envirowise
Practical Environmental Advice for Business

GG405

Paint and powder coating: use less, save more

Paint and powder coating: use less, save more

This Good Practice Guide was prepared by Envirowise

Prepared with assistance from:

Enviros Consulting Ltd

Summary

Many companies in the coating and surface finishing sector are reaping commercial and environmental benefits by moving away from the traditional use of solvent degreasing, solvent-based paints and conventional spray guns. While many of these changes have been driven by the need to comply with legislation, meet quality demands, and win and retain business in an increasingly competitive market, adopting a more cost-effective approach has realised wider benefits, such as lower operating costs, higher product quality, and better public image.

This Good Practice Guide is intended to provide a useful tool for any company in the coating and surface finishing sector looking to achieve more efficient paint and powder coating, reduce the use of solvents and other materials, and hence save money. The guidance includes:

- a brief introduction to the legislation impacting the sector;
- an introduction to some good practice approaches;
- a brief outline of the continuous improvement process;
- a list of useful Envirowise publications.

The benefits of following this advice are illustrated in seven case studies based on experiences in UK companies. These industry examples cover a wide range of company sizes and core business activities but, in each case, both operating costs and environmental impact have been significantly reduced.

Successful changes include switching from solvent-based coatings to water-based paints and powder coatings; moving to high efficiency spraying (for example, using electrostatic or robotic technology) or using phoretic dipping processes to improve transfer efficiencies; and changing degreasing operations. Use the case study selection matrix opposite to help you go directly to the case study of most interest.

By making these changes, a number of the companies featured have fallen below the solvent-use threshold set under current environmental regulations, eliminating both annual authorisation fees and the management time associated with achieving compliance. Additionally, many of the companies have improved their product quality, throughput and image with important customers.

There is a worksheet at the end of this Guide to help you to identify cost saving opportunities in your company.

Case study selection matrix

Page	Company name	Core business activity	Number of staff	Net annual saving	Reduction measures						
					Non-solvent preparation	Powder coating	Water-based coatings	Autophoretic coating	HVLP spray guns	Electrostatic spraying	Robotic spraying
14	*ABT Products Ltd*	Makes vehicle cabs	70	**£39 000**	✔		✔	✔		✔	
16	*Advanced Colour Coatings*	Coats automotive components	30	**£31 500**	✔					✔	
19	*Link Lockers*	Makes storage lockers	120	**£140 000**	✔	✔				✔	
21	*Peatey's Coatings*	Trade coaters for diverse products	56	**£90 000**	✔	✔			✔	✔	
24	*Plasma & Thermal Coatings Ltd*	Carries out a wide range of thermal spray processes	30	**£6 000**							✔
27	*SMP Playgrounds*	Makes children's playground equipment	64	**£40 000**	✔	✔				✔	
28	*Wellington Garage*	Independent car repair body shop	22	**£28 000**			✔		✔		

Contents

Introduction

Over the last ten years, the coating and surface finishing sector has come under increasing pressure to improve its environmental performance. At the same time, competition within the sector has been driving businesses to provide better quality products while holding down production costs.

As a result, an increasing number of companies are examining their current operations to find ways to meet these challenges cost-effectively. Many have moved away from the traditional use of solvent degreasing, solvent-based paints and conventional spray guns, and have adopted more cost-effective approaches that have less impact on the environment.

This Guide is aimed at managers in the coating and surface finishing sector who are looking for practical ways to improve performance and comply with environmental regulations, while reducing costs. The guidance is applicable to companies of all sizes operating in all sub-sectors, from metal and plastic powder coating to vehicle refinishing.

The guidance goes hand-in-hand with quality management systems (such as the ISO 9000 series) and environmental management systems such as ISO 14001 and EMAS. More detailed information on all points raised can be found in other Envirowise Guides and Case Studies, as listed in section 5.

1.1 The benefits of better practice

With coatings costing several pounds per litre and solvents costing hundreds to thousands of pounds per tonne, maximising material utilisation is clearly essential. Despite this, companies often waste 40% or more of these materials through, for example, excessive overspray and poor material recovery.

Productivity is just as important. Many companies have the potential to increase throughput and turnover significantly without the need for extra labour or larger premises.

Finally, image and reputation with stakeholders cannot be ignored, particularly as customers, financiers, staff and local communities now take far more interest in environmental performance.

Taking waste minimisation and solvent management seriously is not only good business practice, but also offers clear and strong commercial benefits. Some of the benefits resulting from common operational changes are listed in Table 1 overleaf.

1.2 Legislation and the SEA Code of Practice

Organic solvents are widely used in UK industry for a range of processes. Typically, the coating and surface finishing sector uses trichloroethylene, xylene, methyl ethyl ketone (MEK) and white spirit, mainly in paints and for cleaning and thinning processes. These, and other organic solvents, give rise to volatile organic compound (VOC) emissions. Currently, levels of these VOCs in the atmosphere are a subject of widespread concern and regulation. This is primarily because of their role in the formation of low-level air pollution affecting human health, crops and natural vegetation, but also because they contribute to global warming.

