


*Managing water use and benchmarking
in ceramic manufacture*





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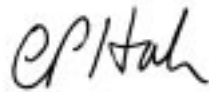
Foreword from the British Ceramic Confederation

The British Ceramic Confederation welcomes the publication of this Guide that will assist companies to improve their performance and make valuable savings. The examples from industry are of particular value in demonstrating that the aims and benefits of the Guide are not theoretical, but readily attainable in practice.

The importance of a responsible approach to managing environmental impacts, including the use of natural resources, cannot be overstated. Companies within the industry must be able to demonstrate that their activities are sustainable in environmental terms. The immediate bottom line benefits that can be realised through improved resource utilisation are a powerful motivating factor.

Efficient water use is best achieved as part of an integrated environmental management system. The methodology described in this Guide is common to that of most systems, enabling the techniques to be incorporated within a broader environmental management framework.

We endorse the advice contained in this Guide, and commend its adoption by all companies within the industry.



Chris Hall
Commercial and Public Affairs Director of the British Ceramic Confederation

Summary

This Good Practice Guide will help companies in ceramic manufacturing to save money through reducing water use and effluent levels.

The Guide provides benchmark data against which companies can compare their performance, and practical hints and tips on how to reduce their water use and effluent generation, saving money directly in terms of water and raw materials and indirectly in terms of energy and labour.

Industry Examples highlight companies and the measures they have taken and the cost savings and other benefits that have resulted.

Although UK water costs are relatively low, there is much scope to make savings - more than companies might think. Simply by taking measures that cost little or nothing to implement, such as those suggested in this Guide, a company could save many tens of thousands of pounds every year through reducing water use and recovering materials.

This Guide covers measures at all process stages, from delivery to cleaning, and gives advice on reducing effluent through the recovery of materials for direct re-use.

The best way to tackle waste is in a systematic manner. Section 7 details an approach that will ensure continuous improvement. It will help companies to look at their own process for cost-saving potential and includes tried and tested techniques to help this process. Measuring and benchmarking against good practice and a company's own on-going data, will help those taking action to improve control of their process and save money in all areas.

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1.1 What is this Guide about?

This Good Practice Guide will help companies in the whiteware ceramics sector to save money through reducing water use and effluent levels. It covers glaze and clay use and recovery from the effluent stream. The Guide is aimed at companies of all sizes, primarily in the whiteware sector, covering tableware, sanitaryware, decorative/houseware and glazed tileware. Recent reductions in heavy metals use in glazes mean the industry's effluent is increasingly harmless in environmental terms. However, there is still potential to reduce costs, both directly in terms of water and raw materials and indirectly in terms of energy and labour.

This Guide will help companies to save money by providing:

- benchmark data (based on a 1999/2000 industry survey) against which companies can compare their performance;
- clear, concise water/effluent reduction and re-use advice in terms of:
 - practical hints and tips;
 - a systematic approach to monitoring and control.

The Guide also provides Industry Examples that highlight cost savings and other benefits, and a worksheet and checklist to be used around any site(s) to help identify cost saving opportunities. This Guide is intended to be used by managers who are looking for practical ways of reducing waste and hence costs. This includes those attempting to make improvements within the framework of an environmental management system such as that defined in ISO 14001 or EMAS. The Guide complements Good Practice Guide (GG271) *Reducing Solid Waste Costs in the Whiteware Industry*¹, which also addresses the issue of glaze and clay process use and 'high density' (non-effluent) recovery.

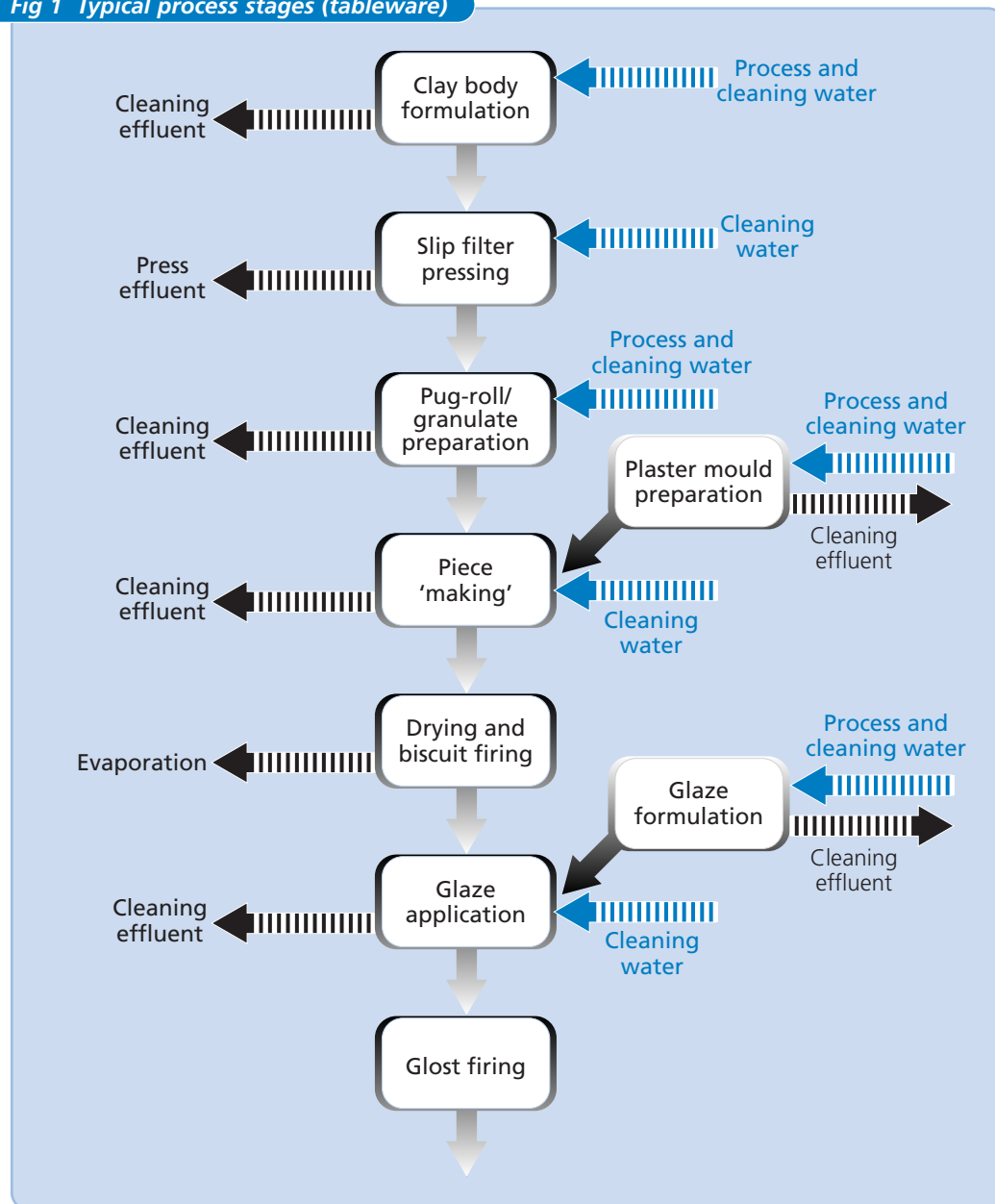
1.2 Water use and its cost

Water is used at many stages of the ceramics process, with associated effluent being produced, as indicated in Fig 1. While water is a relatively cheap commodity (typically around 70 pence/m³, with effluent discharge to sewer typically costing around 40 pence/m³), sludge disposal costs can be very high indeed (typically £20/tonne). Overall, given that there is relatively little sludge compared to overall effluent volumes, it is estimated that every m³ of water wasted costs around £1.80, taking into account water, trade effluent and sludge removal charges.

However, this does not take into account clay and glaze material losses to effluent. One hotelware company estimated that it was losing around 15% of its glaze to effluent, despite recovering all the high-density glaze from spray booths etc. Given that prepared clay body typically costs well over £100/tonne and white glaze typically costs around £900/tonne, any losses to effluent can be very significant. Companies that start to recover glaze from effluent can typically save in the region of £100 000/year. It is also worth noting that there are hidden costs in terms of the wasted energy (eg for mixing and pumping) and the labour associated with making clay and glaze that ultimately goes down the drain.

¹ This Guide is available, free of charge, through the Environment and Energy Helpline on freephone 0800 585794.

Fig 1 Typical process stages (tableware)



1.3 The benefits of effluent reduction and better management

There are sound economic reasons for taking water and effluent minimisation and management seriously, as the examples from industry in this Guide show. One hotelware company is saving around £250 000/year through reduction, segregation and re-use of its effluents. As well as saving money directly, this company and others are often benefiting in less obvious ways, eg through:

- improving product quality and reducing waste;
- improving overall site efficiency and productivity;
- reducing environmental impact and so improving company image with customers, the local community etc;
- improving shop-floor conditions and staff morale, thus reducing staff absenteeism and improving staff retention;
- reducing environmental risk, liability and insurance premiums.

It is estimated that the whiteware industry could collectively save an extra £10 million/year through relatively simple reduction and re-use measures as described in this Guide.

The relationship between waste reduction and profit

Waste reduction can have a dramatic effect on the bottom line. Assume that a company with a £4 million turnover makes 10%, or £400 000, operating profit (including overheads but pre-tax) each year. Waste probably costs the company around £40 000, or 1% of turnover, mainly as a result of material and product losses and effluent disposal costs. Reducing these costs by only 20% will put £8 000 on the bottom line, increasing profits by 2%.

Water management principles

2.1 The waste hierarchy

Effluents should not be thought of as wastes, rather as valuable secondary materials. The most cost-effective way of dealing with waste will be as high up the waste hierarchy as possible, ie eliminate, reduce, re-use, recycle.

- *Eliminate and reduce:* Prevention at source should be the first priority since this tackles the root cause of water and material waste. This means optimising the process - to get it right first time with minimum losses.
- *Re-use:* Re-use of water and effluent (eg for cooling and cleaning), with minimal processing, is the second priority.
- *Recycle:* Recycling, involving some sort of 'extra' processing (eg microfiltration to recover materials and purify water) follows.

Disposal of sludge and discharge to sewer must be considered a last resort, although even then a number of steps can be taken to reduce volumes and costs.

Waste minimisation is primarily about reduction at source and hence it goes hand in hand with quality management systems (such as the ISO 9000 series) and environmental management systems such as ISO 14001 and EMAS. In recent years many companies have benefited enormously from their involvement in waste minimisation initiatives. Some of these, such as the Aire and Calder scheme in Yorkshire and the Leicestershire Waste Minimisation Initiative², are well known, saving the participating companies millions of pounds a year collectively. There are, however, many more waste minimisation schemes and clubs all over the country (for further information contact the Environment and Energy Helpline on 0800 585794).

The approach taken in this Guide is to re-examine processes to see where waste can be prevented from being generated in the first place.

2.2 Additional general principles

If waste minimisation is to be effective there are a few important principles that are worth keeping in mind:

- *Waste is not inevitable.* Many companies have accounting and purchasing systems that provide an allowance for 'costed' or 'natural' waste. This approach hides the true cost and limits the potential for improvement - so always start at a zero-waste base-line.
- *Old ways of doing things can almost always be improved.* Technology and costs change and hence what was not possible or economic a few years ago may well be now. Don't be put off by those who tell you, 'That's the way we've always done it' or 'We tried that and it didn't work'.
- *Evolution is usually easier and more effective than revolution.* Keep things simple and take things one step at a time, using appropriate trials etc to prove ideas. That's not to say that new techniques and technologies should be avoided, just that they should be introduced progressively and with care.

² For more information, contact the Environment and Energy Helpline on freephone 0800 585794.

- *Waste minimisation should be done in an integrated way*, in the context of the manufacturing process as a whole and taking into account health and safety considerations. It is clearly no good reducing levels of process cleaning if this will have a detrimental effect on product quality or on staff health.
- *Monitoring leads to understanding, control and greater efficiency*. Monitoring is an essential part of any quality management system. You have to understand where waste arises before you can determine why it happens and do something about it.
- *People make things happen*. Having a team of staff, involving everyone from the shop-floor supervisor to the production director and led by someone who really wants to make a difference (a 'Champion' of the cause), will make the whole waste minimisation process that much more effective.
- *Management commitment is essential*. No matter how enthusiastic your team and how good your ideas, nothing will happen without senior management commitment - and you won't get that without justifying what you want to do in hard cost-benefit terms.

