AEAT-5015 Issue 2

Options for Improvement of the National Atmospheric Emissions Inventory

A report produced for the Department of the Environment, Transport and the Regions, the National Assembly for Wales, the Scottish Executive, and the Department of the Environment in Northern Ireland

N R Passant & M Wenborn

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Title	Options for Improvement of the National Atmospheric Emissions Inventory
Customer	Department of the Environment, Transport and the Regions
Customer reference	
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File reference	aeat5015.doc
Report number	AEAT-5015
Report status	Issue 2

Telephone 01235 463024
Facsimile 01235 463038

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	Name	Signature	Date
Author	N R Passant		
Reviewed by	J Branson		
Approved by	M Woodfield		

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1 Introduction

1.1 BACKGROUND

This report has been prepared under the DETR research programme 'Emission factors and cost curves for air pollutants'. However it also contains material of relevance to a further DETR research contract, that covering the preparation of the National Atmospheric Emissions Inventory or NAEI.

The NAEI is the UK's official inventory of emissions of about 30 air pollutants or groups of air pollutants. It is updated annually by the addition of estimates for a further year. In addition, the NAEI is continuously being improved by the inclusion of better emission estimates for earlier years. These improvements come about both as a result of development activities carried out within the NAEI programme and as a result of the feeding in of new data from other sources including industry, Government and the research community.

The research programme 'Emission factors and cost curves for air pollutants' is intended to be a major provider of new, measurement-related, data for use in the NAEI. The objectives of this programme include the following:

1. Assess the adequacy of emission factors used in the UK NAEI in relation to :
   photoxidant precursors and acid gases (except for NH_3)
   toxic metals
   persistent organic compounds
   PM_{10},
   and, for local inventories :
   benzene and 1,3-butadiene.

   Develop a priority list of sources requiring improved characterisation, giving attention to assessing comparability between estimates for processes covered by Parts A & B of the EP Act 1990.

2. Develop emission factors for poorly characterised sources, identified in 1 above, using measurements where appropriate.

3. Provide improved emission factors for VOCs, acid gases, persistent organics and metals to the UK NAEI contractor, LRC emission factor database and the UNECE Emission Inventory Guidebook.

This report will address the first objective listed above.

1.2 STRUCTURE OF REPORT

The report looks in turn at the emission inventories for each of a set of pollutants or pollutant groups:

- polyaromatic hydrocarbons
- dioxins and furans
- polychlorinated biphenyls
- hexachlorohexane, pentachlorophenol, and hexachlorobenzene
- particulate matter
- heavy metals
- carbon monoxide
- hydrogen chloride
- sulphur dioxide
- oxides of nitrogen
- volatile organic compounds

Areas of uncertainty in each inventory are highlighted and possible courses of action discussed which would address those uncertainties. The areas of uncertainty have been reviewed in consultation with the NAEI contract team and the following rough guide has been used:

high uncertainty	emission estimate accurate to > +/- 50%
medium uncertainty	emission estimate accurate to > +/- 25%
low uncertainty	emission estimate accurate to < +/- 25%

The NAEI contract team have also been involved in the development of a preliminary list of actions which could be carried out in order to improve the NAEI. This list of actions is presented here together with estimates of the resources necessary for each task, and an assessment of the impact of the action on inventory quality. Finally, a priority list of actions has been developed showing which are considered the most cost effective measures for improvement of the inventory.

2 Inventory Requirements

2.1 COMPLETENESS

A primary requirement of an inventory is that it should include all sources of a particular pollutant. This is an important early objective in inventory development since it is necessary to obtain an estimate of the total emission of a pollutant in order to be able to judge the significance of emissions from each individual source. Only then can further development work to improve the accuracy of individual estimates be prioritised properly.

We believe that UK emission inventories are complete or nearly complete in all cases. There are a few examples of known or suspected emission sources which are not included in inventories (for example road resuspension) but these are relatively rare. Nonetheless, the completion of inventories by the inclusion of estimates for all remaining sources is an important priority.

2.2 ACCURACY

As well as including all sources, an inventory needs to be reliable. Almost all emission estimates are derived using some sort of emission factor approach i.e. by combining an activity statistic, such as the number of items manufactured, with an emission factor, such as the emission per item manufactured. The quality of the emission estimate is dependent upon both the emission factor and the activity statistic.

In most cases, good activity data do exist, since the Government collects statistics on many activities of special relevance for pollution including fuel use and production of fuels, metals, minerals, chemicals, and manufactured goods. Some improvements could be made to the data which are available for use in the NAEI, however such work is outside the scope of this programme. Emission factors, on the other hand, are usually subject to greater levels of uncertainty. For most pollutants, emission factors have to be measured and the emission factors in use in the NAEI can be based on limited data. Emission factors can be developed from a relatively small number of measurements carried out at a single plant and then extrapolated to an entire sector of industry. Uncertainties can be high because emissions vary from process to process and even for a single process show significant variations with time. The measurements made are therefore not fully representative. Alternatively, measurements can be inaccurate or have been carried out using methods of unknown accuracy. In extreme cases no measurements have been made at all and emission factors are simply estimates (although it should be noted that in some cases estimates may be the most appropriate means - for example in the case of a process in which solvent is deliberately evaporated and where VOC emissions are assumed to be equal to solvent input i.e. an emission factor of 1 kg VOC per kg solvent used).

More emission factor measurements would be beneficial for large parts of the UK emission inventory. In the case of many sectors, further measurements would lead to an appreciable improvement in the estimation of emissions for that sector. However, measurements are expensive and not all measurements would be equally cost effective in improving the overall

quality of the inventory. It is therefore important to prioritise effort, comparing the cost of doing measurements against the gain in inventory quality.

Emission factor measurements can be made by and for industry and by workers in other countries. It can be more cost effective to tap into the results of these measurements rather than duplicate the work. Such measurement data is widely used in the UK inventory and there is therefore only limited scope for improving the inventory though this source. Nonetheless, where data are likely to be available, their inclusion is viewed as a priority.

Finally, in cases where measured emission factors are not required, desk based research can still be fruitful, for example by consultation with industry experts and the analysis of process data. As with emission factor measurements, some degree of desk based research would be beneficial to large parts of the inventory. Again, it is important to prioritise effort, ensuring the best use of resources.

2.3 DETAILED CHARACTERISATION

In addition to estimating the total emissions of a pollutant, it is necessary to characterise emissions in more detail, for example by estimating the particular species emitted, or by estimating the temporal variations in or the spatial distribution of emissions.

Speciation of emissions is important in the case of organic pollutants such as VOC, PAH, dioxins, and PCB. Speciation of emissions generally requires emission measurement and the need for speciation data is considered when prioritising research options. In the case of NMVOC emissions a detailed critique of the current VOC speciation, together with recommendations for further research, are given in Appendix 1.

Emission inventories need to include both long term temporal variations in emissions i.e. annual totals, and short term changes such as diurnal variations. An annual time series covering the period 1970-1997 is available for most pollutants. In the case of some persistent organic pollutants, no time series is currently available. In the first instance, an annual time series is produced by combining a constant emission factor with the varying activity in each year. Ultimately, a time series should take account of changes in emission rates as well and so it is necessary to consider whether emission factors might be changing when prioritising further inventory development work. For example, it is important for the inventory to reflect changes in emissions which are occurring as a result of abatement introduced in response to the Environmental Protection Act 1990.

An understanding of short term variations in emissions is more important for some pollutants than others, for example NOx, NMVOC, and PM_{10}. This report does not specifically address the need to collect information on these short term variations.

As well as the need to estimate emissions from industry sectors, the inventory also needs to contain information on the location of individual point sources. This report does not deal specifically with the spatial resolution of emissions except where this might occur as a side benefit as a result of collecting emissions data in a particular method.

3 Options for Improvement to the Inventory

3.1 POLYAROMATIC HYDROCARBONS

Key Points

- Previous inventory work generally reported 'total PAHs'. Whilst giving an indication of potential sources, a speciated inventory is much more useful.
- The current speciated inventory was recently developed and is the first to cover the majority of known UK sources.
- The current inventory is very uncertain.
- The uncertainty in the inventory is generally dominated by uncertainties in emission factors rather than activity data. A further detailed review of relevant US EPA documents should help to improve the inventory for a number of sectors.
- Although several days desk-based work can be carried out to improve the inventory in certain sectors, ultimately measurement work is required for the inventory to be developed to a state where policy makers can make reliable decisions.
- Measurements are being carried out at anode baking plant and for vehicles. The inventory should be updated when these measurement data become available.
- Activity data for wood combustion is unreliable and needs to be updated.
- Initial estimates of PAH releases for sources for which no estimate has yet been made, such as off-road vehicles and bitumen/asphalt production and use, can be made relatively quickly through desk-based study.

Summary of Previous Inventory Work

One of the first attempts to produce an inventory for PAH emissions in the UK is contained in the Air Pollution Abatement Review Group (APARG) report (DoE 1996) on the abatement of toxic organic micropollutants (TOMPS). Whilst this inventory was useful in prioritising sources of PAHs, it only reported on total PAHs giving limited information on the speciation of the PAHs emitted. In addition it was not always clear from the reference material used which PAHs were included in the 'total'. Another estimate of PAH emissions was provided in a report by Wild and Jones (1995). This provided some speciation, but on fewer compounds, and covered fewer and broader source categories.

A speciated inventory is much more useful to prioritise sources of the most toxic PAHs in the light of international agreements and national regulations / standards, such as the UNECE

protocols and the Expert Panel for Air Quality Standards (EPAQS) recommendations for air quality standards.

Current PAH Inventory

The first speciated PAH inventory covering the majority of known sources in the UK was developed at AEA Technology Environment (NAEI) in 1998 and was used in the EPAQS report on PAHs.

The inventory covers the 16 PAHs which are designated by the United States Environmental Protection Agency (US EPA) as compounds of interest under a suggested procedure for reporting test measurement results. These PAHs are :

- Naphthalene
- Acenaphthylene
- Acenapthene
- Fluorene
- Anthracene
- Phenanthrene
- Fluoranthene
- Pyrene
- Benz[a]anthracene
- Chrysene
- Benzo[b]fluoranthene*
- Benzo[k]fluoranthene*
- Benzo[a]pyrene*
- Dibenz[ah]anthracene
- Indeno[123cd]pyrene*
- Benzo[ghi]perylene

The inventory also includes the four PAHs to be used as indicators for the purposes of emissions inventories under the UNECE's Persistent Organic Pollutants Protocol (marked with an asterisk).

