enVirowise
Practical Environmental Advice for Business

GG377E

Resource efficiency: cut costs in plastics processing

Additional information manual

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Additional information manual

This package of training material for the plastics processing industry consists of six publications:

Resource efficiency: cut costs in plastics processing (GG377)
Introductory manual

Workbook 1: directing resource efficiency (GG377A)
Session for directors or senior managers involved in the business background

Workbook 2: managing resource efficiency (GG377B)
Session for senior managers who will operate and control the resource efficiency and waste minimisation programme

Workbook 3: supervising resource efficiency (GG377C)
Session for supervisors and managers who will carry out resource efficiency projects

Workbook 4: operating resource efficiency (GG377D)
Session for operators who will carry out resource efficiency projects

Additional information manual (GG377E)
Resource pack with information and ideas for further work on resource efficiency

Some sections of the workbooks contain common information. This is to ensure that there is a common language of resource efficiency and waste minimisation throughout the company.

This information manual was produced by Envirowise

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Summary

This manual is designed as a highly technical publication to supply trainers using workbooks GG377A to GG377D with supplementary information to teach resource efficiency to staff in UK plastics processing companies. It will allow trainers to deliver specific topics in detail.

The manual is not designed to be used by health and safety managers, environmental managers or directors of plastics companies unless they have undertaken some informal or formal training.

For further free help and advice on resource efficiency, contact the Environment and Energy Helpline on freephone 0800 585794. Alternatively:

- for more information about waste minimisation and environmental management systems, visit the Envirowise website (www.envirowise.gov.uk);
- for more information about energy efficiency, visit the Action Energy website (www.actionenergy.org.uk).

Key publications for plastics processors

- *Finding and reducing waste in plastics processing* (GG277)*
- *Energy in plastics processing - a practical guide* (GPG292)**
- *Environmental management systems for the plastics industry* (GG251)*

Available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the appropriate website.

* Published by Envirowise ** Published by Action Energy

Contents

Waste minimisation in plastics processing

1.1 Business reasons for reducing waste

Waste is estimated to cost UK industry at least £15 billion/year - an amount equivalent to some 4.5% of total turnover. In most companies, the cost of waste could be reduced by 1% by implementing a simple but systematic waste minimisation programme.

Effective waste minimisation cuts costs and raises profits. Even when investment is required, the payback period is generally short and the returns can be high.

There are five important reasons for implementing a waste minimisation programme:

- **Waste costs real money.** The costs of waste come directly off your profits. Performing the calculations in Table 1 will give you an initial estimate of the basic and total cost of waste. At a gross margin of 7%, a reduction in waste costs by 1% is the equivalent of increasing turnover by over 14%. Internal effort spent in waste minimisation can produce benefits equivalent to substantially increased sales.

Table 1 Potential benefits of waste minimisation

Calculate your potential savings based on raw material losses:

Amount of main raw material used last year, eg tonnes	..... A
Amount of product produced last year, eg parts	..... B
Amount of main raw material/unit of product, eg polymer/part	 C
Quantity of main raw material in parts last year = (B × C)	..... D
Wasted main raw material = (A – D)	..... E
Purchase cost of main raw material (£)	..... F
Cost of waste main raw material (£)	..... G

The calculations above show only the visible purchase cost of waste raw material. The true and total cost will also include wasted production costs, labour, storage, etc. Consideration of all areas of waste will give a much higher figure.

Calculate your potential savings based on a cost reduction of 1% of turnover:

Turnover last year	£ .....
Potential savings = 1% of turnover	£ .....

- **The true costs are hidden.** Waste costs are either direct or indirect. Direct costs are visible and include waste collection and disposal costs. The bulk of the waste costs are indirect and hidden. They make up the largest portion of the total waste costs in any business and include:
  - raw material costs;
  - energy consumption;
  - water consumption;
  - effluent generation;

- packaging;
- factory and office consumables;
- wasted time and effort.

These costs are hidden in the accounts and are not shown as separate items. However, they exist even for efficient companies. They arise whether you like it or not, and are significant whether you realise it or not. Some companies have found their waste costs were over 20 times higher than they thought; underestimating such costs is very common.

- **Good investment returns.** Cost-effective waste minimisation is a valuable investment that pays dividends for any company. Large savings can be made from small capital spending and money spent on waste minimisation is a sound investment. Waste minimisation has the potential to save significant amounts of money for any manufacturing company.
- **Protecting your image.** Customers, employees and investors all have a growing interest in environmental performance. Waste minimisation shows how effectively and efficiently you control operations.

  Customers are increasingly asking for evidence of good environmental performance. Waste minimisation proves this commitment and is a key part of environmental management. Employees know where materials and resources are being wasted and can see the cost benefits that will make the company more competitive and safeguard their future. For companies involved in waste minimisation, increased employee satisfaction is among the top five benefits of the process.

  Investors want the highest possible return on capital and high dividend growth, while banks want to see efficient use of borrowed capital. Waste minimisation can help to deliver both of these requirements.
- **The legal requirements.** Companies - and key directors and managers - can face stiff penalties for failing to comply with environmental legislation, which gets stricter year by year. Effective waste minimisation helps to prove compliance with existing laws and to save rapid, disruptive and expensive changes to keep within the law in future.

1.1.1 The way ahead

The benefits of minimising waste come only from action. To reap the benefits, begin work on an action plan based on the following:

- establish board level commitment to waste minimisation;
- contact the Environment and Energy Helpline (0800 585794) for further information and to order a copy of *Finding and reducing waste in plastics processing* (GG277);
- appoint a waste minimisation 'champion' or co-ordinator to establish the true cost of waste and motivate the workforce;
- produce regular financial one-line reports on the cost of waste collection and disposal and on the total cost of waste;
- inform suppliers of your commitment and guide them to sources of help.

Cut waste, and you will boost profit. Money saved from waste minimisation goes straight to the bottom line.

1.2 The waste walk around

Waste is all around your business. Some companies put up signs declaring 'Stop waste'. This is unfair because most people would stop waste if only they knew where to look. The signs should really read 'Find waste', because only after finding waste can you really stop it.

The first step in any waste minimisation programme is to start to find the waste in your business. The best way of doing this is to walk around the factory looking for waste and opportunities to reduce waste. The aim of the waste walk around is to gain an overview of your processes and to identify some rapid no-cost or low-cost measures that will save money.

Your waste survey should be carried out as soon as possible - waste is happening now and it is costing you money now. Take an unannounced walk around the site during the middle of a shift. If there is no night shift, it can also be profitable to take a walk around the factory when there is no production being carried out. Always look in your skips - they provide an excellent starter for locating waste!

1.2.1 Simple no-cost and low-cost money saving ideas

Eliminate, reduce, re-use, recycle, dispose

Follow the waste hierarchy: first eliminate the source of waste, then reduce the amount, then re-use any waste that does arise, then recycle the waste and only dispose of the waste when these options have been exhausted.

- Identify the various waste streams produced on-site. Typical inputs and outputs during plastics processing are shown in Fig 1 overleaf.
- Optimise waste segregation and recycling to minimise the amount of waste requiring disposal.
- Avoid contaminating waste polymer as this lowers its value.
- Estimate the true cost of waste. For example, the cost of waste polymer is not just the disposal cost, but includes the purchase cost of the polymer and the embodied processing costs.

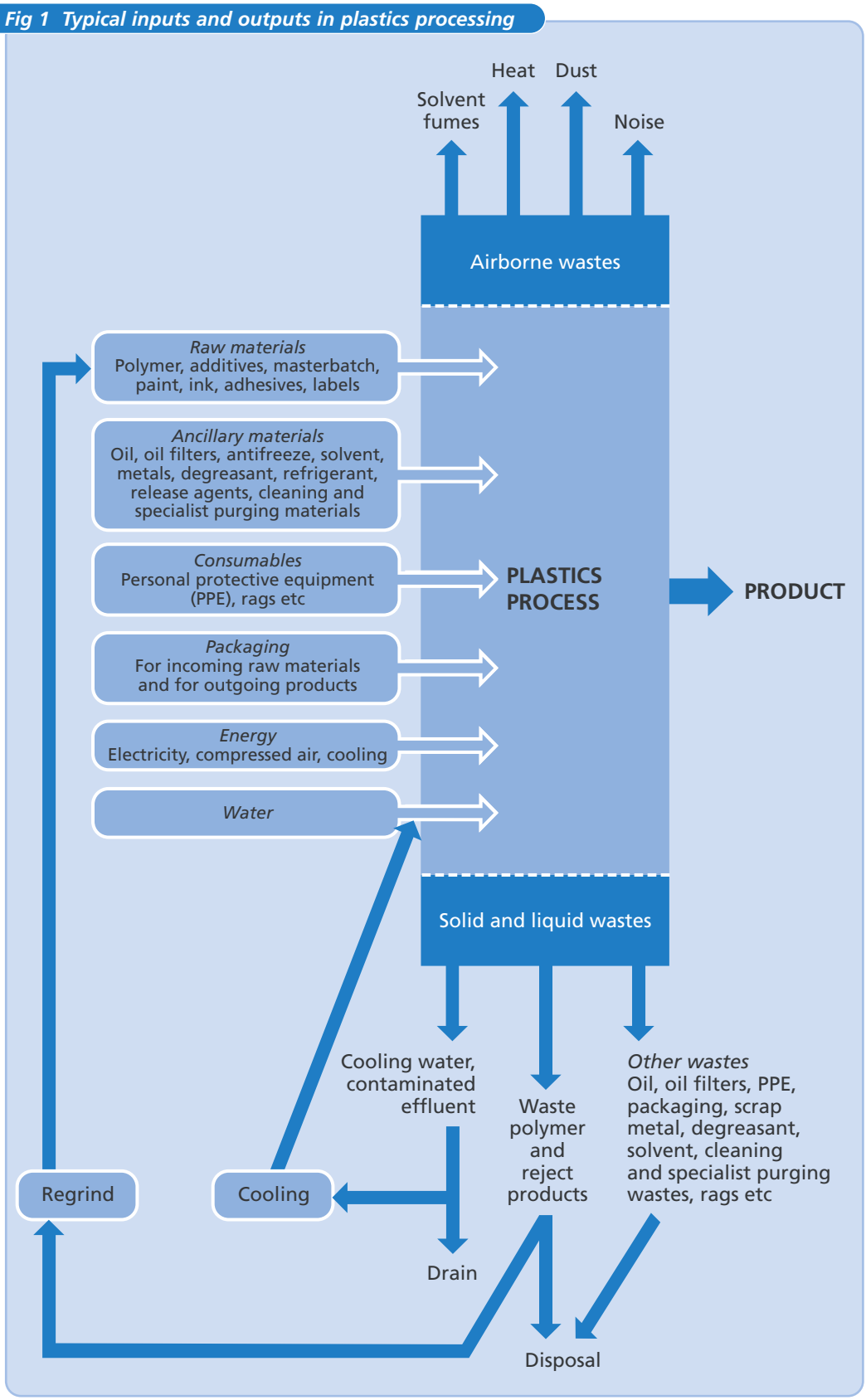
Materials management

- Avoid spills by improving storage and polymer handling techniques.
- Record polymer utilisation wherever possible and track any variations.
- Monitor how much polymer has to be reground and how much is returned from your contract recycler.
- Review product design. Could less polymer be used? Could waste polymer, eg in sprues, be reduced? Could a cheaper polymer be used?
- Minimise the need for polymer recovery, regrinding and re-use. Apart from the additional processing, transport and administration costs, converting the recovered polymer into saleable product occupies process time that could be used to make more product.
- Plan production to minimise changeover losses.
- Establish total material loss over a given period. Compare this with your polymer utilisation rate to find the relative importance of process and material handling losses.

Packaging

- Re-use any packaging for your products, where appropriate.
- Discuss ways of minimising packaging use with both your suppliers and customers.

Fig 1 Typical inputs and outputs in plastics processing



Water

- Make sure everyone is aware of water costs.
- Remind everyone to turn off taps.
- Repair all dripping taps as soon as possible.
- Check for leaks in the water system.

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- Make sure hot water is not above 60°C.
- Make someone responsible for switching off hot water heaters before holidays.
- Check that your hot water control system is set properly (stop heating one hour before the end of daily work).
- Fit time switches to immersion heaters.
- Fit flush controls to urinal systems in all men's toilets.
- Fit trigger controls to hosepipes.

Utility management

- Implement no-cost and low-cost methods of improving energy efficiency (see section 2).
- Review hydraulic oil purchase, storage, handling and disposal procedures.
- Consider the benefits to oil lifetime of installing bypass filters in all hydraulic equipment.

