REDUCE COSTS BY TRACKING SOLVENTS

GOOD PRACTICE: Proven technology and techniques for profitable environmental improvement
REDUCE COSTS BY TRACKING SOLVENTS

This Good Practice Guide was produced by the Environmental Technology Best Practice Programme

Prepared with assistance from:
ECOTEC Research and Consulting Ltd
Companies that use their organic solvents wisely can become more competitive while helping to protect the environment by reducing volatile organic compound (VOC) emissions. This Good Practice Guide is intended to help companies track their solvent use and identify opportunities to reduce solvent consumption and waste, thus reducing costs.

The simple and logical procedure described in this Guide is based on understanding and measuring how much solvent goes into and out from your processes. The Guide shows how information is collected and then used to prepare a simple solvent mass balance. This approach to analysing solvent use is compatible with solvent inventory requirements under Local Air Pollution Control (LAPC), particularly for non-arrestment VOC reduction strategies.

To assist you in the process of preparing a mass balance, the Guide is supplied with a computer disk containing a spreadsheet in Microsoft® Excel 5.0. If you use a spreadsheet other than Excel 5.0 (or later versions), please contact the Environmental Helpline on 0800 585794. If possible, the Helpline will send you the spreadsheet in your required format.

Using this Guide and the accompanying computer spreadsheet will help you to:

- improve your understanding of how your company uses solvents;
- identify the most wasteful processes/departments;
- track progress as improvements are implemented;
- fulfil the solvent inventory requirements of LAPC.

Further advice on solvent management is available free through the Environmental Helpline on 0800 585794.
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</table>
Many industrial solvents and solvent-based coatings are expensive to buy, and give rise to emissions that have the potential to harm the environment. Go-ahead companies have already used solvent management and good housekeeping techniques to achieve significant savings in reduced raw material costs and waste disposal charges. In some cases, reducing solvent consumption has allowed companies to meet their legal obligations under Local Air Pollution Control (LAPC) without having to install expensive volatile organic compound (VOC) abatement equipment.

Using the simple and cost-effective procedure for measuring solvent use and analysing data described in this Good Practice Guide, you will be able to identify opportunities to reduce your solvent consumption and thus save money. You won’t need expert knowledge or special equipment to produce a solvent mass balance for your company - just common sense and attention to detail, although a computer with spreadsheet software will save you time.

If you have adopted a non-arrestment VOC reduction strategy approach to compliance under LAPC, then the Guide will help you produce most of the information your local enforcing authority requires. If you are following an end-of-pipe abatement approach, then the Guide will help you produce a solvent inventory of total organic solvent inputs and outputs for submission to your local enforcing authority.

Although this Guide is intended to help technical/production managers in all solvent-using companies analyse their solvent use, it is particularly aimed at those using solvent-based inks, paints, lacquers and adhesives.

1.1 THE BENEFITS OF REDUCING SOLVENT CONSUMPTION

Reducing solvent consumption and waste has many potential benefits including:

- reduced raw material and waste disposal costs;
- compliance with LAPC without the need for expensive abatement equipment;
- a better working environment;
- improved relationships with ‘green’ customers and local residents;
- lower insurance premiums due to reduced risks from holding solvent stocks on site.

For more detailed advice on solvent management and the measures that can be taken, see Good Practice Guide (GG13) Cost-effective Solvent Management. Good Practice Guide (GG60) Practical Measures to Save Money in Screen Printing describes in detail how to measure and manage solvent use. Even though the latter Guide focuses on screen printing operations, the information is relevant and useful to any company that uses solvents. These Guides and other Environmental Technology Best Practice Programme publications are available free to UK businesses through the Environmental Helpline on 0800 585794. Details of other relevant publications are given in the Appendix.

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2 For the purposes of this Guide, a ‘solvent’ is a volatile organic compound (VOC) that evaporates readily at normal temperature and pressure.

3 Compliance is achieved through the use of low solvent inks, coatings, etc.
1.2 INFORMATION REQUIREMENTS UNDER LAPC

If you are regulated under LAPC, you will have to supply your local enforcing authority with the following information each year:

- total solvent input;
- total solvent output;
- total solvent consumption.

You may need to provide your environmental health officer (EHO) with an indication of the uncertainty in these figures. Information on how to calculate the overall mass uncertainty in your data is given in an appendix to the relevant Process Guidance Note. For more information contact the Environmental Helpline on 0800 585794.

In addition, you should also submit:

- A list of all the solvent-containing materials used on site. The list should include the solvent content and details of the supplier.
- A comparison of the present year's total consumption with that of previous years. A graph is generally the best way of presenting this comparison (see Fig 1). These comparative data will allow the EHO to see immediately whether solvent consumption is increasing or decreasing. If a significant change has occurred, it could alter your authorisation.

If you are adopting a non-arrestment VOC reduction strategy, you will also need to calculate the target emission for your site (for details see the relevant Process Guidance Note). Using the information generated from the points above, you should be able to demonstrate whether or not you are operating within that limit.

This Guide will help you satisfy these legislative requirements. However, when calculating your solvent mass balance, remember that local enforcing authorities are looking for precise information and will not be satisfied by rough approximations. Section 3 gives details of print-outs from the spreadsheet that will help.