Should other PAHs or related species need to be included in the inventory then this could be done. However, extra paper studies and/or measurement work would probably be needed. For example, emissions of polychlorinated naphthalenes are of concern due to reasons of toxicity. These are industrial chemicals rather than products of incomplete combustion like the PAHs listed above and so significant extra work would probably be needed to construct an inventory for them.

The PAH inventory is considered reasonably complete in that estimates have been made for all of the sectors presently believed to be major sources. However, much of the inventory is very uncertain. Benzo[a]pyrene is the most commonly measured and reported PAH. The benzo[a]pyrene inventory is summarised in Table 3.1.

Table 3.1 Emissions of benzo[a]pyrene in 1996

Source	% emission (1996)	Uncertainty
Vehicles - petrol	22	High
Industrial coal combustion	17	High
Anode baking	17	High
Natural fires and open agricultural burning	13	High
Domestic combustion of coal and smokeless solid fuel	9	High
Aluminium production	6	High
Domestic combustion of wood	4	High
Coke ovens	4	High
Vehicles - diesel	4	High
Other sources	2	High
Industrial wood combustion	<1	High
Wood treatment	<1	High

The uncertainty in the inventory is generally dominated by uncertainties in emission factors rather than activity data.

Improvements to the PAH Inventory

Anode baking is the largest source of the sixteen PAH species. Measurements are being carried out by the industry to show compliance with authorisations. We should maintain our good relationship with the industry so that they make the results available for the inventory to be updated.
Task

- maintain contact with the 2 aluminium producers and update inventory [1 day, high priority]

Vehicle emissions are also of major significance and current emission estimates are very uncertain. Part of the uncertainty relates to the fact that measurements have generally been made on serviced vehicles, which are unrepresentative of the UK vehicle fleet. Measurements are being made under other, existing, DETR programmes.
Task

- liaise with measurement programme contract manager and contractor and advise on/discuss measurements, use network of contacts (e.g. UNECE Task Force, Auto Oil programmes) to obtain data which can be used for verification and update inventory [2 days, high priority]

In all other sectors, better emission factors are needed to improve the inventory. A detailed review of relevant US EPA documents should help improve the inventory for a number of sectors, particularly those for which no emission estimates have been included in the current inventory.

One sector that is probably growing in significance is **domestic wood combustion**. Better emission factors are needed. There is also uncertainty surrounding the quantity of wood burnt and official energy statistics do not currently include a full time series for wood. However, improvements in these data are being sought by the NAEI contractor.
Task

- update emission factors through measurement [sub-contract, high priority]

Similarly, emissions due to industrial wood combustion are subject to considerable uncertainty and measurements are necessary to improve the estimates. In particular, measurements need to be made on small combustion plant.
Task
- update emission factors for small industrial wood burning appliances [14 days, medium priority]

The effect of size of combustion plant is important for emissions of PAH from **industrial coal combustion**. Emission factors exist for different sizes of plant but a better idea of the numbers of different sized plant is needed for the inventory. Better emission factors are also required, and should concentrate on those appliances near the smaller end of the range.

Tasks:
- use updated activity data on quantity and size of plant to improve emission estimates [2 days, high priority]
- use measurements to improve emission factors for small combustion plant [14 days, high priority]

Whilst in the 'high' uncertainty category, the estimates of emissions from **domestic combustion of coal** are more reliable than most of the other sources. Nonetheless, given the significance of the source, the measurement of better emission factors should still be a high priority.
Tasks
- measurement work to derive improved emission factors for domestic combustion of coal [sub-contract, high priority]

No estimates of emissions are currently included in the inventory for **bitumen and asphalt production and use**. There is also little information on the processes involved and so a better understanding of this industry sector is required. Any measurement data from emissions from asphalt use are likely to have some uncertainty.
Tasks
- review industry sector, potential sources of emissions, abatement etc., obtain relevant activity data and estimate emissions [3 days, high priority]

Estimates need to be made for **off-road vehicles** and other forms of transport such as diesel trains. Emission factors are likely to be available for many of these sources from the USA, so initial estimates can be made to review the potential emissions relative to the other sources.
Task
- review existing data and make preliminary estimates [2 days, high priority]

There is also a paucity of data for **petroleum coke combustion**, which is used as a fuel in the domestic sector and by the cement and lime industry. No estimates for this potential source currently exist in the PAH inventory and initial estimates would help in assessing the relative contribution of this source to total emissions.
Task
- review available data, reports etc., obtain activity data and estimate emissions [up to 2 days, high priority]

Emission factors are required for **Coke works** other than those owned by British Steel (i.e. Barnsley, Bolsover and Llanwit Farde). British Steel should be contacted to obtain any new data for their coke plant.
Tasks

- measurement work at coke works [22 days, high priority]
- maintain contacts with British Steel and update inventory with any new information [1 day, high priority]

As with all relevant pollutants, a further review of the literature and other sources of information are necessary so as to improve estimation of emissions from **natural/accidental fires.** Activity data need to be significantly improved to improve the quality of the emission estimates, and reliable activity data is unlikely. This task is therefore given a low priority.
Task

- review literature and update emission factors, activity data and emission estimates if additional information is found [1 day, low priority]

Analyses of creosotes would improve the estimation of emissions from **wood treatment plants**.
Task

- analyse creosotes [sub contract, medium priority]

A recent report from Sweden suggests **tyre wear** could be a potential source of PAH releases. An initial assessment and estimation of this source is required.
Task

- assess emissions from tyre wear and estimate emissions [1 day, high priority]

3.2 DIOXINS AND FURANS

Key Points

- The UK dioxin inventory is significantly more reliable than the PAH inventory.
- The inventory has been updated in several areas since the initial inventory in the APARG report.
- The dioxin inventory would be more informative if the base year was updated to a year as recent as possible.
- Improvements in emission estimates for the non-ferrous metals sector and accidental fires are a high priority.
- Work to improve activity data for wood combustion and industrial coal combustion would improve the inventory, and there would be overlap with work required to improve the PAH inventory.

Summary of Previous Inventory Work

The UK dioxin inventory was first developed in 1995. The base year for the inventory was 1993. This inventory was published in the APARG TOMPs report. It has been updated in several areas since then as emissions from several sources have changed because of improved abatement. This is particularly the case in the incineration sector, where emissions from MSW incinerators have decreased from over 600 g I-TEQ in 1990 to 416 g I-TEQ in 1995, but would have decreased significantly further since then.

Emission sources for which improvements to the inventory have been made since the APARG report are :

- incineration
- non-ferrous metals
- oil-fired power stations
- electric arc furnaces
- accidental fires
- open agricultural burning

In contrast to the PAH inventory, there has not been any difficulty in deciding which compounds to include. The dioxin inventory covers the total of the 17 congeners in the international toxic equivalence (I-TEQ) scheme. However, there is a need to review the WHO TEQ scheme and assess the work required should the inventory need to be reported using the WHO scheme.

Current Dioxin Inventory

This inventory is considered to be less uncertain than that for PAH, however there are a number of areas where further work is desirable. The inventory is summarised in Table 3.2

Table 3.2 Emissions of PCDD/F in 1995

Source	% emission (1995)	Uncertainty
MSW incineration	57	Low
Accidental fires	8	High
Clinical waste incineration	6	Medium
Other sources	6	Medium
Sinter plant	6	Medium
Power stations (coal and oil)	4	Medium
Non-ferrous metal production	3	High
Vehicle - gasoline	2	Medium
Industrial coal combustion	2	High
Domestic coal combustion	2	Medium
Domestic wood combustion	1	High
Electric arc furnaces (iron & steel)	1	Medium
Chemical waste incineration	1	Medium
Sewage sludge incineration	1	Medium
Industrial wood combustion	<1	High
Coke production	<1	Medium
Vehicle - diesel	<1	Medium
Chemical industry	<1	High

Improvements to the Dioxin Inventory

The dioxin inventory would be more informative if it were updated on an annual basis. The total emissions from MSW incinerators would have decreased significantly since the current base year of 1995. This would require desk-based work to update activity data and emission factors where applicable. However, this activity should most probably be carried out under the existing NAEI contract.

Desk based studies might be worthwhile in order to improve the reliability of estimates of emissions from **accidental fires**. This depends on the availability of representative emission factor data and the availability of more detailed data on the number and type of these fires in the UK. The improved activity data is unlikely to be available and the reliability of these estimates is unlikely to significantly improve.
Task

- review sources of emission factor data and activity data [2 days, low priority]

Emissions from the **iron and steel industry** are important but it is anticipated that estimation of these emissions will improve over the next few years as a result of measurement work carried out for the industry and the need for better reporting to the Environment Agency's Pollution Inventory (PI). The inventory should be updated as the new data become available.
Task

- Update emission estimates for iron and steel industry with new information as new data become available [1 day, medium priority]

Similarly, the **non ferrous metal industry** is a significant source of emissions and better emission factors are required. In the original inventory a range of emission factors was used to cover the whole non-ferrous sector. Since then, the inventory has been updated by using individual emission factor data for some sectors. Although some new emissions data might be available, further measurements are required. Some measurement work may be funded by the EC, however this is unlikely to cover all of the areas of potential interest. Very little information is available on **foundries** and the **secondary metal industry** and both emission factors and activity statistics are needed. The areas where measurement work is required include:

1. secondary aluminium
2. secondary copper
3. secondary lead
4. primary lead / zinc (particularly the sinter plant at this site)

Tasks

- For foundries, initial estimates should be made through a desk-based study to assess the potential sources within this sector [3 days, high priority]
- Carry out emission factor measurements at a non ferrous metal process [22 days, high priority]

As with the PAH inventory, emission factors for **industrial coal combustion** do exist for different sizes of plant but a better idea of the numbers of different sized plant is needed for the inventory.
Task

- update activity data on quantity and size of plant and update emission estimates [1 day (but overlap with PAH work), high priority]

Domestic combustion of coal and wood are not perceived to be major sources, however, current estimates are subject to significant levels of uncertainty and better emission factors are needed. For combustion of wood, measurements should be made for emissions from both treated and untreated wood. Improved activity data on the quantity of both treated and untreated wood burned is also required. Measurements would be less worthwhile if the activity data on quantities of wood burned cannot be improved. The impact on emissions of burning household waste on open fires deserves attention.

