Organic Solvent Emissions in Some Industrial Processes

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Introduction

A new European Union directive EU/13/1999 defines limits for outdoor organic solvent emissions for several type of solvents using premises (1). The emission limits are expressed either by concentration limits in exhaust gas and the fugitive emission values or by total emission values (Table 1). Those premises that can not comply with the limit values have to use a reduction scheme, specified in the directive. The premises have to comply with the directive requirements at leatest October 2007. So far there is only little experience of applying the directive in practice.

Table 1. Examples of threshold values of outdoor solvent emissions for existing plants defined in the VOC-directive EU/13/1999.

activity	threshold of solvent consump. (t/a)	emission limit value in waste gas (mgC/m^3)[1]	fugitive emission value[2]	total emission value[3]
manufacture of paint, ink and resin	100 -1000 >1000	150 150	5 3	5% of solvent input 3% of solvent input
heatset, offset printing	15 - 25 >25	100 20	30 30	-
wood and plastic lamination	> 5	-	-	30 g / lamin -m^2

[1]= organic carbon concentration
[2]=any emission not in waste gas, uncaptured emissions via windows, doors, vents etc.
[3]= emissions via exhausts + fugitive emissions

In addition to environmental aspects, the knowledge of indoor solvent emission rates are important in a systematic design procedure of industrial ventilation (2). Based on the target concentration of solvents and emission rate information the ventilation configurations and the fresh airflow can be designed. Alltougth some studies of the solvent emissions in industrial processes have been reported more data from different processes are needed (3-4).

The aim of this study is to produce data of organic solvent emissions from selected industrial processes for designing. The data will be also used for evaluating how well the VOC-directive requirements can be met in practice.

Materials and Method

The three case plants in this project i.e manufacturing of paints, inks and resins, laminating of plastic represents high-volumes organic solvents using workplaces. The main solvents used are acetone, ethyl acetate, ethanol, propanols, styrene, toluene, xylenes

and solvent naphtas. The indoor emissions in these plants were controlled by different types of local ventilation systems, from advanced spraying hoods to traditional local exhausts. The exhaust air was not cleaned.

Outdoor emissions

Solvent concentration in the exhaust air was measured with on-line monitoring low-resolution FTIR analyser (Gasmet, Temet Inc.) equipped with a multipoint-sampling unit. The analyser has a Peltier-cooled MCT detector and a 1.1 litre gas cell with an absorption path length of 3 m. The spectral response range of the analyser is 4000–950 cm^{-1}. The volumetric exhaust airflow rates in the exhaust ducts are measured by using the pitot tube method according to the ISO 3966 standard. The solvent emission rates were calculated by multiplying the mean solvent concentration and the total air flow rate.

Emissions to the work air

The tracer gas technique was used for determining the total airflow rate in the production room. The solvent concentration and the tracer gas concentration in the work air was measured by using a continuously monitoring open path FTIR analyser (Bomem MR100 LP). The open path FTIR-instrument transmits IR-beam trough an open space, *e.g.* a production hall, to the remote mirror and detects the returned beam. The measurement result is an integrated gas or vapor concentration along the path. The IR-beam is transmitted by Newtonian type telescope with 25 cm diameter mirror. The instrument has a liquid nitrogen-cooled MCT detector and Kbr-beam splitter. The spectral response range of analyser is 7000–450 cm^{-1}. In addition to FTIR-sampling also charcoal tube samples was collected from the working areas. The indoor solvent emission rates were estimated by multiplying the beam path average solvent concentration and the total air flow rate.

Results

The summary of the results obtained so far is shown in Table 1. The example of temporal variations of solvent emission rates to work air and to outdoors are shown in Figure 1. The total exhaust air flow rates and the from 8000 to 25 000 m^3/h, corresponding air exhange rates of 1.1–7.5 h^{-1}. The mean organic carbon concentrations in exhaust air ducts varied between 20–120 mgC/m^3 (13–80 % from the directive limit value) and the mean outdoor and indoor solvent emission rates between 1.1–3.6 kg/h and 0.3–2.3 kg/h, respectively.

