TITLE: **OTHER USE OF SOLVENTS & RELATED INDUSTRIES**
Underseal Treatment and Conservation of Vehicles
Vehicles Dewaxing

NOSE CODE: **107.04.07**
107.04.09

NFR CODE: **3 D**

1 ACTIVITIES INCLUDED

This chapter addresses the application of protective coatings to the undersides of cars and the removal from cars of temporary protective coverings that are applied to protect the car's paint work during transport.

2 CONTRIBUTION TO TOTAL EMISSIONS

Underseal treatment of cars and vehicle dewaxing are unlikely to be a significant source of emissions.

Table 2.1: Contribution to total emissions of the CORINAIR90 inventory

Source-activity	**SNAP-code**	**Contribution to total emissions (including nature) [%]**							
		SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
Underseal Treatment of Cars	060407	-	-	0.15	-	-	-	-	-
Vehicle Dewaxing	060409	-	-	0.2	-	-	-	-	-

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

Note that the above contributions represent emissions reported from 9 countries for 060407 and 8 countries for 060409.

3 GENERAL

The following description of the processes and controls is based on discussions with SMMT, ACEA and Ford Europe (see references, section 17).

3.1 Description

3.1.1 Underseal treatment

The application of coatings to the underside of car bodies can be divided into Original Equipment Manufacture (OEM) sector and the aftermarket (repair) sector. For the OEM sector a coating of PVC plastisol[1] is applied during manufacture to the underneath of car bodies at the same time as the primer. The body is then heated in an oven at 135°C for about 5 minutes to cure both the primer and the PVC coating. This coating is applied for protection from stone chips and for sound deadening. The PVC coating is 97% - 99% solids and is an integral part of the vehicle’s coating “package”. Any emission during manufacture will be included in any estimate of the emission from painting during vehicle manufacture (activity 060101 "paint application: manufacture of automobiles").

In the aftermarket sector coatings are applied to the underside of cars only during repair of damaged bodywork. This coating is the same type as in the OEM sector. These emissions will be included under activity 060102 “car repairing”.

Before the early 1980s car manufacturers did not apply any coating to the underside of their cars. If a car owner wanted to protect their car against rust and stone chip damage they had to pay to have their car ‘undersealed’ at a garage or workshop. This involved the application of a bituminous coating. The market for this service no longer exists in much of Western Europe. It may still occur in Eastern Europe and in the restoration and maintenance of vintage cars but this activity is likely to be very small indeed.

3.1.2 Vehicle Dewaxing

Some new cars have a protective covering applied to their bodies after painting to provide protection during transport. In the UK this is usually done only on cars destined for export. Removal of the coating is usually done only at import centres. Cars produced for the home market are not usually given a protective covering unless there is a specific reason, for example problems at their storage location. In continental Europe cars are transported long distances on land as well as being imported from overseas so the driving forces affecting the use of such coatings may be different.

Transport protection coverings are not applied to the whole car body but only to regions of the body considered vulnerable to damage during transport. The pattern of application varies from one manufacturer to another. Some manufacturers do only the bumper, some do only the drivers door, some do the horizontal surfaces and some do the sides as well.

There are a number of methods for applying coverings for protection during transport. Traditionally a hydrocarbon wax has been used which had to be removed using a mixture of hot water, kerosene and detergent. Recently two alternative methods have been introduced. The first of these is a water soluble wax which can be removed with hot water alone without the need for the kerosene. The second is a self adhesive polyethylene film called “Wrap Guard”. This can be peeled off by hand and disposed of as ordinary commercial waste. Most European car manufacturers are currently either already using self adhesive polyethylene film

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[1] a colloidal suspension of fine PVC particles in a liquid plasticiser which solidifies on heating to give a rubbery material

or are evaluating it. It is expected that within a few years all European manufacturers will be using self adhesive polyethylene film as their only method of applying transportation protective coverings, as has been the situation in the US for a number of years already.