Other measures

- Ensure machines are suitable for the processes being carried out, set up to obtain optimum polymer and energy consumption, and maintained regularly.
- Ensure employees are trained and understand the effects of their actions. Employees are vital to the success of waste segregation. Employees also need to be made aware that, while regrinding waste polymer saves the company money, it does mean additional costs.

1.2.2 Your action plan

- Your waste walk around should have identified some obvious areas for improvement. You can now make some 'fast starts' to reduce waste in these areas.
- Monitor the amount of polymer used on each machine. How much is reground? How much is sent off-site for reprocessing or final disposal? In addition, monitor utility and packaging use.
- Find out where and why waste polymer is being generated by your process. Getting it 'right first time' is the easiest way of increasing your profits.
- Record your starting position and publicise improvements to both motivate employees and maintain senior management commitment.
- If you don't measure, you can't manage.

Reducing waste by no-cost and low-cost measures will increase profits significantly.

1.3 Assessing performance

A systematic waste minimisation programme can save you up to 1% of turnover (or more than 10% of profit) from effective and low-cost measures.

To find out your current costs and performance, use Tables 2 - 5 to calculate your specific costs. The information you need should be easy to obtain.

- Use the accounts department's records of purchased material and invoices for contract recycling, waste disposal, etc.
- Use production records to find out how much polymer is used, rather than how much is ordered and delivered.

- Use waste transfer notes (a legal requirement) to find out how much solid waste has left the site. You may have to estimate the waste polymer percentage if you do not segregate your wastes.
- Companies or suppliers covered by the packaging waste regulations will already have data on packaging use.

1.3.1 Polymer use

Identify your three main polymers, group the rest under 'Others' and complete Table 2.

Table 2 Polymer use

Polymer	Amount used (tonnes/year)	Cost (£/tonne)	Annual cost (£)
1			
2			
3			
Others			
Total polymer use	**A**	**B**	**C**

1.3.2 Cost of polymer waste

Complete Table 3 to determine the cost of polymer waste.

- **Waste reground on-site.** The cost of regrinding is about 5% of the polymer cost. This includes rejects, trimmings, etc which are reground. Some of these wastes may not be measured and may be hidden.
- **Waste reground by contractor.** You may use a contractor to regrind. This can be cost-effective, but it is useful to examine the full financial case.
- **Loss from polymer sold as scrap.** Sending polymer for scrap will reduce its value by at least 50%. Any income from scrap represents, at best, a corresponding loss of revenue to the same sum. Fill in the amount received for your scrap - the value lost will be at least this.
- **Polymer sent for disposal.** This may include items such as purgings, which require specialist regrinding, or items that have become contaminated with oil or dust.

  If your waste costs are high, then change the disposal route to maximise the value, eg use a contract regrinder or regrind in-house rather than selling as scrap.

Table 3 Cost of polymer waste

Polymer waste route	Amount used (tonnes/year)	Cost (£/tonne)	Annual cost (£)
1. Waste/rejects reground on-site			
2. To contract recycler			
3. Loss in value of polymer sold as scrap		–	–
4. Sent for final disposal			
Total polymer waste	**D**	**E**	**F**

1.3.3 Process yield

Use Table 4 to calculate your process yield. Is the site's process yield better or worse than the general industry average of 95%? This industry average may seem acceptable, but it covers more than the cost of the polymer that is lost or recycled. There are also associated losses in direct and additional labour, overhead costs such as energy and consumables, and the simple costs of recycling.

For example, a steady process yield of 90% costs around 1.4% of turnover (equal to nearly 15% of profits) in the short term and, in the long term, costs 4% of turnover or nearly 50% of typical profits. Process yield waste has a large and direct impact on profitability.

Table 4 Process yield

Process yield (%)	$= 100 - \left(\frac{D}{A} \times 100\right)$	%

1.3.4 Cost of general waste disposal

Use Table 5 to calculate the cost of general waste disposed of in skips. General waste consists of all non-plastic waste and unsegregated plastic waste.

Table 5 Cost of general waste disposal in skips

General waste route	Amount used (tonnes/year)	Cost (£/tonne)	Annual cost (£)
Disposal charges, eg skip lifts			
Less income from segregated waste			
Total general waste	**G**	**H**	**I**

1.3.5 Benchmarking

Your initial waste survey will provide you with a base-line to measure improvement in your performance.

To benchmark yourself against the rest of the industry, ask the Environment and Energy Helpline (0800 585794) for a copy of *Are you focused on waste?* (BG381). This presents figures for other plastics processing companies obtained from a benchmarking survey carried out by Envirowise during 2002. The full survey results are reported in *Benchmarking report on waste in plastics processing* (GG376), which is available only as a PDF file from the Envirowise website (www.envirowise.gov.uk).

If you don't measure it, then you can't manage it.

1.4 Improving performance

The success of any waste minimisation programme depends on the active support of the managing director and other senior managers. Senior management can:

- demonstrate visible leadership;
- encourage employee participation;

- set clear waste minimisation targets;
- promote a company-wide policy on environmental issues.

1.4.1 Choosing a co-ordinator

A waste minimisation co-ordinator is necessary because reducing waste in one area of the business may require action in other areas. The co-ordinator or 'champion' needs three essential qualities:

- management authority or direct access to senior management;
- the enthusiasm and ability to motivate people;
- a working knowledge of waste minimisation or a willingness to learn.

The role of co-ordinator is not necessarily a 'full-time' job and could be performed by the managing director, production manager or quality manager.

The main responsibilities are:

- co-ordinating waste segregation and measurement;
- identifying opportunities to prevent and reduce waste;
- locating priority action areas;
- setting up waste reduction teams;
- allocating 'ownership of waste';
- raising awareness of waste;
- creating monitoring systems for regular feedback to both managers and the workforce;
- working with suppliers to identify areas for materials reduction or recovery.

This may sound a lot of work, but the role is to co-ordinate and facilitate. The waste reduction team(s) will actually achieve the results.

More information about teams and champions

Contact the Environment and Energy Helpline on freephone 0800 585794 to order a free copy of *Saving money through waste minimisation: teams and champions* (GG27). Alternatively, you can download a PDF file of this guide from the Envirowise website (www.envirowise.gov.uk).

1.4.2 Making 'fast starts'

In order to make 'fast starts' on obvious waste reduction opportunities, the first task is to identify the priority areas for action. Implementing some quick and cheap cost-saving measures will provide evidence of the real benefits to the company of following a systematic approach.

- **Gather available information.** To identify the 'fast starts', you need to obtain information about your site and its activities. Concentrate on collecting readily available information.

Key actions

- Walk round and review the site.
- Write down the quantities and direct costs of the 'wastes' that you can see. Identify major sources of waste such as packaging, lubricants, energy, water and rework.
- Don't worry if information is not available. Make 'best' estimates or take simple measurements to provide approximate information.
- Take photographs of waste and where it is being produced. These will demonstrate how much waste there is and help comparisons with future improvements.

Useful further actions

- When estimating costs, remember to go beyond the obvious such as wasted material. Estimate the consequential costs of wasted process time, handling, etc.
- Try to identify the main areas and quantities of energy, water and raw materials used. Compare these values with their total use. If there are major discrepancies, try to find out why. Unexplained use of energy, water or raw materials may be one of your biggest sources of waste.
- Good communication is essential to success. Involve people in reducing waste and tell them about the successes.
- To make sure all wastes have been identified, use a process flow sheet and review the process with key staff.

These actions should help to highlight areas for improvement.

- **Identify priorities.** Generate some ideas for reducing major wastes to achieve immediate savings. Decide on the priorities to ensure some early successes:
  - Find the major sources of waste.
  - Identify the priority areas. These may be the largest quantities, eg solid waste to landfill, or the highest net costs, eg disposal costs, energy consumption or raw material wastage.
  - Talk to the staff involved in the activity generating the waste to understand why it is produced. Is it because no one had seriously considered there was a problem or because an established practice is no longer relevant?
  - Ask the waste reduction team(s) and other staff to come up with ideas for preventing major wastes. Informal 'brainstorming' sessions are the best way of generating ideas. Estimate the savings you will achieve from the best ideas.
  - Focus on a few major areas with the largest financial savings and where there are practical ideas for making changes.

  In one day, you should be able to identify potential actions to make 'fast start' savings and put them in order of priority.
- **Make the first savings.** To make your first savings:
  - draw up an action plan;
  - agree who is going to do what and by when;
  - involve the 'front line' staff controlling operations that produce waste to define aims and priorities, as well as to allocate responsibility;
  - set the plan in motion, and review progress against the plan's aims.

  Remember that simple ideas are often the most effective.

- **Measure savings.** To demonstrate savings, it is necessary to measure:
  - waste production, eg number of skips per month;
  - raw material use, eg amount ordered per month;
  - utility use, eg from the last bill.

  Make sure that simple measuring systems are in place as part of the action plan. These should be both cost-effective and appropriate. Decide on the measurement level necessary to check progress and include regular checks in the plan. Use simple information gathering methods such as:
  - stock control information;
  - meter readings for energy and water;
  - separating key solid wastes to measure waste simply by weight or volume;
  - counting waste containers (helpful for less important wastes, but not as effective as weighing);
  - timing how long it takes a liquid waste to fill a bucket and using this value to estimate continuous liquid flows for a day or week.

  Record these measurements for future reference.
- **Achieve more savings.** Progress reviews will provide evidence that waste reduction is worth the commitment and effort.
  - Take some more photographs to record any visible changes.

  Use this evidence to help convince management and employees that a waste reduction programme is profitable and worth extending.

More information about getting started

Contact the Environment and Energy Helpline on freephone 0800 585794 to order a free copy of *WasteWise: increased profits at your fingertips* (IT313). This interactive waste minimisation CD-ROM can also be ordered through the Envirowise website (www.envirowise.gov.uk).

1.5 Waste minimisation tools

The key tools in waste minimisation are the process flow sheet or map and the 'cause and effect' diagram. These help both to find 'fast starts' and to develop a systematic approach for long-term savings.

1.5.1 Process flow sheet

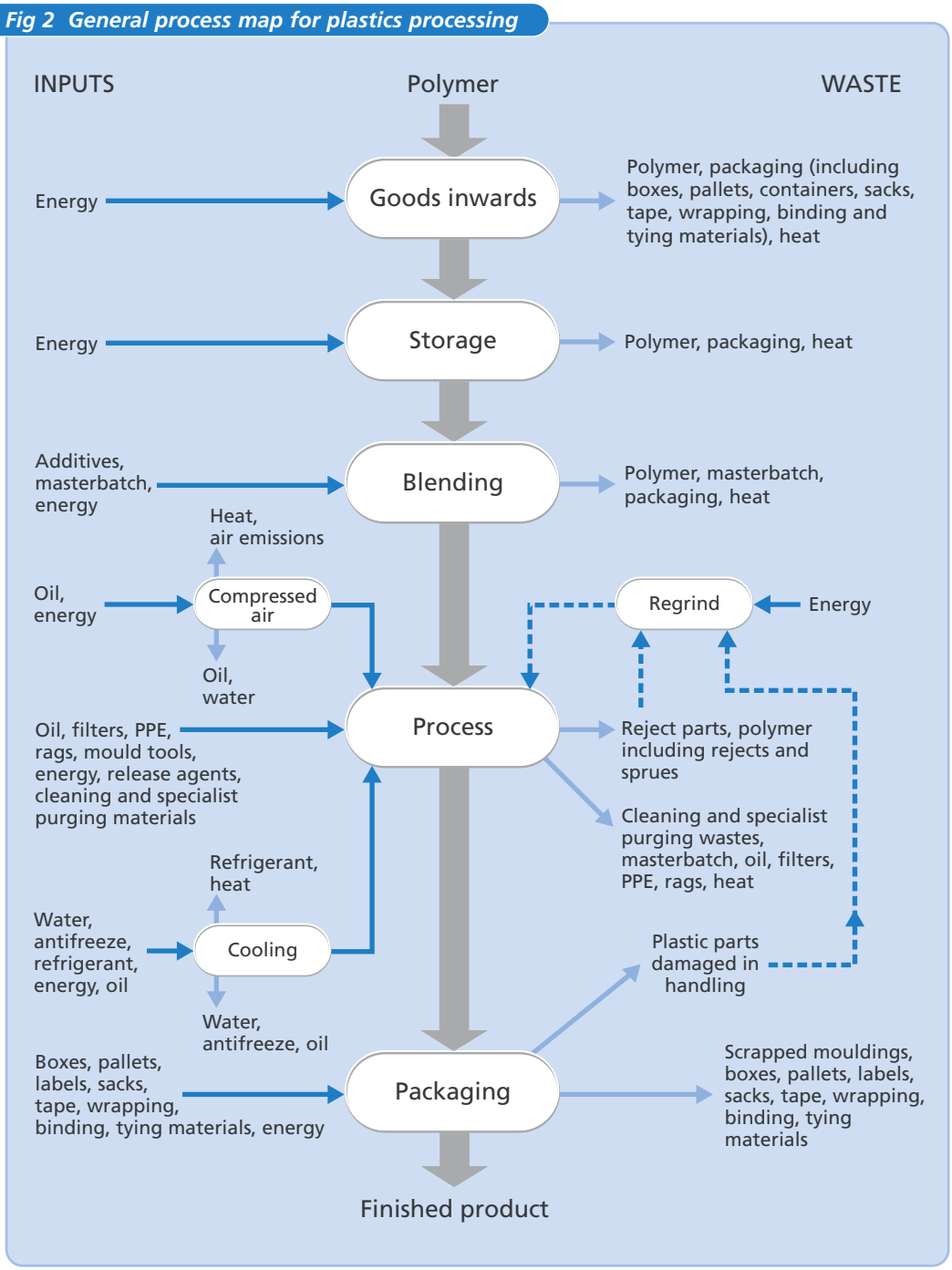
To manage waste effectively and to pinpoint where savings can be made, all the different wastes produced by a company (and the stage at which they are produced) need to be identified. The tool used for this is the process flow sheet or map.