Since the start of the 1990s, surface finishing companies have been subject to air pollution control legislation relating particularly to the control of VOCs. Most coating companies that use

Table 1 Some generic benefits of good practice improvements

New process	Old process	Benefits
Alkaline/aqueous degreasing	Vapour degreasing	Significantly lower VOC emissions Lower material utilisation and waste generation Better workplace environment
HVLP solvent-based spraying	Conventional solvent-based spraying	Rapid payback on investment Improvements possible in material utilisation, product quality, productivity, VOC emissions, workplace environment, energy use and waste generation
'Phoretic' water-based coating[1]	Solvent-based spraying	Significantly lower material utilisation and VOC emissions Better product quality Better workplace environment Lower waste generation
Powder coating	Solvent-based spraying	Significantly lower VOC emissions Better product quality Improved material utilisation and productivity Better workplace environment Lower waste generation

[1] Phoretically applied primers are often used with sprayed basecoats and topcoats.

more than 5 tonnes of organic solvents (1 tonne in the case of vehicle refinishers, dropping to 0.5 tonnes under the Solvent Emissions Directive [SED] requirements) or 20 tonnes of powder coating in any 12 month period are regulated under the Local Air Pollution Control (LAPC) regime (Part B processes) and will switch over to the Local Air Pollution Prevention and Control (LAPPC) regime in the year commencing 1st April 2004.

Companies using more than 200 tonnes of solvent per year are classed as Part A(2) processes, regulated under Local Authority Integrated Pollution Prevention and Control (LA-IPPC). In both cases, enforcement is carried out by the local authority in your area.

Even if your company does not use enough solvent to be regulated, reducing solvent use still offers a route to significant cost savings. Companies approaching the registration threshold may also be able to postpone or avoid registration.

Advice about LAPC, LAPPC, LA-IPPC, the SED and other legislation governing your operation is available from the Environment and Energy Helpline on 0800 585794.

Detailed regulatory requirements are set out in the latest versions of the appropriate Process Guidance Notes, which also encompass the requirements of the SED. The most relevant include:

PG6/20 *Paint application in vehicle manufacturing*

PG6/23A	*Metal and plastic coating processes*
PG6/23B	*Surface cleaning*
PG6/23C	*Winding wire*
PG6/31	*Powder coating*
PG6/33	*Wood coating processes*
PG6/34	*Respraying of road vehicles*
PG6/40	*Coating and recoating of aircraft and aircraft components*
PG6/41	*Coating and recoating of rail vehicles*

Two of the most important Guidance Notes in the context of this Guide are PG6/31 and PG6/23A.

PG6/31 covers powder coating (including organic powders, vitreous enamelling and sheradizing through curing/fusing thermally and by the use of ultraviolet [UV] light) and sets emission concentration limits for particulate matter of 10 mg/m^3 and hydrogen chloride of 30 mg/m^3 as a 15 minute mean.

PG6/23A is the Guidance Note that applies to sectors not directly identified. Under most of these Guidance Notes, compliance can be achieved through meeting VOC emission limits or through a Solvent Reduction Scheme with target mass emissions. Under PG6/23, use of so-called 'compliant coatings', with low VOC content, exempts the user from the emission limits.

Emission limits are expressed as a concentration in air and/or as total mass emissions per unit of production. There are various requirements relating to different circumstances, however, those companies consuming more than 15 tonnes of solvent per year have to meet a limit of 50 mg/Nm^3 (as carbon, 30 minute average) under PG6/23. In vehicle manufacture (under PG6/20) the limit for existing processes is 60 g/m^2 of coated surface. There are also new limits for fugitive (uncaptured) emissions, described as a percentage of the solvent input to the process. Monitoring, regarding emission limits, and a Solvent Management Plan (mass balance) approach regarding the reduction approach, have to be used to demonstrate compliance.

The key PG6/23 compliance dates are:

- replace/control/limit solvents with Risk Phrases R40, 45, 46, 49, 60, 61 - as soon as possible;
- new abatement plant for existing installations - immediately;
- Solvent Reduction Scheme approach for SED activities - 31st October 2005 for first target levels, 31st October 2007 for final target levels;
- new emission limits for contained releases and fugitive emissions - 31st October 2007.

Copies of the Process Guidance Notes are available from The Stationery Office (www.tso.co.uk).

The *Code of Best Practice for the Surface Finishing Industry 2001* deals with environmental protection and occupational health and safety. This is available from the Surface Engineering Association (SEA) (Tel: 0121 237 1123, www.sea.org.uk).

The route to better paint and powder coating

Ideally, businesses want to improve their environmental performance, meet quality demands and reduce costs, without having to compromise in any one area. To achieve this, many companies in the coating and surface finishing sector have moved away from the traditional techniques and technologies, finding approaches that have less impact on the environment, without impacting on product quality or costs. Applying proven good practice is already providing some UK companies with significant cost savings and other benefits, as demonstrated in the case studies in section 4. Your business can benefit, too.

2.1 Consider alternative approaches to surface preparation

There are many approaches to surface preparation. For example, mechanical methods such as brushing, blasting and tumbling/vibration are useful for removing dirt or grease, and provide a better key for coatings.

Common chemical pretreatment methods include acid baths (generally using hydrochloric acid) and solvent vapour degreasing. Aqueous/alkaline or water-based degreasing has become more attractive, now that 1,1,1-trichloroethane is banned as an ozone-depleting substance and trichloroethylene is listed as a Category 2 carcinogen. This water-based degreasing offers equivalent levels of cleaning, but with much lower environmental and health and safety risks.

These chemical degreasing systems generally include a wash stage (sometimes ultrasonically-assisted), combined with rinse and hot air drying stages. Some systems also incorporate a conversion dip to provide extra corrosion protection. In these cases, phosphating dip is preferable to chromating, for environmental reasons. These degreasing systems should eliminate the need for any manual surface preparation, such as handwiping with solvent.