Tasks

- improve emission factors for combustion of coal and wood through measurements [overlap with PAH work, medium priority].

The **chemical industry** covers many activities and several potential sources of dioxin. This sector is likely to have a high potential for releases to land and water, but less potential for releases to air. However, because of the complexity of the sector, limited work has been carried out to assess sources of dioxins and improvement of the estimates would require significant work. Initial estimates suggest that the emission is likely to be low compared with many other sources.

Task

- Review chemical industry in order to identify potential sources of emissions, making estimates where possible [5 days, low priority]

Other sectors which are at present not included in the inventory, such as oil burning, cooking etc., should be investigated – at least to confirm that they are not major sources.

Task

- Review other sectors in order to identify potential sources of emissions, making estimates where possible [5 days, low priority]

3.3 POLYCHLORINATED BIPHENYLS

Key Points

- The PCB inventory is very uncertain. However, emissions are likely to be falling due to restrictions on PCB use, although these restrictions are not strictly being imposed.

- Leakages from capacitors is estimated to be by far the largest source.

- Improvements to the PCB inventory should generally take a lower priority than the other POP inventories as emissions are likely to be decreasing and few additional controls are practical for the main sources.

- Speciation of PCB emissions is an issue and any further inventory work on PCBs should cover this.

Summary of Previous Inventory Work

The first comprehensive PCB inventory was developed in 1995 and published as part of the APARG TOMPs report. The inventory was subject to great uncertainty and yet emissions are

expected to be falling due to the prohibition of PCB use for many years. Limited work has been undertaken to improve the inventory since 1995. The inventory is for 'total PCBs'.

Current PCB Inventory

Table 3.3 below shows the main PCB sources in the current inventory. Leakages from capacitors is estimated to be by far the largest source.

Table 3.3 Emissions of PCB in 1995

Source	% emission (1995)	Uncertainty
Leakages from capacitors	81	High
Iron & steel (inc. sinter plant)	10	High
Fragmentisers	4	High
Leaks from transformers	1	High
Application of sewage sludge	1	High
Power stations	1	Medium
Industrial & domestic combustion	1	High
Incineration	<1	Medium
Manufacture & combustion of RDF	<1	High
Other sources	<1	High

Improvements to the PCB Inventory

The largest emission, leaks from capacitors, is an estimate of low data quality. The activity data used to estimate emissions due to **transformer/capacitor leakage** is the most important improvement required. A short desk-based study to contact electricity network companies and regulators might result in more information on the number of transformers/capacitors still used which contain PCBs, the quantity of PCBs in the electrical equipment, and the frequency of leaks. Even if more information is found, not all electrical equipment containing PCBs is readily identifiable, and there will continue to be significant uncertainty associated with the emission estimates.

Task

- desk based study to obtain improved information on PCB emissions from transformers/capacitors [3 days, low priority]

There is a need for a co-planar congener specific emission inventory so that WHO toxic equivalence factors (TEFs) can be applied. The availability of suitable data should be checked and a speciated inventory developed where the data allow.

Task

- Develop a co-planer congener specific PCB inventory [5 days, high priority]

3.4 HEXACHLOROHEXANE, PENTACHLOROPHENOL, & HEXACHLOROBENZENE

Key Points

- Although the inventories for HCH, PCP and HCB are subject to high uncertainty, the emissions are expected to continue to decrease.

- Significant work would be required to improve the inventories, and the decrease in uncertainty would be small compared to similar quantities of work for other pollutants.

Summary of Previous Inventory Work

Work on the UK inventory of releases to air of HCH, PCP and HCB has been limited. In 1998 the inventories were developed as part of work for DETR on forecasting emissions of heavy metals and POPs (Wenborn et al. 1998).

Current HCH, PCP and HCB Inventories

Table 3.4a Emissions of HCH

Source	% emission	Uncertainty
Evaporation from treated Wood	67	High
Wood Preserving	20	High
Agriculture Pesticide	11	High
Domestic Applications	1	High

Table 3.4b Emissions of PCP

Source	% emission (1995)	Uncertainty
Evaporation from previously treated timber	90	High
Timber treatment - NaPCP	11	High
Waste Incineration - Old Plant	<1	High
Cotton and Textiles	<1	High
Waste Incineration - New Plant	<1	Medium
Timber treatment - PCP	<1	High
Sewage Sludge Incineration	<1	High

Table 3.4c Emissions of HCB

Source	% emission	Uncertainty
Pesticide use - Chlorothalonil	38	High
Chemical industry - Carbon Tetrachloride	29	High
Chemical industry - Trichloroethylene	11	High
Aluminium and Magnesium Foundries	9	High
Chemical industry - Tetrachloroethylene	7	High
Pesticide use - Chlorthal-dimethyl	6	High
Pesticide use - Pentachlorophenol (Na)	1	High
Waste Incineration - Old	<1	High
Pesticide use - Quintozine	<1	High
Waste Incineration - New	<1	Medium

Improvements to the HCH, PCP and HCB Inventories

The inventories of HCH and PCP are dominated by **wood treatment**, particularly from previously treated wood for which emissions continue with time. With the restrictions on use of these chemicals, the emissions from this source will continue to decrease. PCP impregnated wood is also of interest because of the potential for dioxin emissions when it is burnt. If activity data on previously treated wood comes available during studies to improve the PAH and dioxin inventories (where activity data on wood combustion needs updating), then the emission estimates for HCH and PCP should be updated.

The inventory for HCB is dominated by the contamination / use in a number of pesticides and chemical processes. Information on chemical/ pesticide production and use is usually difficult to obtain from relevant companies for reasons of commercial confidentiality. The UK Agrochemical Companies should be contacted to discuss possible analysis work.

3.5 PARTICULATE MATTER

The 1997 inventory for PM_{10} is shown in Table 3.5.

Table 3.5 Emissions of PM_{10} in 1997

Source	% emission	Uncertainty
Road transport	22	Low
Other industrial processes	16	High
Domestic combustion	14	Medium
Industrial combustion	13	Medium
Quarrying	12	High
Power stations	12	Low
Other stationary sources	5	Medium
Other transport	3	Medium
Construction	2	High
Off road transport	1	Medium

Much of the inventory is considered to be high or medium uncertainty and it is generally in need of review in order to identify new sources of information and to document the methodology used to estimate emissions. Combustion sources are, with the exception of power plant, a priority for such a review, as are industrial processes such as cement and lime industry, coke production, blast furnaces, construction, quarrying, and other industry. The last in particular is subject to great uncertainty as it includes sources such as the metals industry, chemical industry and road construction. The current approach to estimating emissions is not very detailed and a thorough review of available emission factors is needed before a more detailed inventory can be developed. Better emission factors are required for domestic and industrial combustion - the priorities are domestic combustion of anthracite, coal, natural gas, and SSF and industrial combustion of coal. Improved emission estimates for industrial processes such as cement and lime industry, blast furnaces and coke production may be available from the Environment Agency's PI, otherwise emission factor measurements may be necessary.
Tasks

- conduct a thorough review of emission factors for industrial processes [20 days, high priority]
- measure emission factors for domestic combustion of solid fuels and industrial combustion of coal. [sub-contract, medium priority]
- measure emission factors for an industrial processes (e.g. cement and lime manufacture or a blast furnace). [22 days, medium priority]

Among mobile sources, improved emission factors and better activity data are needed for off-road vehicles. A survey of off-road vehicle use has previously been carried out which has provided a set of activity statistics for use in the inventory, however a more in-depth survey is needed. However this should be funded under the NAEI contract.

No estimates are made for open cast coal mining, however, emission factors used for quarrying processes could possibly be applied with suitable modifications.
Task

- generate emission estimate for open cast coal mining using existing methodology for quarrying processes [1 day, medium priority]

No sources of data on accidental fires are known: a quick survey of the published literature could be carried out to verify this, taking perhaps one day. Accidental fires may not be a major national source, however they may be important locally and, together with bonfires, have a significant impact upon the ability of the UK to meet air quality standards.
Task

- Carry out literature survey on particulate matter emissions from accidental fires and bonfires [1 day, high priority]

Agricultural emissions are of interest, in particular emissions from pig farming and harvesting. As with accidental fires, a literature survey is needed to identify available data. Due to the rural location for these emissions and the fact that PM_{10} emissions are primary of concern in urban environments, this activity is given a low priority.
Task

- Carry out literature survey on particulate matter emissions from agricultural operations [2 days, low priority]

Road resuspension is recognised as a source but, for lack of a suitable methodology, is not quantified at present. The source is considered to be important in the USA although climatic

differences could make it considerably less so in the UK. Nonetheless, it should be treated as potentially significant. A review of the available information is required.
Tasks

- Review available information and generate initial emission estimate for this source [8 days, high priority]

3.6 HEAVY METALS

The heavy metal inventory is shown in Table 3.6

Source	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	Uncertainty
Industrial combustion	54%	3%	14%	21%	9%	79%	3%	7%	Low
Primary lead/zinc	4%	53%	0%	4%	25%	0%	11%	26%	High
Iron and steel	4%	13%	18%	27%	8%	2%	6%	31%	High
Power stations	11%	5%	38%	26%	18%	7%	2%	3%	Low
Transport	0%	3%	1%	1%	0%	1%	67%	23%	Low
Domestic combustion	23%	2%	9%	10%	6%	7%	1%	0%	Medium
Incineration	0%	8%	0%	4%	20%	0%	1%	1%	Medium
Glass	2%	2%	15%	3%	1%	2%	1%	3%	High
Other stationary sources	1%	7%	5%	3%	6%	2%	2%	2%	High
Secondary lead	3%	3%	0%	0%	0%	0%	5%	5%	High
Chloralkali process	0%	0%	0%	0%	7%	0%	0%	0%	Low

The inventory is, like that for particulate matter, fairly uncertain. Some better emissions data for Environment Agency regulated processes are likely to become available as a result of new reporting requirements for the PI.