Fig 2 shows a general process map for plastics processing. Each process step both adds value and incurs a cost from the labour, materials and utilities used during that step.

- The true cost of waste includes the cost of wasted resources and rejects at each stage in the process. The cost of rejects includes the value added to the material by the time it is rejected; this increases through the process.

- Consider your production operation as a series of processes. Each process has its own inputs, outputs and waste. Using Fig 2 as an example, track your wastes by making a map of your complete process. Once you have this global view of the process, create an 'opportunity sheet'[1] for each step of the process. This sheet places amounts and costs on the wastes for each step. Add up the total costs to give the overall cost of waste to your business.
- If the information you need is not available, make a 'best' guess or carry out some simple measurements. Then decide whether improved information collection is justified.
- You should now have a good picture of the 'cost of waste' to the business. Combine the details from the process map to see if there are discrepancies in overall values, eg between identified and total actual water use, and raw material and energy consumption.
- Dig deeper if there are major discrepancies. They may be a major cost and a major opportunity for savings.

Fig 2 General process map for plastics processing



[1] A template for an opportunity sheet is given in both *Workbook 2: managing resource efficiency* (GG377B) and *Workbook 3: supervising resource efficiency* (GG377C).

1.5.2 Cause and effect diagram

Cause and effect diagrams[2] are a standard tool for quality improvement and will be familiar to many people. They are used to identify opportunities for eliminating/reducing waste in each process step and are helpful when you need to identify possible causes of a problem in a structured manner. For each effect there are likely to be several causes.

In manufacturing, the key causes are:

- people;
- methods;
- materials;
- machinery.

Remember to look for ways to cure the cause(s) of the problem and not just the symptoms.

- Ask the people who work on the process to suggest reasons (without blame) for the problem.
- List their suggestions against each cause (they know the process better than you).
- Involve everyone in the development of solutions.
- Implement no-cost measures as soon as possible.

Free advice on waste minimisation

For free help and information on all aspects of waste minimisation, contact the Environment and Energy Helpline on freephone 0800 585794 or visit the Envirowise website (www.envirowise.gov.uk).

Companies employing fewer than 250 employees can request a *Fast*Track visit - a confidential, on-site waste review that includes up to a day's free advice on resource efficiency from an environmental expert.

[2] *Workbook 4: operating resource efficiency* (GG377D) shows two examples of a cause and effect diagram.

Energy efficiency in plastics processing

2.1 Reducing energy costs: the first steps

Energy costs are generally seen as somebody else's problem and the plastics processing industry tends to regard energy as an overhead and as a fixed cost. This is untrue; energy is both a variable and a controllable cost. In addition, the Climate Change Levy (CCL)[3] has increased the cost of electricity in the UK by 0.43p/kWh.

Most plastics processors could easily reduce energy costs (without major investment) and increase profits through simple measures to provide good energy management practice.

The real secret to reducing energy costs does not lie in the technical aspects of any process, but in the management attitude. A desire to reduce costs through energy management and an effective implementation and monitoring programme will produce the results and the commercial benefits.

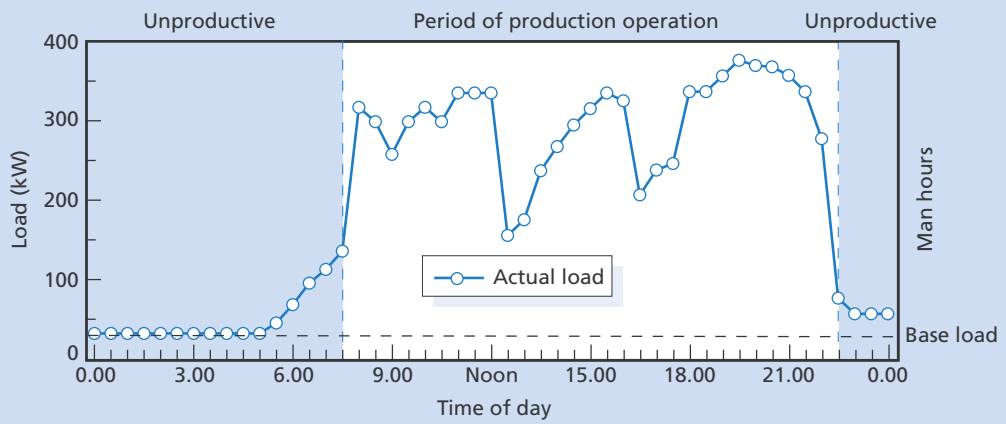
Failure to control energy costs will affect your profitability.

2.1.1 The vital questions

Before you can start to reduce your energy costs, you need to understand when, why, how much and where you use energy. This information provides the benchmarks and signposts for improvement.

- **When are you using energy?** The time at which you are using energy is important and a graph showing demand plotted versus time will give invaluable information on how to reduce the energy costs. Data for such graphs should be available from your supply company. Look for unusual peak variations from day-to-day and energy use when there is no production. Fig 3 shows a demand graph for a company operating a daytime and a 'twilight' shift (from 18:00 to 22:00).

Fig 3 Typical site energy use over time

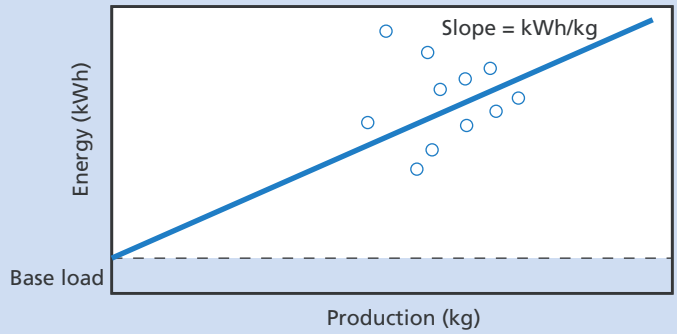


A demand graph also helps you to find the 'base load'. This is the load used for heating, lighting, compressors and pumps when there is no production.

[3] For more information about the Climate Change Levy, visit www.defra.gov.uk/environment/ccl/index.htm

- **Why are you using energy?** Another way of finding the base load at your site is to record the meter readings (in kWh) and production volumes (in kg) at the end of each shift. Plot the amount of polymer processed against the energy consumption, as in Fig 4. From the graph, the energy use at zero production gives an idea of the 'base load'. Reducing the base load is a sure way to make savings.

Fig 4 Production output v energy use



Ideally, energy should be used only to produce good product. The most important energy benchmark is the energy used to process good product (in kWh/kg). This is called the specific energy consumption (SEC) and can be found from the slope of the graph used to find the base load (see Fig 4). It can be compared to the industry averages to provide targets for energy reduction.

- Is energy being used to keep machines idling when they could be turned off?
- Are heaters running that are not being used?
- Are compressors running just to pump air out of leaks?

Finding out why you are using energy will reveal a wide range of possible measures for reducing energy use.

- **How much energy are you using?** Electricity charges are based on a combination of factors (see box below) and an initial survey (see section 2.2.1) will reveal areas for potential savings. Sometimes, actions as simple as changing the tariff can reduce costs at no cost. 'Peak demand lopping' to reduce short peaks in the maximum demand can also be effective.
- **Where are you using energy?** The main users of electrical energy are motors and drives, heaters, cooling systems and lighting systems. A simple site energy distribution map will show where energy is being used.

  If you only have a single meter, it may be cost-effective to use sub-meters to get further information on the areas of high energy use. Sub-metering allows you to begin to calculate the cost of energy for each operation and to identify areas of high energy use - a key factor in reducing energy costs.

  A first step is to produce an energy map of your site to locate areas for monitoring and improvement.

Factors affecting the cost of electricity

Maximum power requirement (MPR) is the maximum current a site can draw at the supply voltage. Reduce the cost by:

- staggering start-ups;
- matching the MPR to the requirements;
- getting the MPR right for new premises to avoid costly charges;
- negotiating an annually based maximum demand instead of an MPR charge.

Factors affecting the cost of electricity (continued)

Maximum demand (MD) is the current drawn at the supply voltage averaged over half an hour. Reduce the cost by:

- staggering start-ups;
- giving machinery time to stabilise before starting up new processes.

Power factor (PF) is a measure of the phase shift created by machinery and low power factors may be penalised by an electricity supplier. Lightly loaded machinery tends to have a high phase shift and a low power factor. Improve the power factor with correction equipment to get power factors close to 1.

Load factor (LF) is a measure of the hours per day that the user draws from the supply. Reduce the cost by:

- running for longer than a single shift;
- carrying out selected operations (eg regrinding) outside the main shift pattern.

2.1.2 Get free advice and help

Energy management will save money and make you more competitive. Start your energy management programme today and reap the benefits of improved profits by cost-effective investment and management.

Action Energy provides free advice and resources for energy management and cost reduction in plastics processing, eg:

- *Energy in plastics processing - a practical guide* (GPG292) gives essential information on how to start reducing your energy costs and signposts further free information.
- *FOCUS - the manager's guide to reducing energy bills* (FOCUS) suggests practical measures to reduce energy use in ten areas of utility use (eg lighting, compressed air and buildings).

These and other free publications can be obtained through the Environment and Energy Helpline on freephone 0800 585794 or via the Action Energy website (www.actionenergy.org.uk).

Energy is an easily controlled cost.

2.2 The rewards

Energy efficiency measures can improve your profits significantly for minimum effort and costs.

A plastics company with a turnover of £10 million/year and a net profit of 10% will generate profits of £1 million/year. Its average electricity bill is approximately £200 000/year (ie 2% of turnover). Simple no-cost or low-cost energy efficiency measures can reduce this bill by a minimum of 10% (and up to 20%) and increase profits by at least 2%. This is the equivalent to additional sales of £200 000 - a worthwhile investment by any standards.

The starting point for all improvement plans is an initial site energy survey.

Low-cost energy efficiency measures can improve profits significantly.

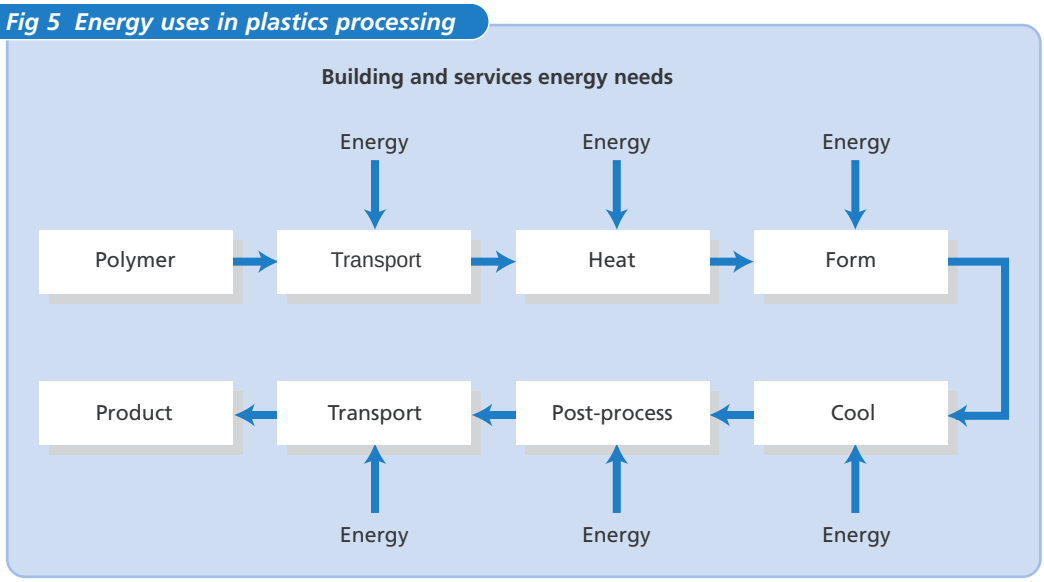
2.2.1 The initial site energy survey

The aim of an initial energy survey is to gain an overview of the site's general energy use. It is a walk around the site with an energy manager's 'hat' on. This will identify some rapid no-cost or low-cost improvements that can be made to save money.