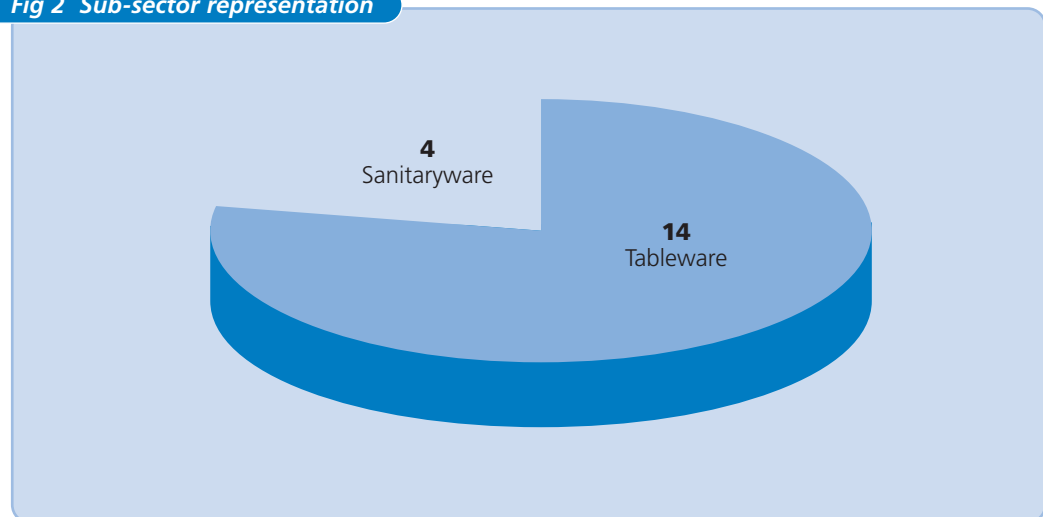
Benchmark data

3.1 Data sources and validation

A 1999/2000 survey of the industry has allowed good quality data on water and materials use to be gathered for the first time. Of around 140 whiteware companies approached, 23 companies provided data, including 18 tableware companies, four sanitaryware companies and one tileware company. Data from a tileware company and some of the smaller 'craft' potteries have, however, been excluded on the grounds that the processes employed are significantly different from those used in the mainstream industry and hence were providing misleading results.

Not all companies responded to every aspect of the survey and some provided data that were evidently estimated. Therefore, almost all of the companies were contacted by telephone, while 13 were also visited to improve the quality of the data and to obtain more detailed case study information. Overall, 18 companies provided good quality water data and slightly fewer provided effluent and material use data. The breakdown of the 18 companies by sub-sector is given below in Fig 2. The data still cover the full range of company sizes, from the smallest through a majority of medium-sized tableware and sanitaryware companies to the larger players.

Fig 2 Sub-sector representation



3.2 Data presentation

All of the data (except the trend data) are for the calendar year 1998 or the financial year 1998/99. They are presented in relation to production volumes, ie per piece, so as to eliminate changes caused purely by increased or reduced production. To make the data more meaningful, as piece size and process emphasis are very different, the sanitaryware data have been separated from the tableware data.

3.3 Water use and effluent production

Virtually all of the companies that responded to the survey were able to provide data on overall water use. These data are presented in the following figures for tableware and sanitaryware. There is a very wide use range per piece, indicating the large gap between good and bad practice. Sanitaryware manufacture uses far more per piece than tableware due to the far greater size of each piece and the reliance on casting methods. It is worth noting that amongst the largest users in both sectors are those which use (and waste) borehole water.

Fig 3 Water use in tableware

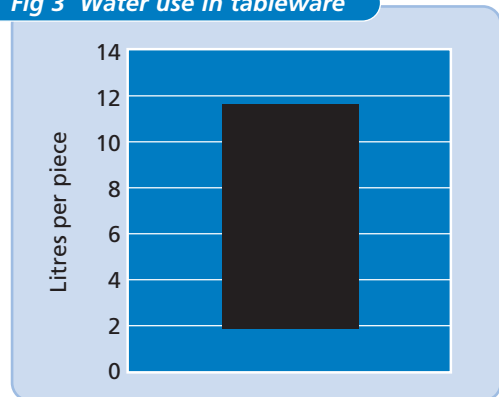
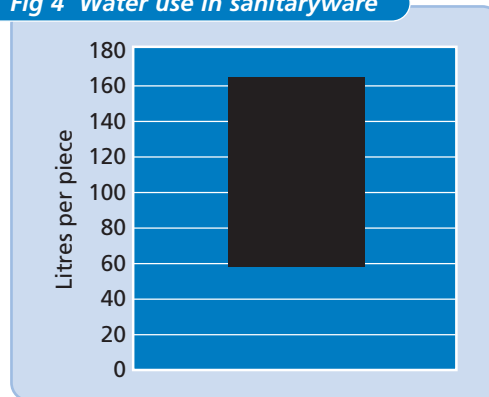


Fig 4 Water use in sanitaryware



Effluent in the ceramics sector comes from various sources, predominantly equipment cleaning (especially in the glazing areas) and cooling, filter pressing of slip, sponging/wiping and even decorating (eg where taps are left running in litho application areas). While a few companies that responded to the survey were unaware of the precise volumes of effluent being produced (the figure often being estimated by the water company), the majority provided good data concerning effluent volumes to sewer and sludge volumes from treatment. These data are presented here.

Fig 5 Effluent to sewer in tableware

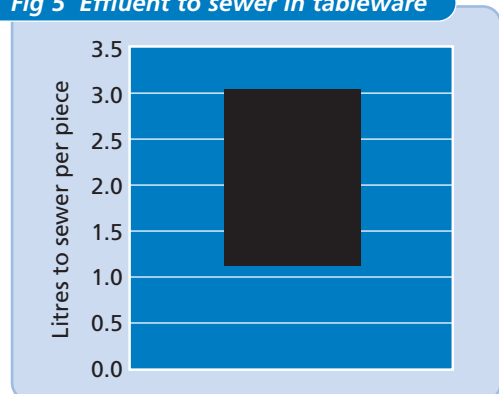
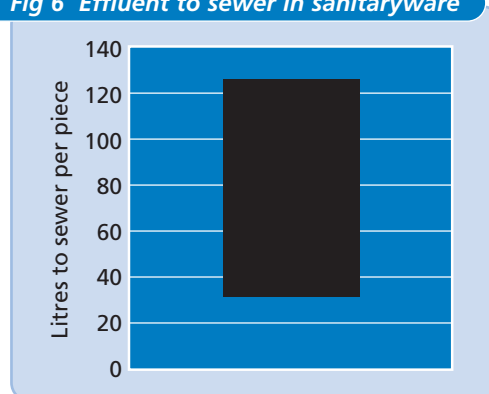
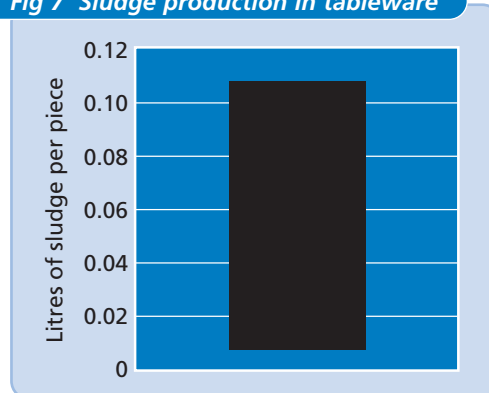


Fig 6 Effluent to sewer in sanitaryware



A high proportion of effluent going to sewer is a good indication of water waste. The data gathered suggest that, on average, around 47% of the water used in tableware goes to drain, the remaining 53% going into the clay, glaze and plaster moulds to be subsequently evaporated off in drying/firing or chemically retained in the moulds. It is worth noting that, for the majority of tableware companies, effluent represents 60% or more of the water used and that only extensive water conservation and re-use measures in a few companies (where effluent levels are less than 25% of water use) bring the average down.

Fig 7 Sludge production in tableware



In sanitaryware around 56% of water goes to sewer on average, although again the figure is far higher in some companies.

3.4 Clay and glaze use

Most of the companies that responded to the survey were also able to provide data on clay and glaze use. The data have been provided as dry weight figures, adjusted where necessary through consideration of the material water content. These data are presented in Figs 8 to 11 for tableware and sanitaryware and reflect the extent to which clay and glaze are being conserved (through more efficient use) and recovered in high density and low density (effluent) forms. Again there is a very large gap between good and bad practice.

Fig 8 Clay use in tableware

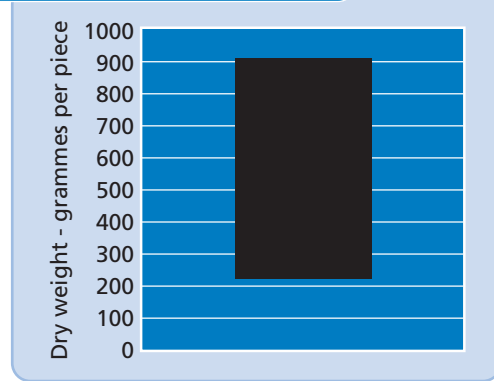


Fig 9 Clay use in sanitaryware

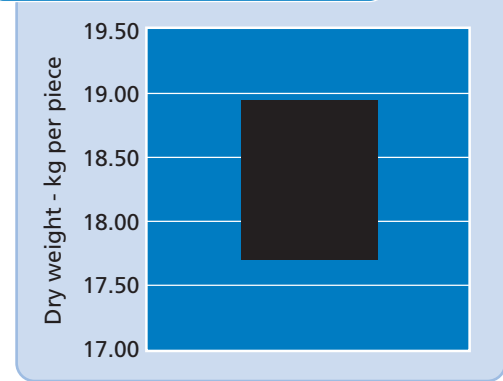


Fig 10 Glaze use in tableware

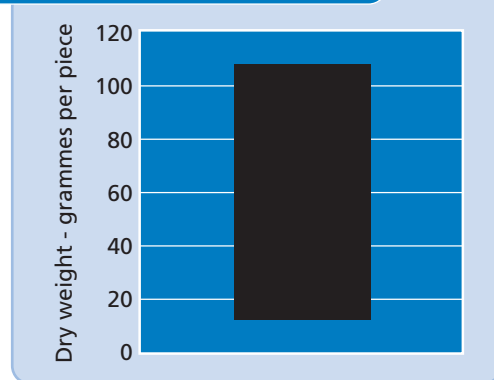
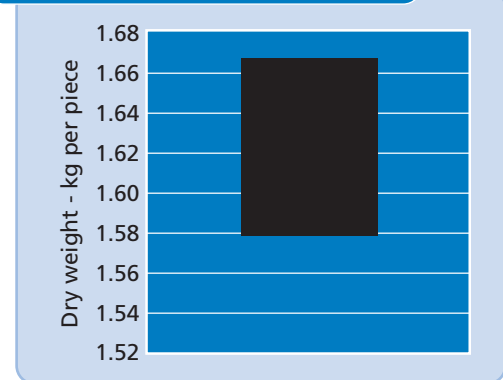


Fig 11 Glaze use in sanitaryware



While most companies provided data for only one year, a few tableware companies provided data for the last three years, giving some indication of trends. While Figs 12 and 13 are not representative of the sector as a whole, they do show that significant gains, around 15% in glaze in this case, can be made in three years.

It is worth noting that Wedgwood and others are seeing a trend towards larger tableware pieces, particularly for the US market, which naturally makes clay and glaze use higher per piece. Efficiency improvements, however, can more than outweigh these increases, giving an overall downward trend as indicated.