Fuel combustion is a major source and improved emission factors are required for domestic combustion. The metal contents of industrial and domestic fuels such as waste oils, petroleum coke, coal, oil and SSF are needed, together with information on combustion plant technology and any abatement systems in use.
Tasks

- Carry out analyses of industrial and domestic fuels [5 days, medium priority]
- Review of combustion technology [5 days, low priority]

The non ferrous metal industry is important and in particular primary lead/zinc manufacture which is carried out at one UK plant. This plant is estimated to be the source of more than half of the UK emissions of cadmium and more than a quarter of the emissions of mercury and zinc, as well as high levels of copper, lead and arsenic. The biggest source of uncertainty in emission estimates for the plant is the significance of fugitive emissions.
Task

- Carry out a measurement campaign at the one UK lead/zinc smelter plant [22 days, high priority]

The iron and steel industry although an important source is considered to be well characterised with the British Iron and Steel Producers Association (BISPA) supplying data. However emissions from foundry processes are estimated with less confidence, especially due to a lack of good activity data. In the case of non ferrous metal foundries no estimates are made at all since neither emission factors or activity data are available.

Task

- Check existing literature for emission factors and, if these are available, derive emission estimates [3 days, high priority]

There are few data on emissions from primary aluminium manufacturing and none at all on secondary aluminium. Similarly, secondary zinc production is not included in the inventory and galvanising processes may also give rise to emissions. Primary aluminium producers already provide information to the inventory and these contacts should be asked about the potential for emissions of other metals. Secondary aluminium production will include the melting of scrap materials and therefore the possibility of emissions of metals in the particulate or vapour phase exists. As with primary manufacture, representatives of the industry could be contacted and asked for information on the likelihood of metal emissions. The secondary zinc industry can include the processing of low grade materials containing other metals such as lead and so there is, without doubt some potential for emissions. However it is not clear whether significant quantities of secondary zinc production exist in the UK. It is important therefore to gather more information on the importance of this sector in the UK before committing significant effort to obtaining emission factors. There are a large number of non ferrous metal processes which fall within both Part A and Part B of the Environmental Protection Act. Data will be available both on the PI and on the public registers maintained by local authorities. Galvanising processes have the potential to emit both zinc and lead which is an impurity in the zinc used by galvanisers. The potential for emissions to air will vary from process to process as will the level of abatement in place. Galvanising processes are local authority regulated processes and therefore some information on emissions may be available from local authorities (about 85 processes are authorised in England and Wales). Other secondary metal processes could give rise to emissions of heavy metals and could therefore be worth further attention. Given the lack of detailed information on the structure of the industry and the limited evaluation of emissions to date, it would seem most appropriate to carry out a thorough review of the potential for emissions from those metal industry processes which are not currently addressed by the inventory. Measurement work could then be carried out if significant potential for emissions is identified by the review.

Task

- Carry out a review of the potential for emissions from non ferrous metal processes, making estimates where possible [20 days, high priority]

Glass manufacture is estimated to be an important source of chromium and also the major source of selenium (62% of total emissions) yet emission estimates are based on a single set of German emission factors. The industry disputes the heavy metal emission factors used in the inventory but have not provided alternative data. It is likely that glass frit manufacture can lead to emissions of many heavy metals and selenium but the potential for emissions from manufacture of flat glass and container glass is less certain. If the German emission factors actually relate to manufacture of glass frit or some other specialist glass then this may explain the industry's difficulties with the current NAEI estimates. More information is required on the processes leading to emissions of heavy metals before a judgement can be made on the reasonableness of the emission factors used. Glass frit manufacture is a Part A process while manufacture of other types of glass including lead glass are regulated under Part B. There are four glass processes listed in the PI and approximately 20 lead glass and 20 non lead glass processes in England and Wales and so a survey of material on the public register could be carried out relatively easily.

Task

- Review heavy metal emissions from glass manufacture [5 days, medium priority]

The ceramics industry (e.g. sanitary ware, bricks etc.) may be a source of heavy metals but no information is available. Fluorides may also be emitted in significant quantities as well.
Task
- Review heavy metal emissions from ceramics manufacture [5 days, low priority]

Crematoria are a major source of mercury emissions. A default factor is used and this might be improved using data from stack monitoring for crematoria carried out in house.
Task
- Review in-house monitoring data to check whether sufficient information is available to allow existing emission factors to be updated [2 days, low priority]

Speciation of the mercury inventory might be required in the future, however for the present this is regarded a low priority
Task
- Review speciation of mercury emissions [20 days, low priority]

The UN ECE Task Force on Emission Inventories (TFEI) has done much work collecting emission factors and other data on heavy metal emissions. This information could be reviewed and the UK inventory updated where appropriate.
Task
- Review latest information from TFEI and update UK inventory where appropriate [10 days, medium priority]

3.7 CARBON MONOXIDE

Table 3.7 summarises the current estimates of emissions of carbon monoxide.

Source	% emission	Uncertainty
Road transport	81	Low
Off-road vehicles	7	Medium
Domestic combustion	4	Low
Other transport	3	Medium
Power stations	1	Low
Other	4	High

Generally, a fairly high level of confidence can be had in the inventory for carbon monoxide. Most emissions occur as a result of fuel combustion and estimates are assigned a low or medium uncertainty. Other sources do contribute a few percent of the total emissions, however the inventory is possibly incomplete since the PI contains emissions that have not been reconciled with the NAEI. For example, emissions reported from the iron and steel industry need to be investigated. This should be carried out under the existing NAEI contract.

The estimate for off-road vehicles is given a medium uncertainty and this is in large part due to poor population/usage data. This problem is discussed in section 3.5.

American emission factors are currently being used to estimate emissions from landfill gas engines but better, UK based, factors are required. This is however a small source.
Task

- Measure emission factors for landfill gas engines. [14 days, low priority]

3.8 HYDROGEN CHLORIDE

Table 3.8 summarises the current inventory.

Source	% emission	Uncertainty
Power stations	82	Low
Industrial combustion	11	Low
Domestic combustion	7	Low

The inventory is considered fairly robust with all estimates described as being low uncertainty. Emissions occur from combustion processes only, however a check against the PI is required in order to ensure that the inventory is complete. This relatively simple task should be carried out as part of the development programme of the NAEI.

Only one area for further research has been identified. Emission estimates for industrial combustion plant are based on the assumption that emissions from small combustion plant are unabated with regards to HCl. This assumption is untested but could be validated by means of a brief survey of small combustion plant. Again, this activity would be carried out as part of the existing NAEI programme.

There are problems with the methodology used to monitor hydrogen chloride, since other inorganic chlorides are picked up. There is therefore potential for emissions to be overestimated. The inventory should be reviewed and the likely impact of these problems estimated.
Task

- Review hydrogen chloride inventory in view of the problems with existing monitoring methods for the pollutant [5 days, low priority]

3.9 SULPHUR DIOXIDE

Emissions data are shown in Table 3.9.

Source	% emission	Uncertainty
Power stations	61	Low
Industrial combustion	25	Low
Other transport	4	Medium
Domestic combustion	4	Low
Road transport	2	Low
Other sources	4	Low

The inventory is generally considered to be well characterised. Emissions are mainly from fuel combustion and emission factors are based on measured sulphur contents. While sulphur

contents of most fuel burnt is reasonably well known, sulphur contents for certain fuels are very uncertain, in particular SSF, petroleum coke, naphtha, and lubricants.
Task

- Analysis of sulphur contents of certain fuels including SSF, petroleum coke, naphtha, and lubricants [5 days, low priority]

The PI needs to be reviewed in detail in order to check that all important sources are included in the NAEI. For example, it is unclear why the processes listed as acid processes in the PI are different from the list of sulphuric acid manufacturers known to the NAEI. This could indicate that other chemical industry processes are sources of SO_2.
Task

- Review the PI and reconcile with the NAEI [5 days, low priority]

3.10 OXIDES OF NITROGEN

Table 3.10 summarises emission estimates for oxides of nitrogen

Source	% emission	Uncertainty
Road transport	44	Low
Power stations	18	Low
Other transport	15	Low
Industrial combustion	12	Medium
Off road vehicles	4	Medium
Domestic combustion	3	Low
Other	4	Medium

The NOx inventory is generally regarded as good. Emissions occur almost exclusively from combustion sources and emissions are calculated by combining emission factors with fuel statistics. The emission factors are largely derived from measurements while the fuel statistics are generally accepted to be accurate. The largest sources are road transport and power stations which are considered to have a low uncertainty rating. Of those sources which are given only a medium uncertainty rating, industrial combustion is the largest emitter.

One improvement would be to separately estimate emissions from glass furnaces since although NOx emissions from these are higher than other industrial combustion devices, no activity data are available with which to separate the fuel use in the glass furnaces and these processes have to be treated as normal combustion devices. Efforts to obtain suitable activity data and to improve the inventory should however be carried out under the existing NAEI programme.

Emissions from stationary engines/turbines could be increasing due to their growing use. Better emission factors are required and could possibly be obtained through a review of the available literature, otherwise through measurements.
Task

- Obtain improved emission factors for stationary engines/turbines through a review of the available literature or through measurements [14 days, low priority]

3.11 VOLATILE ORGANIC COMPOUNDS

The VOC inventory is summarised in Table 3.11.

Table 3.11 VOC emissions in 1995

Source	% emission	Uncertainty
Road transport	31	Low
Domestic solvent use	9	Low
Other industrial solvent use	9	Medium
Oil production & distribution	9	Medium
Chemical industry	5	Medium
Industrial paint use	5	Low
Petrol distribution	5	Low
Other industrial coatings	4	Medium
Forests	4	High
Alcoholic drink manufacture	3	Low
Other transport	3	Medium
Oil refineries	3	Medium
Other food industry	2	High
Off road transport	2	High
Stationary combustion	2	Low
Other stationary sources	2	Medium

The inventory has improved in recent years and much can now be described as being low or medium uncertainty. A major issue with the inventory remains the difficulty in updating it on an annual basis partly due to the difficulty in obtaining suitable activity data from which to construct time series and partly due to the fact that control measures are progressively being implemented in many sectors. The latter is particularly important in the case of industrial solvent use. It will therefore be necessary to develop new emission factors for these processes on a periodic basis. This can be attempted by two approaches. In the case of processes where end-of-pipe controls are being used it will be necessary to develop emission factors based on a bottom up survey of emissions from each process. This has currently been done or is being done for the following

- coil coating;
- metal packaging coating;
- film coating;
- seed oil extraction;
- textile coating;
- leather coating;
- vehicle manufacture.

