Water-based metal cutting fluids are essential for machining a wide range of materials and components throughout the engineering industry. Many operators are, however, unaware of the potential savings that can be made by implementing and improving fluid management and control practices. This Guide provides data and advice to help you reduce fluid consumption so that you can:

- save money on fluid purchase and disposal costs
- reduce machine downtime due to fluid related problems
- optimise intervals between fluid changes
- minimise problems associated with product quality
- improve your working environment and environmental performance
- perform better than your competitors
THE SURVEY

A confidential questionnaire was sent to a cross-section of engineering companies throughout the UK, to determine industry profiles and statistical information on the management and use of cutting fluids (metalworking fluids). While the UK engineering industry is extremely diverse, resulting in a wide variation in the data collected, useful comparisons and conclusions can be drawn from the information.1

The survey of the UK engineering industry highlighted a broad range of companies using cutting fluids in their machining operations. It identified a considerable variation in fluid consumption and management procedures, suggesting that many operators could improve and reduce their use of cutting fluids.

This Environmental Performance Guide:
- summarises the survey findings, allowing you to compare your current fluid use with that of your competitors;
- provides a Fluid Management Index that helps demonstrate the connection between production levels, fluid use, costs, and degree of fluid management;
- will help you estimate the cost savings achievable through improved fluid management;
- presents an Action Plan and suggestions for reviewing and reducing your current level of fluid use, thereby reducing your costs.

Profile of Respondents

Market sectors

The response profile by sector is shown in Fig 1. While many companies serve more than one sector, the dominant markets are general and precision engineering, representing over 65% of respondents.

Respondent size

Figs 2 and 3 show the response breakdown by size of machining operation. Around 40% of companies surveyed use fewer than ten machines or employ fewer than 25 machine operators. Just under 5% of respondents have more than 500 machines and 500 operators.

The aerospace and automotive sectors have the highest proportion of large companies with 69% employing more than 50 operators. This compares with 25% in general and precision engineering.

Machine types

While many different machining operations are used throughout the engineering industry, turning is recognised as the major activity. This is shown in Table 1, which gives the response breakdown of the three main machining processes.

FLUID CONSUMPTION

Trends in Cutting Fluid Use

The respondents’ use of the three fluid types is shown in Table 2.

The survey data indicated high use of semi-synthetic fluid. This fluid offers benefits in terms of increased machining quality and reduced operator health problems such as skin irritation. On the other hand, synthetic and semi-synthetic waste fluids are more difficult to treat and separate on disposal.
Calculation and Comparison of Fluid Consumption

Fluid consumption varies greatly from company to company because of the diversity in production levels, component types, materials and fluid management practices. To compare levels of use across the range of companies, a measure of fluid consumption was devised which links the consumption to component production levels and is based on easily measured and monitored information. This is the Specific Fluid Consumption expressed as litres of fluid used per m\(^3\) of metal swarf generated. Use Table 3 to calculate your company’s Specific Fluid Consumption. Data for a fictitious company, Metalcutters Ltd, are given as an example calculation.

During initial collation of the survey data, only two-thirds of companies could provide readily available data on fluid consumption and/or swarf production. A follow-up exercise increased the response to over 90%. This illustrates that one person at a company is unlikely to know all of the data required for a review of fluid use and a team approach is necessary.

Do you know how much fluid you use?

The Specific Fluid Consumption data for the survey were collated and are shown graphically in Fig 4 to show the ranking of all respondents. You can use the chart to compare your company’s Specific Fluid Consumption with that of others throughout the engineering industry. For example, Metalcutters Ltd uses 1 880 litres of fluid/m\(^3\) of swarf generated. Approximately 82% of respondents therefore use fluid more efficiently than this company.

WHY IMPROVE CUTTING FLUID MANAGEMENT AND REDUCE CONSUMPTION?

Companies often consider cutting fluid to be a low cost, disposable necessity and pay little regard to its purchase, management and disposal. However, the survey showed that the cost of cutting fluid concentrate (all types) ranged between £0.70 - £4.54/litre with an average of £2.32/litre. This equates to an average cost of around £460/m\(^3\) of swarf generated for the lowest users, to over £2 300/m\(^3\) for the highest users (see Fig 4). There is therefore considerable potential for most companies to reduce their fluid costs. Savings of 40 - 60% may be possible for companies with poor management procedures.