Fig 12 Clay use trend - tableware

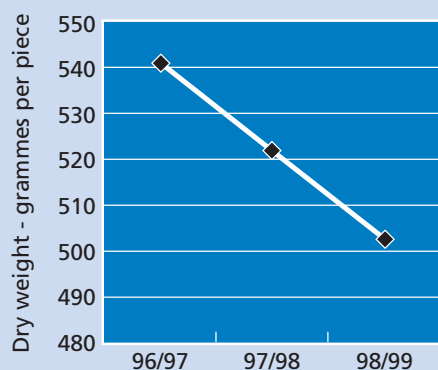
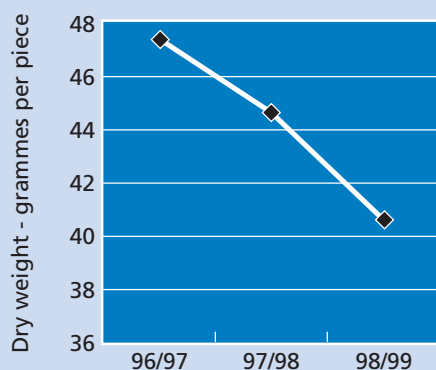


Fig 13 Glaze use trend - tableware



3.5 Breakdown of water use by process

Very few companies monitor water use or effluent production by process stage, having only one or two meters per site. The data gathered have, however, allowed an estimate of the breakdown as shown in Tables 1 and 2. While the figures are very approximate, there is good consensus in terms of the ranking of uses. The three key areas of water use are (in order of importance) slip and glaze preparation, glaze application and 'making' (casting, pressing etc), collectively accounting for around 80% or more. The first two of these probably account for 65% or more of the water used. Note that these figures include **water used for cleaning equipment and floors, the single most important use of water and the one that can often be readily reduced.**

Table 1 Water use by process

Process stage	Water use (%) (incl cleaning)
Clay/glaze preparation	30 - 50
Glaze application	25 - 35
Piece making	10 - 15
Mould making	5 - 10
General cleaning/other	5 - 10

Table 2 Effluent production by process

Process stage	Effluent (%)
Glaze application	40 - 55
Clay/glaze preparation	15 - 25
Piece making	15 - 25
Mould making	5 - 10
General cleaning/other	5 - 10

It should be noted that domestic water use is excluded from these figures, however, the data gathered suggest that typically around 10 - 15% of the water used overall is used in toilets, site canteens, vehicle washing etc.

Table 2 shows effluent production by process stage, mainly reflecting the use of cleaning waters and filter press waters (where slip is pressed). Effluent typically equals around 60% of the water used. Compared with overall water use (in Table 1), the ranking changes, with glaze application exchanging places with clay and glaze preparation. This is because a large proportion of the cleaning waters are used to wash glaze from stands, booths, baths etc. Figures provided by one sanitaryware company suggest that around 55% of its effluent results from conveyor/carousel washing in the glaze spraying area³.

To reduce water use and effluent it is best to concentrate on:

- cleaning in the glaze application area;

³ This particular company does very little cleaning in the glaze and slip houses due to the design of their new facilities and general good practices.

- cleaning and mixing in the clay and glaze preparation areas;
- cleaning in the piece making areas, ie in casting, moulding.

Other areas should not be ignored because useful gains can be made as indicated in the examples from Section 4.

3.6 Benefiting from good practice

Based on the figures above it is worth comparing an 'average' tableware firm with a 'good practice' tableware firm, each making 5 million pieces a year. Table 3 summarises these data.

Table 3 The benefits of moving from average to best practice in tableware

	'Average' company		'Good practice' company		Benefit of good practice	
	Tonnes or m ³	Value (£)	Tonnes or m ³	Value (£)	Tonnes or m ³	Savings (£)
Water use	25 750	18 025	9 550	6 685	16 200	11 340
Trade effluent to sewer	12 000	4 800	5 750	2 300	6 250	2 500
Effluent sludge disposal	225	4 500	40	800	185	3 700
Clay use	2 625	262 500	1 110	111 000	1 515	151 500
Glaze use	228	205 200	60	54 000	168	151 200
Total		495 025		174 785		320 240

The bottom line is that the 'good practice' tableware firm:

- uses 63% less water;
- produces 52% less effluent;
- produces 82% less sludge;
- uses 57% less clay;
- uses 74% less glaze;
- saves over **£320 000/year** in water, material and disposal costs alone.

Practical water and effluent reduction measures

This Section deals with reducing water use and effluent production at source, ie preventing waste. The Section starts with some general measures and then moves on to more process-specific measures. Section 5 deals with effluent re-use.

4.1 Measuring water use

Before starting to reduce water use, it helps to know where to target your efforts, and to be able to measure the results of the action taken. Monitoring of water consumption and effluent volumes is essential if any sort of systematic control and reduction is to be achieved.

4.1.1 Measuring devices available

Ideally meters should be installed to monitor consumption for each major stage of the production process as well as for the site as a whole. Flow measurement can be achieved by using simple meters such as turbine and orifice types, which will cost only a few hundred pounds each for a 50mm (2 inch) diameter pipe and much less for smaller pipes. More sophisticated electromagnetic and ultrasound meters are also available that allow electronic data logging. Some of these types are also 'non-invasive' (strap-on) and hence do not require plumbing and avoid the possibility of subsequent leaks.

Metering to identify leaks

One fine tableware company realised that water consumption had risen fairly steadily over the last few years, at a much faster rate than production. On investigating this, a large leak was detected in late 1998. This was fixed, reducing consumption by around 50%. The company believes that the saving is around 25 000 m³/year, worth around £18 500, although these figures are currently under review with the involvement of the local water company.

Effluent streams in pipes can be monitored in the same way although some meters work better than others with dirty water, part-filled pipes etc. For example, some rely on small pressure tappings that can block. Effluent streams, such as from an effluent plant before discharge to sewer, can be measured using simple weirs (eg V-notch-type) and pressure/ultrasound devices, the level of the water being related to the flow rate.

Electronic devices, which send flow rate information to a control panel or office PC, obviously allow easier information monitoring. It is worth noting that such devices can be retrofitted to certain types of meter in situ. Further information on all aspects of flow metering can be found in Good Practice Guide (GG67) *Cost-effective Water Saving Devices and Practices*⁴.

4.2 Matching quality of supply with use

Most companies use high-quality, treated mains water for all purposes including cleaning. While high-quality waters are required for boiler feeds and certain process applications, lower quality water can be used for certain types of cleaning and for certain other applications such as wet air pollution control equipment. Even where effluent re-use is not practised there may be

⁴ This Guide is available, free of charge, through the Environment and Energy Helpline on freephone 0800 585794.

opportunities to use cheaper and untreated borehole or abstracted waters (eg from a canal or river) for cleaning. Trent Bathrooms uses canal water for much of its general cleaning. Those companies that are in a position to do this can save perhaps 80% on their cleaning water costs, assuming the need for some pretreatment.

However, it should be noted that the use of low-cost supplies such as boreholes often leads to poor practices and hence increased water waste and effluent. Companies are often much more efficient and less wasteful if a resource is costly.

4.3 Material delivery and storage

The delivery of materials involves the risk of spillage and great care should be taken when unloading vehicles and tankers, particularly when dealing with liquids. Preferably delivery should be supervised and carried out in a bunded area or one with appropriate drains and/or oil interceptors (see Section 5).

- Bulk delivery into arks (tanks), or in returnable containers (such as intermediate bulk containers (IBCs) or drums) should reduce the need for container washing and hence water use and effluent production (as well as reducing packaging waste).
- Ark and silo space can sometimes be created without buying new tanks and silos. This can be done by switching slow-moving materials from bulk delivery to delivery in IBCs, drums and bags and by having deliveries made 'just-in-time'.
- When dealing with high value materials, such as ready-mixed glazes, it may be worth asking your supplier to use plastic bag inserts in drums and rigid IBCs. While this creates some extra solid waste, the bag can be wrung out to reduce material residues and avoid the need for washing prior to the return of the main container.
- When dealing with viscous materials, it is worth emptying the delivery container in a warm environment to reduce residues. Drum and IBC 'warmers' can be used if necessary.

Poor material storage and handling can lead to spillage, not only wasting valuable product, but also increasing water use and effluent generation in the clean-up.

- Stable stacking of materials minimises the risk of spillage. Palletised containers and IBCs should be stacked no more than two high or singly on proper racking systems.
- Materials should be kept well clear of marked fork-lift routes and walkways. Fork-lift trucks can damage stored materials and can be fitted with protective equipment (eg rubber tipped forks or wider platens).
- Fibreglass arks are particularly vulnerable to impact damage and should be protected using appropriate bars and rails.
- Arks and other vessels should also be fitted with overflow warning and prevention devices. Warning devices should be able to be seen and heard near the relevant tank/vessel, and also in a control room. Prevention devices usually involve a level sensor combined with pump and valve shut-offs.

4.4 Material distribution and handling

Handling and distribution, as well as storage, require considerable care if spillages are to be avoided.

- Ideally slip and liquid glaze should be piped from the slip/glaze house to the casting and glaze areas rather than moved around in tubs and drums.

- Peristaltic pumps ('hose' pumps) can be useful as they do not allow the material to come into direct contact with the mechanical parts of the pump, thereby reducing pump wear and the risk of slip and glaze contamination. Such pumps also eliminate the risk of air entrainment and flow pulsing, thereby improving product quality (see Section 5.4).
- Where piping is not possible or practicable, using larger re-usable containers such as 1 000 litre IBCs rather than many smaller drums will reduce residue losses.
- When using large drums it is better to use drum pumps, or decant using small containers, rather than attempt to pour and risk injury or spillage.
- As with material delivery, bag inserts can be used in tubs, drums and IBCs to reduce residue losses and to eliminate the need for container cleaning.

Improved material and product handling

One of the large sanitaryware companies now delivers glaze to its spray guns along dedicated lines. This has eliminated the need for the barrels in which glaze was previously carried around the site. The measure has also resulted in improved glaze consistency and quality (ie zero contamination) and the elimination of barrel glaze residue waste.

- Large containers should preferably be re-usable, have integral wheels and a low centre of gravity to minimise the risk of spillage and facilitate handling.
- Fork-lift and trolley loads should be made secure and stable, eg by using on-vehicle stabilising devices or by using strapping, stretch-wrap or drum catches.

4.5 Equipment design

The design of mixing vessels, spray booths etc can have a significant impact on the amount of water used in cleaning.

- Equipment should be designed with as few material 'traps' as possible. For example, mixing vessels should, where possible, be conical at the base with smooth contours.
- Spraybooths and dip baths should have as few angular joints and corners as possible, while sumps should be readily accessible.
- In some cases, permanent plastic lining for baths, spray booth sumps etc, can help to facilitate cleaning and glaze reclamation and reduce the risk of glaze contamination by rust.
- Particular attention needs to be given to the design of air extraction vents on spraybooths, which can be difficult to clean.
- While they are water users in their own right, simple water-recirculating cascades ('wet collectors') have sumps to collect the glaze sludge, hence facilitating glaze recovery.
- Care also has to be taken with regard to the design of glazing line conveyors and stands, the same principles applying. Use of wire stands with little surface area rather than solid stands, for example, helps to reduce glaze carry-over and the need for washing. More is said on this subject in the complementary Good Practice Guide (GG271) *Reducing Solid Waste Costs in the Whiteware Industry*.
- Fully enclosed vessels reduce evaporation to atmosphere and hence reduce the need for cleaning.

Elimination of vessel cleaning

A sanitaryware company installed two new dedicated and enclosed glaze blungers and associated equipment, and after two years had not cleaned them. The company checks deposits occasionally and has found that negligible build-up occurs.

4.6 Maintenance practices and related issues

Much water waste is caused by leaks, particularly from pipes, tanks and other vessels, most of which could be avoided by regular and appropriate maintenance. All pipes and tanks should, where possible, be located fully above ground so as to allow easy maintenance and simple detection of leaks. Leaks often occur from pumps, valves, joints, tanks (eg where a ball valve is not operating properly) and from corroded areas of pipes and tanks. These areas should be given particular attention. Note that in abrasive applications peristaltic 'hose' pumps can offer a low maintenance solution, being less prone to damage than centrifugal and diaphragm pumps (see Section 5.4).

Computer software is available to help with a scheduled maintenance programme. It can also help with the resetting and recalibration of process equipment (eg flow control valves, metering devices on mixing vessels, thermostats on cooling equipment).

The cost of small-scale leakage

A weeping joint or dripping tap can cost a lot more over a year than you might imagine given that you may be paying for both the water and the effluent. A trickle can equate to as much as 100 ml (a tenth of a litre) a minute or around 53 m³/year. With only 20 minor leaks around a site the annual loss will be 1 060 m³, costing the company around £1 200/year in direct water and effluent discharge costs alone (assuming no sludge to dispose of).

Valves used to control flow rates to equipment are sometimes also used for isolation purposes and subsequently reset incorrectly. This can be avoided by having a separate 'quarter turn' isolation valve in the supply line and removing the handle/handwheel from the main flow control valve. Tamper prevention can also be achieved by using locks and straps. The latter, where fitted to critical, especially safety critical, valves should be easy to break or cut in the event of an emergency.