The survey should be carried out as soon as possible - if energy is being wasted now, it is costing money now. Fig 5 shows the main areas where energy is consumed during plastics processing. Use Fig 5 as a guide during your search for areas of high or unnecessary energy use.

- Take an unannounced walk around the site at around mid-shift. If there is no night shift, it can also be profitable to take a walk around the factory when there is no production.

Fig 5 Energy uses in plastics processing



2.2.2 The questions to ask (and answer)

- Which areas have the largest electrical load? Look for the largest machines - they are most likely to have the largest motors and create the largest load.
- Is the thermal insulation, if present, on all the machines in good condition? If there is no insulation, then why not?
- Look for areas of energy use where no productive work is being carried out and yet machines are running and using energy.
- Look for signs of machines that are not in production, but have motors or ancillary equipment running (eg conveyors, pumps, granulators, fans and machine heaters).
- Are there any good reasons why machines need to be kept idling to be ready for the next production run?
- Which motors are left running when not doing productive work?
- Why are the motors the size they are and would a smaller motor be more efficient?
- Which cooling water pumps (and chillers) and vacuum pumps are still running?
- Is the airflow from fans being throttled back with dampers and could variable speed drives be used instead?
- Look for water, air or steam leaks.
- Where can you hear steam and compressed air leaks? The hissing noise you hear from leaks is costing real money. If there is no production being carried out, then why is the compressed air system still running?

- Is compressed air being used for expensive applications where other cheaper methods (eg cleaning or drying) could be used?
- Does the compressed air pressure need to be so high or the vacuum so low?
- Is the lighting dirty or broken?
- Are basic maintenance activities carried out?
- Are 'accepted' practices wasting energy? Can they be modified at no cost?
- Are there clear setting instructions for all machines and products? Are they implemented when a machine is set up?

2.2.3 Turning the survey findings into energy savings

A site energy survey is pointless unless action is taken as a result of the findings.

- Use the survey to estimate the site's excess energy use. Arrange for an electrician to measure the factory's electrical load and calculate the costs involved.
- Use the survey to identify operating practices that cost money and need to be changed.
- Distribute the survey results together with full recommendations for improvement and the costs of implementing them.

2.2.4 Raising energy awareness

The cost savings possible from energy efficiency will be achieved only if there is a management commitment to actually carry out the work necessary and save the money.

This commitment will be ensured by having an energy policy that is as much a part of the overall company operations as its quality policy. The energy policy should ideally be part of a broader company environmental policy and, at the very least, should be formally adopted with top-level management commitment.

- Appoint a designated energy manager with clear responsibility for energy matters and the company's energy policy.
- Ensure regular formal and informal communication with major users. They should be held accountable for their energy use, which should be monitored and subject to improvement targets.
- Quantify the savings achieved as a result of the energy policy. Publicise these savings within the company and use the successes to create a favourable climate for investment in other energy saving measures.

Energy efficiency is a competitive advantage in any market and an initial site survey is the start of gaining that advantage for your company.

2.3 Injection moulding

Electricity accounts for over 90% of the energy costs in injection moulding. Electricity purchasing is, therefore, critical for moulders and costs can be reduced significantly by good purchasing and operational controls.

Only 5 - 10% of the total energy used in the process is actually input to the polymer; the other 90 - 95% is used simply to operate the machine. Substantial savings can be made.

2.3.1 Moulding machines

As with most machines, the initial cost of a moulder will be less than the cost of energy used during its lifetime. The energy cost will be even more for machines that are not energy efficient. Although it may cost more initially, energy efficiency will save money in the long term. This factor is becoming more important in markets where customers expect decreasing prices through the lifetime of a product.

- Use 'whole life costing' for new machines and include the energy costs.
- Contact machinery suppliers for information on additional equipment to reduce energy consumption.
- New generation machines often have improved energy efficiency and can reduce product costs by over 3%.
- Getting the right machine for the job is vital and the machine should be matched closely to the product.
- Using large machines for small products is inherently wasteful. Are all jobs carried out on the appropriate machines?
- Total efficiency decreases as the operating conditions move further away from the design conditions.

Electric motors account for 60% of the electricity used in moulders. The moulding cycle causes intermittent, variable loads with power factor (PF) values in the region of 0.7. If your electricity supplier is charging you a low PF, correction equipment can increase the factor to over 0.95 with a payback period of less than one year.

- Improving the PF is cost-effective and simple, with excellent payback.
- Motors are most efficient near their design load. Oversized motors at part load are less efficient than small motors at full load. Check all motor sizes to ensure they match the job.

Controlling the start-up sequence of machines can reduce energy costs with no other effect. Starting all the machines at the same time will increase the maximum demand (MD) and the energy cost.

- Fit a warning device to the MD meter to sound when the site load approaches the allowable limit.
- Plan and control the start-up sequence.

Machines use energy even when idling; the amount varies with the machine but can range from 52% up to 97.5% of the full moulding consumption. An idling machine costs money.

- With idle periods of between 20 and 45 minutes, it may be cheaper to switch off and restart.
- Are barrel heaters and cooling fans left on between runs?
- Is cooling water circulating through idle tooling?
- Is compressed air supplied to, and leaking out of, idle machines?

'All-electric' machines are an energy-efficient moulding solution and can both reduce energy use and make computer control easier and more direct. On conventional machines, the hydraulic systems provide peak power for a very short time and the hydraulic system is overrated for most of the time.

- The use of accumulators for rapid hydraulic energy release can reduce the size of the hydraulic system significantly by leveling the load on the pump so that less time is spent in energy-wasteful idling.

Heat transfer to the barrel is improved by pre-seating the heating element to the barrel and by using flexible metal-bearing coupling compounds.

- Thermal efficiency can also be improved by barrel insulation. This has a rapid payback period (generally less than a year) and improves other areas (eg health and safety, and process temperature fluctuations due to air currents).

Preventative maintenance such as de-aeration of the oil system and maintenance of the controls will reduce energy costs.

- Monitor energy use to identify deterioration of the machine.
- Increased maintenance can lead to significant energy savings.

2.3.2 Moulds

Product cooling time is generally more than 50% of the cycle time. Efficient cooling can greatly reduce cycle times and energy use - a double benefit.

- Is your cooling water chilled too much? Are additives too high or too low? How efficiently is it treated and distributed?
- Air in the cooling system reduces the cooling effectiveness. Degassed and pressurised systems can reduce corrosion, cycle times and energy use.
- Active mould temperature control can save considerable cycle time and energy.

Excessive tool change times will waste energy if the machine is idling. Rapid set-up of tooling reduces energy use and improves overall factory effectiveness.

- Are tool changes planned into production schedules? Are they quick?

2.3.3 Ancillaries and services

Ancillaries, such as driers, conveyors and granulators, use energy in electric motors and the consumption of utilities. For highly automated production, the total ancillary energy demand can be comparable to the machine energy demand. The main opportunities are minimising the demand for utilities. Motors are generally small and run intermittently, and it is often not cost-effective to retrofit more efficient motors or controls.

- Specifying energy efficiency during the design of handling equipment and ancillaries will give a rapid payback on any additional costs involved.
- Check that handling systems can be set to operate ‘on demand’ only.
- Match utilities to the demand.

Granulation and scrap recovery use large amounts of energy and can increase energy bills considerably.

- Carry out granulation at night. Run granulators on demand or in batches, not continuously.

Heat recovered from hydraulic systems and chiller units through heat exchangers can be used to provide space heating for offices and other areas with payback periods of around six months.

- Look for opportunities to recover heat and re-use energy.

2.3.4 Management control

Tweaking of machine settings by operators causes more lost time and energy than almost any other cause.

- Optimising the machine settings reduces the electrical energy needed. Ensure that machines are set right, record the settings and do not change them unless absolutely necessary.
- Use statistical process control[4] to control machine settings and performance.

Management is really at the heart of energy efficiency. Without good management, neither energy efficiency nor any other change in operating practices will be effective.

Energy-efficient injection moulding is simply good moulding practice.

Good practice is inexpensive and reduces all costs - not just energy costs.

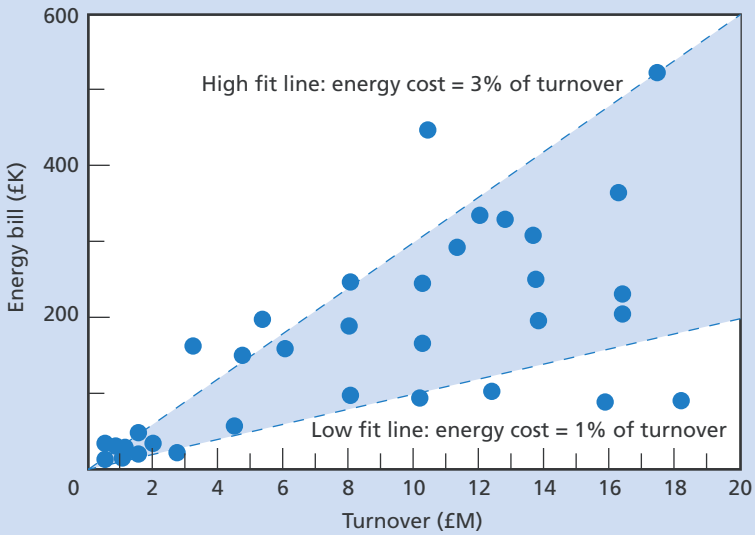
2.4 Extrusion

Extrusion is not only a final forming process for products, but is also an intermediate process for other processing techniques such as injection moulding, blow moulding and film blowing.

The efficient operation of extrusion screws is, therefore, essential for much of the plastics processing industry. The process is highly dependent on electricity and most of the energy used is directly related to machine operation. For profile extrusion, the energy used to drive the extruder itself is 50% of the total and the remaining energy is used for items such as ancillaries (eg granulators and haul-off) and utilities (eg cooling and compressed air).

Fig 6 shows the cost of energy to extrusion companies. Industry surveys show that a typical company should be able to reduce energy use by 10% without major capital investment.

Fig 6 The cost of energy to extrusion companies



[4] For more information, see *Preventing waste in production: practical methods for process control* (GG224). Available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

2.4.1 The extruder

The initial cost of energy-efficient extruders may be higher, but they will give rapid returns on the extra investment. Options such as high efficiency AC motors and variable speed drives (VSDs) have good payback for both new purchases and when replacing motors and drives.

Whatever the age of the machine, it is essential to get the right extruder for the job.

- Check the screw diameter and design to make sure they are right for the polymer and the product.
- Using large extruders for small profiles is wasteful.
- Total efficiency (including energy efficiency) is best when equipment is operating at full capacity and within the design conditions.
- Set the extruder to run at its most efficient speed (usually maximum design speed) and control the screw speed to give an extrusion rate as close to the maximum as possible while still producing good product.

Motors run most efficiently close to their design output - a large motor at part load is less efficient than a small one at full load.

- Size and control the electric motor to match the torque needed by the screw.

Also, optimising the extruder speed maximises the heating efficiency from the mechanical work of the screw and minimises the amount of electrical energy needed. Provided the downstream equipment does not limit the output, energy consumption can be nearly halved by doubling the rotational speed of the extruder screw.

Accurate temperature control is needed for good extrusion - excess temperatures are wasted energy.

- Keep the polymer close to the optimum processing temperature through monitoring screw speed, melt temperature and product quality.
- Barrel insulation saves energy with a payback period of less than one year, and reduces health and safety risks and temperature fluctuations from air currents.
- Check the controls to make sure that heating and cooling are working efficiently together.