Consequently it is recommended that the VOC emission from this source is assumed to be rapidly approaching zero.

3.2 Definitions

Vehicle refinishing	The repair of vehicles damaged in accidents and also the repainting of old vehicles to improve their appearance (see SNAP 060102).
OEM	Original Equipment Manufacture - refers in this context to the manufacture of new vehicles.
Aftermarket	Products and services supplied to vehicle owners in connection with their vehicle but not as part of the vehicle manufacture itself (see SNAP 060102).

3.3 Techniques

The techniques used in the activities are described in Section 3.1.

3.4 Controls

Aftermarket underseal treatment of vehicles using bituminous coatings is no longer carried out in Europe on modern cars. What little is carried out is likely to be during the restoration and maintenance of vintage cars. This market is very small indeed. Where it is carried out emissions could be reduced by:

- using alternative non-solvent containing materials
- carrying out the coating operation in a cabin with an extract system leading to abatement plant.

Atmospheric emissions from the application of transport protective coverings can be eliminated by the use of non-solvent containing products such as self adhesive plastic film. The major European car manufacturers are already changing over to this method and within a few years it is expected that all will have done so.

4 SIMPLER METHODOLOGY

The current emission from the sources covered by this chapter can be assumed to negligible.

In some circumstances it may be necessary to calculate an emission estimate for previous years, for example, in assessing emission reductions under the UNECE VOC protocol. To estimate an emission for vehicle dewaxing for previous years when the process was still carried out, an emission factor is given in section 8. This emission factor should be applied only to a proportion of the cars sold in the country in question.

5 DETAILED METHODOLOGY

Not applicable, because the emission is very small.

6 RELEVANT ACTIVITY STATISTICS

6.1 Simpler Methodology

For vehicle dewaxing in previous years when the process was still carried out on a large scale, emission estimation requires knowledge of the number of vehicles dewaxed in a year. This can be ascertained from local motor industry representatives. In the UK, for example, it would apply only to those vehicles imported into the country from overseas. In continental Europe it may apply only to those vehicles transported over longer distances.

6.2 Detailed Methodology

Not applicable.

7 POINT SOURCE CRITERIA

These activities do not lead to atmospheric emissions.

8 EMISSION FACTORS QUALITY CODES AND REFERENCES

8.1 Simpler methodology

Compound	Process	Emission factor	Data quality	Reference	Country
NM VOC	Dewaxing of new vehicles following storage / transport	1 kg/car (1)	E	van der Most, pers. com.	The Netherlands

(1) Emission factor assumes 3 kg of solvent is used per car, with 2 kg of solvent recycled.

No emission factors are available for underseal (aftermarket) treatment.

8.2 Detailed methodology

Not Applicable

9 SPECIES PROFILES

No available information.

10 UNCERTAINTY ESTIMATES

There is probably a small amount of bituminous coating still used in the restoration and maintenance of vintage cars. This activity is usually carried out by small firms or by amateurs so reliable statistics are difficult to obtain. The extent to which the practice is still continued is likely to represent only a small deviation from zero.

The emission factor for vehicle dewaxing of 1 kg/car is subject to a number of uncertainties. These are:

1. manufacturers do not coat the whole car surface and the pattern of application varies from one manufacturer to another - consequently the smaller the amount of coated surface the less emission there will be from removing it.
2. the factor itself was not based on actual measurements but rather on “engineering judgement”

Also, not all cars sold in a country are dewaxed. It is necessary to obtain an estimate of how many cars are dewaxed and this estimate may also be subject to considerable uncertainty.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

Underseal treatment and dewaxing activities which are within the coverage of this chapter are rapidly declining or are not carried out by major manufacturers across Western Europe. This needs to be confirmed for all countries with manufacturing plant.

Lack of data means that it is difficult to reliably estimate emissions in previous years, if required, but the emission was likely to be low compared to other NMVOC sources.

These activities, however, could be widespread in Eastern European countries and, if this is the case, then emission factors need to be developed, particularly for underseal (aftermarket) treatment.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

Not applicable.