For more information about surface preparation, see *Surface cleaning and preparation: choosing the best option* (GG354), available free of charge through the Environment and Energy Helpline on 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

2.2 Look at alternative coatings

Many companies have moved away from coatings with a high solvent content for cost, quality, legislative, and health and safety reasons. Alternative coating systems involve the following, either singly or in combination:

- medium/high-solids paints, which contain 40 - 70% solids (30 - 60% VOCs), compared with 20 - 40% solids for conventional wet paints;
- water-based paints, which have a similar solids content to conventional paints, but with far lower VOCs (typically 10 - 20%);
- powder coatings, which are a 100% solids, zero VOC mixture of paint pigment and resin binder;
- specialist thermal/plasma coatings, such as metal and polymeric coatings that have to be applied at high temperatures.

Certain low-solvent coatings are regarded as 'compliant coatings' and exempt companies that use them from emission limit compliance requirements under the appropriate Process Guidance Note. Water-based coatings are now often used as a primer and/or basecoat, with a medium-to-high solids topcoat. Powder coatings (applied electrostatically) are often applied without a primer coat.

The curing/stoving of these coatings does differ. Water-based coatings generally require longer to cure and more energy input than solvent-based coatings, although this can be countered by using energy-efficient ovens (eg with air recirculation and heat exchangers). High-solid content and powder coatings require less energy input and dry very quickly, and can, therefore, potentially increase productivity. Some coatings are designed to cure quickly using infrared (IR) heat or UV light. With UV-cured coatings, care must be taken not to expose coatings to light prior to spraying, as this can lead to loss of coating (eg in reservoirs) and can make cleaning difficult.

For more information about coating materials, see *Cost-effective paint and powder coating: coating materials* (GG386), available free of charge through the Environment and Energy Helpline on 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

2.3 Consider ways to improve application

Better application techniques and equipment can prove the key to reducing waste and costs.

Find the right technique

Generally, coatings and surface finishing are applied by spraying or, less commonly, dipping.

Conventional, air-atomised spray guns (whether gravity, siphon or pressure fed) operate at high tip (air cap) pressures. They do produce the finest sprays, but suffer from bounce back, high levels of 'fog' and overspray. Transfer efficiencies are typically 30 - 50%, meaning that for every litre of paint applied, another litre has been wasted.

Air-assisted airless guns use a combination of hydraulic pressure and air pressure to atomise the paint. They result in less fog and offer a better transfer efficiency than conventional spray guns (typically around 60 - 65%).

High volume low pressure (HVLP) spray guns atomise using high volumes of air at low pressures, giving better control, better coverage of recesses and cavities, and far better transfer efficiency (typically 65 - 85%). HVLP guns are available for gravity, siphon and pressure feeds. While HVLP guns produce a slightly less fine spray than conventional ones, and cannot easily spray certain heavy/viscous materials, they are now used in a very wide range of applications. Heating equipment can be used on the paint supply (for certain coating types) to reduce viscosity, enabling HVLP application.

Electrostatic spraying with wet paints allows the charged paint to be attracted to the earthed work piece. The technique provides some 'wrap around' onto the back of the work piece and gives a high transfer efficiency. Electrostatic enhancement can be applied to all types of spray gun. Combined with HVLP technology, electrostatics can typically achieve a transfer efficiency of 65 - 95%, depending on the shape of the object being coated and its conductivity. In 'centrifugal' electrostatic guns, atomisation takes place as paint spins off a spinning 'bell' or disc rather than in a normal atomisation chamber. Air is used only to help direct and contain the paint fan.

Powder coating is a dry electrostatic process, generally carried out by spraying or, less often, through the use of a fluidised bed dip. With spraying, a cloud of paint particles (pigment and a binder resin) is attracted to all sides of the piece, resulting in a very high transfer efficiency and a high quality coating. Powder systems are relatively simple. The powder does not have to be atomised as such: compressed air is used to make it fluid. The powder must be cured immediately after application, before the attractive charge is lost. In some cases, IR heating is used prior to the normal stoving oven, which may use either convected or IR heat. Unlike wet paints, any wasted powder can be readily collected and recirculated. Appropriate encapsulation, extraction and the use of cyclones, filters and sieves can allow powder utilisation levels in excess of 90% where product specification allows (eg with respect to small blemishes).

Electrophoretic and autophoretic dipping offer very high material utilisation and produce high quality priming and corrosion-resistant coating. Both processes are water-based, thereby eliminating VOC emissions. Electrophoretic deposition (EPD) generally uses a specially formulated polymeric coating, and involves the use of electrodes connected to the bath and the jigs to create the attraction between paint and substrate. E-coat, as it is often called, is usually stoved at around 180°C.

Autophoresis operates by allowing a dilute acid to attack the metal surface releasing ferrous (Fe_2) ions, which break down an emulsion and allow the synthetic polymeric coating to coagulate and be deposited on the metal surface. No electrical field has to be created, the process involves no heavy metals and the coating can be stoved at temperatures as low as 100°C.

Optimise equipment

Spray gun arrangements and settings are also critical if waste is to be minimised. With manual spray guns, the main issues for consideration are the fan pattern and the way the gun is used. Ideally, the fan pattern should be only a little wider than the object being sprayed. Gun movement should be at a constant speed (eg from side to side), at an optimum distance (finding a balance between the bounce back occurring when the gun is too close and fogging when it is too far away) and parallel to the object being sprayed to avoid fan tails at the extremes and uneven coating.