Advice on the most recent legislation regarding solvents and their use in industrial processes can be obtained through the Environmental Helpline on 0800 585794.
1.3 DATA ANALYSIS USING A COMPUTER SPREADSHEET

Using a computer spreadsheet makes the task of recording and analysing solvent consumption data much easier and faster. The disk supplied with this Guide contains spreadsheet files to help you record and analyse your data. Example and blank workbooks are provided in Microsoft® Excel 5.0. If you use a spreadsheet other than Excel 5.0 (or later versions), please contact the Environmental Helpline on 0800 585794. If possible, the Helpline will send you the spreadsheet in your required format. Alternatively, you can use the following pages to assist you in developing appropriate spreadsheets on paper or in a different computer format for your company.

Instructions on how to use the spreadsheets are contained within the spreadsheet files and Section 3 of this Guide.
Compiling a solvent inventory, ie a record of solvent supply, stock, consumption and waste, will help you to identify opportunities to reduce solvent consumption. The mass balance or inventory approach described in this Guide is based on measuring and understanding solvent inputs and outputs by weight.

2.1 THE SOLVENT CONTENT OF MATERIALS

To understand your use of solvents, you first need to:

- list all the materials used on your site that are, or contain, organic solvents such as trichloroethylene, white spirit, methyl ethyl ketone (MEK), isopropyl alcohol (IPA) and toluene;
- establish how much solvent these materials contain by weight.

Some materials will be virgin or recovered solvents used for dilution, cleaning, etc. Other solvents will be coatings such as inks, paints and adhesives. Cleaning solvents are usually 100% solvent.

2.1.1 Converting solvent volumes to weights

Local enforcing authorities require information about the weight in kilograms of solvent used and disposed of. To convert solvent volumes to weights, you need to know their density. Table 1 gives the densities of some common industrial solvents. If you don’t know the density of the solvents that you use, ask your supplier. The equation below calculates weight of solvent from its density and volume.

\[
\text{Solvent weight in kg} = \frac{\text{Volume in litres} \times \text{Density in g/litre}}{1000}
\]

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Density (g/litre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>791</td>
</tr>
<tr>
<td>Alcohols, eg ethanol, methanol and isopropyl alcohol</td>
<td>790</td>
</tr>
<tr>
<td>Gunwash</td>
<td>800</td>
</tr>
<tr>
<td>Methylene ketone</td>
<td>805</td>
</tr>
<tr>
<td>Toluene</td>
<td>867</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>1460</td>
</tr>
<tr>
<td>White spirit</td>
<td>775</td>
</tr>
<tr>
<td>Xylene</td>
<td>881</td>
</tr>
</tbody>
</table>

Table 1 Density of some common industrial solvents

2.1.2 Solvent content of coatings

The solvent content of a coating should be included in the information provided by your supplier, ie on technical and safety data sheets and/or delivery notes/invoices. If this is not the case, your supplier is legally obliged - under the Chemicals (Hazard Information and Packaging for Supply) Regulations 1994 (CHIP2) - to tell you the solvent content of a purchased material.

You may need to calculate the solvent content of made-up coatings, ie those that have been diluted or thinned ready for use. This calculation is explained opposite with the help of an example.
2.1.3 Calculating the solvent content of made-up coatings

Before attempting your own calculation, you need to know:

- the percentage solvent content of the coating by weight (A%);
- either the density of the coating including solvent (B) in g/litre (or kg/litre), or its specific gravity\(^4\) (C);
- the amount, in litres, of diluting solvent per litre of coating (E);\(^5\)
- the density of the diluting solvent (F) in g/litre (or kg/litre).

If necessary, ask your coatings and solvent suppliers. Suppliers may supply density figures in g/litre or kg/litre, so you may need to convert from one to the other through the calculation, as most appropriate.\(^6\) The worked example for a litre of coating is in g/litre; the overall consumption example is in kg/litre.

The first step is to calculate the solvent content of the coating in terms of g/litre.

\[
\text{Coating solvent content (D) in g/litre} = A\% \times B
\]

or

\[
\text{Coating solvent content (D) in g/litre} = A\% \times C \times 1\,000
\]

You can now calculate the solvent content of the diluted coating in g/litre:

\[
\text{Solvent content of the diluted coating (G)} = \frac{D + (E \times F)}{1 + E} \text{ g/litre}
\]

**Worked example - coating solvent content**

A coating that contains 60% solvent (A%) by weight has a specific gravity (C) of 0.9, i.e., a density of 900 g/litre.

\[
\text{Coating solvent content (D)} = A\% \times C \times 1\,000
\]

\[
= 60\% \times 0.9 \times 1\,000
\]

\[
= 60\% \times 900
\]

\[
= 540 \text{ g/litre}
\]

The coating has been diluted 30% by volume (i.e., 0.3 litres of diluting solvent are added to every litre of coating (E)) using a solvent of density 800 g/litre (F).

\[
\text{Solvent content of the diluted} = \frac{D + (E \times F)}{1 + E} \text{ coating (G)}
\]

\[
= \frac{540 + (0.3 \times 800)}{1 + 0.3}
\]

If the initial volume of coating is one litre, 240 g of diluting solvent (30% of 800 g) will have been added to the 540 g of solvent already in the coating.

\[
= \frac{540 + 240}{1.3}
\]

This gives a total of 780 g of solvent.

\[
= \frac{780}{1.3}
\]

However, the total volume has increased to 1.3 litres.

\[
= 600 \text{ g/litre}
\]

Therefore, the solvent content for the made-up coating is actually 600 g/litre or 0.6 kg/litre.