13 TEMPORAL DISAGGREGATION CRITERIA

Several decades ago the use of bituminous coatings to “underseal” cars was common. However, this practice ceased in the late seventies/early eighties.

The use of hydrocarbon waxes as protective coatings is only coming to an end now. In previous years there would have been an atmospheric emission from this source. It may be assumed that in 1988 transportation protective coatings in Europe were entirely of hydrocarbon wax. However, the timescale over which the transition from to the present situation has taken place is uncertain.

14 ADDITIONAL COMMENTS

No additional comments.

15 SUPPLEMENTARY DOCUMENTS

Not required

16 VERIFICATION PROCEDURES

Not applicable.

17 REFERENCES

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18 BIBLIOGRAPHY

Not applicable

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SNAP CODE: **060408**

SOURCE ACTIVITY TITLE: **OTHER USE OF SOLVENTS & RELATED ACTIVITIES**
Domestic Solvent Use (Other than Paint Application)

NOSE CODE:

NFR CODE: **3 D**

1 ACTIVITIES INCLUDED

This chapter addresses non-methane volatile organic compound (NMVOC) emissions from the use of solvent containing products by members of the public in their homes. However many of these products are also used in industry and commerce. In many cases it will be difficult or impossible to separate total sales into domestic and industrial parts. This section does not include the use of decorative paints. That is covered in section 060104.

2 CONTRIBUTION TO TOTAL EMISSIONS

Table 1 Contribution to total emissions of the CORINAIR90 inventory *(13 countries)*

Source-activity	**SNAP-code**	**Contribution to total emissions (including emissions from nature) [%]**							
		SO_2	NO_x	NMVOC	CH_4	CO	CO_2	N_2O	NH_3
Domestic Solvent Use	060408	-	-	2.3	-	-	-	-	-

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

Table 1 shows that the most important emission from the domestic solvent use sector is NMVOCs. In addition, emissions of sulphurhexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and some POPs (eg trichloroethylene and trichloroethane) could be significant (ETC/AEM-CITEPA-RISOE 1997; ref. 19).

3 GENERAL

3.1 Description

VOCs are used in a large number of products sold for use by the public. These can be divided into a number of categories:

Cosmetics & toiletries	Products for the maintenance or improvement of personal appearance health or hygiene.
Household products	Products used to maintain or improve the appearance of household durables.

Construction/DIY	Products used to improve the appearance or the structure of buildings such as adhesives and paint remover. This sector would also normally include coatings however these fall outside the scope of this section (see B) and will be omitted.
Car care products	Products used for improving the appearance of vehicles to maintain vehicles or winter products such as antifreeze.

A further distinction can be made between aerosol and non aerosol products.

Pesticides such as garden herbicides & insecticides and household insecticide sprays may be considered as consumer products. Most agrochemicals, however, are produced for agricultural use and fall outside of the scope of this section.

3.2 Definitions

Consumption	Refers to sales of products in the country concerned
Decorative Paints	Paints applied to internal walls, ceilings, woodwork etc. As well as being decorative they also provide protection against moisture penetration and consequent damage.
DIY	“Do It Yourself” i.e. home decoration by the general public.
Domestic	Refers to the use of products by members of the public in their own homes. These products will usually have been purchased from retail stores.
Formulation	The substances from which the product is manufactured. For aerosols this includes the propellant and solvent. Does not include the packaging materials.
Industrial use	Refers to the use of products by firms engaged in business. Includes products used for cleaning and maintaining buildings and vehicles as well as those used in the production process itself. Many products are used in industry and by households. In the construction industry there is almost complete overlap with most of the products used by the industry also sold to the DIY market.
Production	Refers to the amount of product manufactured in the country concerned. In many cases production statistics have to be used instead of consumption statistics. They are, however, less appropriate and if they are used the resulting emission will have top be assigned a lower data quality.