With automatic spray guns, fixed guns are generally wasteful. They are often set with wide fan patterns and consequently result in high levels of overspray. On a flat surface, 'nodding' guns create an uneven coat with a fan tail at the extremes. Depending on the size and shape of the work piece, reciprocating guns (ie those that move up and down on tracks parallel to the piece) generally offer benefits in terms of even coating and reduced overspray. Robotic spraying is expensive but desirable where large and complex shapes are being sprayed, as it offers extremely high transfer efficiencies, high quality finishes and reduced labour costs. Compared with manual spraying, robotic spraying often reduces coating use by 20 - 30%.

For more information about application technology, see *Cost-effective paint and powder coating: application technology* (GG387), available free of charge through the Environment and Energy Helpline on 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

2.4 Minimise losses during colour changeover and cleaning

Minimise colour changes

Often, colour changes are responsible for significant levels of coating wastage and solvent/cleaner use. The use of colour-dedicated lines, pots and spray guns significantly reduces the problem, because cleaning has to be done far less often. Careful batch sequencing, ie following one batch with another of the same or very similar colour, also reduces the need for cleaning and hence reduces wastage.

Pick the right equipment for the job

Siphon cup guns are inherently wasteful. Typically 5 - 10% paint residue is left in the gun cup and wasted during cleaning. Gravity-fed guns are better in this respect, as all the paint can be used. Larger remote pressure pots are only of benefit where larger production runs are the norm: when only part-filled, they result in higher losses, as the surface area to be cleaned is large relative to the volume of paint used.

Some newer low-pressure pumping equipment can supply a number of spray guns (eg HVLP/electrostatic) directly from one paint container or reservoir without the need for intermediate pressure pots. The equipment offers a gentle, stall-free and pulse-free action, suitable for direct delivery to the gun.

On automatic/robotic spraying equipment, dedicated paint lines often feed a colour changer that then supplies the spray gun down a feed line. The closer the colour changer is to the gun, the lower the wastage of paint and cleaning materials at changeover.

Select the best cleaning method

Cleaning is normally done using solvent or other cleaning agent. On automatic cleaning systems, air pulsed in the direction of the paint supply can be used together with cleaning materials to improve cleaning and reduce material use. Reversed compressed air pressure can be used to drive unused paint down the supply line and back into the pressure pot or container, saving both paint and cleaning agents.

There are various ways of reducing paint wastage and solvent use, including:

- ‘pigging’ of the lines, driving the pig (usually a rubber bung) with solvent and/or compressed air: this allows paint to be recovered down a return line, but still uses significant quantities of solvent;
- locating the colour changer and pumps in the robot arm close to the spray head: the number of dedicated lines is usually limited to 24, due to the volume available in the arm and weight constraints;
- replacing the feed lines with cartridges that can be loaded onto the paint atomiser, as described in the Toyota example overleaf.

Good housekeeping measures also provide a low cost route to reducing the use of cleaning materials, for example:

- carry out manual gun cleaning in enclosed gun washing cabinets, to reduce emissions and solvent use;
- improve control over the use of cleaning solvents by providing operators with a set amount each day in triggered spray containers, rather than giving them free access to cans;
- use paper masking in spray booths to reduce the need for booth cleaning.

Many no cost and low cost measures are described in *Good housekeeping measures for solvents* (GG28), available free of charge through the Environment and Energy Helpline on 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

Paint and solvent reduction at Toyota

Toyota has adopted a paint system, called the Cartridge Bell System (CBS), on its robotic/electrostatic guns. The cartridge is a paint container with 0.5 litre or 0.8 litre capacity that is mounted on the atomiser. Paint is dispensed directly into the electrostatic bell cup via the cartridge paint feed tube. Paint does not fill the atomiser as on normal guns (whether fitted with a bell or not) and waste is, therefore, practically zero. Only the paint that remains on the bell cup is lost between paint colour changes, significantly reducing paint waste and solvent use.

Each cartridge is placed on a special filling and emptying station connected to the paint supply lines. Depending on the total number of colours used, individual cartridges can either be dedicated to one specific colour, resulting in minimum flushing, or used for a number of different colours, each cartridge being flushed between uses.

The CBS is now fitted at a number of Toyota plants worldwide with potential savings of 27% on paint shop operating costs and an estimated 45% reduction in VOC emissions.

Table 2 indicates typical paint and solvent wastage resulting from one colour change on a typical robotic system and the overall cost for 50 000 changes.

***Table 2 Cleaning of robotic spray feeds: paint wastage and solvent use** (assuming a paint cost of £5/litre and solvent cost of £0.50/litre).*

	CBS (dedicated cartridges)	Colour changer on robot arm	Colour changer off arm and pig system
Paint waste	0.29 cm^3	40 cm^3	60 cm^3
Cleaning solvent	55 cm^3	250 cm^3	200 cm^3
Cost for 50 000 colour changes	£73 + £1 375 = £1 448	£10 000 + £6 250 = £16 250	£15 000 + £5 000 = £20 000

For more information about managing coating materials and minimising waste, see *Cost-effective paint and powder coating: materials management* (GG385), available free of charge through the Environment and Energy Helpline on 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

2.5 Recover solvents where economical

It can prove economical to save waste solvent-based paints and used cleaning solvents. These waste products can be put through a distillation unit on-site, or you can use a specialist contractor who will recycle the materials off-site. High levels of solvent can be recovered for re-use (eg as cleaning solvent), leaving a much smaller volume of sludge for disposal, generally as special/hazardous waste.