---

\(^4\) The specific gravity of a liquid is its density relative to water. The density of water is 1 000 g/litre.

\(^5\) If given as a %, remember to convert to a number, e.g., 10% = 0.1

\(^6\) 1 kg = 1 000 g. For example, 800 g/litre = 0.8 kg/litre. When dealing with larger quantities, 1 000 kg = 1 tonne.
2.2 IDENTIFYING SOLVENT INPUTS AND OUTPUTS

Once you have established which solvent-based materials you use and how much solvent they contain, you need to find out how much of these materials your site uses.

Recording material movements - both for the site as a whole and from process to process - allows unintentional losses and wasteful processes to be identified.

Use the sources of information listed in Table 2 to help you understand your solvent inputs and outputs. Waste is used to mean all residue materials, including those sold for recovery or to be burnt as a fuel.

<table>
<thead>
<tr>
<th>Type of material</th>
<th>Source of information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs:</td>
<td></td>
</tr>
<tr>
<td>Bought-in solvents</td>
<td>Purchase/dispense records, stocktaking</td>
</tr>
<tr>
<td>Coatings, eg inks, paints and adhesives</td>
<td>Purchase/dispense records, data sheets, stocktaking</td>
</tr>
<tr>
<td>Outputs:</td>
<td></td>
</tr>
<tr>
<td>Waste solvents, eg from cleaning</td>
<td>Disposal and sales records, audits</td>
</tr>
<tr>
<td>Waste coatings, eg process residues</td>
<td>Disposal and sales records, audits, analyses</td>
</tr>
<tr>
<td>Wastes containing solvent</td>
<td>Disposal and sales records, audits, analyses</td>
</tr>
<tr>
<td>Solvent-based products</td>
<td>Sales records, stocktaking</td>
</tr>
</tbody>
</table>

Table 2 Typical solvent inputs and outputs

2.3 CALCULATING SOLVENT INPUTS AND OUTPUTS

In practice, these calculations are best carried out for one material at a time. You can then add the results together to give the overall figure for the site.

The same units - usually kilograms of solvent - should be used throughout the input and output calculations. The quantities in the equations below can be calculated by multiplying the volume of material in litres by the proportion of solvent it contains. The method for calculating the proportion of solvent is shown in Section 2.1.

**Inputs and outputs must be measured over the same time period.**

2.3.1 Inputs

For any given period (say six weeks), the overall solvent input to the site can be calculated from the following equation:

\[
\text{Overall input} = \text{Initial stock} + \text{Material purchases} - \text{Final stock}
\]

Note that ‘stock’ should include redundant materials.

2.3.2 Outputs

This calculation is similar to that for inputs, but solvent-containing wastes and any solvent-containing products are substituted for purchases and stocks of raw materials.
The equation used for calculating overall solvent output is:

\[
\text{Overall output} = \text{Final waste and/or Final product stock levels} + \text{Waste disposals and/or Product sales} - \text{Initial waste and/or Initial product stock levels}
\]

For companies that use coatings/inks, the solvent content of the product can generally be considered to be negligible. However, companies that manufacture coatings and fine chemicals will need to take account of the solvent content of product that has been reacted, sold or is in stock.

Solvent discharges to water/drain are also usually negligible. However, if this is not the case, eg when hosing down printing screens, these discharges should be measured or estimated and recorded as a disposal.

**Minimising uncertainty**

Unlike the overall input calculation, the calculation of overall solvent output from the site can contain more uncertainties.

Major errors can be minimised by:

- keeping waste streams separate so that the proportion of solvent is always known;
- only mixing similar materials, eg low-solvent inks.

You may wish to have some of your waste streams analysed to obtain accurate solvent content figures. Such analyses can be carried out cheaply, ie for tens of pounds. You can obtain the names and contact details of local laboratories offering analytical services from local business directories.

Cleaning solvents that contain only a small amount of waste coating can generally be treated as though they are 100% solvent.

### 2.4 CALCULATING OVERALL CONSUMPTION

Overall consumption, ie emissions to air including unintentional leaks and spillages, can be calculated from the following equation:

\[
\text{Overall consumption} = \text{Overall input} - \text{Overall output}
\]

Any solvent that is recovered by distillation and subsequently re-used on site should not be included; it is both an input and an output and therefore it is assumed to cancel out in the calculations.

The solvent inventory calculations will allow you to identify, for a given period:

- the overall quantity of solvent and each solvent-based material coming onto the site;
- the overall quantity of solvent-based waste of each type;
- the overall consumption of solvent-based material.

This information can be quite revealing. You might find yourself asking:

- Why is so much gunwash being used?
- Where is the waste screen wash going?
Worked example - consumption calculation

In one year, a company buys 6 000 litres of solvent for thinning/cleaning and 10 000 litres of coating containing 0.35 kg/litre of solvent (D). The density of the solvent for thinning/cleaning is 0.8 kg/litre (F). At the beginning of the year the company had 500 litres of solvent and 1 000 litres of coating in stock. At the end of the year it had 700 litres of solvent and 800 litres of coating in stock.

The first step is to calculate overall input.