4.7 Equipment dedication and batch sequencing

The principle of equipment dedication is an important one in that the fewer tanks, mixing vessels, pipes etc are used for different material mixes (eg different colours of glazes, different clay bodies), the less regularly they will have to be cleaned. There is a limit to the number of vessels, pipe-runs etc that can be accommodated in a typical factory, however, a sensible balance can be reached such that the majority of the equipment is used only for one or two 'recipes'. One company surveyed operates a dual supply pipe system on its glaze lines, one for dark glazes and one for light ones.

Careful batch sequencing, particularly in the mixing of glazes, should also be practised where possible to improve quality and reduce cleaning water use. This involves making similar colours/recipes in a sequence, eg going from light to dark glazes. The ability to do this does, of course, depend to a large degree on the predictability of demand and the practicality of batch storage on-site. Ideally, you need a few weeks' warning from customers to allow proper planning.

In some cases it may be desirable to extend material storage time slightly, perhaps making use of one or two new vessels to accommodate mixes and bactericides to stop any natural deterioration. As with material deliveries, storage vessels can sometimes be freed-up by putting small-volume, slower turnover materials (eg certain glaze colours) into IBCs and drums.

Batch sequencing to reduce washing

Simpsons, a small tableware company, uses many different coloured glazes and has to clean spraybooths between batches. The company has tried to minimise cleaning by moving from light glaze through to dark glaze over a period of a week or two. It has found that a switch from white to cream glaze only may involve 15 - 30 minutes' cleaning of the spraybooths, whilst a switch from blue to white, for example, could take two hours or so. This change has been difficult to achieve during periods of peak demand, because of unpredictable short lead-time ordering. However, during other periods the approach has been of significant benefit. The company is also trying to avoid short production runs, which can last less than a day, so as to reduce cleaning and downtime.

4.8 Cleaning practices and equipment

Shop-floor cleanliness is crucial for high product quality and floors and equipment need to be washed or vacuumed regularly. Cleaning is the single largest use of water and very worthwhile reductions can be made by improving cleaning practices and equipment:

- Dry cleaning, eg with scrapers, to remove residues before cleaning with water, will reduce water use and allow material recovery. This is particularly important in the case of coatings where the material can be recovered straight from application areas, allowing direct re-use.
- It helps if general cleaning is done as soon as possible after material gets on to the equipment, floor etc and before it can dry out and stick. In practice, this may mean shop-floor staff carrying out the occasional quick wipe-down during the day to make scheduled cleaning less water-intensive.
- When cleaning off sticky and viscous materials, the first stages of cleaning should involve mechanical methods rather than hosing⁵. Pipelines carrying glaze, plaster etc can be physically cleaned out using 'pigging' systems (see box below). While more commonly applied in the food and speciality chemicals sectors, at least two of the ceramic companies surveyed were using pigs on a regular basis, one for cleaning plaster lines in the mould shop (via an outside contractor) and another (Ideal Standard at the Hull site) for recovering slip from the slip distribution system.

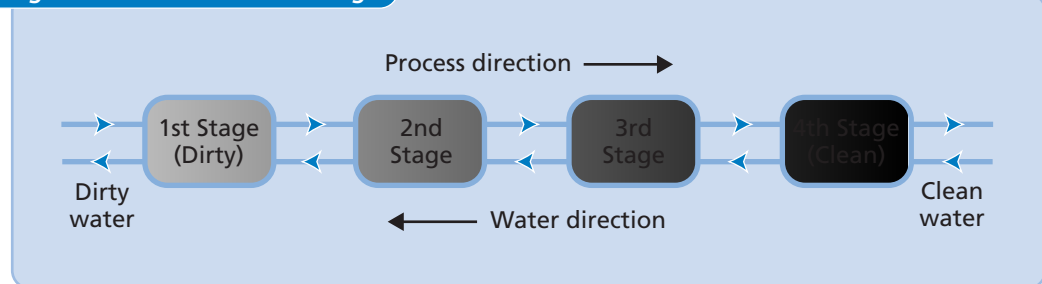
Pigging systems

Pigging systems are simple devices used for cleaning pipes and recovering raw materials. They usually involve a rubber bung (the pig) being propelled through the pipe by compressed air, pushing the residue material out at the other end prior to a final rinse through using water. The systems can be quite simple, involving a pig launcher and catcher and the appropriate valve gear, and can cost less than £10 000. Typically, they pay for themselves within a few weeks.

⁵ Further information about the recovery of high-density glaze can be found in the complementary Guide on solid waste minimisation, Good Practice Guide (GG271) *Reducing Solid Waste Costs in the Whiteware Industry*.

- The use of 'peel-off' paper sheet and plastic film to line spraybooths baths, etc can help to reduce the need for cleaning and hence the use of water. However, it creates more solid waste and generally reduces the amount of glaze that can be recovered, particularly where effluent glaze recovery systems are in operation. Using plastic bag liners in containers (eg drums and IBCs) can, however, allow greater recovery of residue materials and reduce water use.
- Cleaning water quality should be matched to its use - clean water does not have to be used every time. For example, slightly contaminated water should be used to wash moderately contaminated equipment and floors and moderately contaminated water should be used to wash very contaminated equipment and floors, as in a 'countercurrent' or 'cascade' approach. In terms of mould washing, for example, the clean water should be used for the last wash (the 'polish'), the effluent from this being used in the penultimate wash, the dirty water being used for the first wash. Fig 14 shows this diagrammatically.

Fig 14 Countercurrent cleaning



In some cases, cleaning water can be recirculated in situ as the example below from H&R Johnson demonstrates. This approach may be particularly attractive where the costs of piping to and from the effluent plant are prohibitive, although it does require local 'treatment' and the regular removal of sludges.

Recirculation of tile-wiper cleaning water

At H&R Johnson's Valley site, the tiles have their edges wiped by a series of rubber disks that are constantly washed with clean water then passes to drain with only very slight contamination. Johnson's has been trialling a home-made unit (designed by one of its Improvement Teams) which allows recirculation of this cleaning water via a small settlement tank and filter. Johnson's estimates that if this approach was applied to all glaze lines at the Valley site the saving would amount to around £20 000, implying a water saving of around 14 000 m³/year, or around 54% of the cleaning water used at the site.

- Pressurised spraying is generally more water-efficient than merely 'filling and swilling'. The worst approach is to repeatedly fill and empty a vessel or container to remove contamination such as glaze. When dealing with sticky and viscous materials, high-pressure cleaning systems are usually the best option. While these systems use far more water per minute than low-pressure systems, they can do the job far more quickly. Flow rate is actually proportional to the square root of pressure, so doubling pressure actually only increases flow rate by around 41%. However, it may reduce the time required to 10% or less, improving productivity and giving a net reduction in use of 86%. Many companies find that in difficult cleaning applications the reduction is as great as 90%. High-pressure washing systems are often found in mixing vessels, on glaze lines and in dishwasher systems (eg used after decoration and prior to overglazing).

Redesign of a glaze line washing system

Ideal Standard, at its Cheshire works, uses a 'chair wash' system which cleans glaze from the glazing carousel conveyor. The old system, which used a low-pressure pump and multiple spray nozzles, has been replaced by a new system which makes use of a high-pressure pump and a single jet spray bar. Water consumption has been cut by 67% to 19 litres/minute while cleaning performance is thought to have marginally improved.

- When using high-pressure systems, ensure that the pressure is optimum (ie not so high as to increase the water used overall) and that the nozzle/spray ball provides the optimum jet/fan of water (ie covering the 'target area' only) for the optimum period of time (given the set pressure) in relation to what is being cleaned. Cleaning-in-place (CIP) systems (usually computer-controlled and involving a permanent, in situ, high-pressure sprayball or nozzle) can be extremely effective for mixing vessels, spraybooths etc, particularly where a wash 'programme' (eg involving set times, pressures, temperatures and/or additives) needs to be applied. More information can be found in Good Practice Guide (GG120) *Cost-effective Vessel Washing*⁶. While most CIP systems are related to vessel washing, automated filter cloth/membrane cleaning systems represent another form. These can generally be retrofitted to existing presses.
- General mains-pressure cleaning hoses should be fitted with triggers (rather than taps) so that they switch off automatically when not in use. This can save a lot of money and water as the worked example below indicates. Where the flow rate is higher than required, restrictor valves should be fitted as well as triggers.

The cost of leaving hoses running

A regular 25mm (1 inch) mains-pressure hose left running constantly will typically lose over 2 m³ of water an hour. Assuming that there are 20 such hoses around a site, each left running unnecessarily for only one hour/day on average, the total loss per day would be 40 m³. Over a year, the loss would be over 10 000 m³ of water costing at least £11 000 in direct water and effluent charges alone.

- Items of equipment or areas of the shop-floor that do not need water supply constantly can have the supply controlled to ensure that hose water, cooling water etc is not left running. This can be done through existing process control systems or separately, eg through simple interlocks (eg that switch off the supply when a vessel lid is closed) or timer switches. Passive infrared sensors can also be used to switch off the water supply when the area is unoccupied, perhaps in conjunction with switching off lights and electrical power.
- General floor cleaning, that has to be carried out regularly for health and safety reasons, should be done using 'wet vacuum cleaners' which use a high-pressure jet to wet the floor and then suck up the water again. These machines use far less water than the general hosing down approach and are generally far quicker.

4.9 Equipment cooling

In some companies, plant equipment, including filter presses, vacuum pumps and casting presses, is water cooled, the water generally making one pass before being discharged to sewer. The use of cooling water can be reduced through the use of thermostats which reduce or stop the flow when the equipment is sufficiently cool and increase it when the equipment heats up. Given the inclusion of a heat exchanger in the circuit-cooling water can be recirculated directly.

⁶ This Guide is available, free of charge, through the Environment and Energy Helpline on freephone 0800 585794.

Such systems are widely used and generally give a payback period of well under 12 months (for further details see Good Practice Guide (GG67) *Cost-effective Water Saving Devices and Practices*). Being relatively uncontaminated, cooling water can also be quite readily re-used for other purposes such as cleaning (see Section 5). As the example from Spode below indicates, cooling water costs can be considerable.

Control of cooling water

At tableware company Spode, clean water was used constantly to cool equipment, this then being discharged straight to drain. As an initial step to reduce water use, thermostatic valves were fitted so that coolant ran only when needed. This reduced flows from 2 m³/hour to around 0.6 m³/hour, an immediate 70% reduction. This water is now all passed back to a holding tank in the slip house for re-use. Overall, the measure is thought to have reduced water use in the slip house by around 25%. This amounts to a saving of around 3 000 m³, or around £3 300/year taking into consideration both use and discharge savings.

4.10 Milling and mixing

The clay, glaze and mould preparation areas are the largest single uses of water for most ceramics companies and improved cleaning practices, batch sequencing and vessel dedication can go a long way to reducing water use.

Pumping directly from bulk tanks, silos and IBCs rather than decanting from drums and sacks also allows material to be introduced into the mix in a controlled manner with little risk of spillage. Further reductions in water and material use can be made if glaze and plaster are currently 'bucket' mixed at the side of the process. Changing to centralised, and, preferably computer-controlled mixing will invariably improve material quality, reduce spillage and hence reduce the need for washing down and the waste of materials to effluent.

Slip, glaze and plaster are often made only to an approximate solids:water ratio (eg 36 oz per pint), sometimes relying on the operator's judgement alone to obtain any material density.

- Adding ingredients (including water) through computerised metering systems, preferably making use of load cells on vessels, but at least using accurate scales and/or flowmeters, will help to improve accuracy.
- Where mains pressure is high, water additions can be difficult to control and more water than is necessary can be added. Flow restrictor valves should be installed to allow more accurate control.
- The monitoring of material density directly, eg using a simple hydrometer, can take into account variations in raw material moisture content.
- Slip filter pressing generates large volumes of very dirty effluent, wasting materials and water (ie those already in the slip and those used in press cleaning) and, while it is still necessary for companies making thin and translucent china and porcelain products using traditional casting and moulding techniques, many companies have now eliminated it as a process step by mixing slip directly. Some of these companies monitor slip conductivity using a probe to ensure that salt concentrations are not becoming too high.⁷

⁷ Direct slip mixing, without filter pressing, is now common practice in the sanitaryware sector, in parts of the earthenware and stoneware sectors (ie for the casting aspects of making, dewatering is still necessary for pug roll production) and where granulate pressing is used (ie granulate being spray-dried from direct-mixed slip). This change has been partly brought about by improvements in raw material quality and through better process control.

