

SNAP CODE:	060406
SOURCE ACTIVITY TITLE:	OTHER USE OF SOLVENTS & RELATED ACTIVITIES <i>Preservation of Wood</i>
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	NM VOC	CH ₄	CO	CO ₂	N ₂ O	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	0	30	5.5	55

Wood preservation is unlikely to be a significant source of sulphurhexafluoride (SF₆), hydrofluorocarbons (HFCs) or perfluorocarbons (PFCs), (ETC/AEM-CITEPA-RISOE 1997).

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

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 carbolinum. 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.

NMVOG - 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 m³ 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).

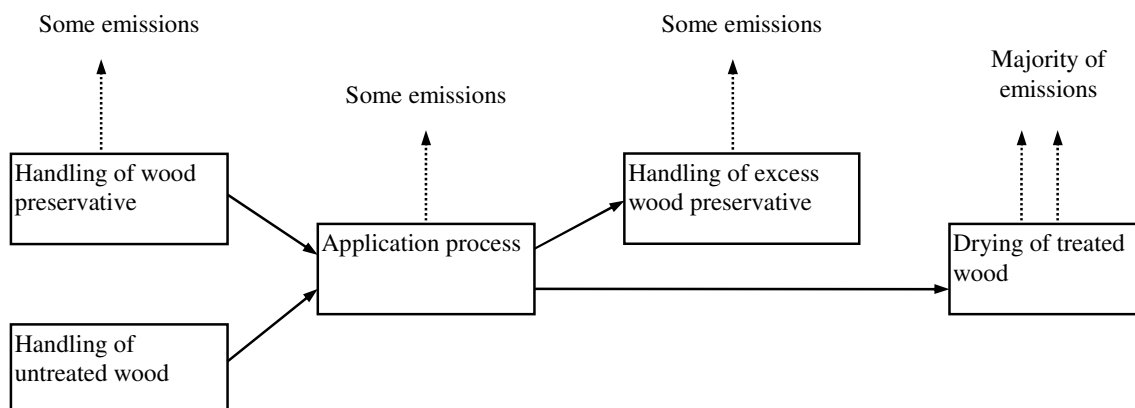
3.4 Emissions

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 :

$$\text{Emission} = [\text{Baseline emission factor}] \times [1 - \text{abatement efficiency}] \times [\text{Mass of preservative used}] \quad (1)$$

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 :

1m³ of wood requires 75 kg of creosote

1m³ of wood requires 24 kg of solvent borne preservative

1m³ of wood is approximately 1 t.

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

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 :

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

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 m³ 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.

OTHER USE OF SOLVENTS & RELATED ACTIVITIES

Activity 060406

su060406

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 used²	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 used³	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 used⁴	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 used⁵	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

OTHER USE OF SOLVENTS & RELATED ACTIVITIES

Activity 060406

su060406

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 throughout 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.

17 REFERENCES

Berdowski J.J.M., Veldt C., Baas J., Bloos J.P.J., and Klein A.E. (1995) Technical paper to the OSPARCOM-HELCOM-UNECE emission inventory of heavy metals and persistent organic pollutants. Report no. TNO-MEP - R95/247.

Chem Systems Ltd / ERM (1996) Costs and Benefits of the Reduction of VOC Emissions from Industry.

ETC/AEM-CITEPA-RISOE (1997) Selected nomenclature for air pollution for CORINAIR94 inventory (SNAP 94), version 0.3 (Draft).

Giddings T.J., Marlowe I.T., and Richardson S.J. (1991) Reduction of Volatile Organic Compound Emissions from Industrial Coating and Impregnation of Wooden Surfaces, CEC Contract No. B6611-90-005745.

Hein J., Kippelen C., Schultmann F., Zundel T., and Rentz O. (1994) Assessment of the cost involved with the Commission's draft proposal for a Directive on the limitation of the organic solvent emissions from the industrial sectors. Karlsruhe.

IARC (1985) IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, Vol.35, International Agency for Research on Cancer.

Passant N.R., Rudd H.J., and Marlowe I.T. (1996) Technical Briefing for CEN/TC264/WG4 ('Total Organic Compounds') on Solvent Emissions : Processes, Species, Concentrations and Factors Affecting their Measurement. AEA Technology, UK Report No. AEAT/21058100/REMA-254.

West European Institute for Wood Preservation, 109-111 Rue Royale, B-1000 Brussels, Belgium.

Wild S.R., and Jones K.C. (1995) Polynuclear Aromatic Hydrocarbons in the UK Environment : A Preliminary Source Inventory and Budget. Environmental Pollution. Vol.88, pp.91-108.

Zierock K-H., (1993) Methodology for the Estimation of Emissions from the Preservation of Wood [SNAP 060406], UBA Germany.

18 BIBLIOGRAPHY

APARG (1995) Report on the Abatement of Volatile Organic Compounds (VOCs) from Stationary Sources. Air Pollution Abatement Review Group, DoE, UK. Available from National Environmental Technology Centre, Culham, Abingdon, Oxfordshire, OX14 3DB, UK.

Richardson B.A. (1978) Wood Preservation., The Construction Press Ltd.

19 RELEASE VERSION, DATE AND SOURCE

Version: 2.2
Date: 2 February 1999

Updated by: Mike Wenborn
AEA Technology Environment
UK

Original author: Stephen Richardson
AEA Technology Environment
UK

Updated with particulate matter details by:
Mike Woodfield
AEA Technology
UK
December 2006

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

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
Acenaphthylene + 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