Stand-by operation can use significant amounts of electricity in barrel heaters, cooling water, calibration vacuum and lights.

- Find the minimum stand-by settings and train operators to always leave machines in this condition.
- Can you turn off barrel heaters and cooling fans between runs?
- Can you turn off cooling water and compressed air on idle machines?

Monitoring of energy use can be used as a diagnostic tool to identify deterioration of the machine condition and the need for maintenance.

- Increasing the frequency of maintenance involves effort and cost, but can lead to significant energy savings.

2.4.2 The ancillaries

The main opportunities for energy savings from ancillaries are in minimising the demand for utilities such as vacuum and compressed air. Electric motor drives to local ancillaries are generally small, so replacement with efficient motors is only likely to be cost-effective when motors fail. Specifying energy-efficient features at the design stage will give rapid paybacks on any additional costs.

The first step is to get the extruder right - if the extruder is operating at the optimum conditions, the need for downstream cooling and calibration will be minimised. For utilities, the approach should be to 'minimise the demand and then optimise the supply'.

- Find the maximum acceptable extrudate temperature after cooling. Set the maximum cooling water temperature to achieve this.
- Check that cooling water is not circulating through idle calibrators.
- Check that cooling water is treated, chilled and distributed efficiently.
- Check that compressed air is not supplied to idle machines.
- Check that compressed air is generated and distributed efficiently at the minimum pressure needed by the process.
- Check that the vacuum supply is the minimum needed and that it is generated and distributed efficiently.
- Check that the vacuum supply is switched off when it is not needed.
- If replacing electric motors, then match the size to the actual demand and fit energy-efficient motors.

2.4.3 Management

Tweaking of machines by setters and operators causes more lost time and energy than almost any other cause.

- Ensure that the machines are set correctly, record the settings and do not change them unless absolutely necessary.

Increased maintenance involves additional effort and costs, but can lead to significant energy savings.

- Set up a total productive maintenance (TPM) programme to keep all machines and systems in top condition.

Energy efficiency will save you money - start an energy management programme today and reap the benefits of improved profits by cost-effective investment and management.

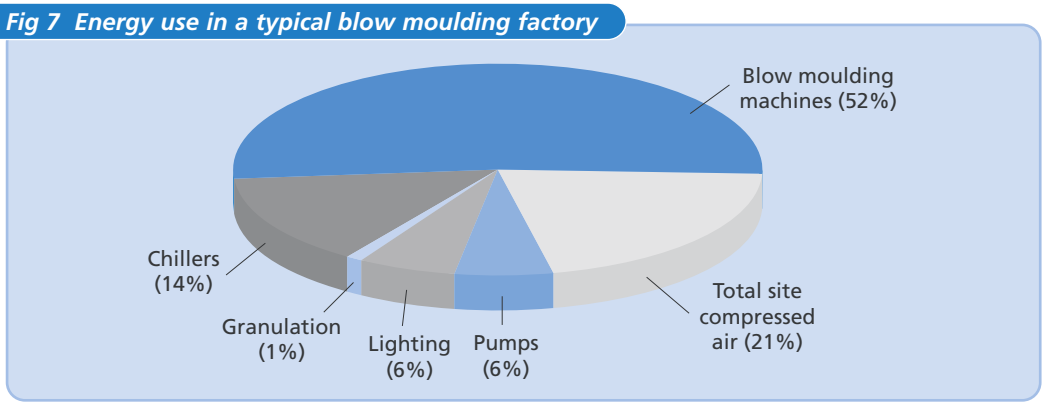
2.5 Extrusion blow moulding

For blow moulding, the specific energy consumption (SEC) - the energy used to process a kg of polymer - varies from 'typical' values of 1.5 - 2.0 kWh/kg up to 'high' values of more than 3.0 kWh/kg.

If your factory's SEC is greater than 2.0 kWh/kg, there are some real savings to be made from energy efficiency. Experience shows that energy savings of 5 - 10% can be made through simple no-cost and low-cost measures. For a company with an annual turnover of £5 million, this means saving £10 000 - £20 000/year for minimal expense. With rising energy prices and the Climate Change Levy, energy inefficient firms will be at a considerable commercial disadvantage.

Fig 7 shows the distribution of energy use in a typical blow moulding factory.

Fig 7 Energy use in a typical blow moulding factory



2.5.1 Machines

The main energy user is the extruder area, which typically consumes 40% of the total energy. As with other processes, energy-efficient machines have lower long-term operating costs than standard machines and will pay back any extra investment.

The use of all-electric machines is an energy-efficient option for blow moulding because these machines remove the energy losses at the electro-hydraulic interface and can reduce energy costs.

Whatever type of machine is used, good process parameter control gives efficient operation and can provide large savings.

- Use just enough energy to complete each process stage. Look for opportunities to reduce heating time, cooling time and other cycle stages to save energy.
- Process controller improvements make it worth investigating upgrades. Controlled, accurate and minimised wall thickness and parison length will improve energy efficiency and material use.

Blow moulding machines use only small amounts of externally applied heat (most is generated mechanically), but heat transfer from barrel heaters can be maximised and evenly distributed by good seating to the barrel and the use of conductive metal compounds. The energy used will be reduced and controlled by barrel insulation jackets. These also improve health and safety, reduce start-up times and generally have a payback period of less than a year.

- Set the polymer at the minimum temperature it actually needs.
- Turn off barrel heaters and cooling fans between runs.

Parison weights are often up to 40% more than the weight of the final product. Any trimmed materials (tops and tails) can be recycled and recovered, but the energy used is lost forever. Large tops and tails cost real money, even if the material is recycled.

- Improved control of the parison and final product size will improve energy and process efficiency.
- The amount regranulated varies from under 10% to nearly 80% of parisons. Improvements can often be made by maintaining the cleanliness of parisons, so that they can go for regrind without reducing material specifications.

Regranulation should be carried out off-line (at night) to minimise energy costs, but first minimise the production of tops and tails (ie reduce production of waste and ***then*** recycle).

When a machine is not producing for a short time, it is not practical to shut down the extruder. However, shutting down the hydraulic systems can give significant energy savings.

Start-up procedures can be set to bring the energy demands on-line at the best possible time, ie heaters until stabilised, hydraulics and finally the extruder drive. Similarly, shutdown procedures can be developed to switch off the energy intensive areas of the machine.

- Develop start-up and shutdown procedures to save energy and time.

2.5.2 Ancillaries

Parison forming must be complete before the outside surface chills and stops surface texture formation. The compressed air pressure for blowing should be just sufficient to form the parison before chilling, but it can then be reduced to hold the parison against the mould surface.

- Use of excessive air pressures for blowing or holding wastes energy.

Most of the heat put in during the melting stage must be removed before the product is released from the die. Product cooling time accounts for about 50% of the cycle time, so minimising the melt temperature will save energy in heating and cooling as well as reducing the cycle time.

- Setters may raise temperatures or increase cooling times to get a job running. Check the settings.

The chiller system uses large amounts of energy and the process efficiency affects both time taken and energy used. Water has a better cooling efficiency than air, and bubbles in the cooling water will decrease the efficiency of the cooling.

- Seal, de-gas and pressurise the water cooling system regularly.

Cooling is most efficient with good contact between the parison and mould. Maintain this using the air feed during cooling.

Hydraulic systems for mould closing should be matched to the demand (blowing pressure × projected area) to reduce the energy needed. The hydraulic oil should be de-aerated regularly to improve the efficiency of the hydraulic system. The hydraulic fluid should also be kept at a steady temperature to improve process control and prolong the life of the oil.

- Some companies use chilled water from mould cooling to cool the hydraulic oil. This may make the hydraulic oil too cold and lead to rapid viscosity changes, and control and quality problems. Check the oil temperature.

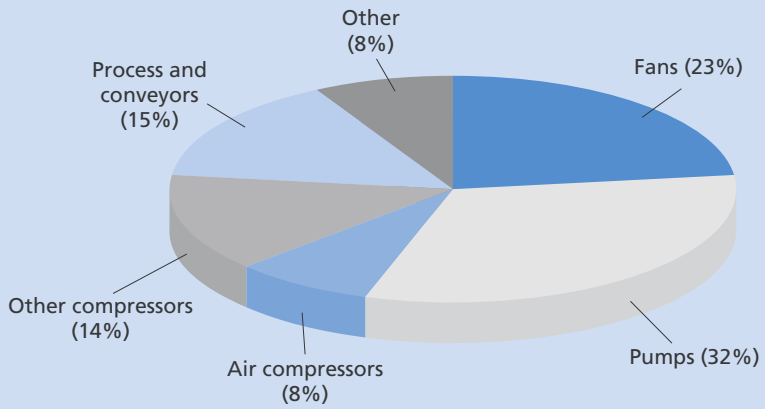
2.6 Motors and drives

Approximately two-thirds of the energy costs in polymer processing are the result of electric motor use. However, motors are often neglected when considering energy use. The motors in the main processing equipment such as injection moulders and extruders are obvious, but most motors are ‘hidden’ in other equipment such as compressors, pumps and fans (see Fig 8).

The life cost of a motor is often over 100 times the purchase cost. The energy cost of a motor can exceed the purchase cost in just 1 000 hours of use.

- Start to save real money by choosing the best motors and systems for your company.

Fig 8 Breakdown of general industrial energy consumption by induction motors up to 300 kW



2.6.1 Motor management policy

The greater importance of running costs over the initial purchase price means that companies need to change the way they look at motors. Decisions need to be made on the 'whole life cost', where all purchase, maintenance, repair and operating costs are considered.

The development of VSDs and high efficiency motors (HEMs) means that, in order to reduce costs, companies should develop and implement a motor management policy for the purchase and operation of motors. This policy should include guidelines on:

- repair and replacement based on lifetime costing;
- the specification of HEMs for all new purchases;
- how to claim enhanced capital allowances for reducing purchase costs.

When new motors are required, the benefits of opting for HEMs are obvious. However, failure of an existing motor raises the question of whether the motor should be repaired or replaced. Repairing a failed motor may appear to be cost-effective, but repair can reduce energy efficiency by up to 1% and may not be the most economical long-term action. A motor management policy can provide the rules for making the best financial decision.

More information about motor management policies

Contact the Environment and Energy Helpline on freephone 0800 585794 and ask about 'enhanced capital allowances' or visit the website (www.eca.org.uk). You can also order a free copy of *Energy savings from motor management policies* (GIL056), or it can be downloaded from the Action Energy website (www.actionenergy.org.uk).

2.6.2 Motor sizing

Motors are most efficient when their load equals, or is slightly greater than, their rated capacity. Motors can even be overloaded for short periods provided that later there is a lower load to allow cooling. If larger machines than necessary are bought or used, then the motor will not reach the design load and will never run at optimum efficiency. Oversized motors are inefficient and equipment needs to be carefully matched with demand. Even 'steady' loads from extruders, fans, compressors and pumps will fluctuate slightly and the basic operating load rarely matches a standard motor.

- It is strongly recommended that expert advice on motor sizing be sought to reduce costs.

- Where motors can be accurately predicted to run at less than 33% of the rated output, it is possible to reconfigure the motor from delta to star connection. This simple low-cost action can produce savings of up to 10%.
- Devices such as VSDs (see section 2.6.4) allow motors to run at the required speed to save energy.

2.6.3 High efficiency motors

The cost premium for HEMs is small and easily offset by the energy savings that result from their use. HEMs achieve efficiency levels of up to 3% more than conventional motors and have a peak efficiency at 75% of load, thus reducing both energy costs and oversizing problems. A 3% efficiency gain may not sound much, but a £500 motor uses approximately £50 000 in energy over a ten-year life and a 3% saving is £1 500 - that's equivalent to three free motors.

2.6.4 Variable speed drives

The speed of an AC motor is fixed by the number of poles and the supply frequency. As a result, the hydraulic pumps in many processing machines are driven at a constant speed even though the demand varies considerably during the cycle. The flow demand changes from the hydraulic pump are controlled by a relief valve and recirculation of the hydraulic fluid.

Another way of meeting the varying demands is to fit a VSD to the motor. A VSD allows the speed of an AC motor to be varied and the pump output can be matched to the variable demand. The benefits of VSDs include:

- significantly reduced energy costs;
- reduced demand on the hydraulic system (this means that the hydraulic oil runs at a lower temperature and requires less cooling - an additional cost saving measure);
- reduced noise;
- lower maintenance costs;
- better all-round performance.

VSDs can also be applied to fans, water pumps and air compressors where the load varies considerably. For constant loads, the use of a correctly sized motor is the best option.