4.11 Slip casting

Traditional slip casting of sanitaryware and other hollow-ware can involve considerable waste of slip, and hence the water it contains and the water used in cleaning up. In terms of reducing spillages, the careful filling and emptying of moulds is critical. Piping the slip directly into the mould, rather than pouring it can reduce the risk of spillage, while the use of triggers rather than tap-style valves can help to reduce the risk of overflow and spillage. The removal of excess slip is best done through piped drainage systems, using pressure/vacuum assistance to pump the slip back to the slip house. Automated (eg pressure casting) systems largely eliminate the risk of slip waste and minimise the use of cleaning waters as they have in-built (CIP) systems.

4.12 Finishing and decorating

While sponging, foot-wiping and decorating are relatively small uses of water in most factories, this is not always the case. Automated sponging can help, while the re-use of sponging waters is also quite common. It is generally best to pipe the sponging waters back into the slip house for reintroduction to the slip mix. This approach allows any contaminants in the sponging waters to be diluted sufficiently so as not to cause any problems with slip quality.

Foot wiping to remove glaze can also be done automatically and, in some cases, it is possible to recirculate the glaze-contaminated wash waters prior to discharge, as the tile-wiping example from H&R Johnson in Section 4.8 shows.

Water use in the decorating areas can also be significant. For example, in relation to washing backing paper from lithographic transfers. It is generally best for each operator to have a bowl or trough of water to use rather than a sink with running water, as taps can be left running for long periods when not in use. At one tableware company, poor control of wash waters resulted in the old tissue printing department (which has now been closed) using around 10% of the site's total water consumption. Litho water in bowls has to be replaced regularly to keep it reasonably clean and to avoid potential quality problems. Controlling water cleanliness by replacing the water requires effort and hence reduces the temptation to waste water, although a balance must be achieved so as not to limit productivity.

4.13 Glaze application and recovery

The more efficient the application of glaze, the less water will be needed. High volume low pressure (HVLP) spray guns and robotic sprayers can reduce the levels of overspray, and hence glaze and water use, significantly when compared to conventional spraying techniques. This avoidance of overspray should be the main objective.

In terms of the recovery of high-density (non-effluent) glaze, good practice essentially involves the recovery of overspray glaze in its semi-solid (high-density) form through the scraping out of vessels, booths etc for return to the glaze make-up area prior to rinsing down.

For booths that use a water cascade (wet collector), good practice involves recovering glaze sludge from the cascade sump. It is also cost-effective to recover glaze from ventilation systems (eg using settlement chambers, cyclones) and pollution control equipment (eg wet scrubbers).

Efficient recovery of high-density glaze is less critical where an effluent glaze recovery system is in use. However, it is worth noting that there are still costs involved in using membrane and other filter systems in terms of energy use, water (eg for flushing), materials (eg membranes and parts) and labour.

More efficient glaze spraying

The introduction of robotic spraying equipment and HVLP guns at Armitage Shanks over the last few years has reduced water use per piece by around 18%. While the data for glaze savings were not available, they are likely to be very similar. Effluent generation has dropped by around 22% per piece as less washing is required on the robotic facilities.

More information on the topic of glaze application and recovery is given in Good Practice Guide (GG271) *Reducing Solid Waste Costs in the Whiteware Industry*.

4.14 Domestic uses

While 'domestic' uses are relatively small compared to the main process uses they are not negligible, typically being around 10 - 15% of overall use. Various measures can be taken to reduce domestic use. These include:

- Installing percussion (push) top taps on all washbasins. These can be retrofitted to standard tap bodies without the need for specialist plumbing skills. Note that such taps usually have a flow restrictor fitted which can set the flow rate to an economical level (so the tap doesn't gush).
- Installing dual-flush (short/long flush) cisterns in WCs or, as a cheaper solution, reducing the flush volume by using 'cistern bags' to displace water in the cistern.
- Installing passive infrared detectors in men's toilets to control the flushing of urinals (ie only when the urinal has been used).
- Switching to 'waterless' urinals as described in the Dudson Duraline example in the box below.

Waterless urinals at Dudson Duraline

The domestic urinals at Dudson Duraline (a tableware company) used to consume around 318 m³ of water per month or around 3 500 m³ each year, costing around £4 200. New waterless urinals have been introduced that use a small quantity of spray cleaner, applied occasionally, and 'bio-sticks' (dropped in the urinal U bend), which cost £2.90/week and £7.70/week respectively, a total of around £500/year. The net saving is therefore around £3 700/year.

- If vehicle cleanliness is an issue, consider installing a water recirculating vehicle wash system (with in-built effluent filtration). Alternatively, use a combination of hand-soaping/waxing and high-pressure 'jet-spraying', rather than low-pressure hosing which can take longer and use more water overall.

Most of the measures described above will typically have a payback period of less than a year.

Effluent drainage, treatment and re-use

Measures should always be taken first to reduce the use of water, and the amount of effluent generated. However, there will inevitably be process effluent, most of which will contain valuable clay and glaze materials. Steps should be taken to reduce its concentration. Recovering these valuable raw materials and re-using the treated effluent itself will produce considerable savings. It is also important to minimise the risk of local watercourse pollution.

5.1 Drainage and pollution prevention

It is essential, from a compliance perspective in particular, that companies understand where their drains go so that they can be used appropriately. Ideally, a drain plan should show which drains go to the effluent plant or foul sewer and which go to other outlets such as streams, rivers and canals. The drains on the plan and the drain covers on-site should be colour-coded appropriately, eg using red for foul sewer/effluent plant connections and blue for other connections. The latter should only be used for surface water (rainwater) runoff and other uncontaminated waters. Where the destination of drains cannot be established, or where you do not want to risk the pollution of local water courses, drains should be permanently isolated (blocked).

Material storage areas should be located above ground and be 'bunded' (to 110% of the capacity of the largest container, or 25% of the combined capacity, whichever is the larger). Bunding requires an impervious floor and impervious wall (with no drain points) to ensure that any spill will be contained. Bund walls should be sufficiently high, or far enough away from vessels, so that liquids cannot 'jet' over them. Rainwater should be regularly pumped out of the banded area so as to maintain its capacity. Material delivery areas and areas where vehicle refuelling and washing take place should also be banded or connected to foul sewer with oil interceptors installed if necessary.

You should also have contingency plans to cover any serious spillages. Ideally, you should provide spillage kits around the site to clean up any large spills, and have the means to isolate surface water drains. The simplest and cheapest option is to have drain covers/bungs available for use during certain procedures or in the event of an accident.

More detailed information on pollution prevention can be obtained from the Environment Agency through the web site, www.environment-agency.gov.uk or through the Agency enquiry line on 08459 333111.

5.2 Stream segregation and material recovery

Given that material recovery should be, after pollution control, a key objective of effluent treatment, it is crucial that steps be taken to segregate effluent streams and, in particular, to separate the glaze and clay streams. This means extra drains/pipework, valves and tanks, however, this will allow clay and glaze recovery.

Glaze recovery

Glaze does not settle out particularly well in isolation and thus recovery of glaze from effluents is most effectively done through the use of separation technologies in the form of filter presses and more sophisticated microfiltration systems. The latter employ cross-flow membranes made from cloth or ceramic materials. Several companies use such systems (see overleaf).

Glaze recovery at Royal Worcester, Ideal Standard and Spode

At Royal Worcester, a ceramic membrane glaze recovery system was recently installed at a cost of around £60 000. The expected payback period of 18 months was reduced significantly with the investment being recovered in six to eight months, with 200 m³ of water from the system re-used yearly by recycling on spray machine spindle washing, saving a further £220 or so in direct water and effluent discharge costs.

Ideal Standard has also installed a ceramic microfiltration system which recycles most of the glaze washings. The membrane system saves approximately 5 tonnes of materials (dry weight) a week or around 236 tonnes/year. The glaze savings are costed at £300/tonne, giving a yearly raw material saving of just over £70 000. Given that the ceramic filters are replaced every six months, at a cost of about £8 000 each year, the net yearly saving is just over £62 000.

At one large tableware company, dedicated tanks have been installed to collect the wash water for the bulk glazes used (unusual colours are not recovered). The glaze is allowed to settle out (some flocculants being added to assist this) prior to direct recovery. The system cost only £15 000 and is believed to produce savings of around £60 000/year.

Spode passes glaze effluent through two filter presses, one for earthenware glazes, one for china glazes. The glaze cakes are then remixed with water in an open bath for re-use. No flocculant is used so that the glaze is chemically unaltered. Recovery has approximately halved the use of glaze per piece saving around £90 000, with a payback period of less than five months.

In most cases, only the key high-volume glazes, including white, are diverted to the recovery systems, leaving the low-volume (generally coloured) glazes mixed in the remaining effluent. While coloured glazes can be very expensive (well over £1 000/tonne), recovery of low-volume colours separately can be costly due to the capital costs of the recovery system, extra pipework and storage tanks, and labour costs. Care should therefore be taken when deciding if it is cost-effective.

Some companies do use flocculants (eg aluminium sulphate) in their recovery systems without there being any noticeable deterioration in glaze quality. However, the minimum amount of flocculant should be used to avoid altering the chemical composition of the recovered glaze.

Clay recovery

While of far lower value than glaze, recovery of clay solids from effluent can also be very cost-effective. Simple settlement (with or without the use of flocculants) in clarifier cones allows sludges, or filter cake if more convenient, to be mixed back at a low concentration into the clay body. H&R Johnson recovers clay solids this way, re-using sludges directly by trickling them back into the clay body mix. One large tableware company is also investigating this option, but may choose to segregate the effluents from the three different 'bodies' so that they can be re-used directly in the clay body from which they were generated.

Ideal Standard uses a more sophisticated ceramic membrane system to recover its clay solids, as featured in Case Study (NC81) *Solids Recovery Reduces Costs and Minimises Waste*⁸. This describes how around 6 tonnes of clay solids were being lost each day at Ideal, amounting to around 2 000 tonnes/year worth around £140 000, of which around 58% is now being recovered saving £60 900 in raw material costs alone.

⁸ This Case Study is available, free of charge, through the Environment and Energy Helpline on freephone 0800 585794.

5.3 Effluent treatment

While it is necessary for a company to stay within the limits set by its effluent discharge consent, it is worth noting that anything that can be done to reduce effluent volumes and/or solids content will reduce trade effluent charges (these being based on volume and suspended solids) and sludge removal costs. Good practice in effluent treatment (apart from glaze and clay recovery), is to use semi-automated and continuously monitored treatment plant, such as that operated at Denby and Armitage Shanks. The main components of a good system are:

- flocculation with aluminium sulphate and, if necessary, polyelectrolytes;
- buffering (eg with NaOH, lime) to adjust pH and ensure maximum precipitation;
- clarification in a settlement cone;
- sludge filter pressing to produce a dewatered cake to reduce the costs of disposal;
- final settlement (eg in a lagoon) or filtering to polish prior to discharge;
- a turbidity meter on the final effluent stream to monitor effluent quality;
- a V-notch weir or other metering device to monitor effluent volumes;
- holding tanks, downstream of the plant, to allow extra storage capacity in emergencies.

It is particularly important that pollution accidents are prevented, eg those relating to a major spillage, a torn filter press cloth or a failure in the control of the effluent plant. Turbidity meters, linked electronically to valves and other equipment, eg filter presses, ensure that if the level of suspended solids in the effluent goes above a certain percentage (say 50%) of the consented discharge limit, the flow will be automatically diverted to a holding tank or stopped.

Filter pressing of sludges is also well worth doing as it can dramatically reduce disposal tonnages and costs as the example from Dudson Duraline below shows. Filter cake can be used in brickmaking and in some cases (depending on the level of contamination) in certain clay ceramic bodies. It is also important to optimise control of the effluent treatment plant, eg through the use of controlled dosing pumps, which can reduce chemical use significantly, and save thousands of pounds a year.

Introduction of sludge filter pressing at Dudson Duraline

Dudson Duraline produces around 20 tonnes/week of sludge amounting to a total of 970 tonnes/year which costs over £27 000/year to dispose of at £28/tonne. The company is now filter pressing, producing around 55 tonnes of cake each year which costs around £1 300/year to dispose of, saving £26 700. The new filter press cost around £12 000, giving a payback period of less than six months. The resulting effluent can be re-used for cleaning, saving on water use and effluent discharge costs. At a later stage, the company also hopes to find markets for the filter cake.