Propellant	A compressed gas present in the headspace of an aerosol can. Until recently CFCs were used for this purpose but now hydrocarbons such as butane are often used. Propellants are chosen to be liquid under pressure so that when propellant vapour is lost from the headspace on discharge of the aerosol it is replenished by evaporation of the liquid. The liquid propellant is intimately mixed with the active ingredients and can also act as a solvent thereby blurring the distinction between propellant and solvent. If the propellant were replaced by a mechanical pump extra solvent would be needed.
Solvent	A liquid present in an aerosol can to dissolve solid active ingredients.
VOC Content	The VOC content of a product such as a coating can be inferred from its formulation or measured by evaporation tests. The latter are more accurate but such data are unlikely to be available.

3.3 Techniques

NMVOCs in consumer products are mainly there as solvents. In aerosols NMVOCs such as butane and propane are also used as propellants. Propellants generally act as solvents as well. Switching from an aerosol to a non aerosol form of product will not necessarily reduce the proportion of solvent used in the product.

3.4 Controls

Emissions occur due to the evaporation of VOCs contained in the products during their use. For most products all of the VOC will be emitted to atmosphere. However, in some products the VOC will be lost mainly to waste water. Control of emissions from use of consumer products can only be achieved through reformulation of products to contain less VOC or measures to promote the use of lower VOC products.

4 SIMPLER METHODOLOGY

The simpler method uses a single emission factor expressed on a per person basis to derive an emission estimate for the activity by multiplying the emission factor by population.

5 DETAILED METHODOLOGY

The detailed method involves the collection of data on the VOC content of each type of consumer product. This can then be combined with consumption or production statistics in order to obtain estimates of quantities of VOC used in each category of product. The VOCs contained in some consumer products may not all be emitted to atmosphere therefore the VOC usage statistics are combined with suitable emission factors to derive emission estimates.

6 RELEVANT ACTIVITY STATISTICS

6.1 Simpler Methodology

The relevant activity statistics are national population figures.

6.2 Detailed Methodology

Production or preferably consumption statistics are required for each type of product together with data on typical formulations so that the VOC content can be calculated.

7 POINT SOURCE CRITERIA

Domestic products should be considered as area sources.

8 EMISSION FACTORS QUALITY CODES AND REFERENCES

8.1 Simpler methodology

The following per person emission factors have been derived from data for the UK Canada and the United States. Sources of these data are as follows:

- UK Atlantic Consulting 1995
- Canada UN ECE 1990
- USA EPA consumer products survey 1995 (draft only)

Table 8.1 - NMVOC Emission Factors in g/year per person

Product category	**NMVOC Emission Factor (g/year per person)**		
	UK	**Canada**	**USA**
Cosmetics & toiletries			1061.3
Non aerosol	236.6	400.4	
Aerosol	536.3	384.8	
Household products			431.4
Non aerosol	183.0	230.7	
Aerosol	55.4	346.9	
Car care products			649.0
Non aerosol	324.3	649[1]	
Aerosol	103.8	331[1]	
DIY/buildings			
Adhesives	70.1	47.6	277.2
Other[2]	(221.9)	(221.9)	221.9
Aerosol propellant	785.5	included above	included above
Total	2516.9	2612.3	2640.7

1. These emission factors are given as 0.649g/year/person and 0.331g/year/person in the reference. The units are incorrect and should be kg/year/person. (personnel communication Deslauriers Environment Canada 1995).
2. No data are available for Canada and the UK so the USA figure has been used in order to enable a comparison of total emissions.

The overall emission factors for the three countries are similar although there are some differences in the detail. The average of these three emission factors is recommended for calculating emissions from this sector :

Emission factor 2590g(VOC)person^{-1}year^{-1}

It should be noted that the per capita emission factor is likely to vary considerably between countries, particularly Western and Eastern European countries.

In the case of car care products the ownership of cars may be a more accurate activity statistic than population and if the number of vehicles is known then the following emission factor can be used:

Emission factor 782g(VOC)person^{-1}year^{-1}

If this factor is used for car care, then the average factor of 2590g(VOC)person-1year-1 should be modified to 1904g(VOC)person-1year-1 (i.e. the car care component removed).