The approach could be extended to a limited number of other process types, for example tyre manufacture and printing of flexible packaging. As already stated it will also be necessary to develop new emission factors for these processes on a periodic basis. It can be assumed that operators of processes of the types listed above will implement control measures in time to meet

the upgrade deadlines given in Secretary of State's Guidance Notes. It will therefore be important to monitor emissions from these processes at around these deadlines. Key dates are:

seed oil extraction	April 1996
coil coating	October 1997
film coating	June 1998
leather coating	June 1998
printing of flexible packaging	December 1998
metal packaging coating	December 1998
tyre manufacture	June 1998-April 1999
textile coating	September 1999
vehicle manufacture	April 2001

The data already collected for seed oil extraction processes should take account of upgrading but in the case of many of the remaining processes collected emissions data relate to processes prior to upgrading. New emission factors will be required for flexible packaging printworks and for tyre manufacturers and revised factors will be required for the remaining coating industry processes listed above. This would involve contacting a maximum of about 140 local authorities in England and Wales, although a reasonably reliable estimate could probably be made by contacting a lesser number.

Task

- Collect emissions data for local authority-regulated processes [10 days, medium priority]

In other cases where the solvent is used at a large number of different sites, for example, vehicle refinishing, adhesives use and surface cleaning, bottom up approaches are too resource intensive. In these cases, the most valid approach for development of new emission factors is likely to be through consultation with industry via trade associations and any research should be carried out under the existing NAEI contract.

Emissions from the petrol distribution network are expected to change significantly over the period 1999-2005 due to the implementation of controls on petrol loading and storage. The methodology used to calculate emissions for this sector will need to be revised to take account of these controls.

Task

- Revise methodology for petrol distribution to take account of controls [3 days, high priority]

Emissions from oil production and distribution, refineries, and chemical industry processes are assigned a medium uncertainty. However many processes are required to submit data for inclusion in the Environment Agency's PI. These new data and further data provided by industry will allow emission estimates for these processes to continue to be refined by the NAEI contractor and no other research is recommended at present. One emission source within the petroleum sector which has not to date been quantified is crude oil stabilasation. This will be a source of methane as well as VOC.

Task

- Quantify emissions from crude oil stabilisation [3 days, high priority]

Emission factors for some food industry processes are very weak. The most significant emissions are estimated to occur from sugar production and animal feed production. A number of approaches could be adopted for improving these estimates. Firstly, many such processes are

regulated by Local Authorities and the public registers maintained by these authorities may contain some useful data. This information could be obtained either directly from the council or indirectly from, for example, local inventories. Approximately 30 authorities regulate a total of 46 processes related to the manufacture of animal feeds or the drying of vegetable matter.
Task

- Gather information on VOC emissions from food processes from local authorities or from local inventories [4 days, medium priority]

One area of uncertainty in the 'other stationary sources' area of the inventory is the gas industry. Currently estimates are available for gas production facilities and gas terminals and for gas distribution via low pressure mains but not for any intermediate processes. First estimates could be made using data from the Environment Agency's PI to supplement estimates derived using the methodology given in the CORINAIR/EMEP Atmospheric Emission Inventory Guidebook. Emissions are likely to be very small.
Task

- Derive initial estimates of emissions from gas industry processes using the PI and the CORINAIR/EMEP Atmospheric Emission Inventory Guidebook [2 days, low priority]

Better speciation is required. Speciation of emissions from processes and solvents has been reviewed - see Appendix 1. This review deals with emissions of benzene and 1,3-butadiene.

4 Summary of tasks and prioritisation

The following table summarises the recommendations by pollutant, and shows the author's opinion on the relative priorities of actions together with estimates of resource requirements.

Task	Duration	Priority
Polyaromatic hydrocarbons		
maintain contact with the 2 aluminium producers and update inventory	1 day	High
update inventory with results from vehicle monitoring programme	2 days	High
measure emission factors for industrial wood combustion	14 days	Medium
measure emission factors for domestic wood combustion	sub-contract	High
Incorporate impact of size of plant into emission estimates for industrial coal combustion	2 days	High
Measurement work to derive improved emission factors for domestic combustion of coal	sub-contract	High
measure emission factors for industrial coal combustion	14 days	High
estimate emissions from tar and bitumen processes	3 days	High
review existing data and make preliminary estimates for off-road vehicles	2 days	High
review available data and estimate emissions for petroleum coke combustion]	2 days	High
Measurement work at coke works	22 days	High
update inventory with any new information on Brit. Steel cokeworks	1 day	High
review literature and update emission estimates for natural fires	1 day	Low
analysis of creosotes	sub contract	Medium
assess emissions from tyre wear and estimate emissions	1 day	High
Dioxins and furans		
review emission factors and activity data for accidental fires	2 days	Low
update emission estimates for iron and steel industry with new information as new data become available	1 day	Medium
For foundries, initial estimates should be made through a desk-based study to assess the potential sources within this sector	3 days	High
Carry out emission factor measurements at non ferrous metal processes	22 days	High
update activity data on quantity and size of plant and update emission estimates for industrial coal combustion	1 day	High
improve emission factors for domestic combustion of coal and wood through measurements	see above	Medium
Review chemical industry in order to identify potential sources of emissions, making estimates where possible	5 days	Low
Review other sectors in order to identify potential sources of emissions, making estimates where possible	5 days	Low
Polychlorinated biphenyls		

Obtain improved information on leakage from transformers & capacitors	3 days	Low
Develop a co-planer congener specific PCB inventory	5 days	High
Particulate matter less than 10 microns (PM_{10})		
review emission factors for industrial processes	20 days	High
measure emission factors for domestic combustion of solid fuel and industrial combustion of coal	see above	Medium
measure emission factors for an industrial process (e.g. cement and lime manufacture, or a blast furnace)	22 days	Medium
generate emission estimate for open cast coal mining using existing methodology for quarrying processes	1 day	Medium
Carry out literature survey on particulate matter emissions from accidental fires and bonfires	1 day	High
Carry out literature survey on particulate matter emissions from agricultural operations	2 days	Low
Review available information on road resuspension and generate initial emission estimate for this source	8 days	High
Heavy metals		
Carry out analyses of industrial and domestic fuels	5 days	Medium
Review of combustion technology	5 days	Low
Carry out a measurement campaign at the UK lead/zinc smelter plant	22 days	High
Check existing literature for emission factors for foundries and, if these are available, derive emission estimates	3 days	High
Carry out a review of the potential for emissions from non ferrous metal processes, making estimates where possible	20 days	High
Review heavy metal emissions from glass manufacture	5 days	Medium
Review heavy metal emissions from ceramics manufacture	5 days	Low
Review in-house monitoring data to check whether sufficient information is available to allow existing emission factors for crematoria to be updated	2 days	Low
Review speciation of mercury emissions	20 days	Low
Review latest information from TFEI and update UK heavy metal inventory where appropriate	10 days	Medium
Carbon monoxide		
Measure emission factors for landfill gas engines	14 days	Low
Hydrogen chloride		
Review hydrogen chloride inventory in view of the problems with existing monitoring methods for the pollutant	5 days	Low
Sulphur dioxide		
Analysis of sulphur contents of certain fuels including SSF, petroleum coke, naphtha, and lubricants	5 days	Low
Review the PI and reconcile with the NAEI	5 days	Low
Oxides of nitrogen		
Obtain improved emission factors for stationary engines/turbines through a review of the available literature or through measurements	14 days	Low
Volatile organic compounds		
Collect VOC emissions data for local authority-regulated processes	10 days	Medium

Revise methodology for petrol distribution to take account of controls	3 days	High
Quantify emissions from crude oil stabilisation	3 days	High
Gather information on VOC emissions from food processes from local authorities or from local inventories	4 days	Medium
Derive initial estimates of emissions from gas industry processes using the PI and the CORINAIR/EMEP Atmospheric Emission Inventory Guidebook	2 days	Low

We propose to carry out only those tasks which are given either a high or a medium priority. A proposed scheduling of the tasks is shown in Figure 1.

5 References

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Appendices

CONTENTS

Appendix 1 Workplan for improvement of VOC speciation

Appendix 1
Workplan for Improvement of VOC Speciation

GENERAL

The current species database includes species profiles for most sectors, although many of these could be improved. There are some gaps in the database, in particular there is a lack of profiles for hydrocarbon solvents such as kerosene, solvent xylene and special boiling point (SBP) solvents. Previously, the chemical make-up of the solvent white spirit has been determined in collaboration with the Solvents Industry Association (SIA) and it is recommended that further co-operation be sought.

Recommendations for workplan

- Further refine data and test key assumptions through discussion with SIA

PAINT APPLICATION

Critique of current information

Passant & Lymberidi (1998) state that species profiles are taken from Rudd (1995) with additional data for white spirit from Rudd & Marlowe (1998).

Rudd (1995) does not report sources of data. The main sources were probably:

(1) Solvents Industry Association (SIA) survey data, which have been updated since 1995;
(2) British Coatings Federation (BCF) estimates.

Both these sources are essentially untestable directly, although similar industry surveys may be available from sector associations if requested - such as the European Coil Coaters Association (ECCA); Society of Motor Manufacturers and Traders (SMMT); Metal Packaging Association.

The species profile for this sector is probably changing with time, due to several factors:

(1) technical innovation leading to new product formulations;
(2) increasing penetration of "greener" products: notably high solids coatings, waterborne coatings and powder coatings;
(3) probably significant introduction of end-of-pipe abatement technologies in the industrial sectors.

Factors (2) and (3) are probably the more significant.

Box 1 summarises a proposed new model of emissions in the paint application sector.