- Initial stock (I) = (500 x 0.8) + (1 000 x 0.35) = 750 kg
- Material purchases (M) = (6 000 x 0.8) + (10 000 x 0.35) = 8 300 kg
- Final stock (FS) = (700 x 0.8) + (800 x 0.35) = 840 kg
- Overall input = I + M - FS
  = 750 + 8 300 - 840
  = 8 210 kg

During the year, the company disposes of 1 000 litres of spent solvent and 2 000 litres of made-up coating prepared by diluting 20% by volume (E) with solvent. At the beginning of the year there were 40 litres of spent solvent and 200 litres of waste coating stored at the site. At the end of the year there were 80 litres of spent solvent and 160 litres of waste coating.

Using the equation in Section 2.1.3, the solvent content of the made-up coating can be calculated.

Solvent content of the diluted coating (G) = \( \frac{D + (E \times F)}{1 + E} \)

\[ = \frac{0.35 + (0.2 \times 0.8)}{1 + 0.2} \]

\[ = \frac{0.35 + 0.16}{1.2} \]

\[ = \frac{0.51}{1.2} \]

\[ = 0.425 \text{ kg/litre} \]

- Initial waste (IW) = (40 x 0.8) + (200 x 0.425) = 117 kg
- Waste disposals (WD) = (1 000 x 0.8) + (2 000 x 0.425) = 1 650 kg
- Final waste (FW) = (80 x 0.8) + (160 x 0.425) = 132 kg
- Overall output = FW + WD - IW
  = 132 + 1 650 - 117
  = 1 665 kg
- Overall consumption = Overall input - Overall output
  = 8 210 - 1 665
  = 6 545 kg
  = 80%

This calculation shows that 80% of the solvent input is emitted to air via the local exhaust ventilation (LEV) system or unintentional fugitive emissions.
Other methods

In some cases, eg when numerous small quantities of coating are mixed each day or where materials are pumped from bulk containers, it may not be practicable to record dispenses on a log. In such cases take an alternative approach, eg:

- measure the remaining stock levels, eg the number of five-litre cans, to establish how much material has been dispensed;
- check the mixing record on the mixing machine;
- install simple meters to keep track of piped solvents.

This information can then be entered in the dispense log - preferably on a daily basis.

Helpful tips

When decanting from large drums, use measures of known size (eg litre jugs) or mark set measures (eg 1 litre, 2 litres) on the side of large containers such as buckets and intermediate bulk containers (IBCs).

Use dipsticks for large (eg bulk) containers without level meters.

Weigh part-filled containers (eg five-litre containers) and subtract the weight of the empty container. This quick method avoids solvent evaporation and spillage. Otherwise use dipsticks.

2.5.2 Calculating process inputs and outputs

The information on the dispense and waste logs should allow you to examine the efficiency of specific processes and/or departments. The calculations are essentially the same as those for the site as a whole.

**Process inputs**

\[
\text{Process input} = \text{Initial stock} + \text{Quantity dispensed} - \text{Final stock}
\]

In this case, the stock level may refer to existing containers (cans, drums, etc) on the shopfloor and/or machine reservoir levels.

**Process outputs**

\[
\text{Process output} = \text{Final waste and/or Final product stock levels} + \text{Waste disposals and/or Product sales} - \text{Initial waste and/or Initial product stock levels}
\]

Don’t forget any waste left in containers on the shopfloor, which should be included in the calculation.

**Process consumption**

\[
\text{Process consumption} = \text{Process input} - \text{Process output}
\]

If an individual process such as a degreasing machine has its own recovery/re-use cycle, this can be ignored because the process is only interested in net inputs and outputs.

This information will allow you to compare solvent consumption and waste between processes and departments. However, to obtain unambiguous information, you need to relate waste and consumption data to production. Section 3.5 describes how to link solvent inventory data to production levels.
The disk supplied with this Good Practice Guide contains two spreadsheets in Microsoft® Excel 5.0. First of all look at example.xls with the accompanying notes and this Section. The file blank.xls is for you to record and analyse your own input and output data. If you don’t have access to Excel 5.0 (or later versions), contact the Environmental Helpline on 0800 585794 for advice. Instructions on how to load the spreadsheets onto your computer are given in the back of this Guide.

The spreadsheet, which contains all the necessary formulae, will automatically calculate your solvent consumption and solvent mass balance. Once you have entered your production figures for the corresponding time periods, the spreadsheet will also calculate your solvent consumption per production unit. It is possible to carry out the same calculation by hand, and details are given in Good Practice Guide (GG13) Cost-effective Solvent Management.

In addition to using the spreadsheet to identify opportunities for reducing solvent consumption, you can use a print-out of the Mass Balance worksheet to submit information about your site’s annual solvent consumption to your local authority. A print-out of the Materials worksheet will provide a list of your solvent-containing materials.

The Excel spreadsheet is broken down into several worksheets within a single workbook. You can navigate between worksheets by clicking on the labelled tabs at the bottom of the screen. If you click on a tab to open a worksheet and the screen appears blank, you can jump to the top of the screen using the keyboard shortcut Ctrl + Home. The table or graph will then come into view. The screens have been designed so that you will only need to scroll up and down.

When adding your own data you only need to fill in the white cells - the yellow cells contain formulae, and will be filled in automatically.

Before you start entering your data, you are advised to spend some time reading the rest of this Section and looking at the example spreadsheet on the attached disk. This spreadsheet contains data from a fictitious printing company that uses six inks with different solvent contents and two cleaning solvents. The following subsections correspond with the worksheet tabs in the spreadsheet.

### 3.1 INSTRUCTIONS

Before starting to use the spreadsheet, print out and read the Instructions worksheets from blank.xls and example.xls.