More information about motors and drives

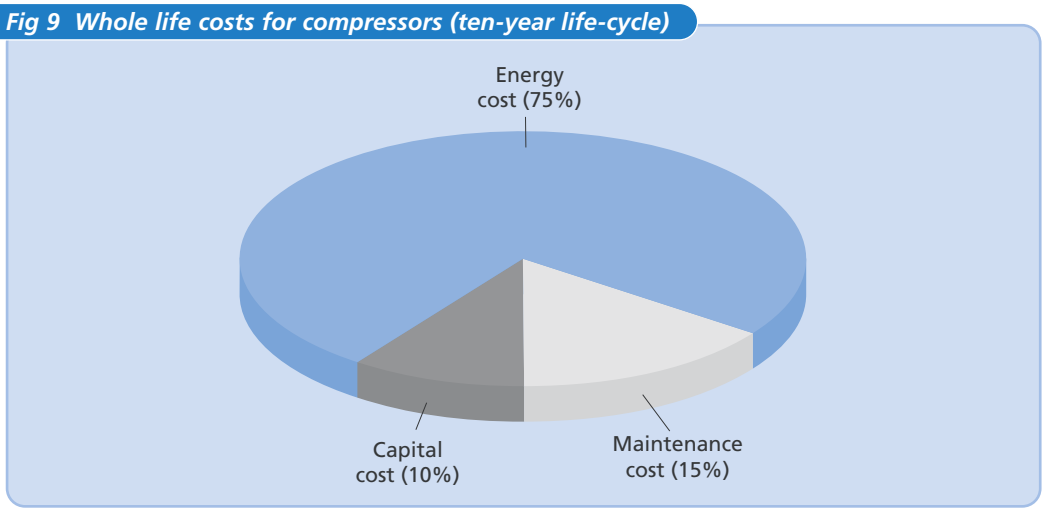
Contact the Environment and Energy Helpline on freephone 0800 585794 to order a free copy of *Energy savings with electric motors and drives* (GPG002). This Guide can also be downloaded from the Action Energy website (www.actionenergy.org.uk).

2.7 Compressed air

Compressed air is a convenient and often essential utility, but it is expensive to produce. In fact, most of the energy used to compress air is turned into heat and then lost. At the point of use, compressed air costs more than ten times the equivalent quantity of electrical power, ie an equivalent cost of around 50 p/kWh. At this price, it should never be wasted and only be used when necessary. Air also needs to be treated to remove moisture, oil and dirt and the higher the quality required, the greater the energy consumed by the treatment system. Fig 9 shows the cost of compressor ownership over ten years.

The cost of compressed air makes it an expensive resource and the way to achieve the best savings is to minimise the demand and then to optimise the supply. Savings of up to 30% can be made by inexpensive good housekeeping measures such as making end-users aware of the cost of generating compressed air and enlisting their help in reporting leaks.

Fig 9 Whole life costs for compressors (ten-year life-cycle)



2.7.1 Minimise the demand

Reduce leakage

A significant amount of energy is wasted through leakage. Typically, leakage rates are up to 40%, ie 40% of the generating power is wasted in feeding leaks. A 3 mm hole in a system at 7 bar (700 kPa) will leak at about 11 litres/sec and costs £1 000/year. In a system with numerous leaks, this cost will escalate rapidly.

Simple leak surveys and maintenance can produce dramatic cost reductions. In some cases, leak reporting and repair have enabled companies to shut down some compressors for all or most of their operating time.

- Perform regular walk around surveys. Tag leaks and repair them as soon as possible.
- Isolate redundant pipework, this is often a source of leakage.
- Measure losses due to leakage and target reductions.

Reduce use

Compressed air is often misused because everyone assumes it's cheap. Check every application to see whether it is essential or simply convenient.

- Stop the use of compressed air for ventilation or cooling - fans are cheaper and more effective.
- Fit high efficiency air nozzles - the payback period can be as short as four months.
- Consider the use of electric tools instead of compressed air tools.
- Do not use compressed air for conveying granules or products.

2.7.2 Optimise the supply

Reduce generation costs

The higher the compressed air pressure, the more expensive it is to provide the air. Twice the pressure means four times the energy cost. The actual requirement may be lower than you are supplying. In some cases, the machine rating is for a 7 bar (700 kPa) supply but pressure reducers are fitted inside the machine. What are your real needs?

- Check that compressed air is not being generated at a higher pressure than required.
- Switch off compressors during non-productive hours. They are often only feeding leaks or creating them.
- Check that compressors are not idling when not needed (they can draw up to 40% of full power when idling).
- Position air inlets outside if possible. It is easier and cheaper to compress cold air.
- If there is a machine or area that requires compressed air longer than the rest, consider zoning or a dedicated compressor so that others can be switched off.
- Investigate electronic sequencing to minimise compressors going on and off load.
- Maintain the system - missing a maintenance check increases costs.

Improve distribution

The longer the compressed air pipeline, the greater is the pressure loss over the pipeline and the higher the cost of the system.

- Make sure that pipework is not undersized. This causes resistance to air flow and pressure drops.
- Use a ring main arrangement in each building. Air can converge from two directions. This reduces the pressure drop and makes changes to the system easier.
- Avoid sharp corners and elbows in pipework as these cause turbulence and hence pressure drops.

Reduce treatment costs

- Treat the bulk of air to the minimum quality necessary, eg 40 µm filters are usually sufficient. Specifying a 5 µm filter will increase cost, replacement frequency and pressure drop.
- Test filters regularly to make sure the pressure drop does not exceed 0.4 bar (40 kPa). Replace the filters if the pressure drop is higher than this as the cost of power to overcome this drop is usually greater than the cost of a filter.
- Manual condensate traps are often left open and act as leaks. Consider replacing them with electronic traps.

More information about reducing the costs associated with compressed air

Contact the Environment and Energy Helpline on freephone 0800 585794 to order a free copy of *Compressing air costs* (GPG126). This Guide can also be downloaded from the Action Energy website (www.actionenergy.org.uk).

2.8 Buildings

Buildings-related energy use is often seen as secondary to process-related use, but it actually represents an average of 17% of the total energy costs. Buildings-related energy is an easy area in which to make energy savings because any changes do not affect production. In most cases, a simple site survey can reduce costs considerably.

The plastics processing industry has seen vast improvements in factory buildings and working conditions in recent years. This upgrading of conditions has produced significant improvements in all-round site efficiency, and this has resulted in a general reduction in the use of energy. However, significant opportunities remain for energy savings in areas such as lighting, space heating and general hot water supplies.

Many processes generate excess heat and it is worth investigating if this can be used for other purposes, eg space heating on colder days.

- Processes that involve vaporising solvents will require 'local exhaust ventilation'. Processes that only generate heat have options for general or local ventilation or, preferably, energy recycling through a heat exchanger.

Building energy costs are a significant percentage of the total energy costs.

2.8.1 Building audit tips

The starting point to reduce building energy use is an audit of the buildings and systems. The following tips can serve as a basis for the initial audit:

Existing buildings

- The top priority is to reduce the heating load, so prevent unnecessary heat loss by making buildings as airtight as possible. Draught-proofing doors and windows is cheap, but effective.
- Automatic, fast-acting roller shutters save energy on external access doors used with fork-lifts and other mechanised access.
- High ceilings increase your heating costs. Investigate the use of false ceilings or destratification fans to blow hot air from the roof space down to the working area.
- Restrict the areas to be heated by using partitions or local systems to control the key areas. Don't ventilate or heat the whole building space for a few small areas.
- Do not heat areas where you have windows or outside doors open.
- Do not heat lightly occupied stores or warehouses when you are only trying to prevent excessive dampness.
- Insulate supply pipes to radiators.
- Install tamper-proof thermostats and controllers to prevent interference. For larger sites, building energy management systems control energy costs without relying on staff.

New buildings/refurbishment

- Ask the Environment and Energy Helpline (0800 585794) for a free copy of *The purchaser's guide to energy-efficient buildings for industry* (GPG304). Look for energy-efficient designs with passive solar heating, passive ventilation, added thermal mass and natural lighting systems.
- Review building insulation and fabric to ensure it meets current best practice.
- Double-glazing can both reduce heat loss and improve comfort. Modern low-e glass and systems are even more effective than standard double-glazing.
- Condensing boilers are the best option for new or replacement small hot water systems.

2.8.2 Lighting

Although they form only a relatively small part of overall energy use, lighting systems offer easy opportunities to save energy. A well-designed lighting system can be a permanent energy saving feature.

- Use occupancy sensors or time switches in areas with high or continuous lighting levels and no or low occupancy.

- Fit reflectors on fluorescent tubes at high levels. Reflectors increase light levels, which may mean that the number of fittings can be reduced.

Examples and information on improved lighting methods are available from Action Energy via the Environment and Energy Helpline on freephone 0800 585794.

- Many major lamp manufacturers also offer advice and contract consultancy on lighting. Take advantage of free help to save energy.
- Replace normal tungsten bulbs with compact fluorescent (CF) lighting. Although they cost more, this will save money in the long term as CF bulbs use only 25% of the energy of tungsten bulbs and last about ten times longer. The reduced maintenance costs, especially for lights in high fitments, can easily fund the extra purchase costs.
- Install high frequency tri-phosphor T8 tubes when replacing or refurbishing existing older systems where good colour is needed. For areas where colour is not critical, high-pressure sodium lighting is an option. Research shows that lighting switched on in the morning will rarely be switched off until the evening - regardless of the changes in light levels in the intervening period.
- Use natural daylight where possible and keep skylights clean to reduce the amount of artificial lighting needed.

Improving building energy efficiency also improves staff comfort and work output.

Free advice on energy efficiency

For free help and information on all aspects of energy efficiency and energy management, contact the Environment and Energy Helpline on freephone 0800 585794 or visit the Action Energy website (www.actionenergy.org.uk).

Companies can request a free, on-site energy survey conducted by an Action Energy consultant, who will assess the site's overall energy use and draw up a savings plan.

Environmental management systems

3.1 Clean business equals good business

Environmental management systems are rapidly becoming an important issue in the plastics industry. Many companies are under pressure from their customers to develop an environmental management system (EMS), while others recognise the environmental impacts of their business and want to minimise these.

Companies that have implemented an EMS have often achieved substantial cost savings and improved their environmental performance. An EMS with a strong emphasis on minimising waste and continual improvement will help your company to reduce costs. This section explains how to implement an EMS that is focused on waste minimisation to reduce costs and environmental factors while still complying effectively with legislation and customer requirements.

A good EMS is a practical management tool to help you to:

- identify, assess and manage the environmental consequences of your operations;
- reduce waste and operating costs;
- gain a competitive advantage;
- establish and demonstrate a system for continual environmental improvement;
- demonstrate compliance with legal obligations;
- improve your public image.

Free help from Envirowise to help you implement your EMS

This section summarises the practical advice to help plastics processors implement an EMS given in *Environmental management systems for the plastics industry* (GG251). Example forms, worksheets and procedures are given as Microsoft® Word files on a disk that accompanies the Guide.

To order a copy or for free advice about any aspect of an EMS, contact the Environment and Energy Helpline on freephone 0800 585794.

3.1.1 Waste minimisation and EMS

An EMS focused on waste minimisation rather than just compliance will produce cost savings from reduced waste, scrap, rework and energy use. An Envirowise survey carried out in 1999 found that the average process yield rejection rate in the polymer processing industry was over 10%. This increases all operating costs as well as reducing capacity (ie the lost opportunity to produce saleable product). As well as the obvious cost of waste disposal, the true cost of waste also includes labour, regrinding costs, raw material value and energy consumption.

Many businesses spend around 4% of their turnover generating waste. The cost of waste is not just the cost of disposal, but includes wasted raw materials, water, consumables and labour. The true cost of waste can be between five and 20 times the disposal cost and, for an average company, is around ten times the cost of disposal.

3.1.2 The waste hierarchy

All waste costs money. Eliminating or reducing waste not only benefits the bottom line, but also has environmental benefits by reducing the use and waste of resources. The 'waste hierarchy' helps to identify the most cost-effective opportunities to reduce waste and save money. Focusing on the top levels of the waste hierarchy (ie eliminate, reduce and re-use) within the framework of their EMS allows companies to optimise the benefits.

3.1.3 What does an EMS involve?

An effective EMS includes:

- an assessment of the environmental aspects and associated impacts of the company's activities, products, processes and services (see sections 3.3.3 - 3.3.7);
- an environmental policy;
- an environmental improvement programme with objectives and targets;
- identified roles and responsibilities for all employees;
- a training and awareness programme;
- written procedures to control activities with a significant environmental impact;
- a controlled system of records;
- a programme of regular auditing;
- a formal review process.