Box 1

Essentially, the emissions total can be thought of as having a number of components:

$$\mathbf{E = \Sigma\ (EF_{tpi,j} \times A_{tpi,j,t}) + (EF_{npi,j} \times A_{npi,j,t}) + (EF_{gpi,j} \times A_{gpi,j,t}) + (EF_{eopi,j} \times A_{eopi,j,t})}$$

where:

E = total emissions for paint application;

$\mathbf{EF_{tpi,j}}$ = emission factor for "traditional product" *i* in sector *j*;
$\mathbf{EF_{npi,j}}$ = emission factor for "new product" *i* in sector *j*;
$\mathbf{EF_{gpi,j}}$ = emission factor for "green product" *i* in sector *j*;
$\mathbf{EF_{eopi,j}}$ = emission factor for product *i* with end-of-pipe abatement in sector *j*;

$\mathbf{A_{tpi,j,t}}$ = activity statistic for "traditional product" *i* in sector *j* and year *t*;
$\mathbf{A_{npi,j,t}}$ = activity statistic for "new product" *i* in sector *j* and year *t*;
$\mathbf{A_{gpi,j,t}}$ = activity statistic for "green product" *i* in sector *j* and year *t*;
$\mathbf{A_{eopi,j,t}}$ = activity statistic for product *i* with end-of-pipe abatement in sector *j* and year *t*.

Each emission factor will have a different species profile associated with it; and each activity statistic will change from year-to-year.

In practice, the definitions of "traditional product", "new product" and "green product" are likely to be blurred; as far as possible, emission factors and activity statistics should be used for each identifiable product or product group (high solids, UV-curing etc.) and the product(s) defined as tightly as possible.

Developments in product formulations, and in penetration of "greener" products, are being assessed by DGXI for the vehicle refinishing and domestic paints sectors. There may be knowledge of trends in product formulation/markets resident in the Environmental Technology Best Practice Programme (ETBPP). The BCF could be asked to provide an overview of trends, as could sector trade associations. If known, the BCF could be asked to describe the assumptions used to produce their earlier submissions.

The species profile emitted by end-of-pipe control technologies has not been thoroughly studied, although some work has been carried out by AEA Technology for a CEN study. Generic species profiles need to be developed for the main technologies probably employed:

- incineration
- carbon adsorption.

For *carbon adsorption*, there may be some alteration of the uncontrolled species profile through selective adsorption, but probably as a first order estimate the

uncontrolled profile could be used. For *incineration* the profiles probably consist of three components:

- generic products of incomplete combustion (mainly simple substances e.g. methane, ethane, propane, formaldehyde);
- process-specific uncombusted products (for which the existing profiles could be used);
- process-specific reformed substances (where VOCs present in the incinerator feed may be partially combusted and/or rearranged to produce new stable complex molecules).

For the generic products of incomplete combustion, there are data available in published US EPA reports. There may also be data available from process authorisations and from consultants who undertake stack monitoring.

Reformed products will be difficult to assess. Phthalates are probably quite common. There is a possibility that benzene could be formed as a stable intermediate, particularly in the combustion of aromatic solvents. Again process authorisations and stack monitoring consultants may be able to assist.

If the work programme allows, the species profile from solvent incineration could be assessed in a monitoring trial under this contract. However, since incinerators are highly effective at destroying VOC, emissions from them will be very small and this activity is therefore very low priority.

In the domestic paints sector, it is possible that improved species profiles (or at least product market share data) could be provided by retailers. Much work has been done by B&Q to assess their own environmental impact, including a detailed inventory of materials stocked. However, this approach would probably only be worthwhile if the BCF were unable to provide data.

Recommendations for workplan

- Sector trade associations (such as ECCA, SMMT) should be approached – to ask what data they have available already, and what could be gathered.
- The ETBPP should be asked about what information they hold on trends in product formulations/markets.
- The BCF and sector trade associations should be asked to give overviews of trends in product formulations/markets.

PRINTING

Critique of current information

Passant & Lymberidi (1998) modified the species profiles given in Rudd (1995) and included the profile for white spirit in publication gravure (from Rudd & Marlowe,

1998). The precise methodology is not documented in either report. The 1998 modifications drew partly on new information, and partly on a reappraisal of ten year old information.

The sources drawn on by Rudd (1995) included:

- SIA estimates, which have since been updated;
- estimates provided by the Society of British Printing Ink Manufacturers (subsequently merged into the BCF);
- company estimates.

The data for this sector are due for reassessment. In the decade since Warren Spring Laboratory first collected detailed information, there have been a number of developments, particularly:

- increasing use of "greener" products such as high solids inks, UV-curing inks and waterborne inks;
- a number of printers have used end-of-pipe technologies, particularly incineration and carbon adsorption, to comply with emission limits introduced under the Environmental Protection Act.

It is proposed therefore to adopt the model presented in **Box 1** above; the priorities for improvement are to work with the relevant trade associations to develop trends in product formulations and to update the current market mix;

The ETBPP has done a lot of work in the printing sector and may possess relevant data.

Recommendations for workplan

- The BCF and other trade associations in the sector should be asked to provide information about trends in product formulations and to update the current market mix;
- The ETBPP should be asked to provide any relevant non-confidential data in their possession.

ADHESIVES COATING

Critique of current information

Passant & Lymberidi (1998) adopted the species profiles given in Rudd (1995) without any update. The latter publication gives no indication of the source material or how data were derived. In fact most of the information was provided by the SIA.

This is a difficult source to study, because:

- an enormous range of products are used in a great variety of industries, often for small volume speciality applications;
- the trade association best scoped to assist, the British Adhesives and Sealants Association, does not have the remit or resources to handle environmental considerations;
- by nature the sector is strongly innovative, with new products continuously being developed and superseded.

It may be worth contacting a few major suppliers, and sector associations such as the Shoe and Allied Trades Research Association (SATRA) and the Furniture Industry Research Association (FIRA) to enquire whether they can provide data; otherwise the inventory must continue to rely on the SIA's overview data.

As with other solvent using sectors, it is likely that emissions have been controlled to a significant extent using end-of-pipe technologies. It is unlikely, however, that the extent of control will be identifiable. It is proposed to ask trade associations if they can make an estimate, otherwise a nominal assumption would have to be made based on information from other sectors.

Recommendations for workplan

- SATRA, FIRA and other relevant sector associations should be contacted to discuss whether/how they may be able to assist.

FILM COATING

Critique of current information

The emission estimates and species profile for this sector have been updated recently by Passant & Lymberidi (1998) using a survey of the authorising local authorities. The sector is therefore seen as low priority for updating. It may be worth conducting a further survey in the final year of the present contract (2001/2002) to establish a trend; especially as this would be after the deadline for upgrading (June 1998).

Recommendations for workplan

- A repeat survey of local authority data could be conducted in 2001 to establish a trend.

TEXTILE COATING

Critique of current information

A species profile is presented in Passant & Lymberidi (1998) based on estimates provided by the SIA. This report also indicates that emission estimates have been collected from local authorities responsible for authorising the processes, of which there are about eighty operating. Speciated data could be sought from the relevant local authorities or plant operators. In view of the small size of the emissions from this source, further work to develop a species profile is regarded as low priority.

Recommendations for workplan

- No action is recommended.

LEATHER COATING AND DEGREASING

Critique of current information

Rudd (1995) and Passant & Lymberidi (1998) were not able to give a species profile for this sector; the latter report suggests that benzene could possibly be emitted from hydrocarbon mixtures if they are used, for example, in wet degreasing of pelts.

From a total inventory perspective this source is small and therefore is a low priority for further work. Nevertheless the possibility of benzene emissions suggests that some further work should be undertaken. It is proposed to contact the British Leather Confederation (BLC) to characterise the nature of solvents used in the industry and especially any hydrocarbon mixtures which could possibly contain benzene. The SIA could then be asked for a view on the composition of any identified mixtures.

Recommendations for workplan

- The BLC should be asked to identify any hydrocarbon mixtures used in leather coating and degreasing; the SIA could then be asked for compositional information.

MANUFACTURE OF COATINGS

Critique of current information

Rudd (1995) presented a species profile for paint manufacture and another for ink manufacture, both based on the assumption that the composition of emissions from the manufacture of coatings is the same as the solvent composition of the coatings. Passant & Lymberidi (1998) adopted a similar approach, with the addition of adhesives manufacture.

This sector is relatively small, with emissions in 1996 estimated as about 9 kt (Passant & Lymberidi, 1998). So the source does not warrant a high priority for further work.

Recommendations for workplan

- No action is recommended.

SURFACE CLEANING

Critique of current information

Rudd (1995) used a simple methodology to derive a species profile from SIA data, with a nominal assumption that mixed hydrocarbons were a 50/50 mixture of toluene and white spirit. Passant & Lymberidi (1998), with access to more recent SIA data, added in estimates for three oxygenated solvents (1-propanol, acetone and 2-butanone) which were assumed to be used and emitted in equal proportions.

This source is very complex and it is difficult to derive better emission estimates other than by using the top-down data provided by the SIA. A great many industries employ solvents for cleaning raw materials, products, equipment and shop floors.

The SIA data for 1996 shows the majority of solvents were chlorinated hydrocarbons (69%), with a significant proportion of mixed hydrocarbons (26%) and some oxygenates (5%). The SIA have indicated in the past that the solvent use data they have provided for this source are probably underestimated: their data represent solvents known to be sold by solvent manufacturers for the purposes of cleaning, whereas in practice there will be a substantial amount of solvent used for cleaning which is sold for other purposes by other suppliers, for example as make-up (or diluent) for paints and inks. The latter solvents are probably largely captured in the estimates for paint application, printing, and adhesives coating (see above).

This is a substantial source, with emissions for 1996 estimated as 54 kt (Passant & Lymberidi, 1998). In view of this, it is recommended that the SIA data are tested by a limited survey of companies likely to use solvents for cleaning purposes, in the following industrial sectors:

- general engineering (where solvents will be primarily used for degreasing metal components);
- electronic components manufacture;
- industrial surface coating operations.

It will be important to survey a mix of company sizes, as there may be significant differences in working practices.

As well as seeking information on the composition of solvents used for cleaning, it would be helpful to understand how solvents are released into the atmosphere - in particular, whether the emissions are captured and treated in a manner which would change the species profile.