### 3.2 MATERIALS

The first step is to fill in details of the materials you use on the Materials worksheet (Fig 3). Click on the Materials tab at the bottom of the workbook.

Enter the solvent description, supplier, supplier’s product code and solvent content in the cells provided. Note that solvent content should be calculated in kg/litre as described in Section 2.1.

If you use a number of materials that all have the same solvent content then they can be grouped together. For example, if three inks have the same solvent content, then just have a description ‘ink’
in the Solvent Description column. If the solvent content of a material changes then it will be necessary to treat it as a separate material. If you have more than eight materials, see the Instructions worksheet print-out for details of how to add additional materials to the tables.

### Materials

**See Section 3.2 of the Guide for details of how to use this worksheet.**

<table>
<thead>
<tr>
<th>Table 1</th>
<th>List of materials used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>Solvent description</td>
</tr>
<tr>
<td>1</td>
<td>Ink</td>
</tr>
<tr>
<td>2</td>
<td>Ink</td>
</tr>
<tr>
<td>3</td>
<td>Ink</td>
</tr>
<tr>
<td>4</td>
<td>Ink</td>
</tr>
<tr>
<td>5</td>
<td>Ink</td>
</tr>
<tr>
<td>6</td>
<td>Ink</td>
</tr>
<tr>
<td>7</td>
<td>Cleaning solvent</td>
</tr>
<tr>
<td>8</td>
<td>Cleaning solvent</td>
</tr>
</tbody>
</table>

**Fig 3** Materials worksheet Table 1, from example.xls

#### 3.2.1 Hints and tips

- List each material separately; you may have more than eight. To add further rows see the Instructions worksheet in the blank.xls workbook for step-by-step guidance.
- If in doubt about the solvent content see Section 2.1 and, if necessary, check with your supplier.
- The spreadsheet allows you to include reference data for each material, and an example is shown in Fig 3.
- Listing the supplier and supplier’s product code will assist you in identifying materials, but it is not critical to the mass balance.

#### 3.3 BASE DATA ENTRY

You can now enter the data you want to use for base-line comparison, ie before starting to manage solvent, on the Base Data Entry worksheet (Fig 4). Data from six time periods are required for each solvent-containing material to ensure a representative base position - the spreadsheet has been designed to work with this number of data periods. If data are not available, estimates can be entered and the spreadsheet updated when sufficient base data are available. The spreadsheet will then calculate the total solvent input, output and consumption for each period and relate them to production during that period. The process for gathering this information is described in Sections 2.2 and 2.5 in the Guide.

### Base Data Entry

**See Section 3.3 of the Guide for details of how to use this worksheet.**

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Solvent containing material 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material description</td>
<td>Ink</td>
</tr>
<tr>
<td>Time (period)</td>
<td>Initial stock (litres)</td>
</tr>
<tr>
<td>1</td>
<td>5.00</td>
</tr>
<tr>
<td>2</td>
<td>8.00</td>
</tr>
<tr>
<td>3</td>
<td>10.00</td>
</tr>
<tr>
<td>4</td>
<td>12.00</td>
</tr>
<tr>
<td>5</td>
<td>15.00</td>
</tr>
<tr>
<td>6</td>
<td>18.00</td>
</tr>
</tbody>
</table>

**Fig 4** Base Data Entry worksheet Table 2, from example.xls
You also need to enter the measure of production if you wish to compare performance against output. Go to the Mass Balance worksheet and on Table 4 insert production units for time periods 1 - 6. Production measures are described in Section 3.5.

### 3.3.1 Hints and tips
- You can add the waste or product description to the white box in the top bar of each table.
- You can select the time period to suit your operation. Time period 1 could be a month, a week or a day. The time period should be consistent for each material.
- Some of the definitions of the table headings are given below. For more details on how to calculate inputs and outputs see Section 2.
  - **Initial stock** is how much of the material you had at the start of each time period. This is filled in automatically after the first time period.
  - **Material purchased** is the amount of new material (in litres) that is issued/introduced during the period.
  - **Input** is the total amount of solvent input to your process in each material.
  - **Initial waste/product** is the amount of waste that contains solvent that is to be disposed of (or is in storage before disposal), plus the amount of product containing solvent awaiting dispatch.
  - **Waste disposals/product sales** is the amount of waste that contains solvent that has been disposed of, plus the amount of product containing solvent that has been dispatched.
  - **Final waste/product** is the amount of waste and product containing solvent that, at the end of the period, has yet to be disposed of and dispatched.
  - **Solvent content** is the amount of solvent in kg/litre of material. You may need to estimate this for your different waste streams.
- If in doubt, estimate; you can always update the values on the spreadsheet at a later date.

### 3.4 CURRENT DATA ENTRY
You can now start to input data for each subsequent time period. Fig 5 shows Table 3 completed following 13 time periods. These current data points will be plotted automatically on the scatter graphs, allowing you to check performance compared with the base-line.

*Fig 5  Current Data Entry worksheet Table 3, from example.xls*
To allow comparison against production you will need to enter the units of production for the time period in Table 5 on the Mass Balance worksheet. Production measures are described in Section 3.5.

### 3.4.1 Hints and tips

- As you enter data at the end of the time period, the spreadsheet will automatically work out performance compared with the base-line.
- Remember that you need to complete records for each solvent-containing material.
- Definitions of the table headings are given in Section 3.3.1.