3.1.4 Approaches to EMS

Environmental management systems for the plastics industry (GG251) uses the ISO 14001 model to explain the operation of an EMS. However, it is also possible to follow the EC's Eco-Management and Audit Scheme (EMAS) or to develop an in-house EMS. Companies using the first two approaches can obtain formal certification to ISO 14001 or EMAS verification, respectively.

It is not necessary to obtain external recognition for your EMS to obtain many of the benefits, but the formal approach increases the commitment to continual improvement and to identifying opportunities for on-going improvements and cost savings. External recognition increases the credibility of an EMS with customers and suppliers and, provided you have implemented your EMS systematically and properly, then certification does not require much more effort.

3.1.5 Key factors for success

- **Gain senior management commitment.** Strong senior management commitment is essential to ensuring the successful implementation and operation of an EMS. The benefits and aims of the EMS should be explained to senior managers before starting the implementation process. Convincing senior managers will require a project plan and a detailed estimate of the potential costs and savings from adopting an EMS.
- **Build on existing systems.** There will be links between existing quality management, health and safety management, and other management systems. These links should be reinforced and not re-invented, eg document control procedures used in other management systems may be suitable for use in your EMS.
- **Getting certified.** To be ready for certification to ISO 14001, the EMS should have been fully operational for at least three months and at least one Management Review should have been conducted. For initial registration to EMAS, participants need to have a fully operational EMS

with an audit programme already in place and started, and to produce an initial and validated Environmental Statement.

Many companies use the same certification body for their EMS as for their QMS. However, it is important to check that your certifier is accredited by the United Kingdom Accreditation Service (UKAS)[5] for ISO 14001 certification. You should also check that the proposed certifier/verifier has relevant experience in the plastics industry.

Certifiers use a range of methods for certification. Make sure you understand the different stages of the proposed certification process and what the certifier will be looking for at each stage. Ask your chosen certifier to run through the process of certification with you. Before the certifier visits the site for the first time, hold a meeting to ensure everyone knows about the certification and what it will entail.

An Initial Review (see section 3.2.2) will help you to gather the data that will give a 'snapshot' of where your company is now with environmental issues. Regular reviews will help you to quantify the savings made and maintain the momentum for implementing your EMS.

Formal certification of an EMS is a significant milestone, but it is not the end of the journey. Every EMS needs continued attention to deliver continual improvement and savings. Senior managers need to appreciate this, otherwise the initial enthusiasm for the EMS may decline after certification is achieved.

3.1.6 What to do next

Implementing an EMS with a focus on waste minimisation and continual improvement will help to reduce costs and improve environmental performance. The practical steps in implementing an EMS are:

- obtain commitment from senior management[6];
- understand the main elements of an EMS and familiarise yourself with the requirements of ISO 14001;
- appoint someone to oversee the implementation and operation of the EMS;
- develop an environmental policy (see section 3.2.3);
- identify your company's environmental aspects (see section 3.3.3);
- evaluate the significance of your environmental aspects and draw up an Aspects Register (see sections 3.3.5 - 3.3.7);
- identify legislative requirements and draw up a Register of Legislation (see section 3.2.5);
- set objectives and targets;
- assign responsibility;
- develop employee awareness and conduct training;
- prepare procedures to deliver operational and document control;
- implement a programme of regular monitoring and measurement of significant aspects, eg waste, water use and energy use;
- develop an internal audit mechanism and timetable;
- review progress and, if necessary, revise your policy, objectives and targets.

5 UKAS. Tel: 020 8971 8400. Website: www.ukas.com

6 *Waste minimisation pays: five business reasons for reducing waste* (GG125) will help you convince the board of the benefits of implementing a systematic approach to waste minimisation through the framework of an EMS. To obtain a free copy, contact the Environment and Energy Helpline on freephone 0800 585794 or visit the Envirowise website (www.envirowise.gov.uk).

3.2 Starting out

Planning and organisation is vital to the successful implementation of an EMS. It is important to involve a range of people in EMS implementation, particularly when the EMS overlaps with their normal roles or functions. A formal implementation team will help to keep the EMS on track and to identify and remove obstacles to progress. The team should include representatives from environmental, health and safety, quality, production and senior management. Representatives from other departments may need to be involved from time to time.

An EMS 'champion' should be made responsible for implementing the EMS and co-ordinating the efforts of the implementation team. The team should agree a common and collaborative approach and share out the work. To ensure progress is made, it is essential that team members be allocated sufficient time and resources. The team should meet regularly - perhaps fortnightly - with adequate secretarial support to ensure minutes are taken and, most importantly, action plans are updated. To keep the whole project on track, the EMS champion should review any action plans weekly. The EMS champion may find it useful to set up separate teams to tackle specific issues such as waste minimisation, packaging use, water use and energy efficiency. These teams should involve employees from all levels of the business. Using a senior manager to steer the team and provide an overview will facilitate progress and ensure good communications with the board.

3.2.1 Timescale for implementation

The time taken to implement an EMS is usually around 12 - 18 months, but there is no correct or standard timescale for developing an EMS and other business pressures may take precedence. Where customers are demanding an EMS, they will often accept a reasonable timescale if it is accompanied by a good, realistic implementation plan.

3.2.2 Initial Review

An Initial Review will help to assess the environmental aspects and impacts (see section 3.3.3 and section 3.3.4) of your operations and provide benchmark data to help achieve continual improvement. ISO 14001 does not insist on a formal Initial Review, but it does require an assessment of aspects and impacts. Carrying out an Initial Review will help to:

- gain a strategic overview of the company attitude to waste and environmental issues;
- prepare/revise the environmental policy;
- identify the environmental aspects of activities and their impacts;
- assess relevant legislation;
- identify opportunities to improve performance;
- set objectives and targets for improvement.

The main tasks in an Initial Review are data gathering and analysis. Relevant data may be held by many different managers and operators. Checklists and worksheets from *Environmental management systems for the plastics industry* (GG251) will help you identify and locate the documents needed to determine the company's environmental aspects and impacts. All documents gathered for the Initial Review should be filed for future reference. The worksheets can be used to collect information about:

- the site and its environmental history;
- raw material consumption and storage;
- utility consumption and costs;

- solid waste amounts and management;
- emissions to atmosphere.

3.2.3 The environmental policy

Once the Initial Review is complete, it is possible to write an effective environmental policy. The statements made in the policy should be reasonable and practical, and match the business's needs. The policy may commit the company to different management approaches and both customers and members of the public may want to see it. It should be reviewed regularly and, if necessary, revised to take account of developments in the EMS.

Section 4.2 of ISO 14001 requires a written environmental policy and has requirements for the policy.

The policy should refer to the aims for significant environmental aspects, to continual improvement (through objectives and targets) and to compliance with legislation. It could also refer to:

- training and awareness for employees;
- working with the supply chain to improve environmental performance;
- planning for emergencies;
- relations with neighbours and regulators;
- the concept of sustainability.

3.2.4 Objectives and targets

Setting objectives and realistic targets is the best way to achieve continual improvement from an EMS.

Section 4.3.3 of ISO 14001 requires that objectives and targets be set for continual improvement.

Objectives

These are the guiding aims of the EMS and should be set to achieve improvements in:

- significant aspects;
- the environmental policy;
- technical options;
- financial, operational and other business requirements.

Targets

An objective can have more than one target and setting targets for each objective gives a short-term measurable goal for assessing performance. Opportunities to reduce waste identified during the Initial Review can aid target setting, eg reduce packaging use by 15% and reduce water consumption by 10% within a year. Targets can be one of three types:

- **Measurement.** Improvement targets cannot be set without base-line measurements.
- **Improvement.** Measuring an aspect and then identifying the scope for improvement allows improvement targets to be set (and quantifies the cost/benefits for senior managers).
- **Control.** After improvements have been made, control targets are used to 'hold the gains'.

Owners for individual targets should be identified to ensure that the workload is shared out, that individuals are clearly responsible for different issues and that they know where to focus their efforts.

3.2.5 Legal requirements and EMS

Compliance with the law is a key part of any EMS. The way to be confident of full compliance is to put the appropriate controls in place. It is necessary to:

- identify a source of guidance to environmental legislation (eg the Environment and Energy Helpline);
- identify the legislation relevant to the site and its operations;
- obtain a copy of the acts, regulations or codes of practice (as necessary)[7];
- list the appropriate legislation and how it applies to the site in a Register of Legislation.

Section 4.3.2 of ISO 14001 requires a procedure to identify and obtain access to all environment-related legal requirements.

The method used to identify the legal requirements should be a procedure within the EMS. This procedure should require at least an annual review/update of the Register and the review should be linked to an annual assessment of compliance. When the Register is updated, key changes should be summarised at the front and relevant employees should be notified. If you are not sure which legislation, regulations and codes of practice apply to your site, seek specialist advice from the Environment and Energy Helpline on freephone 0800 585794.

3.3 Managing interactions with the environment

Identifying and understanding how a company interacts with the environment helps to develop an effective EMS to reduce waste and improve environmental performance. The information gathered during the Initial Review provides a starting point for this part of the EMS.

ISO 14001 requires proof that all possible environmental aspects have been considered and evaluated.

3.3.1 Identifying activities and processes

Companies often find that compiling a list of environmental aspects and impacts, and assessing their significance, is the most difficult stage of implementing an EMS.

- Start by making a list of the various departments on the site, eg manufacturing, utilities, stores and engineering maintenance. In addition, include upstream and downstream processing activities such as goods inward, assembly, printing, packaging and dispatch.
- Then identify the different processes that make up these activities.

3.3.2 Process mapping

Draw a box for each activity and add the inputs and outputs to this diagram (see section 1.5.1). Remember to consider all emissions to air, water and land (as waste or through spills) on the process map, however small they may be. The process map will help to identify all of the environmental aspects and clarify the operations where waste may be arising as well as opportunities for waste reduction.

[7] Much UK legislation can be downloaded from www.legislation.hmso.gov.uk

Consider what happens under abnormal situations (eg start-ups, shutdowns and cleaning) as well as the potential for incidents and accidents. Also consider non-core processes and processes such as refrigerants in cooling and air conditioning, and polychlorinated biphenyls (PCBs) in electrical transformers. These will not normally escape into the environment, but the EMS should have procedures for dealing with them during maintenance and final disposal.

3.3.3 Identifying aspects

Aspects are the 'cause' of an environmental impact or effect. Environmental aspects also include measures you have already taken to prevent or reduce pollution. From the process map, decide which inputs and outputs may interact with the environment and are, therefore, environmental aspects. Remember to include aspects that are not covered by legislation - they may still be significant.

3.3.4 Identifying impacts

Impacts cannot be directly controlled - they are generated by aspects that have previously been identified. An aspect can generate more than one impact and many aspects have indirect impacts. Electricity use (an aspect) has three indirect impacts, ie climate change due to carbon dioxide emissions, air pollution from acid gas emissions, and resource depletion through fossil fuel use.

3.3.5 Assessing significance

The next task is to assess which aspects are significant. Environmental aspects that are judged to be significant are the ones that will be managed by the EMS. The Initial Review should reveal which activities are covered by legislation and/or have a high cost. These will be areas where improvement activities will have a high beneficial environmental impact and reduce costs significantly. Assessing significance through a formal procedure enables a company to:

- concentrate on taking action to reduce major impacts;
- make effective use of resources;
- avoid having to try to deal with all impacts (including insignificant ones).

Section 4.3.1 of ISO 14001 requires identification of significant aspects using a formal procedure. ISO 14001 does not specify a set method for assessing the significance of environmental aspects. However, the procedure used to assess significance should be recorded in a systematic manner for future reference. Certifiers will want to see these records.

When assessing significance:

- be consistent;
- use criteria that provide a rational basis for the rest of your EMS;
- record the method and decisions in a systematic manner.

There is no set method for assessing the significance of environmental impacts. Various techniques to assess significance are available; choose the approach that is the most appropriate to your company. The keys to success are to:

- develop a consistent approach that allows each issue to be treated in the same way;
- be able to demonstrate and justify the methodology used.

Numerical rating/weighting method

The first step is to award each impact a score under normal operating conditions. These scores reflect the relative importance of major issues such as:

- legislation;
- environmental damage;
- interested parties;
- quantity.

Scores are weighted according to the likely effect of the impact. The weighting assigned is arbitrary, but should reflect the company's priorities. Comparing total scores for each impact allows prioritisation of efforts under normal operating conditions.