Recommendations for workplan

- A limited survey of companies should be undertaken to assess the types of solvent used for surface cleaning operations, and how they are emitted to the atmosphere. A cross-section of companies representing a range of sizes should be selected from the general engineering sector, from electronic components manufacture, and from companies employing industrial surface coating operations.

DRY CLEANING

Critique of current information

Both Rudd (1995) and Passant & Lymberidi (1998) give tetrachloroethylene as the only VOC emitted from dry cleaning in the UK. This assumption is not likely to be substantially inaccurate. No further work in this sector is recommended.

Recommendations for workplan

- No action is recommended.

SEED OIL EXTRACTION

Critique of current information

Both Rudd (1995) and Passant & Lymberidi (1998) give hexane as the only VOC used in seed oil extraction in the UK. In view of the small magnitude of emissions from this source no further work in this sector is recommended.

Recommendations for workplan

- No action is recommended.

RUBBER PROCESSING

Critique of current information

Passant & Lymberidi (1998) present a species profile derived from SIA data. This profile is probably sufficient for general inventory purposes. However, the same authors draw attention to the possibility that the carcinogen 1,3-butadiene could be emitted during the processing of synthetic rubber. It is recommended that this possibility is investigated further through contacts with the British Rubber Manufacturers' Association (BRMA), relevant companies, and their corresponding local authorities.

Recommendations for workplan

- The potential for release of 1,3-butadiene should be discussed with the BRMA, with companies which process synthetic rubber, and with the relevant local authorities.

WOOD IMPREGNATION

Critique of current information

Passant & Lymberidi (1998) present a species profile derived from SIA data. This profile is relevant to solvent borne preservatives only, and does not cover waterborne preservatives, or creosote. The latter preservative could potentially contain benzene.

This source has emissions of intermediate magnitude (Passant & Lymberidi, 1998, estimate 1996 emissions of about 24 kt). However the emissions are estimated by extrapolation from 1990 estimates using an index of manufacturing output. In view of the age of the original data, the lack of a species profile for the potentially significant creosote sector, and the possibility for benzene emission, this source is considered a priority for further investigation.

A substantial audit survey of the sector was carried out by the Health & Safety Executive (HSE) in 1997; they should be approached for relevant data.

Suppliers of creosote could be asked to comment on the composition of this material, and the likelihood of benzene being present.

Recommendations for workplan

- Creosote suppliers should be identified and contacted for compositional information. Analysis of the creosote could then be carried out.

OTHER SOLVENT USE

Critique of current information

Rudd (1995) presented a species profile for the 71 kt identified by the SIA as "other solvent use". Passant & Lymberidi (1998) added no new information but used a revised SIA figure of 44 kt.

Since the source is poorly defined it is not considered possible to improve the species profile through new work. The SIA should be asked to comment on whether the revision in the total solvent usage estimate implies any change in the species profile, particularly as several solvent sources are now treated separately (film coating, textile coating, leather coating & degreasing, rubber processing, wood impregnation) which were not separately treated by Rudd (1995).

Recommendations for workplan

- We should work with the SIA to clarify what is covered by "other solvent use".

AEROSOL USE

Critique of current information

Rudd (1995) presented a species profile based on information supplied by the British Aerosol Manufacturers Association (BAMA) and by the SIA; no new information was given by Passant & Lymberidi (1998).

This is a substantial source, emitting about 90 kt in 1996 (Passant & Lymberidi, 1998). The species profile contains some crude assumptions:

- that of the 51% of emission which is hydrocarbon other than white spirit, propane and butane are used in equal proportions;
- that of the 35% of emission which are alcohols, ethanol, 1-propanol and 2-propanol are used in equal proportions.

In view of the size of the source, of the age of the species profile, and of the crudity of these two key assumptions, further work is warranted.

It is proposed to renew contact with BAMA to ask if new data have become available and, if not, whether they could comment on the above assumptions. If BAMA are unable to help, it is proposed to approach major manufacturers directly.

An alternative approach for domestic aerosol products would be to conduct a limited survey through a retailer. This would give the opportunity to disaggregate the species profile according to product type, and to test BAMA data. A survey of the author's home showed that only 3 out of 9 aerosol products indicated the composition of the contents (including propane, butane, isobutane, diethyl ether and denatured alcohol) but without any quantitative information. This approach is unlikely, therefore, to provide much useful information.

Recommendations for workplan

- BAMA and major aerosol product manufacturers should be asked to provide information and comment on key assumptions.

NON-AEROSOL CONSUMER PRODUCTS

Critique of current information

Passant & Lymberidi (1998) presented species profiles for cosmetics & toiletries, and for household & automotive products, based on information supplied by the SIA.

This is a substantial source, emitting about 90 kt in 1996 (Passant & Lymberidi, 1998). It is not self-evident whether the SIA data can be improved upon. Therefore it is proposed to conduct a limited survey to test whether improved data can be found.

A partial survey of the author's home revealed 19 out of 47 products reported compositional information (no quantitative data), including:

triethanolamine x5
liquid paraffin
alcohol
propylene glycol x8
denatured alcohol x10
phenoxyethanol x6
benzyl alcohol x4
formaldehyde
acetone

While a survey of a retailer's products might considerably extend this list, it is unlikely to provide a species profile suitable for inventory purposes.

A species profile for cosmetics and toiletries could be sought from the Cosmetics, Toiletries & Perfumeries Association (CTPA). Other product manufacturers may be represented by the British Association of Chemical Specialities (BACS) but automobile product manufacturers may not be represented by a trade association.

Recommendations for workplan

- CTPA and BACS should be asked whether they can provide any relevant data to test the SIA estimates.

AGROCHEMICALS USE

Critique of current information

Rudd (1995) presented a species profile but did not explain how it was derived. It is likely that the profile was taken from the SIA. The assumptions appear to be that:

- 15% of the emission is hexane;
- 85% of the emission is aromatic, half consisting of toluene, the other half of mixed xylenes in equal proportions for each of the three isomers.

The assumptions for the aromatic constituents, notably xylenes, appear to be crude and should be tested. As this is a fairly significant source (45 kt in 1996 - Passant &

Lymberidi, 1998) it is proposed to investigate this sector further through discussion with the SIA and the British Agrochemical Association (BAA).

Previous investigations have identified the Pesticide Usage Survey Group to be a potentially important source of information. They could be contacted and asked whether they hold any data relating to solvents used in agrochemical formulations.

Recommendations for workplan

- The SIA and BAA should be asked to provide relevant data.
- The Pesticide Usage Survey Group should be asked to provide any speciation data they hold.

EXTRACTION, TREATMENT AND LOADING OF CRUDE OIL

Critique of current information

The present species profile was presented by Rudd (1995) without explanation of its derivation. The published profile is extremely simple, and is unlikely to give a representative picture of the emissions from this group of sources. The existing profile does not include benzene which is surprising since crude oil contains this species.

This is probably a major source of emissions. Although it is arguable whether offshore emissions should be included in the UK national inventory, there is evidence to suggest that offshore emissions contribute significantly to atmospheric chemistry over the UK (Stedman, personal communication). Pipeline terminals may also be a significant onshore source. It is recommended therefore that further work should be undertaken to improve the species profile.

Most of the emissions are likely to come within the purview of the United Kingdom Offshore Operators Association (UKOOA) who have undertaken a number of inventory studies in recent years. It is recommended that UKOOA are asked what data they have or could make available.

UKOOA will not be able to comment on emissions from the transportation of crudes produced outside the UK region. A view could be sought regarding these from the United Kingdom Petroleum Industries Association (UKPIA).

The former BP component of BP Amoco has made considerable efforts to inventorise emissions at all their sites around the world. If UKOOA and UKPIA are unable to assist, it would be worth asking BP Amoco whether they can make suitable data available.

If no progress can be made through UK contacts, then an alternative perspective is given by detailed Canadian data which have been published and are readily available via the Internet.

It is also recommended that opportunities should be sought to make measurements (including analyses) of emissions from crude loading. UKOOA/UKPIA may be able to assist in identifying candidate sites.

Recommendations for workplan

- UKOOA, UKPIA or operating companies should be asked whether/how they could assist.
- Options for measuring and analysing emissions from crude loading should be explored with UKOOA and UKPIA.

REFINERIES

Critique of current information

The present species profile was presented by Rudd (1995) without explanation of its derivation. The published profile is extremely simple, and is unlikely to give a representative picture of the emissions from this source.

This is a substantial source of emissions (Passant & Lymberidi, 1998, gives the 1996 emission as 76 kt). It is recommended therefore that further work should be undertaken to improve the species profile.

Published data are available in the Internet for all refineries located in Canada and in California. The UK profile could be compared with profiles from these regions to identify any significant anomalies; any anomalies found should be discussed with UKPIA to identify the underlying reasons.

In the first instance, it is recommended that approaches for improving the species profile are explored with UKPIA.

Recommendations for workplan

- Possible approaches for improving the species profile should be explored with UKPIA

PETROL DISTRIBUTION

Critique of current information

Detailed species profiles for winter blend gasoline were developed by Rudd *et al.* (1997) based on measurement work at two filling stations. No species profiles are available for summer blend gasoline.

The winter blend profiles have not yet been discussed with UKPIA. These discussions should now be held so that the industry can comment on their general representativeness. UKPIA should also be asked whether/how a summer blend profile might differ from the winter blend.

Recommendations for workplan

- The published profiles for winter blend gasoline should be discussed with UKPIA and any differences expected for the corresponding summer blend profiles should be identified.

BITUMEN USE

Critique of current information

Passant & Lymberidi (1998) describe the derivation of an emission estimate (about 8 kt in 1996) based on discussions held 10 years earlier with the Transport & Road Research Laboratory and the Refined Bitumen Association. The key assumptions are that:

- VOC emissions are associated only with the kerosene component of cutback bitumens and emulsions;
- cutback bitumens contain 10-15% kerosene, while cutback emulsions contain 1% kerosene;
- an additional 3.5 kt of kerosene is sold separately for further dilution of cutbacks;
- 70% of the kerosene is emitted, while the remainder is retained within the bitumen.

Passant & Lymberidi recommend that the species profile for white spirit is used in the absence of a profile for kerosene.

While the source may well prove to be small, it is due for reappraisal. It is hoped that a species profile for kerosene may be obtained through collaboration with the SIA (see above).