The US survey is comprehensive and for many product categories includes formulation data for practically all products sold within that category. There is likely to be greater uncertainty over the proportion of solvent lost to atmosphere from such products however the overall quality of the US emission factors is likely to be good. A data quality B rating is probably realistic. The UK factors for non aerosol products are based on a smaller set of formulation data however the results have been discussed with industry who were in broad agreement with the estimates. A data quality B rating was given to these estimates. Emissions from aerosols are based on a survey by the UK aerosol manufacturers. These estimates are assigned a C data quality. The methods used to calculate the Canadian figures are not known and so no data quality rating can be given. The application of per person emission factors to other countries does increase the uncertainties in emission estimates however a data quality C rating seems justified for emission estimates calculated using the simpler method.

8.2 Detailed methodology

Studies such as that carried out in the US are useful in providing an extensive list of consumer products which contain VOC. However the bulk of VOC emissions will be due to the use of a relatively small number of consumer products and these should be given priority in developing detailed estimates. Based on the US and UK data the following products may contribute significantly to emissions :

Cosmetics and toiletries
Aerosols all types
Styling aids, pumps
Styling gels
Other hair care, pumps
Antiperspirants/Deodorants, pump
Perfumes
After shave
Nail polish remover
Astringent
Healthcare products (external)
Rubbing alcohol

Household products
Aerosols all types
General purpose cleaners
Glass cleaner
Air freshener slow release
Toilet blocks
Disinfectants
Waxes and polishes

Car care products
Aerosols all types
Antifreeze
Brake fluids
Car waxes and polishes
De-icer pumps
Engine degreasers
Windscreen washing fluid

DIY/buildings
Carpet/tile adhesives
Pipe cements
Construction adhesives
Paint thinners
Paint remover
Solvents

The proportion of solvent contained in a product which is actually emitted to atmosphere will vary depending upon the manner in which it is used. The US and UK surveys assumed 100% VOC emitted to atmosphere except in the case of products which are either used diluted in water (ie dishwasher detergents fabric detergents bleach etc.) in which case 1% was generally assumed or products which are removed with water after performing their function (i.e. shampoos soaps toothpaste household cleaners etc.) which were assigned factors of between 5% and 50% VOC emitted to atmosphere. The data quality of estimates made using the detailed method will depend upon the quality and quantity of data used. In theory it may be possible to obtain estimates deserving of an A rating.

9 SPECIES PROFILES

There are few data on the VOC species present in consumer products. A breakdown of VOC emissions from all consumer products has been given by a Swiss study (ATAL 1992).

Table 9.1 - breakdown of VOC emissions from all consumer products

VOC compound class	Total emission (t/a)	% of total emission
Aliphatic hydrocarbons	3200	22
Alcohols	7300	50
Amines	210	1
Ketones	70	1
Esters	140	1
Ethers	2780	19
Aromatic hydrocarbons	450	3
Chlorinated hydrocarbons	190	1
Organic acids	190	1

The VOCs used are stated to include propane butane ethanol isopropanol ethyl acetate and butyl acetate. The following breakdown for emissions due to the use of aerosols is given in Passant 1993:

Table 9.2 - breakdown for emissions due to the use of aerosols

Compound	%wt
Alkanes	60
Alcohols	35
111-trichloroethane	2
Esters & ketones	1
Dimethylether	2

The alkanes present in emissions will be predominantly butane and propane propellants. Ethanol is likely to be the most commonly used alcohol. The most widely used solvent in cosmetics and toiletries is ethanol and in the absence of more detailed information it is recommended that all emissions from non aerosol cosmetics and toiletries are assumed to be ethanol. No data have been found for solvent types used in household and car care non aerosol products.