Adopt a systematic approach to continuous improvement

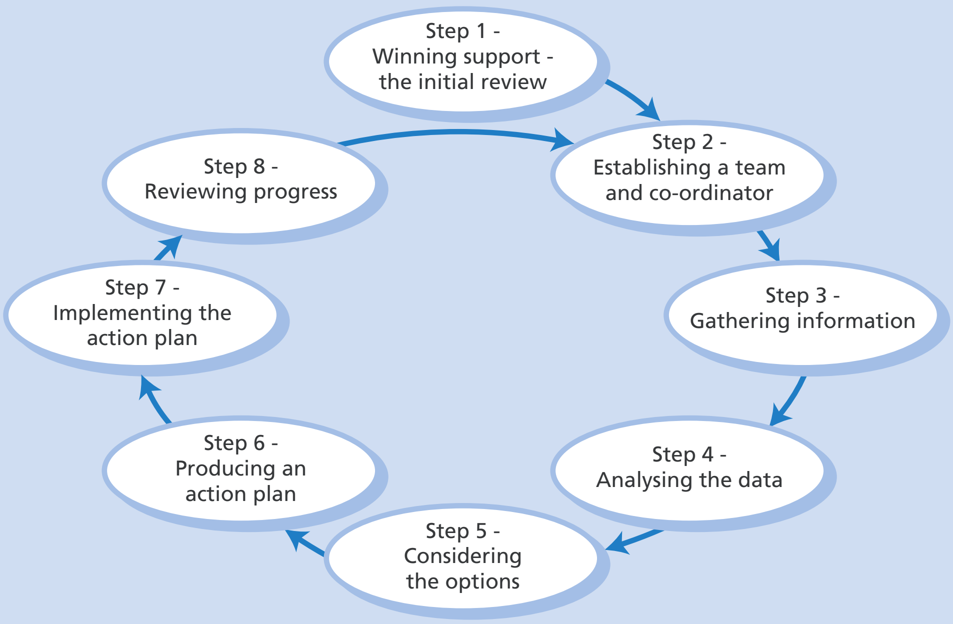
Taking a systematic approach to solvent management and continuous improvement is the best way to:

- reduce VOC emissions and remain compliant with current environmental legislation;
- improve material utilisation;
- save money.

One approach that has worked in many companies is shown in Fig 1, and a brief description of what each step entails follows.

> You can find out more about solvent management in *Reducing solvent use by good housekeeping* (GG413) and *Cost-effective solvent management* (GG429), which also contains a simple spreadsheet mass balance tool. Both of these Guides are available free of charge through the Environment and Energy Helpline on 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

Fig 1 A systematic approach to solvent management



3.1 Step 1: Carry out an initial review and win support for your initiative

Nothing can change without senior management commitment to that change. In general, you will need to estimate potential savings and associated costs before you can gain this support. Carrying out an initial review of current practices will give you a good idea of costs and savings.

- Walk around the site to discover key areas of wastage and emission sources, and identify saving opportunities.
- Estimate the approximate savings associated with a few of the more promising opportunities identified. There is an example worksheet at the end of this Guide to help you to estimate the cost savings and payback period.
- Present the 'business case' for taking action to senior managers and other decision-makers, and gain their full support for further work.

3.2 Step 2: Build a team and appoint a co-ordinator

In most companies you will find that responsibilities, knowledge and skills are spread across several departments and job functions, involving many individuals. Try to establish a team that includes:

- environmental, health and safety managers;
- manufacturing and product development managers;
- appropriate shop-floor staff.

The work on solvent management and continuous improvement initiatives will involve only part of their time, so let them know that they will be called upon only as necessary. Additional people can be brought in as required, for example, procurement staff may be involved if a new material is considered. If necessary, involve suppliers - they may be able to help with technical problems - and keep customers informed, so that you can resolve any concerns they may have.

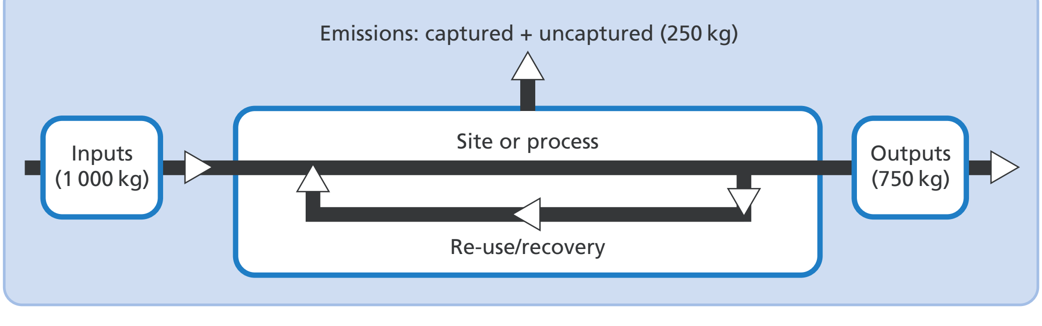
You will also need an empowered and enthusiastic co-ordinator or 'champion' to lead and facilitate the work of the improvement team. Make sure that time is set aside for the champion to take on the new duties, and carry out the environmental responsibilities along with existing tasks.

More information about selecting team members and appointing a champion can be found in *Saving money through waste minimisation: teams and champions* (GG27), available free of charge through the Environment and Energy Helpline on 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

3.3 Step 3: Gather information, monitor material usage and wastage

You need to have a thorough understanding of coatings and solvent use, and the wastage and emissions generated, if you are going to be able to comply with environmental legislation and implement targeted and cost-effective improvements. Essentially, solvent management requires accurate measurement of inputs to, and outputs from, a process to enable VOC emissions and usage to be estimated. Essentially, what goes in to a process (in mass terms) must come out, as shown in the mass balance in Fig 2.