### 3.5 MASS BALANCE

The Mass Balance worksheet will have calculated consumption for all solvents (Fig 6). Waste and consumption data are of limited use unless they can be related to an appropriate production measure. To relate consumption to production, fill in your production figures for the corresponding time periods in Mass Balance worksheet Tables 4 and 5.

#### Table 4 Base Data

<table>
<thead>
<tr>
<th>Time period</th>
<th>Input (kg)</th>
<th>Output (kg)</th>
<th>Consumed (kg)</th>
<th>Production units</th>
<th>Input/production (kg)</th>
<th>Output/production (kg)</th>
<th>Consumed/production (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1144.20</td>
<td>354.30</td>
<td>789.70</td>
<td>500.00</td>
<td>2.28</td>
<td>0.71</td>
<td>1.56</td>
</tr>
<tr>
<td>2</td>
<td>1174.65</td>
<td>364.80</td>
<td>810.35</td>
<td>550.00</td>
<td>2.11</td>
<td>0.81</td>
<td>1.60</td>
</tr>
<tr>
<td>3</td>
<td>791.95</td>
<td>262.40</td>
<td>469.58</td>
<td>350.00</td>
<td>3.33</td>
<td>1.13</td>
<td>2.00</td>
</tr>
<tr>
<td>4</td>
<td>1188.80</td>
<td>360.50</td>
<td>808.30</td>
<td>650.00</td>
<td>1.75</td>
<td>0.59</td>
<td>1.19</td>
</tr>
<tr>
<td>5</td>
<td>927.20</td>
<td>287.40</td>
<td>639.80</td>
<td>450.00</td>
<td>1.58</td>
<td>1.12</td>
<td>4.27</td>
</tr>
<tr>
<td>6</td>
<td>939.35</td>
<td>268.10</td>
<td>671.25</td>
<td>450.00</td>
<td>3.76</td>
<td>1.07</td>
<td>2.69</td>
</tr>
<tr>
<td>Average</td>
<td>1028.08</td>
<td>322.90</td>
<td>703.18</td>
<td>380.00</td>
<td>3.26</td>
<td>1.03</td>
<td>2.25</td>
</tr>
<tr>
<td>Totals</td>
<td>6156.45</td>
<td>1937.40</td>
<td>4210.06</td>
<td>2280.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Table 3 Current Data

<table>
<thead>
<tr>
<th>Time period</th>
<th>Input (kg)</th>
<th>Output (kg)</th>
<th>Consumed (kg)</th>
<th>Production units</th>
<th>Input/production (kg)</th>
<th>Output/production (kg)</th>
<th>Consumed/production (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>945.40</td>
<td>261.50</td>
<td>653.90</td>
<td>650.00</td>
<td>1.45</td>
<td>0.45</td>
<td>1.01</td>
</tr>
<tr>
<td>2</td>
<td>870.60</td>
<td>262.50</td>
<td>578.00</td>
<td>510.00</td>
<td>1.17</td>
<td>0.57</td>
<td>1.13</td>
</tr>
<tr>
<td>3</td>
<td>731.70</td>
<td>211.90</td>
<td>519.80</td>
<td>380.00</td>
<td>2.40</td>
<td>0.69</td>
<td>1.70</td>
</tr>
<tr>
<td>4</td>
<td>875.00</td>
<td>294.20</td>
<td>581.70</td>
<td>375.00</td>
<td>3.14</td>
<td>0.78</td>
<td>1.56</td>
</tr>
<tr>
<td>5</td>
<td>792.10</td>
<td>329.10</td>
<td>663.00</td>
<td>650.00</td>
<td>1.42</td>
<td>0.48</td>
<td>0.96</td>
</tr>
<tr>
<td>6</td>
<td>1047.60</td>
<td>354.90</td>
<td>692.70</td>
<td>780.00</td>
<td>1.34</td>
<td>0.43</td>
<td>0.89</td>
</tr>
<tr>
<td>7</td>
<td>912.40</td>
<td>247.20</td>
<td>665.20</td>
<td>445.00</td>
<td>2.05</td>
<td>0.55</td>
<td>1.49</td>
</tr>
<tr>
<td>8</td>
<td>851.10</td>
<td>236.00</td>
<td>645.10</td>
<td>510.00</td>
<td>1.31</td>
<td>0.48</td>
<td>1.26</td>
</tr>
<tr>
<td>9</td>
<td>658.70</td>
<td>187.70</td>
<td>471.00</td>
<td>250.00</td>
<td>2.03</td>
<td>0.75</td>
<td>1.86</td>
</tr>
<tr>
<td>10</td>
<td>864.70</td>
<td>249.40</td>
<td>615.30</td>
<td>595.00</td>
<td>1.48</td>
<td>0.42</td>
<td>1.07</td>
</tr>
<tr>
<td>11</td>
<td>971.80</td>
<td>339.00</td>
<td>632.80</td>
<td>650.00</td>
<td>1.50</td>
<td>0.52</td>
<td>0.97</td>
</tr>
<tr>
<td>12</td>
<td>1067.70</td>
<td>395.50</td>
<td>672.20</td>
<td>725.00</td>
<td>1.47</td>
<td>0.55</td>
<td>0.93</td>
</tr>
<tr>
<td>13</td>
<td>1074.90</td>
<td>361.50</td>
<td>633.40</td>
<td>780.00</td>
<td>1.38</td>
<td>0.49</td>
<td>0.89</td>
</tr>
<tr>
<td>Average</td>
<td>915.74</td>
<td>293.12</td>
<td>658.85</td>
<td>558.85</td>
<td>1.16</td>
<td>0.55</td>
<td>1.21</td>
</tr>
<tr>
<td>Totals</td>
<td>11004.60</td>
<td>3810.50</td>
<td>7184.10</td>
<td>7285.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fig 6** Mass Balance worksheet Tables 4 and 5, from example.xls

The chosen production indicator must be measured over the same time period as that for solvent consumption.
When comparing processes or departments, it is best to consider the output from that process or department rather than from the site as a whole. Examples of direct production measures could include:

- number of items coated or cleaned per week;
- area coated or cleaned per week;
- volume of coating manufactured.