5.4 Re-use of excess waters/effluents

Cooling waters and most effluents, treated and sometimes untreated, can be used around the site, primarily for cleaning purposes but in some cases also in the product itself. However, it is important to match the quality of the effluent to the application. Local collection and re-use (eg of slip house wash waters) are desirable as they avoid the need for long pipe runs and hence high investment and pumping costs, even though the opportunities for re-use will be more limited. Use of 'clean' treated effluent offers more possibilities, in most cases allowing at least 60% of the effluent to be re-used.

Note that the dirtier the effluent the more likely it is to cause blockages and abrasion in pipes, pumps, valves etc. In terms of pipes, nozzles etc, it is worth noting that:

- pipe runs should be designed with as few bends and other sediment traps as possible;
- circular holes/nozzles are less likely to block than flattened ones of the same area;
- larger diameter holes can be used, spraying onto a diffuser plate to give the required fan coverage;
- self-cleaning pipes and nozzles are available.

Lower pressure pumping can be achieved using peristaltic or 'hose' pumps, where water does not come into contact at all with mechanical parts. Instead, it is squeezed through by a cam which acts on the outside of a flexible pipe. Such pumps can achieve flow rates of 80 m³/hour and pressures up to 16 bar (230 psi). While they typically cost at least twice the price of conventional pumps, eg centrifugal pumps, they are low maintenance and use less energy than conventional pumps, making them cheaper in the medium term. The payback period is typically around two years in abrasive applications. Such pumps are already used for pumping slip in some ceramics companies.

Where a high proportion of the effluent is to be re-used for cleaning sensitive areas, eg vessels and pipelines, it is appropriate (at least initially) to keep a check on salt levels, eg by using a conductivity probe. Salts can build up within the closed cleaning/effluent loop. Clean water can be mixed continually with the diverted effluent to reduce concentrations. Continuous monitoring of salt levels is essential where the effluent is to be used in the product mix itself, as at Denby.

Re-use of filter press water at Denby

Denby, a producer of stoneware tableware products, recycles slip house filter press water back into slip production. To ensure that no quality problems occur, a conductivity probe is used to measure salt concentration. On reaching a certain threshold, contaminated water is bled off and fresh water introduced.

Staff training and participation

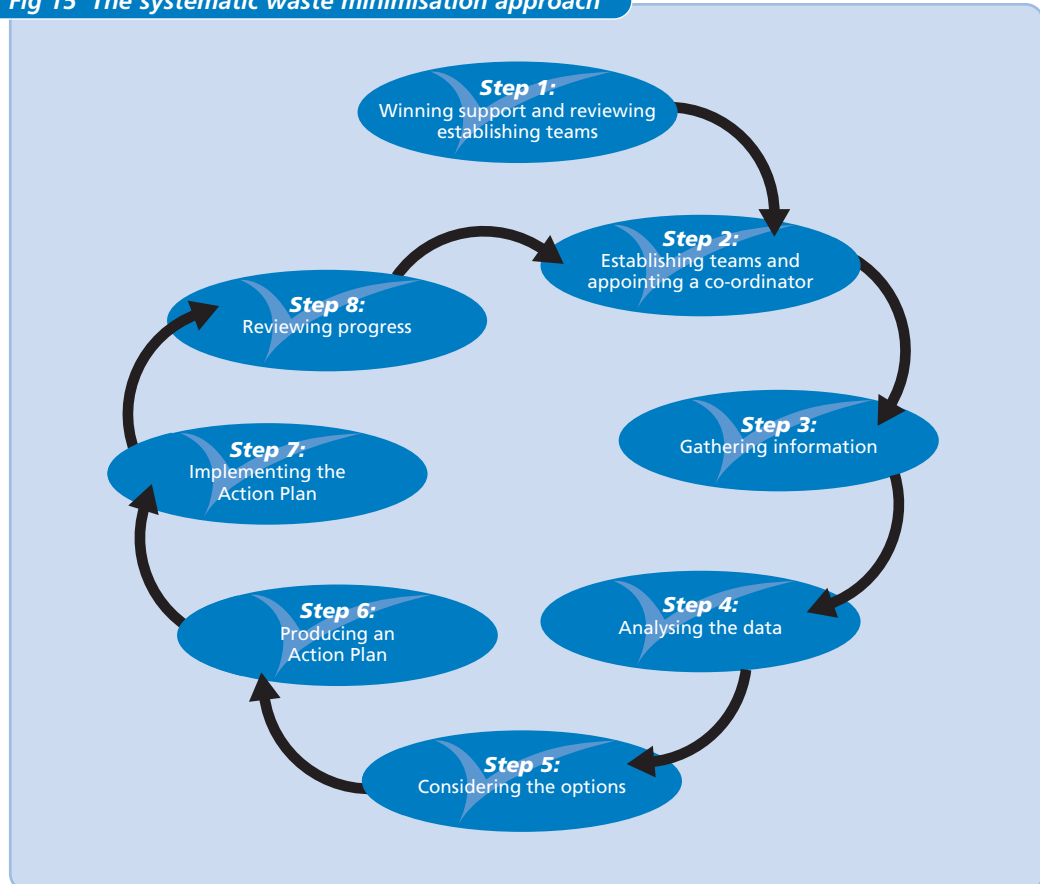
Staff at all levels can play an important role in reducing water consumption and effluent generation. Training of process operators and supervisory staff is particularly important in relation to using the correct machine settings and procedures, the correct handling of materials and the early identification of problems. All this should be done through formal rather than on-the-job training, emphasising the value of materials and waste and the impact that improvements can have on salary, job security and working conditions. Occasional refresher courses should also be used, as appropriate, in part to keep staff up-to-date with developments. Written procedures should be provided and displayed to ensure that staff know exactly what is expected of them.

Accountability can also be an effective tool in reducing waste. Using separate water meters for different process stages or departments makes shop-floor staff and managers more accountable and hence more likely to take water waste seriously. In terms of staff involvement in waste minimisation procedures, it is particularly important that any improvement teams that are established include shop-floor staff and supervisors, the people who are often aware of particular water waste issues and the practicality of measures that can be taken to deal with them. Suggestion schemes can also be useful, not least because they help to make people feel more involved. It is important to provide feedback on progress, through team briefings, newsletters, notice-boards etc; some companies having salary-based incentive schemes related to improvements. These incentive schemes have been shown to be extremely effective at encouraging staff to reduce waste.

Taking a systematic approach

The best way to make things happen is to take a systematic continuous improvement approach, perhaps within a wider health, safety, energy and environment programme across all sites. Fig 15 shows a simple sequence of steps.

Fig 15 The systematic waste minimisation approach



Step 1: Winning support and the initial review

The first step must be to convince senior management, eg the production director or managing director, that the site would benefit from improvements aimed at reducing water use and effluent generation. This may be difficult without some supporting evidence gained in an initial review. The initial review should involve:

- Walking around the site to identify areas of waste and savings/re-use opportunities using the **checklist (Appendix 1)** as a guide.
- Estimating the approximate benefits, including quality benefits as well as cost savings, associated with a few of the more promising measures identified. An example **worksheet (Appendix 2)** is provided to help you to demonstrate the cost savings.
- Presenting the potential savings to senior managers to gain their full support for further measures.

Step 2: Establishing teams and appointing a co-ordinator

In most companies, the impact and responsibility for water use and waste are spread over a number of departments. It is, therefore, usually essential to establish a team that includes:

- the health, safety and environment manager;
- manufacturing/production managers;
- shop-floor staff.

Not all of these people will necessarily be involved at all stages of the process, however, they should be identified at the start and called upon as necessary. In some cases it may be necessary to establish more than one team, for example, where there is more than one site or division. It is useful to have one overall project co-ordinator or 'Champion', to lead and facilitate the work. The leader or co-ordinator should preferably be someone with:

- sufficient authority to make things happen or direct access to someone with that authority;
- a good understanding of how the company operates in all areas and preferably personal contacts in these areas;
- an ability to listen to the views of others and make objective decisions;
- enthusiasm for, and belief in, waste minimisation.

Out of necessity, the co-ordinator is likely to have to fit in the new responsibilities with existing ones and it is important that time is clearly set aside for them to do so. For more information on this subject, see Good Practice Guide (GG27) *Saving Money Through Waste Minimisation: Teams and Champions*⁹.

Step 3: Gathering information

Monitoring and understanding water use and effluent generation are essential to allow improvements to be carefully targeted. In simple terms, if you don't measure it, you can't manage it. Mains water use can be determined by looking at site meter readings, preferably a company's own rather than those taken by the water company. Even where water is abstracted from a borehole, canal or watercourse, a company should still monitor volumes to a) ensure that the abstraction consent is not exceeded and b) to allow accurate water use analysis.

The discharge to sewer from the effluent plant should also be monitored using an appropriate meter (see Section 4). Be wary of water company bills as they may be inaccurate, in particular, in relation to effluent volumes which are often based on historical data, spot readings and estimates. As noted earlier, typically around 40% of the water will be evaporated off during a ceramics production process and hence a company should be billed only on the remaining 60% or so.

While site level data can be very helpful, ideally the company 'Champion' should monitor water use, and if possible effluent generation, at the key water-using stages of the manufacturing process. This approach can be very valuable in that it helps to identify and deal with the causes of water waste and makes departments more accountable. The most important areas are the:

- clay and glaze preparation;
- making areas, ie casting, moulding, pressing;
- glaze application.

⁹ This Guide is available, free of charge, through the Environment and Energy Helpline on freephone 0800 585794.

However, the only simple way of achieving this is to meter supply and effluent pipes to and from the specific areas of interest. Simple and, in some cases, non-invasive (strap-on) meters can be installed for a few hundred pounds a time (see Section 4.1.1).

An alternative or supplementary approach involves the use of audit techniques. It is possible to estimate consumption rates for a production area by considering the various flows into that area individually. In some cases, pump rates will be known and if not, estimates can be made (for low pressure flows) by temporarily disconnecting pipes or opening valves to allow a container of known volume to fill up. For example, if a 15 litre bucket takes 2 minutes 30 seconds to fill then the flow rate is:

$$15/2.5 = 6 \text{ litres/minute or}$$
$$6 \times 60/1\ 000 = 0.36 \text{ m}^3/\text{hour}$$

Timing the number of hours that the supply is in use allows a total consumption figure to be derived. For example, if the supply noted above goes to a glaze line washing system which is used for five hours a day, the daily use would be:

$$5 \times 0.36 = 1.8 \text{ m}^3$$

It should be remembered that the mass of water is always preserved. Water that comes into a process must:

- leave as effluent;
- evaporate;
- be retained in the product (chemically or temporarily as it dries out).

In other words, inputs must equal outputs in what is known as a 'mass balance'. Knowing some of the information can therefore allow certain 'unknowns' to be estimated. While this approach can be complicated for a site overall, given the various aqueous materials used and transferred around site and evaporation from product at various stages, a mass balance can be very useful in certain circumstances and for certain 'contained' areas as the worked example in the box opposite indicates.

Note that when recording data for analysis, for the site as a whole or for parts of it, you must stick to regular intervals of time. While yearly data are useful, it is necessary to use a shorter time interval to monitor progress and identify potential problems. It is best to record data on a four-weekly basis if possible, with yearly summaries covering 13 periods. Calendar months vary, making period to period comparison more difficult.

Mass balance example

In one flatware pressing area there is a flow of cooling water (I1), a flow of sponging water (I2) and also one hose which is used for occasional cleaning (I3). It is estimated that, as a daily average:

$$I1 + I2 + I3 = 21 \text{ m}^3/\text{day}.$$

All of this water goes to drain once it has been used and then directly to the effluent plant where the average daily outflow (O1) is measured to be 12 m³. As the area is generally kept at around 20°C, evaporation (O2) is thought to be less than 5% overall, say 1 m³. Note that while moisture in the granulate is strictly an input and an output (it will evaporate off), it is completely separate from the other streams and can be ignored. We can see, therefore, that we can account for only 13 m³ of the input water, suggesting that there is a loss (O3). The mass balance is therefore:

$$21 = O1 + O2 + O3 \Rightarrow 21 = 12 + 1 + O3$$

$$\text{therefore } O3 = 21 - 13 = 8 \text{ m}^3$$

It seems that 38% of the input water is being lost, probably due to a leak from a drain or perhaps through seepage from the floor into the ground or to other areas.