Fig 2 The solvent/VOC mass balance



Use the data available to generate a mass balance for your *process*, not the site, but you will need to be aware of any material stock or waste that is sitting in the yard. The process inputs are the coatings and solvents that you buy in, the outputs are the various waste streams. You will need to know the solvent content, by weight, of the materials that you use. Most firms build up a spreadsheet or database, where details of the solvent content of the materials are recorded. You must include solvents used for thinning coatings prior to application. If you want to investigate solvent usage and emissions in more detail, use a dispense log or meters (where materials are piped). Table 3 lists some common data sources that will help you to generate a mass balance.

Table 3 Example data sources

Inputs	Source of information
Bought-in solvents	Purchase/dispense records, stocktaking
Bought-in coatings	Purchase/dispense records, data sheets, stocktaking
Outputs	**Source of information**
Waste solvents (eg from cleaning)	Disposal records, audits, analyses
Waste coatings (process residues)	Disposal records, audits, analyses
Solvent recovery sludges	Disposal records, audits, analyses
Solvent to drain (under consent)	Trials, analyses, estimates

Note: ‘waste’ here means all residue materials, including those for off-site re-use/recovery.

You can ignore solvent recovery carried out on-site, other than in terms of the sludge that ends up as a waste output. When recording data for analysis, stick to regular time intervals. If possible, record data on a four-weekly basis, with yearly summaries covering 13 periods. Using calendar months introduces a systematic variation in the time period and makes period-to-period comparison more difficult.

3.4 Step 4: Analyse the data and investigate potential problems

Analyse solvent and material use with the aim of:

- meeting legislative compliance requirements;
- improving efficiency;
- saving money.

From the compliance perspective, emissions are the key factor. Their value can be determined from the mass balance (Fig 2):

$$E = I - O$$

Emissions = inputs – outputs

Some of these emissions will be captured and vented through stacks, for abatement or other action, while others will be ‘fugitive’, ie lost, primarily through leaks and spills.

When analysing the data, it is essential to relate emissions (E) to production throughput (P) over the same period you used for the solvent data. Ideally, try to quantify production in terms of the area coated in m^2 or in terms of appropriate ‘units’.

Relating emissions to production - an example

In vehicle respraying, you could record the number of 'jobs' that go through the spray shop and use this as the production measure. However, each job will be different and, while they should balance out over a long period (say several months), there may be significant variation from month to month.

A better approach is to assign so many 'units' to each type of job, based on the relative surface area coated. For example, a vehicle spray shop may record 11 jobs in a week:

3 complete resprays	@ 100	=	300 units
4 front wings	@ 8	=	32 units
1 bonnet	@ 16	=	16 units
2 doors	@ 8	=	16 units
1 bumper/grill	@ 4	=	4 units
Total		=	**368 units**

Overall, the shop will have sprayed the equivalent of almost 3.7 complete cars (assuming 100 units equates to one complete car). While this method is imprecise, it is far more accurate than simply using 11 'jobs' as a measure.

With emissions and production data, you will be able to look at how solvent emissions change on a month-by-month basis and to compare one similar process (eg one booth) with another. Plotting data on graphs will clearly show any differences. A number of important questions can be asked, for example:

- Is E/P reducing over time? Is I/P (O/P + E/P) reducing? Is there still potential for further improvement?
- How do E/P and I/P compare from one booth to another? Should they be very similar (eg are the booths running the same process/equipment)? Is the variation normal or is there a problem? Is it possible to identify the good practice that is creating the lower losses?

Use the answers to help you identify the real issues and problems. Brainstorming sessions can prove useful at this stage. Make sure you involve all relevant staff in these investigations, including the shop-floor staff who are often in the best position to offer constructive comments and suggestions.

3.5 Step 5: Consider the improvement options

Once you have investigated the causes of any problems, start to consider the costs, benefits and feasibility/difficulty of doing something about them. In terms of costs, as a minimum include the material costs (coating and solvent), disposal costs, energy costs and productivity costs (ie lost production time). This will give you some indication of the net benefit of making the change and will allow you to calculate a simple payback period.

Use these cost and benefit data, along with further brainstorming, to prioritise actions. Staff suggestion schemes, linked to some sort of reward, may prove useful in terms of generating improvement ideas. 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'. Technology and costs change, so what was not possible or economic a few years ago, may well be now. If necessary, carry out trials to ensure that suggested changes are feasible.

Put the easiest, low cost measures first on the list of priorities so that results will be achieved quickly. Success will motivate everyone concerned and give them the confidence needed to tackle the more difficult, and perhaps more costly, measures.

3.6 Step 6: Produce 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. Targets should relate to parameters that are being measured so that progress can be assessed; for example, to reduce overall solvent use per production unit by 20%.

Consult with as many relevant staff as possible and get their comments on the practicality of the plan, potential barriers, etc. Make everyone aware of the potential benefits of the measures such as improved profitability, better job security and so on, through presentations, newsletters and notice-boards. Consider incentive schemes, for example, offering rewards for those who achieve the most savings. The final plan should be agreed at senior management level to gain their full commitment to implementing the necessary improvements.

3.7 Step 7: Implement your action plan

Implementing the action plan will involve detailed team work, however, taking action will prove much easier and more productive as a result of the steps that have gone before it. Again, make sure that you get everyone involved in implementing the plan and keep people informed of progress, to maintain interest and motivation.

3.8 Step 8: Review progress regularly

Once the action plan is underway, carry out regular reviews of progress against targets. To start with, review every, say, six months; later on, yearly reviews may prove sufficient. It may also be helpful to review:

- how successful the process monitoring and data gathering steps were;
- team performance, because different members and even a different co-ordinator may be needed as the work progresses.