Indirect measures could include:

- number of production hours per week;
- number of operating hours per week;
- value of production in a batch.

Where known factors alter the quantity of solvent used, e.g., a printing substrate or the product design, the production measure should be adjusted to compensate. For example, if a different substrate is known to require 20% more ink than the usual substrate, the production figure should be multiplied by 1.2.

Inputs, outputs and consumption can all be related to the production measure, for example, kilograms of solvent per car resprayed, or grams of solvent used for each printing screen cleaned.

### 3.6 PERFORMANCE CHARTS

The example spreadsheet on the computer disk supplied with this Guide demonstrates the use of scatter plots and bar charts to relate solvent use to a production measure (Fig 7). Similar graphs will be produced automatically when you enter your data in the blank spreadsheet.

Click on the remaining tabs to view the graphs that have been produced. Titles, axes and line labelling can be altered as required. The graphs are labelled as follows:

- **Plot I - P** - scatter plot of solvent input versus number of production units;
- **Plot O - P** - scatter plot of solvent output versus number of production units;
- **Plot C - P** - scatter plot of solvent consumption versus number of production units;
- **IP - time** - solvent input per unit of production;
- **OP - time** - solvent output per unit of production;
- **CP - time** - solvent consumption per unit of production.

The spreadsheet will plot scatter graphs of solvent input, output and consumption versus the number of production units. The line of best fit is drawn by the computer through the base data and can be used as the base-line against which progress can be assessed - the aim being to move as far below this base-line as possible.

If a new point is below the line of best fit, this shows that performance has improved during that time period. However, if the new point is above the base-line, performance is worse. You can also use the bar charts of solvent input, output and consumption per production unit to identify periods with the highest waste.

Production-adjusted figures will allow you to monitor changes from month to month and from process to process. Leaks, poor operator practices, etc should then become easier to detect.
More detailed information on the analysis and interpretation of solvent inventory data is given in Good Practice Guide (GG60) *Practical Measures to Save Money in Screen Printing*, available free to UK businesses through the Environmental Helpline on 0800 585794.

It is possible to create other performance charts, for example comparing individual processes, or day shifts to night shifts, but these are beyond the scope of this Guide.

### 3.7 PRINTING

Individual pages, worksheets or the complete workbook can be printed from Excel in the normal way. The Materials and Mass Balance worksheets can be presented as part of your annual Local Air Pollution Control authorisation process. The graphs may be used to help motivate staff, and can be included in management and environmental reports.
4.1 COST-EFFECTIVE MEASURES TO REDUCE SOLVENT CONSUMPTION

The spreadsheet will help you identify the main areas and processes where solvent is being used inefficiently. Many of the measures you can take to reduce solvent consumption are no-cost or low-cost. However, all waste-reducing measures should bring significant cost savings in the short-to-medium term.

Some of the most cost-effective measures include:

- staff training to improve working practices;
- modified cleaning practices, eg use of dirty solvent for the first wash;
- planned preventive maintenance, eg to avoid leaks from valves;
- use of larger containers and dedicated mixing vessels to reduce residue and cleaning losses;
- improved containment of degreasing equipment, printing presses and mixing vessels;
- centralised/computerised mixing of coatings;
- piping of solvents and coatings in fully enclosed systems;
- use of high-efficiency spray guns, eg high volume low pressure (HVLP) spray guns;
- use of coatings with a low solvent content, eg water-based, ultraviolet-cured and high solids coatings;
- use of solvent recovery equipment.

Many more low-cost and no-cost measures are described in Good Practice Guide (GG28) Good Housekeeping Measures for Solvents, available free through the Environmental Helpline on 0800 585794. Good Practice Guide (GG36) Reducing Costs in Vehicle Refinishing and the series of four complementary Guides to cost-effective paint and powder coating (GG50 to GG53) contain specific advice about these processes. The Appendix gives further details of these and other useful publications from the Environmental Technology Best Practice Programme.

4.2 MAINTAINING PROGRESS

Set up a continuous improvement programme with clear actions and realistic targets. Involving all employees in this solvent management programme will help to give them a sense of ownership. As time goes on, you can introduce more ideas for reducing solvent consumption and possibly consider some new measures. As you reduce your solvent consumption, don’t forget to set new targets.

Using the type of simple analysis described in Section 3 will allow you to track your progress in reducing solvent consumption, both for individual processes and the site as a whole. Using the spreadsheet on the attached disk will make it easy to track progress and prepare annual reports for your local enforcing authority.

The spreadsheet will also produce graphs showing solvent use compared with production unit. These graphs will help to:

- motivate everyone concerned;
- identify when things have begun to slide, eg new operators have not received training or poor working practices have crept back in.