Used cutting fluids are a mix of chemicals that require careful disposal. As environmental legislation tightens, disposal methods are becoming more stringent and costly. Consequently, reduction of disposal volumes can yield additional savings and environmental benefits.

Table 3 Calculating your metalworking specific fluid consumption

<table>
<thead>
<tr>
<th>Cutting fluid concentrate used in one year</th>
<th>litre A</th>
<th>Weight of swarf produced using water mix fluid in same period:</th>
<th>tonne B</th>
<th>tonne C</th>
<th>tonne D</th>
</tr>
</thead>
<tbody>
<tr>
<td>(all water mix types)</td>
<td></td>
<td>eg for steel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>eg for aluminium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>eg for titanium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equivalent volume of swarf produced: (+ by density)**</td>
<td>m(^3) E</td>
<td>Steel-based (= (B \div 8))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>m(^3) F</td>
<td>Aluminium-based (= (C \div 2.8))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>m(^3) G</td>
<td>Titanium-based (= (D \div 4.5))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific fluid use (litres/m(^3) swarf generated)</td>
<td>litres/m(^3) A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \frac{A}{E+F+G} \]

* Metalcutters Ltd uses 2 500 litres of one semi-synthetic fluid, 1 800 litres of another semi-synthetic fluid and 325 litres of macro emulsion per year, a total of 4 625 litres of cutting fluid concentrate. It manufactures precision components and produces 14 tonnes/year of steel-based swarf and 2 tonnes/year of aluminium alloy swarf.

** Use the same calculation for any other metals that you use, eg iron (density 7.5), copper (density 8.9), brass (density 8.5), bronze (density 8.0), nickel (density 8.9), zinc (density 7.0).

Fig 4 Specific fluid consumption benchmark table
Fluid management plays an important role in maximising fluid life and reducing fluid costs. The companies surveyed were asked to provide data on their normal fluid monitoring and maintenance procedures together with their usual reasons for fluid disposal. Indices were assigned to each category, as shown in Table 4.

Determine your fluid management status by following the procedures given in Table 4.

Figs 5, 6 and 7 show the response based on each Fluid Management Index. It is interesting to note:

- 39% of companies reported that fluid is replaced due to reasons attributable to loss of control (see Table 4, Section C);
- a further 37% replace fluid on a schedule basis.

In both cases the fluid life could potentially be extended by improving fluid management practices.

Over half of the companies surveyed reported one reason for replacement as being that of excessive suspended solids or tramp oil, or reasons often attributable to these conditions (such as increased oil mist or smoke). In many such cases the use of filtration or oil skimming equipment would be beneficial.

In order that the effect of fluid management on fluid consumption can be determined, the three separate management indices are combined into an overall Fluid Management Index, as shown at the bottom of Table 4. Again, Metalcutters Ltd is used to illustrate the calculation.

### Table 4: Estimating your overall fluid management index

<table>
<thead>
<tr>
<th>Survey results</th>
<th>Fluid management techniques</th>
<th>Example for Metalcutters Ltd*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A Fluid Monitoring</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fig 5 Monitoring index response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Index 0 15%</td>
<td>Monitor sump level only</td>
<td>Monitoring index 0 ✔</td>
</tr>
<tr>
<td>Index 1 35%</td>
<td>Monitor sump level + fluid concentration</td>
<td>Monitoring index 1 □</td>
</tr>
<tr>
<td>Index 2 50%</td>
<td>Monitor sump level, concentration + pH/other fluid parameters</td>
<td>Monitoring index 2 □</td>
</tr>
<tr>
<td><strong>B Fluid Maintenance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fig 6 Maintenance index response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Index 0 2%</td>
<td>No maintenance carried out</td>
<td>Maintenance index 0 □</td>
</tr>
<tr>
<td>Index 1 52%</td>
<td>Diluted fluid added</td>
<td>Maintenance index 1 ✔</td>
</tr>
<tr>
<td>Index 2 46%</td>
<td>Diluted fluid + other additives as required</td>
<td>Maintenance index 2 □</td>
</tr>
<tr>
<td><strong>C Fluid Replacement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fig 7 Replacement reason index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Index 0 (Early replacement) 39%</td>
<td>Loss of control of fluid (eg foul smell, corrosion problems, reduced tool life, increased smoke/misting, foaming, H &amp; S problems)</td>
<td>Replacement index 0 □</td>
</tr>
<tr>
<td>Index 1 24%</td>
<td>Early disposal (eg routine replacement, shutdown opportunity)</td>
<td>Replacement index 1 ✔</td>
</tr>
<tr>
<td>Index 0 (Scheduled replacement) 37%</td>
<td>Normal ageing (eg extreme concentration or pH, high bacterial level, build up of floating contamination, sludge or suspended solids)</td>
<td>Replacement index 2 □</td>
</tr>
<tr>
<td><strong>D Overall Fluid Management Index</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(= Index A + B + C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