Case studies - learn from others in industry

4.1 Autophoretic coating technology reduces solvent use and saves ABT Products Ltd £39 000/year

ABT Products Ltd (ABT) makes various cabs for fork-lift trucks and other vehicles. The company has long been aware of the scale of savings and other benefits available through improved solvent utilisation. In the late 1990s, ABT introduced electrostatic spray guns and solvent recovery equipment, which realised savings of some £16 800/year. Since then, the company has continued to make good progress, improving both environmental performance and product quality. Measures taken have reduced solvent use to such an extent that ABT no longer requires authorisation under Local Air Pollution Control (LAPC).

A recent initiative has been the installation of an autophoretic primer coating system, which has realised many benefits, including:

- an 8 tonnes/year reduction in paint usage, saving around £35 000/year;
- a 2 tonnes/year reduction in special waste generation, saving around £3 000 in waste disposal costs;
- the elimination of both the £790 annual authorisation fee under LAPC and the management time needed to compile a yearly solvent inventory;
- improved product quality and corrosion resistance;
- better workplace and local air quality, through a reduction in solvent emissions.

Background to ABT's action

ABT is a medium-sized company, situated in the environmentally sensitive area of Ross-on-Wye, Herefordshire. ABT employs around 70 people at its factory in Ross-on-Wye and has a turnover of £5 million. The company has been operating since 1971 and specialises in the manufacture of vehicle cabs for fork-lift trucks and other material-handling vehicles. In 1998, ABT featured as an Envirowise case study, having saved some £16 800/year by introducing electrostatic spray guns and solvent recovery equipment.

In the late 1990s, ABT began to experience problems with paint adhesion, and had some complaints and returns from its customers. A consultant was brought in to investigate the problem and it was linked to the priming process.

Around the same time, the company realised that it should look at a process with less environmental impact, which could bring solvent use below the LAPC threshold. While ABT should have been authorised under LAPC from the early 1990s, the local authority had yet to deal with its application and hence the company had an opportunity to avoid authorisation costs altogether.

Recognising the opportunity to deal with the quality and compliance issues at the same time, ABT decided to install a better primer coating process that would eliminate the need for manual spraying.

The autophoretic primer process proves cost-effective and efficient

ABT decided to install an automatic, water-based autophoretic coating plant. While the new autophoretic plant cost approximately £1 million, investigations led the company to believe that this approach would prove cheaper in the medium term than an equivalent electrophoretic process.

Autophoretic coating is extremely cost-effective, due to its very low energy requirements and moderate materials requirements. At the time of installation, this autophoretic plant was the largest sub-contract facility in Europe and had the capability of processing two vehicle cabs together.

The autophoretic process produces a black latex vinyl-based hard coating that is highly corrosion-resistant. The coating process is activated by the presence of ferrous ions on the component's surface and can be applied uniformly to complex shapes. The process does not embrittle higher tensile parts and, due to its relatively low curing temperature, can be used on parts containing rubber. The top coat is still applied using the existing electrostatic spraying process.

Significant material and VOC reductions result from the new process

Autophoretic application uses around 30 - 40% less paint than an electrostatic spraying process. At ABT, introducing the new primer coating process has saved in the region of £35 000/year.

The change has also eliminated VOC emissions from the primer process. The company is now well under the 5 tonnes/year solvent use threshold for authorisation under LAPC, saving the yearly registration charge of £790 plus the management time required to compile an annual solvent use inventory.

There have also been associated health and safety benefits through improved workplace air quality and reduced exposure to sprayed paint.

Waste disposal costs are cut

Introducing the autophoretic dip process has significantly reduced waste generation. The primer paint is entirely water-based, and many of the process systems recirculate and are virtually self-cleaning. Wastewater from the system is taken through an on-site automated effluent treatment plant (ETP), where it is filtered and allowed to settle. The small quantities of sludge waste that result are non-hazardous and are disposed of by the normal waste contractor. This has cut waste disposal costs by around £3 000, as special waste quantities have been reduced by 2 tonnes/year. The effluent from the plant is extremely clean and can be discharged to the main sewer under a discharge consent at no additional cost. The costs of running the ETP are small compared with the overall cost savings.

Autophoretic heating systems do not impact on overall energy use at ABT

Moving to an autophoretic dip process has had little impact on energy use at ABT. The reduction in energy related to the removal of pumps and compressors associated with electrostatic primer spraying is offset by the use of heating systems within the autophoretic process.

Changes lead to improved product quality

The autophoretic process has significantly improved primer coating adhesion and paint is applied more uniformly. Together with the use of high quality paint, this has resulted in high corrosion resistance (over 1 000 hours salt spray resistance), thereby extending the potential lifespan of ABT products.

> *"The changes made at ABT have resulted in the company growing from a small agricultural engineering company to an organisation that can be proud of its quality products and its environmental performance. This presents the company with a significant opportunity to increase the customer base to include multinational companies and hence to substantially increase sales."*
>
> **Nigel Mummery, Managing Director, ABT Products Ltd**

4.2 Environmental improvements save Advanced Colour Coatings over £31 000/year

Advanced Colour Coatings (ACC) coats various metal parts to the very highest standards for the automotive and electronics sectors, using chrome, powder and wet coatings. The company realised that taking action to lessen its environmental impact could realise many additional benefits, including improved product quality, lower operating costs, and a better workplace environment, as well as enhancing its public image and reputation.