Step 4: Analysing the data and investigating potential problems

Water use and effluent data should be examined and analysed with the aim of improving efficiency and saving money. The first step in analysing the data is to relate them to production throughput for the same period as covered by the water data. As indicated in earlier, it is generally best to record water use and effluent production per piece manufactured so as to eliminate variations caused by changes in production. The figure should include all product manufactured, including 'best', rework and pitcher, ie all aspects of production that have involved water use. 'Final best' quantities are only a good indicator if 'best' yields stay approximately the same. The box below suggests a few more indicators of water use efficiency to consider.

Suggested water/effluent indicators*Site Level:*

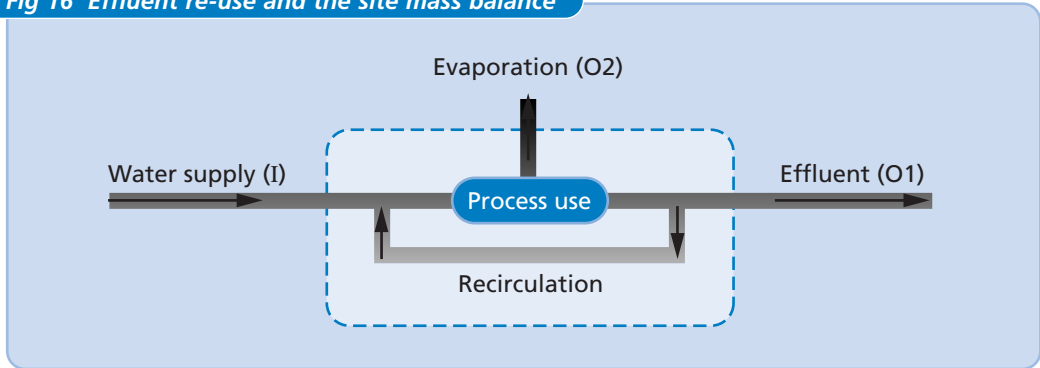
- Site water use per piece. This is perhaps the most fundamental. Remember to include all sources, including boreholes, canal water etc as well as mains water.
- Site effluent to water use ratio. This should decline quickly as non-product water is used more efficiently and effluent re-used (see Fig 17 overleaf).

Process Level (in order of importance):

- water use in the glazing area(s) per piece glazed;
- water use in the clay preparation area per quantity (eg tonne or m³) of clay/slip produced;
- water use in the glaze preparation area per quantity (eg tonne or m³) of glaze produced;
- water use in the making area(s) per piece made;
- water use in the mould preparation area per mould produced.

It is instructive to think about the effluent to water use ratio in terms of the mass balance idea and re-use. Considering the site as a whole provides the situation depicted in Fig 16.

Fig 16 Effluent re-use and the site mass balance



Given that the recirculation goes on internally within the 'box' the mass balance must mean that:

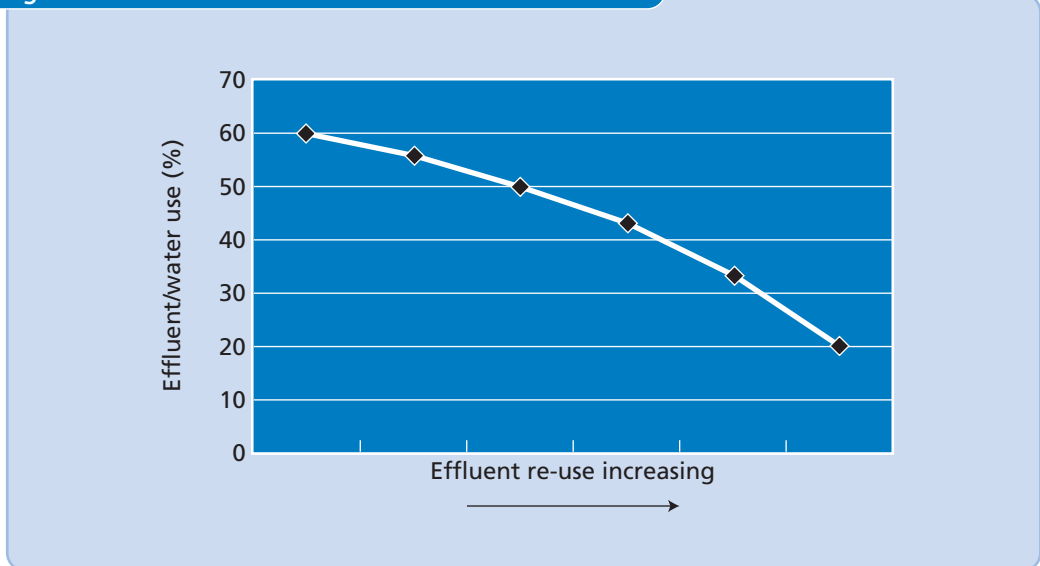
$$I = O1 + O2$$

Therefore as more and more effluent is re-used, 'O1' diminishes and 'I' can be reduced by exactly the same amount; 'O2' stays the same as necessitated by the process (ie the fixed amount of water in the clay and glaze). Table 4 below shows the situation for a site which initially uses 20 000 m³ of water with 12 000 m³ of effluent and which then begins to re-use an increasing amount of this effluent. The change in the effluent/water use percentage is shown in Fig 17.

Table 4 Effluent re-use and the effluent/water use ratio

Water supply	Effluent to sewer	Effluent/water use (%)
20 000	12 000	60.0
18 000	10 000	55.6
16 000	8 000	50.0
14 000	6 000	42.9
12 000	4 000	33.3
10 000	2 000	20.0

Fig 17 Effluent re-use and the effluent/water use ratio



In terms of analysing key stages of the production process, it can be very useful to look at the change of water use on a month by month basis and even to compare one process with a similar one, eg two glaze lines. A number of important questions can be asked, for example:

- Is water use per piece reducing over time? Is there still potential for further improvement?

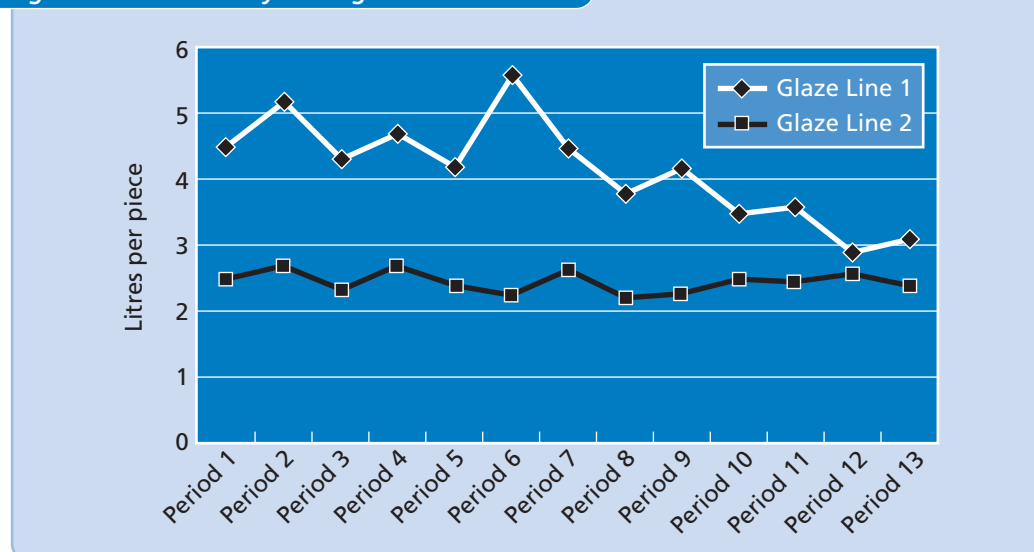
- How does water use per piece compare from one production line to another? Should they be very similar (eg same equipment and same product)? Is the variation normal or is there a problem? Is it possible to identify the good practice that is causing the lower water losses?

Generally, the best way of considering this type of question is through the use of graphs. Fig 18 shows how water use per piece is changing over a year (13 four-week periods) for two glaze lines.

In this case it is clear that Line 1 uses significantly more water per piece than Line 2, the difference perhaps being caused by a leaking cleaning hose or water pipe on Line 1. It is also interesting to note that the **variation** in use is far less on Line 2 than Line 1, indicating, as could be expected, that the more economical line is better controlled.

It is also worth noting that Line 1 uses a particularly large quantity of water in Periods 2 and 6, perhaps caused by a particular problem encountered and dealt with at that time. Clearly there is a need to investigate the causes of both the higher overall use and the significant variations. If the problems can be identified and fixed, the water consumption on Line 1 can be brought down to around the same levels as on Line 2.

Fig 18 Water use analysis for glaze Lines 1 and 2

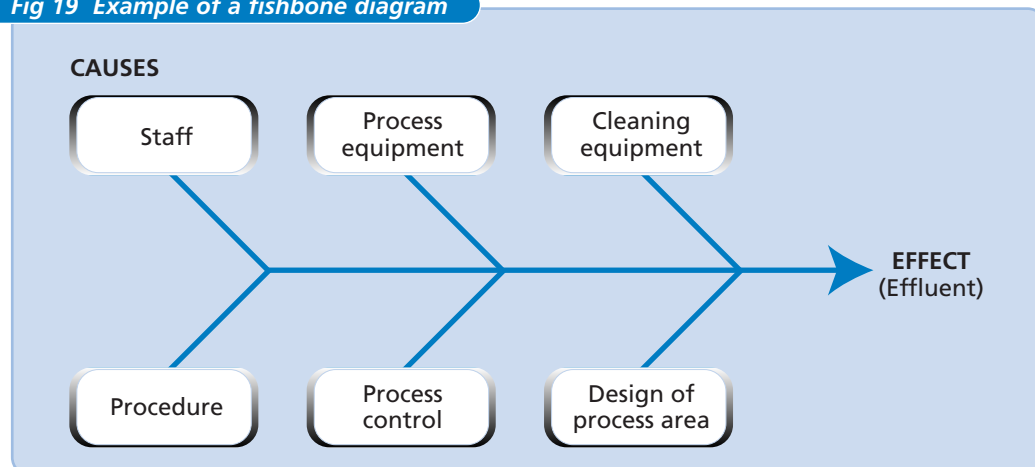


Clearly all possibilities have to be investigated in a systematic way to establish the real issues and problems. Brainstorming sessions, aided by the use of cause and effect 'fishbone' diagrams (which can have as many bones on them as you have possible causes, and further fishbones for each of those causes), can be a useful tool at this stage, helping to set out the possibilities and record the brainstorming session. It is worth noting that the vast majority of the 'effect' is probably caused by only a handful of causes. This is sometimes referred to as the Pareto or 80:20 rule (ie 80% of the effect caused by 20% of the causes).

Make sure you involve all relevant staff in these investigations (including the shop-floor staff who are often in the best position to help with constructive comments and suggestions) so as to cover all possibilities and improve motivation and ownership of the problem. It is worth noting that problems which do not appear to relate to any obvious causes or which have proved difficult to solve in the past, may be the result of a complex mix of causes. Such problems may need more detailed scientific investigation, making use of extra information and statistical methods¹⁰.

¹⁰ Statistical process control allows more detailed analysis as explained in Good Practice Guide (GG223) *Preventing Waste in Production: Industry Examples* and (GG224) *Preventing Waste in Production: Practical Methods for Process Control*, available free of charge through the Environment and Energy Helpline on freephone 0800 585794.

Fig 19 Example of a fishbone diagram



Once the causes of the various problems have been investigated it is worth converting each major 'effect' (ie water waste) into a financial value through consideration of the costs as discussed earlier. As a minimum, consider the material costs (water, lost glaze and lost clay) and disposal costs (effluent discharge and sludge/filter cake disposal). This sort of cost data will be useful in setting priorities and will provide useful facts when persuading senior managers to implement improvements.

Step 5: Considering the improvement options

Having established where there is a waste problem, and the probable cause(s), the various improvement options can be considered and prioritised. The **checklist** (see Appendix 1) should be useful again here in identifying opportunities for waste reduction, re-use and recycling in relation to the identified problem areas. At this stage it is particularly important to involve all personnel from the team to ensure that all opportunities are considered. Brainstorming sessions can again be useful to draw out the key improvement measures. Staff suggestion schemes, linked to some sort of reward, can also be useful in terms of generating improvement ideas. Once again, it is worth noting the 80:20 rule. The majority of the desired improvement can usually be obtained through only a small number of measures.