The second step is to award each impact a score under other operating conditions (eg abnormal operations, accident or emergency, past activities or planned activities). Allocating scores to these conditions allows the overall importance of the impact to be calculated.

Risk assessment method

This approach uses conventional risk assessment methods to predict the likelihood and severity of outcomes or events. It is similar to the failure modes effects analysis (FMEA) approach used in quality and design management. It is also similar to some of the risk assessment methods used in health and safety work. In all these methods, ratings of severity, likelihood and detection are assessed individually and then combined to produce an overall assessment of the risk. A risk factor rating is given to each potential impact after considering the following:

- hazardous properties;
- size;
- frequency or likelihood of occurrence;
- presence of sensitive environmental receptors, eg people, a watercourse or site of special scientific interest (SSSI);
- presence or absence of environmental controls, eg techniques designed to control the environmental impact.

For each impact, decide the degree of severity (minor, moderate, major) and how likely it is to occur (unlikely, likely, very likely). A total risk assessment is obtained by combining the severity of the consequences with the likelihood of occurrence for each impact. A numerical rating is given to each, with a negative number indicating an adverse impact.

3.3.6 What is significant?

After assessment, an impact is considered significant if the score is above a threshold value. For risk assessment methods, the absolute score is the important value for ranking. For numerical weighting methods, some impacts may be significant in only one category, others in both. Individual companies set the scores over which impacts are considered significant, but the reasons for the decision should be recorded.

Remember to assess new projects according to the chosen method and to link the evaluation procedure to the capital expenditure application and authorisation process.

3.3.7 Recording decisions

Written procedure for evaluating significance

The reasons for decisions should be recorded in a systematic manner for future reference and to show certifiers. The procedure to identify and assess aspects for significance must be recorded and produce consistent results.

Aspects Register

The collection of lists of environmental aspects and evaluation of significance make up the Aspects Register. This Register should give details of the company's environmental aspects, together with an analysis of their impacts. It should indicate whether an aspect is considered significant and how it is linked to the EMS.

3.4 Operating an EMS

3.4.1 Management Programme

This is a written programme of work stating when and how the objectives will be achieved, and who is responsible for achieving them. This helps to achieve effective EMS implementation and ensures a systematic approach to waste minimisation and optimum benefits. The Management Programme is not a detailed project plan, but should include deadlines for completing the tasks associated with the objectives and targets.

Section 4.3.4 of ISO 14001 requires a Management Programme to enable objectives and targets to be achieved.

One key to success is to set intermediate deadlines for each objective. This enables objectives to be completed in small, manageable parts and defines clearly 'what', 'who' and 'when'. Give ownership of each target to a responsible individual and set 'milestones' to allow the objectives, the targets and the programme to be audited.

3.4.2 Organisation and structure

Senior management commitment and delegated power and responsibility are vital for the success of the EMS.

- Ensure a senior manager has responsibility for the system at board level.
- Formally define the roles of the EMS champion and the implementation team.
- Include key roles and responsibilities in the job descriptions of relevant employees.

Section 4.4.1 of ISO 14001 requires ensuring that roles and responsibilities with regard to environmental management are clearly defined and documented.

3.4.3 Training

Training is an essential requirement for the success of an EMS. It should raise general awareness of environmental issues and provide specific technical skills. When developing the EMS, a training needs assessment matrix should be produced. This should include the relevant job functions and the different types of technical knowledge required to operate the EMS.

- Identify the issues and procedures where employees need training and the key roles that require training.
- Ensure that all employees (including new recruits) receive basic training in environmental awareness, waste minimisation and the elements of the EMS.

It is important to provide proof of training and to ensure that if a key training session is missed, then this is rescheduled for a later date. Many quality management systems (QMS) also include procedures for recording training needs and attendance.

Section 4.4.2 of ISO 14001 requires the identification of training needs in a structured and documented method and the development of a training programme.

To maximise cost-effectiveness and minimise inconvenience, training sessions can be run between shifts to reach a larger audience. It is not sufficient to provide training just once. Refresher training and further specialist training may be necessary for the system to mature and provide good results.

3.4.4 Communications

Communicating the reasons for the EMS, the role of individuals and the progress being made will help to achieve ownership of the EMS by all employees and to maintain the momentum for continual improvement. Tell the outside world what is being done and what has been achieved to improve public and customer perception and show that you care for the environment.

Section 4.4.3 of ISO 14001 requires procedures for internal and external communications.

Internal communications
The procedure should specify the methods (eg newsletters and posters) and the approximate frequency of communication. Information relevant to the EMS (eg current performance, successes, incidents, new legislation, site improvements and awards) should be communicated and records kept to prove that this has happened.

External communications
The procedure should be designed to ensure that:

- communications to and from external interested parties are received, documented and responded to by the correct person;
- records of the content of communications are held.

Section 4.4.3 of ISO 14001 requires consideration of external reporting of significant environmental aspects. The decision should be recorded in the Management Review minutes.

Annual performance data can be used as either an internal or an external report.

Remember: say you do and then do what you say.

3.4.5 Management Manual

The Management Manual acts as a guide to the EMS procedures and documents, and describes the entire system. The Management Manual should include:

- a brief history of the company;
- the environmental policy;
- a description of how the EMS works;
- a list of EMS procedures;
- descriptions of key management responsibilities and an organisation chart.

Section 4.4.4 of ISO 14001 requires the maintenance of information describing the EMS.

The format of the Management Manual can follow the format of any existing quality management manual. It is possible to produce a joint quality/environmental/health and safety manual and to refer to it as the 'company manual'.

3.4.6 Document control

Document control for an EMS is similar to that in a QMS. If you are certified to ISO 9000, there should already be a suitable document control procedure in your system. Document control relies on:

- systematic numbering of documents with a title, date and version number;
- review, revision and approval procedures;
- controlled withdrawal of obsolete documents and issue of new versions.

Section 4.4.5 of ISO 14001 requires a procedure for document control.

3.4.7 Operational controls

Operational controls/procedures should be developed for all situations where their absence could lead to a deviation from the environmental policy. Keep procedures simple and use pictures and flow diagrams if possible. If they are controlled by the EMS, simple notices can be regarded as procedures.

Every procedure should have an 'owner', who is responsible for writing the procedure, writing future updates and ensuring that the procedure is used. Decentralised ownership of procedures will spread out the work when they need to be updated.

Existing procedures developed for a QMS may be amended for ISO 14001. These can include procedures for:

- bulk deliveries;
- management of resource consumption;
- site waste management;
- control of pollution abatement plant;
- energy management;
- planned preventative maintenance (PPM) and inspection.

Section 4.4.6 of ISO 14001 requires the identification of critical activities related to significant aspects, policy, objectives and targets, and the development of documented procedures. An examination of supply chain issues for contractors and suppliers is also required.

3.4.8 Emergency procedures

Use existing emergency procedures to develop a procedure to deal with emergencies that:

- identifies the environmental risks associated with the emergency;
- makes a broad assessment of possible emergency situations.

Section 4.4.7 of ISO 14001 requires a written procedure for dealing with emergencies.

3.4.9 Monitoring and measurement

General principles

The EMS should include a procedure for monitoring and measurement related to significant aspects, including waste production. Data collection and analysis is a vital tool in reducing resource use and minimising waste.

Although ISO 14001 specifies a minimum frequency of annual measurements, more frequent measurement is necessary to identify variations and opportunities to reduce waste. The sooner corrective action is taken, the more cost savings will be achieved. The measurements can be used in the Management Review, displayed internally to report success and even turned into a full environmental report. Parameters that should be measured include:

- production levels;
- waste generated;
- water use;
- energy use.

Waste and utility data should be related to a measure of production, eg tonnes of waste per tonne of product or tonnes of waste per number of units.

Section 4.5.1 of ISO 14001 requires procedures to monitor and measure significant aspects and impacts on the environment. There must be adequate calibration procedures for any measuring equipment used. This section also requires an evaluation of compliance with all relevant legislation.

Calibration

A procedure is needed for the calibration of monitoring and measurement equipment.

Assessing legislative compliance

Assessment of legislative compliance should be performed at least annually and always after updates to the Register of Legislation. For some issues, there may be a statutory requirement to supply compliance information to regulators more frequently.

3.4.10 Identifying and correcting problems

Non-conformances are system failures found during audits, inspections and day-to-day activities. They should be investigated and corrective action agreed. The same process should also be used to carry out preventative actions before things go wrong. Check any existing ISO 9000 quality procedures to see if an additional procedure is required or merely changes to existing procedures. Written records of non-conformances and agreed corrective/preventative actions must be kept using corrective action request forms.

Section 4.5.2 of ISO 14001 requires procedures to ensure that when things go wrong (or do not follow the system), there is a process for recognising the non-conformance and defining corrective actions.

3.4.11 Keeping records

The records required for an EMS include:

- Aspects Register;
- Register of Legislation;
- objectives and targets;

- monitoring and measurement data;
- operational data relevant to the EMS;
- non-conformance and corrective action request forms;
- audit reports.

There are legal requirements for the retention of some environmental documents and, although not a legal requirement, some other documents should be held forever to maintain the asset value of the property. Keeping records should be dealt with under an ISO 9000 QMS and existing quality procedures may only need simple changes to meet ISO 14001 requirements.

Section 4.5.3 of ISO 14001 requires procedures for the identification, maintenance and archiving of environmental records.

3.4.12 Internal audits

Internal audits are a systematic inspection and comparison of actual operating methods with policies, procedures, work instructions, etc. Environmental auditing helps to maintain environmental awareness and a sense of responsibility among employees.

Three ISO standards (ISO 14010 - ISO 14012) deal with EMS auditing and cover general principles, audit procedures and criteria for auditors, respectively. Check whether existing ISO 9000 audit procedures meet the requirements of ISO 14001, particularly with respect to auditing objectives/targets and compliance with legislation.

Section 4.5.4 of ISO 14001 requires procedures for audits to periodically assess the effectiveness of the EMS in relation to both the standard itself and good environmental management. These procedures should also confirm that the system has been properly implemented and maintained.

An audit should focus on the significant environmental aspects and compliance with legislation and should:

- determine whether the EMS has been implemented and maintained correctly;
- verify that the system is working and is effective;
- identify weaknesses in the system and/or areas for improvement;
- assess compliance with the requirements of the EMS itself.

The auditor should not have management responsibility for the procedure being audited and should have been trained in auditing and the essential aspects of the procedure.

Audit frequency should be linked to the significance of the environmental impacts and all procedures must be audited at least once a year. The audit programme should take account of areas/issues identified for particular attention by previous audits.

Auditing often works best if the auditor has a list of key questions to ask about the procedure - preferably with simple yes/no responses. These questions can also be part of the procedure. All non-conformances and agreed corrective/preventative actions should be recorded in an audit report and followed up to check that corrective and preventative actions have been taken.

3.4.13 Management Review

Auditing checks whether you are 'doing things right' while the Management Review checks whether you are 'doing the right things'.

The Management Review allows senior managers to consider the effectiveness of the EMS. The discussion and its conclusions should be minuted and agreed actions implemented.

Section 4.6.1 of ISO 14001 requires regular reviews to assess the overall effectiveness of the EMS.

The agenda for management meetings should allocate time to discuss:

- progress in achieving objectives and targets;
- compliance with legislation;
- audit reports;
- non-conformance action reports;
- new processes and any changes to known environmental issues;
- new legislation;
- new customer requirements;
- the need for any revisions to the environmental policy, objectives and targets.

Senior management should also consider whether to report externally on progress in reducing the impact of environmental aspects.

Free advice on implementing an EMS

For free advice and help on any aspect of implementing an EMS, contact the Environment and Energy Helpline on freephone 0800 585794. Don't forget to ask for your free copy of *Environmental management systems for the plastics industry* (GG251).

Envirowise - Practical Environmental Advice for Business - is a Government programme that offers free, independent and practical advice to UK businesses to reduce waste at source and increase profits. It is managed by Momenta, an operating division of AEA Technology plc, and Technology Transfer and Innovation Ltd.

Envirowise offers a range of free services including:

- Free advice from Envirowise experts through the Environment and Energy Helpline.
- A variety of publications that provide up-to-date information on waste minimisation issues, methods and successes.
- Free, on-site waste reviews from Envirowise advisors, called *Fast*Track visits, that help businesses identify and realise savings.
- Guidance on waste minimisation clubs across the UK that provide a chance for local companies to meet regularly and share best practices in waste minimisation.
- Best practice seminars and practical workshops that offer an ideal way to examine waste minimisation issues and discuss opportunities and methodologies.

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