You should review the situation regularly to ensure that progress is maintained and to check whether there are any new opportunities for improvement.
ACTION PLAN

Identify all the solvents and solvent-containing materials used on your site.
Identify all solvent-containing wastes generated on your site.
Establish the solvent content of these materials and wastes.
Identify an appropriate measure of production.
Load the spreadsheet files supplied on the disk onto your computer.
Look at the example spreadsheet.
Measure solvent inputs and outputs.
Enter your data on the spreadsheet.
Calculate your solvent consumption.
If your site is regulated under LAPC, use the spreadsheet to provide your local enforcing authority with the relevant annual data.
Analyse your production-adjusted data to identify waste and opportunities to improve your performance.
Implement a continuous improvement programme with clear targets and actions.
Track progress and review the improvement programme regularly.

IF NECESSARY, OBTAIN HELP.
The Environmental Helpline (0800 585794) can:

- Provide further advice about the techniques described in this Guide;
- Send you copies of relevant Environmental Technology Best Practice Programme publications;
- Provide free up-to-date information on a wide range of environmental issues, legislation, technology and equipment suppliers.
- Arrange for a specialist to visit your company if you employ fewer than 250 people.

Remember:
If you don’t measure it, you can’t manage it.
The Environmental Technology Best Practice Programme publications listed below are available free to UK businesses through the Environmental Helpline on 0800 585794.

Good Practice Guide (GG12) Solvent Capture for Recovery and Re-use from Solvent-laden Gas Streams
Good Practice Guide (GG13) Cost-effective Solvent Management
Good Practice Guide (GG15) Vapour Degreasing
Good Practice Guide (GG28) Good Housekeeping Measures for Solvents
Good Practice Guide (GG36) Reducing Costs in Vehicle Refinishing
Good Practice Guide (GG51) Cost-effective Paint and Powder Coating: Surface Preparation
Good Practice Guide (GG52) Cost-effective Paint and Powder Coating: Coating Materials
Good Practice Guide (GG60) Practical Measures to Save Money in Screen Printing
Good Practice Guide (GG71) Cost-effective Reduction of Fugitive Solvent Emissions
Good Practice Guide (GG87) Solvent Consumption in Dry-cleaning
Good Practice Guide (GG100) Solvent Capture and Recovery in Practice: Industry Examples
Good Practice Guide (GG124) Solvent Management in Practice: Industry Examples
Good Practice Case Study (GC31) Stepping Ahead with Solvent Management (Clarks International)
Good Practice Case Study (GC77) Vehicle Refinisher Saves Money by Reducing Paint and Solvent Use (Browns of Loughton Ltd)
Good Practice Case Study (GC108) Profiting from Computer-based Solvent Management (Ford Motor Company Ltd)

Also available is Encore (IT90), a software package that will help you select the most appropriate coating system for a wide range of metal finishing applications. Where appropriate, it will select a low-solvent option that will reduce your solvent use.
GETTING STARTED

To use the mass balance spreadsheet you will need a copy of Microsoft® Excel 5.0 (or later versions). If you don’t have access to this application, contact the Environmental Helpline on 0800 585794 for advice.

MICROSOFT® WINDOWS® 3.1

Start Windows® File Manager. In C:\ create a directory called balance.

Insert the floppy disk and select drive A:\. Select and copy the files on the floppy disk to the directory in C:\ that you have just created.

The file blank.xls can be copied and renamed - for example, you could call your working copy march98.xls to show when you started recording solvent use.

The spreadsheet files can be opened from within Excel or through File Manager in the usual way.

- Don’t forget that you can create a document icon within a group window on the desktop or within the Startup group window.
- Ensure that your work is backed up.

MICROSOFT® WINDOWS® 95/WINDOWS® NT

Start Windows® Explorer. In the folder C:\My Documents create a folder called Mass Balance.

Insert the floppy disk and select 3½ Floppy (A:). Select the files on the disk and copy them to the folder that you have just created.

The file blank.xls can be copied and renamed. For example, you could call your working copy Mass Balance March 98.xls to show when you started recording solvent use.

The spreadsheet files can be opened from within Excel or through Windows® Explorer in the usual way.

- Don’t forget that you can create shortcuts in the Start menu and StartUp folder as well as on the desktop.
- Ensure that your work is backed up.

A step-by-step approach to using the spreadsheet is given in Section 3 of this Guide. Don’t forget that you can use the Help function to find out how to use Excel. If you have any difficulties using this spreadsheet call the Environmental Helpline on free phone 0800 585794.
The Environmental Technology Best Practice Programme is a joint Department of Trade and Industry and Department of the Environment, Transport and the Regions programme. It is managed by AEA Technology plc through ETSU and the National Environmental Technology Centre.

The Programme offers free advice and information for UK businesses and promotes environmental practices that:

- **increase profits for UK industry and commerce;**
- **reduce waste and pollution at source.**

To find out more about the Programme please call the Environmental Helpline on freephone 0800 585794. As well as giving information about the Programme, the Helpline has access to a wide range of environmental information. It offers free advice to UK businesses on technical matters, environmental legislation, conferences and promotional seminars. For smaller companies, a free counselling service may be offered at the discretion of the Helpline Manager.

**FOR FURTHER INFORMATION, PLEASE CONTACT THE ENVIRONMENTAL HELPLINE**

0800 585794

e-mail address: etbppenvhelp@aeat.co.uk

world wide web: http://www.etsu.com/etbpp/