Each improvement option should be considered in terms of its cost to the company, its likely benefit (ie the potential saving identified in Step 4) and the level of difficulty that may be faced in implementing it. The latter is, of course, linked to the cost to the company in terms of the amount of time and effort that will need to be expended. This approach will give some indication of the net benefit of making the change and will allow calculation of the payback period:

$$\text{Simple Payback Period (Months)} = 12 \times \text{Capital Cost/Net Yearly Saving}$$

Generally it will be best to put the easier and low-cost measures first on the list of priorities so that results can be achieved quickly. This will motivate everyone concerned and give them confidence to tackle the more difficult and perhaps more costly measures later. In some cases it may be necessary to carry out trials work to ensure that suggested changes are feasible¹¹.

Step 6: Producing an Action Plan.

Having considered the various options, prepare an Action Plan. This should set out the various problem areas, the proposed priority improvement measures (complete with cost and benefit information) and ambitious but achievable targets and timescales. In some cases you may want

¹¹ See Good Practice Guide (GG82) *Investing to Increase Profits and Reduce Wastes*, which describes the cost savings and other benefits associated with investment in technology that produces less waste. This Guide is available, free of charge, through the Environment and Energy Helpline on freephone 0800 585794.

to use 'best' performance from the past as a reference for targets. Obviously targets should relate to parameters that are being measured so that progress can be assessed. The indicators noted in Step 3 allow targets to be set and tracked for the site as a whole and for specific parts of the process. Typical targets for one year may include, eg:

- to reducing overall site water use to 3 litres per piece;
- increasing effluent re-use by 50%.

Consult with as many staff as possible to obtain their comments on the practicality of the plan and the potential barriers to it. This will give them some ownership of the project. It is also important to make everyone aware of the potential benefits of the measures (improved profitability, better job security etc). This can be achieved through the use of presentations, newsletters and notice-boards. It is also worth considering incentive schemes.

Once a draft Action Plan has been developed, it should be passed on to senior management for comment. The final modified plan can then be agreed at board level. This step is important since without full management commitment, implementation will be difficult.

Step 7: Implementing the Action Plan.

Implementing the Action Plan will involve much detailed teamwork, however, this should be made that much easier and more productive as a result of the steps that have gone before it. Again it is important to get everyone involved in plan implementation, from the managing director down to those on the shop floor. It is essential to keep people informed of the measures being taken and the progress being made through newsletters, notice-boards, team briefings etc, to maintain interest and motivation.

Step 8: Reviewing progress regularly

Once implementation of the Action Plan is taking place, review progress against targets regularly: perhaps first on a six-monthly basis and then later on a yearly basis. It may also be helpful to review:

- How successful the indicators have been in terms of the accuracy and relevance of the data collected.
- How successful the team itself has been. The team may need to change as the work progresses.

Further assistance

Having read this Guide you may want further assistance. The **Environment and Energy Helpline (0800 585794)** can:

- send you free copies of relevant Envirowise publications and suggest other sources of information;
- provide free advice by telephone concerning all aspects of environmental management and regulation;
- arrange for a Fast Track visit for your company if you employ fewer than 250 people, at the discretion of the Helpline Manager.

You can also visit the Envirowise web site at www.envirowise.gov.uk for the latest information on Envirowise seminars, workshops, publications and links to other sites.

The **British Ceramic Confederation (BCC)** can also provide advice to members on environmental regulation. The BCC has published *Guidance on Introducing an Environmental Management System for Ceramics*, which includes useful advice and industry case studies. Contact the BCC at:

British Ceramic Confederation
Federation House
Station Road
Stoke-on-Trent
ST4 2SA
Tel: 01782 744631
Fax: 01782 744102
E-mail: bcc@ceramfed.co.uk

The **Waste Exchange** in Staffordshire, *Waste Matchers*, can put producers of waste in contact with potential users through their web site: www.waste-matchers.co.uk

Can your company do any of the following to reduce water and material waste:

	Investigate further	Implement now
Material Delivery and Storage		
■ Have materials delivered in areas that are bunded or properly drained to foul sewer/interceptors?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use plastic bag container liners with valuable materials (eg coatings) to reduce residues?	<input type="checkbox"/>	<input type="checkbox"/>
■ Transfer viscous materials in warm areas, or use drum warmers to reduce residues?	<input type="checkbox"/>	<input type="checkbox"/>
■ Have more materials delivered in bulk, straight into enclosed silos/tanks?	<input type="checkbox"/>	<input type="checkbox"/>
■ Have smaller quantities delivered in returnable containers, preferably 1 000 litre IBCs?	<input type="checkbox"/>	<input type="checkbox"/>
■ Store bagged/containerised materials more securely, in stable piles away from fork-lift routes etc?	<input type="checkbox"/>	<input type="checkbox"/>
■ Move underground tanks above ground to reduce the risk of unnoticed leaks?	<input type="checkbox"/>	<input type="checkbox"/>
■ Fit tanks and vessels with overflow protection devices?	<input type="checkbox"/>	<input type="checkbox"/>
■ Fit storage areas with appropriate bunds?	<input type="checkbox"/>	<input type="checkbox"/>
Material Distribution and Handling		
■ Distribute liquid materials (eg coatings) around the site using piped systems?	<input type="checkbox"/>	<input type="checkbox"/>
■ Keep piped systems above ground and away from potential damage (eg fork-lift routes)?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use peristaltic (hose) pumps to reduce pump wear and improve material quality?	<input type="checkbox"/>	<input type="checkbox"/>
■ Dedicate equipment to reduce the need for cleaning (and hence losses to effluent)?	<input type="checkbox"/>	<input type="checkbox"/>
■ Design vessels and spray booths so as to eliminate material 'traps'?	<input type="checkbox"/>	<input type="checkbox"/>
■ Design glaze line stands, belts, carousels etc so as to reduce glaze carry-over?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use enclosed/lidded containers to reduce the contamination and spillage of liquids?	<input type="checkbox"/>	<input type="checkbox"/>
■ Stabilise fork-lift and trolley loads (eg with stretch-wrap/banding) to minimise the risk of spillage?	<input type="checkbox"/>	<input type="checkbox"/>
■ Pump liquids from containers, or use small containers to decant, rather than tipping?	<input type="checkbox"/>	<input type="checkbox"/>

	Investigate further	Implement now
Maintenance and Related Issues		
■ Improve equipment maintenance to prevent leaks?	<input type="checkbox"/>	<input type="checkbox"/>
■ Set up a scheduled maintenance programme, preferably making use of appropriate software?	<input type="checkbox"/>	<input type="checkbox"/>
■ Check equipment settings and calibrations more regularly to ensure optimum control?	<input type="checkbox"/>	<input type="checkbox"/>
■ Fit isolator valves and tamper protection to avoid regulator valves being misused?	<input type="checkbox"/>	<input type="checkbox"/>
■ Keep a drainage plan and colour code drain covers - blue for surface water and red for foul sewer?	<input type="checkbox"/>	<input type="checkbox"/>
■ Block drains which have an unknown destination?	<input type="checkbox"/>	<input type="checkbox"/>
■ Keep spillage kits and drain covers around the site to deal with emergencies?	<input type="checkbox"/>	<input type="checkbox"/>
Cleaning Practices and Equipment		
■ Do more to 'clean as you go' on equipment etc?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use mechanical methods (eg scraping) prior to hosing down?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use 'pigs' to recover material from pipelines prior to rinsing?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use cleaning water in a 'counter-current' way, dirty water for the first wash, clean water for the last?	<input type="checkbox"/>	<input type="checkbox"/>
■ Fit triggers to hoses so that they switch off automatically when not in use?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use timers and sensors to switch off water when areas are unoccupied?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use high-pressure systems for difficult cleaning jobs?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use wet vacuum cleaners for general cleaning rather than hosing down?	<input type="checkbox"/>	<input type="checkbox"/>
Process Measures		
■ Improve control of water additions to the mix, eg using computerised equipment?	<input type="checkbox"/>	<input type="checkbox"/>
■ Mix slip directly without filter pressing, monitoring salt concentration?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use automated and semi-automated slip casting systems?	<input type="checkbox"/>	<input type="checkbox"/>
■ Pump slip to the casting area and back to the slip house for recovery?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use thermostatic control of cooling waters to reduce use?	<input type="checkbox"/>	<input type="checkbox"/>
■ Recirculate cooling waters via a heat exchanger/chiller?	<input type="checkbox"/>	<input type="checkbox"/>
■ Improve equipment/procedures in finishing and decorating?	<input type="checkbox"/>	<input type="checkbox"/>
■ Improve coating application efficiencies using high efficiency spray guns (eg HVLP) and robots?	<input type="checkbox"/>	<input type="checkbox"/>
■ Reduce air extraction rates to reduce coating losses to atmosphere?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use spray booth 'wet collectors' with sumps to allow glaze recovery?	<input type="checkbox"/>	<input type="checkbox"/>
■ Recover coatings from application areas and air extraction systems (eg using settlement/cyclones/filters)?	<input type="checkbox"/>	<input type="checkbox"/>

	Investigate further	Implement now
Domestic Water Use Measures		
■ Install percussion taps on wash basins?	<input type="checkbox"/>	<input type="checkbox"/>
■ Install dual-flush cisterns or cistern bags in toilets?	<input type="checkbox"/>	<input type="checkbox"/>
■ Install passive infrared detectors to control the flushing of urinals?	<input type="checkbox"/>	<input type="checkbox"/>
■ Switch to waterless urinals which use biological methods to break down urine?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use water recirculating systems for vehicle washing?	<input type="checkbox"/>	<input type="checkbox"/>
Effluent Treatment, Re-use and Material Recovery		
■ Segregate main glaze (eg white) and clay effluent streams to maximise re-use opportunities?	<input type="checkbox"/>	<input type="checkbox"/>
■ Recover settled clay sludges to allow direct re-use in the clay body?	<input type="checkbox"/>	<input type="checkbox"/>
■ Recover additional clay from effluent using filter presses or membrane systems?	<input type="checkbox"/>	<input type="checkbox"/>
■ Recover glazes from effluents/sludges using filter presses or membrane systems?	<input type="checkbox"/>	<input type="checkbox"/>
■ Treat remaining effluents using a semi-automated treatment plant?	<input type="checkbox"/>	<input type="checkbox"/>
■ Pump treated effluents for re-use using low-maintenance peristaltic (hose) pumps?	<input type="checkbox"/>	<input type="checkbox"/>
■ Design effluent pipe runs etc with the minimum number of sediment traps?	<input type="checkbox"/>	<input type="checkbox"/>
■ Use different nozzles and spray bars to prevent blocking and allow effluent re-use?	<input type="checkbox"/>	<input type="checkbox"/>
■ If mixed sludge needs to be disposed of, filter press it to dewater and thereby reduce disposal costs?	<input type="checkbox"/>	<input type="checkbox"/>
Staff Training and Motivation		
■ Improve training in terms of water reduction, process control etc?	<input type="checkbox"/>	<input type="checkbox"/>
■ Provide written procedures?	<input type="checkbox"/>	<input type="checkbox"/>
■ Improve staff involvement in waste minimisation activities?	<input type="checkbox"/>	<input type="checkbox"/>
■ Set up a suggestion and/or incentive scheme?	<input type="checkbox"/>	<input type="checkbox"/>
■ Provide better feedback, via newsletters, team briefings etc?	<input type="checkbox"/>	<input type="checkbox"/>
■ Increase department/staff accountability for waste?	<input type="checkbox"/>	<input type="checkbox"/>

Cost savings worksheet

Cost savings worksheet

Area/Department:

Cost-saving measure	Approx. reduction (%)	Quantity affected per year (m ³ , kg etc)	Unit cost (£)	Projected yearly saving (£)	Approx. capital cost (£)	Payback period (months)
	A	B	C	$A \times B \times C / 100 = D$	E	$12 \times E / D$
1. Clay recovery	50%	3 000	120	180 000	60 000	4
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
Totals	n/a	n/a	n/a			

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 AEA Technology Environment and NPL Management Limited.

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 consultants, 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.



Harwell International Business Centre | 156 Curie Avenue | Didcot | Oxfordshire | OX11 0QJ
E-mail: helpline@envirowise.gov.uk | Internet: www.envirowise.gov.uk



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0800 585794**