Recommendations for workplan

- No action is recommended.

CHEMICAL PROCESSES

Critique of current information

No overall profile was given by Rudd (1995), although a profile was presented for pharmaceuticals manufacture. Passant & Lymberidi (1998) presented a composite

profile derived from data given in the former Chemical Release Inventory, and an unpublished profile derived by Rudd.

This is an important VOC emission source, with estimated 1996 emissions of 113 kt (Passant & Lymberidi, 1998). It is a very complex source, however, comprising many diverse processes. As almost all the sector consists of processes prescribed under Schedule B of the Environmental Protection Act and consequently report emissions to the Environment Agency's Inventory of Sources and Releases, it is recommended that this inventory is used as the basis for the national inventory. Therefore no further work is recommended under the present contract.

Recommendations for workplan

- No action is recommended.

BREAD BAKING

Critique of current information

Passant & Lymberidi (1998) recommend that Rudd's (1995) species profile continues to be used. This profile indicates that emissions consist entirely of ethanol, derived from the fermentation process. This profile is not likely to be significantly inaccurate, so no further work is warranted in this area.

Recommendations for workplan

- No action is recommended.

ALCOHOLIC BEVERAGES

Critique of current information

A species profile was presented by Rudd (1995) indicated that 90% of the emission is ethanol, and 10% is unknown. The source of this profile was not recorded.

This profile is intuitively correct. There has been some work carried out in this area by Warren Spring Laboratory (WSL) who made a number of measurements at a now-defunct bitter and lager brewery in England. This work should be examined to see if it sheds any light on the 10% of emissions which are uncharacterised; otherwise no further actions are recommended.

Recommendations for workplan

- The WSL work at a brewery should be assessed to see if any useful data can be gleaned.

OTHER FOOD INDUSTRY

Critique of current information

No species profile is available from Rudd (1995) or Passant & Lymberidi (1998). Emissions are probably relatively low (20 kt is given by Passant & Lymberidi, 1998) but highly uncertain.

This is a very diverse source, and no obvious route to a species profile has been identified.

Recommendations for workplan

- No action is recommended.

IRON & STEEL INDUSTRY

Critique of current information

A species profile was given by Rudd (1995) but the source(s) and derivation of data were not recorded.

This is thought to be a small source of emissions, so no further actions are recommended other than to record the derivation of the published profile.

Recommendations for workplan

- No actions are recommended.

COMBUSTION SOURCES

Critique of current information

Rudd (1995) presented species profiles for:

- domestic combustion of coal and solid smokeless fuel (based on experiments conducted on behalf of the DETR by the Coal Research Establishment);
- domestic combustion of other fuels (natural gas; LPG; oil) of unrecorded derivation;
- industrial combustion;
- electricity generation.

Emissions of non-methane VOC and of benzene were presented in Rudd (1996) for a similar source set. Emission factors and benzene content were taken from work by Warren Spring Laboratory published in the period 1990-1993 or, in the case of domestic coal and solid smokeless fuel combustion, from detailed trials

carried out by the Coal Research Establishment specifically to investigate benzene emissions.

It is unlikely that the work carried out by the Coal Research Establishment could be improved upon without considerable investment in further measurement trials; and as domestic solid fuel combustion is declining in importance no further work is recommended in this area.

Rudd's 1995 profiles for both domestic and industrial combustion of natural gas indicate that as much as 9% of the emissions of non-methane VOC is benzene. This seems rather high in comparison with the corresponding percentage for domestic coal combustion (2.5%). As the source data are now rather old, it is recommended that the species profile and especially benzene content of natural gas combustion should be re-examined. Probably the simplest and cheapest method would be to make measurements at the home of one of AEA Technology's consultants.

Rudd's 1995 profiles indicate that emissions from electricity generation do not include benzene. This is unlikely and should be investigated further, initially through discussion with power generators.

Recommendations for workplan

- The species profile and benzene content of emissions from natural gas combustion should be re-examined, for example through measurements at a house.
- The potential for benzene emissions from electricity production should be explored with generators.

MISSING SOURCES

Passant & Lymberidi (1998) list a number of potential sources of VOC emission which have not been quantified, and for which no species profiles are available. Of these, five sources are identified as requiring an emission estimate. These are:

- open hearth furnace steel plant;
- chipboard manufacture;
- asphalt roofing materials;
- asphalt blowing;
- vehicles dewaxing.

Until estimates are available for total VOC emissions from these sources, it is not possible to form a view on the need for species profiles for these sources.

The SIA has indicated that emissions from kerosene use may have been grossly underestimated and could amount to several tens of kilotonnes per year. It is

recommended that this source is discussed further with the SIA with a view to putting a number to the total emission estimate. Depending on the magnitude of this estimate, a species profile may be required.

Other potential emission sources which occur to the author are:

- diesel distribution;
- lube oil distribution and use;
- jet kerosene distribution;
- bitumen transportation;
- coke manufacture;
- road aggregate manufacture.

Until estimates are available for total VOC emissions from these sources, it is not possible to form a view on the need for species profiles for these sources.

PRIORITISED SUMMARY OF RECOMMENDATIONS

The following table summarises the recommendations by sector, and shows the author's opinion on the relative priorities of actions together with estimates of resource requirements and the scheduling of actions. All of the tasks given a high or medium priority will be carried out in the 1999/2000 financial year. No tasks have been scheduled for the 2000/01 financial year as these will depend upon the outcome of investigations carried out the previous year.

Sector recommendations	Priority	Man Days	Start Date
CONTINUED COLLABORATION WITH SIA • Further refine data and test key assumptions through discussion with SIA	High	5	June 1999
RUBBER PROCESSING • Discussed with BRMA and relevant companies the potential for release of 1,3-butadiene	High	0.5	June 1999
AEROSOL USE • BAMA and major aerosol product manufacturers should be asked to provide information and comment on key assumptions	High	0.5	July 1999
EXTRACTION, TREATMENT AND LOADING OF CRUDE OIL • Ask UKOOA and UKPIA whether/how they could assist	High	1.5	July 1999

Sector recommendations	Priority	Man Days	Start Date
• Options for measuring and analysing emissions from crude loading should be explored with UKOOA and UKPIA	High	1.25	

Sector recommendations	Priority	Man Days	Start Date
REFINERIES			
• Discuss possible ways forward with UKPIA, possibly involving the use of sampling & analysis	High	1.5	Aug 1999
WOOD IMPREGNATION			
• Discuss with trade association (BDWPA) and chemical suppliers to refine SIA data	High	1	June 1999
• Carry out headspace vapour analysis of creosote	Medium	1 + analytical costs	
AGROCHEMICALS USE			
• Contact Pesticide Usage Survey Group to discuss feasibility of using their data	High	1	June 1999
COMBUSTION SOURCES			
• The species profile and benzene content of emissions from natural gas combustion should be re-examined, for example through measurements at a house.	High	2 + analytical costs	Aug 1999
• The potential for benzene emissions from electricity production should be explored with generators.	High	0.75	Sept 1999
PAINT APPLICATION			
• The BCF and sector trade associations should be asked to give overviews of trends in product formulations/markets.	High	0.75	Aug 1999
• The ETBPP should be asked about what information they hold on trends in product formulations/markets.	High	0.5	Aug 1999
PRINTING			
• The BCF and other trade associations in the sector should be asked to provide information about trends in product formulations and to update the current market mix;	High	0.75	Sept 1999
• A species profile for emissions controlled by incineration should be developed; this could draw upon the work described above under paint application;	Low		
• The ETBPP should be asked to provide any relevant non-confidential data in their possession.	Medium	0.5	Oct 1999

Sector recommendations	Priority	Man Days	Start Date
ADHESIVES COATING • Approach SATRA, FIRA and other relevant sector associations to discuss whether/how they may be able to assist	Low		
FILM COATING • A repeat survey of local authority data could be conducted in 2001 to establish a trend.	Low		
TEXTILE COATING • Recommend no action	-		
LEATHER COATING & DEGREASING • The BLC should be asked to identify any hydrocarbon mixtures used in leather coating and degreasing; the SIA could then be asked for compositional information.	Low		
MANUFACTURE OF COATINGS • Recommend no action	-		
SURFACE CLEANING • A limited survey of companies should be undertaken to assess the types of hydrocarbon solvent used for surface cleaning operations, and how they are emitted to the atmosphere. A cross-section of companies representing a range of sizes should be selected from the general engineering sector, from electronic components manufacture, and from companies employing industrial surface coating operations.	Low		
DRY CLEANING • Recommend no action	-		
SEED OIL EXTRACTION • Recommend no action	-		
NON-AEROSOL CONSUMER PRODUCTS • CTPA and BACS should be asked whether they can provide any relevant data to test the SIA estimates.	High	1	Nov1999

Sector recommendations	Priority	Man Days	Start Date
PETROL DISTRIBUTION • The published profiles for winter blend gasoline should be discussed with UKPIA and any differences expected for the corresponding summer blend profiles should be identified.	Medium	1	Aug 1999
BITUMEN USE • Measure emissions from cutback and straight-run bitumens during summer and winter conditions.	Low		
BREAD BAKING • Recommend no action	-		
ALCOHOLIC BEVERAGES • The WSL work at a brewery should be assessed to see if any useful data can be gleaned.	Low		

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ABBREVIATIONS USED

BAA	British Agrochemical Association
BACS	British Association of Chemical Specialities
BAMA	British Aerosol Manufacturers Association
BCF	British Coatings Federation
BLC	British Leather Confederation
BRMA	British Rubber Manufacturers' Association
CTPA	Cosmetics, Toiletries & Perfumeries Association
DETR	Department of the Environment, Transport and the Regions
ECCA	European Coil Coaters Association
ETBPP	Environmental Technology Best Practice Programme
FIRA	Furniture Industry Research Association
HSE	Health & Safety Executive
LPG	Liquefied petroleum gas
PAH	polyaromatic hydrocarbon
SATRA	Shoe and Allied Trades Research Association
SIA	Solvents Industry Association
SMMT	Society of Motor Manufacturers and Traders
UKOOA	United Kingdom Offshore Operators Association
UKPIA	United Kingdom Petroleum Industries Association
VOC	Volatile organic compound(s)
WSL	Warren Spring Laboratory