* Metalcutters Ltd checks there is sufficient fluid in its machines but, while topping up with diluted concentrate, does not maintain the fluid supplier's recommended concentration in the machines. It schedules regular fluid changes for the weekend overtime shift and/or holiday shutdown periods, irrespective of fluid condition.
RELATING FLUID CONSUMPTION TO MANAGEMENT

The respondents’ data were analysed to determine their Overall Fluid Management Index in relation to their Specific Fluid Consumption. These data are presented in the following graphs. Fig 8 will help you to plot your present position and calculate cost savings, Fig 9 shows the general reduction in fluid use as fluid management is improved. Fig 10 uses the Metalcutters Ltd example to illustrate the calculation of potential annual cost benefits to your company.

For companies with poor fluid management procedures, savings of some 40 - 60% may be possible. Even for companies with good fluid management procedures there is potential for making cost savings.

Reviewing Your Fluid Consumption

You have now completed the first step and ascertained your current level of fluid use compared with others throughout the engineering industry, using Table 3 and Fig 4. You will also know your Overall Fluid Management Index from Table 4.

Fig 8 can now be used to obtain an estimate of your potential for fluid and cost savings. The blue line at the top of the blue sector links the highest 25% of users at each level of fluid management, as shown by the survey. Similarly, the orange line links the lowest 25% of users at each of the fluid management indices.

**Step 1.** Plot your Specific Fluid Consumption from Table 3 with respect to your Overall Fluid Management Index (Table 4) on Fig 8 (as shown in Fig 10 for Metalcutters Ltd).

**Step 2.** Follow the contour or contours closest to your current position along to the right hand column of the graph, which represents best practice in fluid management (see Fig 9). Read off the level of Specific Fluid Consumption that could be achieved by improved fluid management. If you are already in column 4 - 5 you will still be able to move closer to the orange sector through regular review and optimisation of your management practices.

**Step 3.** Indicative savings potential can be estimated by comparing the difference in cost of fluid used (see Fig 10).

**Step 4.** The indicative savings potential given in Step 3, multiplied by your current production level of swarf (calculated in Table 3), will give you an estimate of the annual cost benefit to your company of improved fluid management. See the example in Fig 10.

The level of savings that you can make by improving your fluid management procedures is dependent on your particular production requirements.

These estimates of cost savings do not take into account the further savings through increased machine tool lifetime, reduced maintenance downtime, lower product scrap rates, fluid disposal costs, etc. Furthermore, once action is taken and cost savings are achieved it should not stop there - better fluid management is a continuous improvement activity.

Fig 8 is indicative only of the potential savings that can be achieved in cutting fluid use and the associated purchase costs, although the trends shown are based on survey data and should serve as an incentive for companies to make changes in their management practices to achieve cost savings.

---

**Fig 8** Specific fluid consumption in relation to fluid management
Decreasing costs
Reduced specific fluid consumption
Increasing level of fluid management

By increasing your level of fluid management, you can reduce your fluid use and cost.