10 UNCERTAINTY ESTIMATES

The simple method relies upon a per person emission factor. This was derived from emissions estimates for the US UK and Canada. The estimates for the US and UK are likely to be quite accurate perhaps +/- 20%. In the case of the US since data on the VOC content was obtained for products representing most of the US market the largest uncertainty will be the proportion of VOC in some products which is actually emitted to air. There are likely to be differences in the per person consumption of products as the formulations used from country to country vary due to economic geographical and cultural reasons. The overall uncertainty of estimates derived from the simple method may therefore be high perhaps as much as +/- 50%.

The use of the detailed method will remove one uncertainty which is present in the simpler method namely whether per person consumption of products is the same in each country. Depending upon the quantity of data relating to formulations which can be obtained there is no reason why the detailed method should not give an accuracy of perhaps +/- 20%. As with the US data the largest uncertainty may be the proportion of VOC which is emitted to air.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHOD

The weakest aspect of the simple method is the use of per person emission factors. There are likely to be differences in the use of consumer products in different countries due to for instance differences in car ownership household size wealth lifestyle product formulation and climate. Emission estimates from other countries derived using the detailed method should be fed back into the simple method to improve the emission factors. The adoption of a range of factors to reflect geographical and economic factors could be considered.

The detailed method should provide reasonably accurate estimates depending upon the quantity of data on product VOC content which is available. More information is required on the VOC contents of consumer products especially those products which contribute most to emissions. If the formulations used are comparable in different countries then default emission factors could be developed for use in the detailed method. The proportion of VOC in a product actually emitted to atmosphere may be considerably less than 100% for some products. Further research may be necessary to determine the fate of VOCs contained in such products.

Better speciated data are required especially for household and car care non aerosol products.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

National emissions should be disaggregated by population.

13 TEMPORAL DISAGGREGATION CRITERIA

Assume continual emission throughout the year unless better information is available for instance monthly sales statistics. There is likely to be a variation in emissions between summer and winter, with higher emissions likely in summer when more DIY activity takes place, and a strong diurnal variation with emissions highest during the day.

14 ADDITIONAL COMMENTS

No additional comments.

15 SUPPLEMENTARY DOCUMENTS

No supplementary documents are required.

16 VERIFICATION PROCEDURES

Verification of emission estimates can be carried out in a number of ways. The detailed method should be carried out in co-operation with product manufacturers who may be able to provide formulation data and production statistics. Estimates derived using the detailed method could be cross checked against estimates made for other countries. It should be borne in mind however that there may be significant differences in the use of VOCs in consumer products from country to country. Estimates may also be compared with estimates of the quantity of solvent sold to manufacturers of consumer products derived perhaps in consultation with solvent suppliers. Formulation data where obtained from manufacturers could be verified through analysis of products.

17 REFERENCES

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18 BIBLIOGRAPHY

No additional documents to those in Section 17.

19 RELEASE VERSION DATE AND SOURCE

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20 POINT OF ENQUIRY

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SOURCE ACTIVITY TITLE: USE OF HFC, N2O, NH3, PFC AND SF6

ACTIVITY	**SNAP CODE**	**NOSE CODE**	**NFR CODE**
Anaesthesia	**060501**	**107.05.01**	**-**
Refrigeration and Air Conditioning Equipments Using Halocarbons	**060502**	**107.05.03**	**-**
Refrigeration and Air Conditioning Equipments Using Other Products than Halocarbons	**060503**	**107.05.04**	**2 G**
Foam Blowing (Except 060304)	**060504**	**107.05.05**	**-**
Fire Extinguishers	**060505**	**107.05.06**	**-**
Aerosol Cans	**060506**	**107.05.07**	**2 G**
Electrical Equipments (Except 060203)	**060507**	**107.05.08**	**-**
Other	**060508**	**107.05.09**	**3 D**

A specific methodology for these activities has not been prepared yet as this sub-group has recently been expanded. It will be investigated this year.

For general guidance please refer to chapter 060000 Solvent and Other Product Use - Introduction.

The expert panel leaders for this sub group are listed below.

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