Table 1. Summary of the measurement results

activity	mean solvent consump (kg/day)	Q (m^3/h)	n (1/h)	mean C-conc. (mgC/m^3)	m_{out} (kg/h)	emission factor	m_{in} (kg/h)
manuf. of paint and ink	3 300	25 000	1.1	20-120	3.6	1.5 % of solvent input	2.3
manuf. of resin	7 300	18 000-	7.5	55-100	1.3	0.1 % of solvent input	0.3
laminating of plastic	40	8000	2.9	. 120	1.1	250 g per laminating -m^2	0.6

Q= total air flow rate
n= air exchange index
C-conc= Organic carbon concentration in exhaust air ducts
m_{out} = outdoor emission rate of solvents
m_{in}= indoor emission rate of solvents

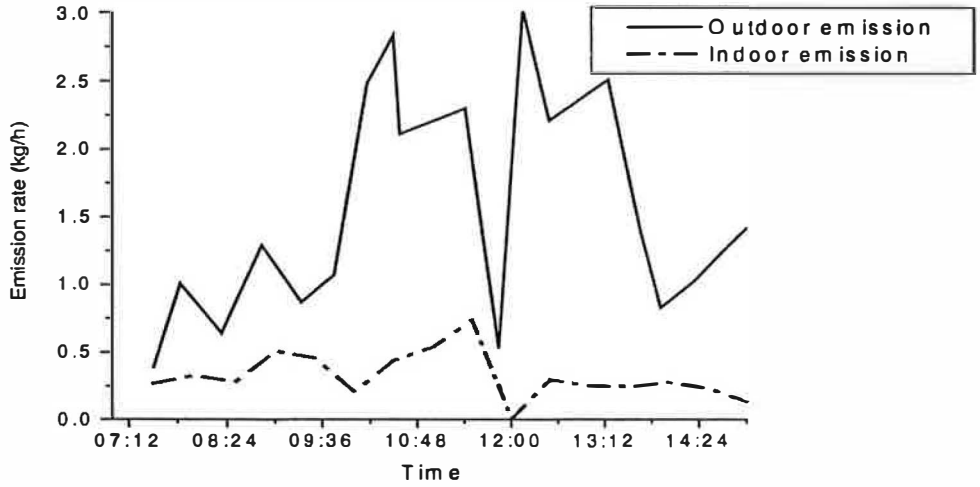

Figure 1. Temporal variation of solvent emission rates during the manufacture of resin. A brake between 11:30–12:00. During 9:30–11:30 and 12:00–13:15 approximately 500 kg of solvents were mixed.

Discussion and conclusions

The results show that in the printing ink, paint and resin manufacturing processes the outdoor emissions were below the VOC-directive's limit value. However, in the laminating work the mean solvent emission per laminated area, 250 g/m^2, exceeded the limit value, 30 g/m^2.

The continuos FTIR-monitoring showed strong variation in the outdoor emissions. As high as 10 kg/h peak emission was observed. The indoor emissions varied between 0.3–2.3 kg/h. These values are 23–64 % from the total outdoor emissions. The strongest outdoor and indoor peak emission rates were observed during blending and weighing operations and in laminating work, as expected, during the spray lamination.

From a practical point of view some definitions in the directive seems to be indistinct. As an example is an unclear meaning of a term "waste gas". In most processes the emission limits are defined as organic carbon concentrations in the waste gas, typically set between 10–150 mgC/m³. In practice the concentration in the local exhaust ducts can be considerably higher due to small airflow rate, but the solvent mass flow rate is still negligible. The directive should also consider more emission control strategies. In principle, it allows to design the ventilation system so that exhaust air emissions are controlled at the expense of work air quality.

References

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