Worked Example
Metalcutters Ltd could potentially achieve a fluid saving of 1000 litres (£2.320)/m³ of swarf. This equates to an actual cost saving to the company of around £5700 based on the current production level of 2.46 m³ of swarf (from E and F in Table 3) and the average respondent’s fluid purchase cost of £2.32/litre (see Fig 10). Metalcutters Ltd will also realise considerable indirect cost savings due to, for example, reduced downtime, improved machining quality and reduced tool wear.

How to identify the cost benefits – a worked example

STEP 4 Estimated annual cost benefit to Metalcutters Ltd: £2.320/m³ x 2.46 m³ = £5700/year
DISPOSAL OF USED FLUID

Used cutting fluids are a mix of chemicals potentially hazardous to the environment and need to be disposed of safely. Disposal costs are increasing and are likely to rise significantly over the coming years.

The survey showed that 78% of respondents dispose of used cutting fluids via a specialist waste contractor, and that 10% have an on-site separation or treatment system to reduce the disposal quantity. The remaining 12% dispose via the drainage system with the consent of the local water company.

Around 75% of respondents were unable to supply disposal quantity or cost information. Of those companies that were able to supply this data, the following costs were indicated:

- Disposal cost of total volume of waste via a specialist contractor - between £0.04 and £0.62/litre.
- Disposal cost of liquid waste following on-site treatment - between £0.01 and £0.03/litre.

Do you know your disposal costs?

IMPROVING YOUR FLUID USE

The measurements and review that you make now should be only the first step in an ongoing improvement process. Regular monitoring of your fluid consumption and fluid management procedures, as shown in the Action Plan (overleaf), is vital.

To make savings in fluid use, the whole company must be involved. Further help and advice about gaining commitment can be found in Good Practice Guide (GG27) Saving Money Through Waste Minimisation: Teams and Champions, available free of charge through the Environment and Energy Helpline on 0800 585794.

The following is a list of fluid use and management practices that will help you start to make savings.

Fluid Use Actions

- Monitor and maintain fluid correctly by measuring fluid parameters.
- Use particulate and tramp oil removal equipment.
- Move away from scheduled-only fluid changes.
- Involve your fluid supplier - he will have seen most problems before and will be able to give valuable advice.

Management Practice

- Make sure everyone is aware of how much fluid is used and how much it costs to purchase and dispose of.
- Involve your operators and maintenance personnel in setting up the fluid management strategy and liaise closely with all departments.
- Employ good housekeeping procedures.
- Choose the optimum waste disposal route.
- Set realistic targets for savings.
- Keep everyone up-to-date on progress being made.
- Recognise the contribution of all personnel in achieving savings.

With continual changes in fluid/disposal costs, legislation and production methods it is important to review your fluid management procedures at regular intervals to ensure that you are still operating in the optimum way.

For details of related publications on best practice in the use of metal cutting fluids, contact the Environment and Energy Helpline on 0800 585794. The Helpline may also be able to help you calculate your potential annual savings through improving fluid management.
Monitor your cutting fluid consumption and disposal quantity in relation to your generation of swarf.

Is your fluid consumption and disposal quantity decreasing?

NO

Implement improved fluid monitoring and maintenance procedures.

Is your fluid consumption comparable with the lowest users in the industry?

NO

Investigate fluid problems promptly.

Consult with your fluid supplier.

Review your fluid management strategy at regular intervals.

Is your fluid consumption decreasing?

YES

YES

NO

NO

Liaise with your fluid supplier.

Consult with your operators and formulate an ongoing fluid management strategy.

ACTION PLAN

This Guide was produced by the Environmental Technology Best Practice Programme.
Prepared with assistance from Pera Technology.

For more information about the Environmental Technology Best Practice Programme and how its free services can help you, please phone the
ENVIRONMENT AND ENERGY HELPLINE 0800 585794
e-mail address: etbppenvhelp@aeat.co.uk world wide web: http://www.etsu.com/etbpp/

THE ENVIRONMENTAL TECHNOLOGY BEST PRACTICE PROGRAMME IS A JOINT DTI AND DETR PROGRAMME MANAGED BY AEA TECHNOLOGY PLC THROUGH ETSU AND THE NATIONAL ENVIRONMENTAL TECHNOLOGY CENTRE