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

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

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.

17 REFERENCES

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18 BIBLIOGRAPHY

No additional references.

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UK
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20 POINT OF ENQUIRY

Any comments on this chapter or enquiries should be directed to:

Panagiota Dilara

Emissions and Health Unit
Institute for Environment and Sustainability (IES)
European Commission
Joint Research Centre
I-21020 Ispra (VA)
Italy

Tel: +39 0332 789207
Fax: +39 0332 785869
Email: panagiota.dilara@jrc.it