In recent years, the company has made environmental improvements across the board, reducing solvent, powder, energy and water use. These improvements have enabled ACC to stay ahead of environmental legislative requirements, and it has gained a competitive advantage from its efficiency programmes. Benefits to ACC include:

- the removal of the need for LAPC authorisation for solvent processes, saving around £1 500/year in annual authorisation and monitoring costs;
- a saving of £26 000/year through reduced powder use;
- an 80% rebate under the sector's Climate Change Levy (CCL) agreement, saving £4 000/year;
- a 44% reduction in water use in the pretreatment rinse baths, with a small associated cost saving.

Customer satisfaction drives changes at ACC

ACC is a small to medium-sized enterprise in the West Midlands, which currently employs around 30 people and has an annual turnover of around £2.5 million. Established over 30 years ago, ACC is a specialist applicator of pretreatments, paints and powder coatings to a variety of metal substrates. Much of the company's high specification work is carried out for major vehicle manufacturers, where attention to detail and quality are paramount. The company is certified to the QS 9000, ISO 9002, ISO 14001 and Investors in People standards, demonstrating its commitment to quality, environmental and social responsibilities.

This commitment to customer needs proved key to the company developing an environmental management system (EMS), at a time when this was uncommon within the paint and powder coating industry. This foresight ensured that ACC was well placed to comply with environmental legislation and brought benefits that continue to this day.

EMS, quality and staff development work hand-in-hand

ACC was able to implement its ISO 14001 EMS with support from the West Midlands' automotive supply chain support programme, Accelerate. A consultant was provided on a weekly basis to help develop the EMS. City College, Birmingham, supported the company in delivering initial training to raise staff awareness of the company's environmental impact. This training now forms part of the staff induction process. ACC gained certification to ISO 14001 in 1999, focusing on three main objectives, namely to reduce powder consumption, energy use and water use.

Many of the environmental improvements have gone hand-in-hand with work to improve product quality and staff competency. ACC is currently certified to ISO 9002, QS 9000, Investors in People and ISO 14001, and was a finalist in the Midlands Excellence Awards under the Small Manufacturing Business category. In the near future, ACC intends to integrate the EMS with the ISO 9002/QS 9000 systems.

Pretreatment improvements bring dividends

Parts are pretreated using a variety of processes, including aqueous/alkali degreasing, phosphating and chromating as appropriate. Parts are then washed by being passed, counter-current, through a series of rinse baths. Water flow rate through these baths was kept high because of fears over quality problems, although water contamination levels were not monitored. The company systematically reduced flow rates and began to take daily measurements of conductivity. A simple form of Statistical Process Control, with carefully defined tolerance limits, allowed water use to be reduced from 1.53 litres/piece to 0.86 litres/piece, a 44% reduction. This has saved an estimated £500/year, although the measures were taken mainly for environmental reasons.

Concern over the use of hexavalent chromium in the passivation process (from a health and safety as well as an environmental perspective) led the company to examine other conversion chemicals. As a result, ACC now has a 'chromate-free' passivation process, which still meets the demanding quality standards. The company expects to have fully removed hexavalent chromium within three years. The new process chemicals are currently more expensive than the traditional chromates, but the price is expected to drop as their use becomes more common. In addition, removing hexavalent chromium will reduce the effluent treatment plant operating costs by £1 000/year.

Increased powder coating efficiencies save money

ACC has reduced powder use by focusing on quality and the reduction of rejects within the coating process, introducing new spraying equipment and careful control with regard to re-use of powder.

The company used to spray components using banks of eight nodding guns. Uneven coating was common, with excess thickness in some areas. The company, therefore, invested in new spray booths, with a single reciprocating gun running up and down a track on each side of the booth. Two such lines are in operation, costing £32 000 in total. The air and powder feed pressures are adjusted to suit the part being coated, according to predetermined settings derived from trials. This information is set out on the booths as a look-up chart. The overall result is a homogeneous cloud of powder that is electrostatically attracted to the part, resulting in good wrap-around and an even coat.

Overspray powder is extracted from the booth, with the majority being recovered through a cyclone. Excess fines are trapped in a bag filter before disposal. The extent to which the powder can be re-used is determined by the customer specification. Standards in the automotive sector are extremely high and, as a result, even very tiny blemishes on certain parts (ie those readily visible when on the vehicle) can result in the part being rejected. While current powder losses are 40%, for most applications this could be reduced to 5 - 10% with careful quality control over the recovered powder and the customer's agreement. For example, ACC's largest customer now benefits from a powder utilisation of 98%.

These various changes have dramatically reduced powder use per part, saving around £26 000/year, while realising higher quality standards and far fewer rejects. Increased production densities and higher throughput have also reduced the energy costs per part, giving a payback period for the new equipment of around six months.

Energy savings mount up

The energy reduction objective of the EMS has allowed ACC to benefit from an 80% rebate under the CCL agreement, negotiated through the Surface Engineering Association. This rebate alone has covered the costs of implementing the EMS. The EMS commits ACC to a ten-year energy reduction programme, which is expected to save the company over £5 000/year by the end of the term. Significant energy gains have already been made through improvements in the powder coating operation. The curing ovens have also been improved through careful control and better air recirculation. ACC also plans to invest in new IR curing ovens, which would significantly reduce energy costs.

Changes at ACC significantly reduce solvent use

Working with powder rather than wet paint, and using a water-based degreasing process, ACC uses relatively little in the way of solvents.

Prior to 1999, the company used a solvent-based oil to protect uncoated areas of certain parts, such as shaft splines, gear teeth, etc. After some lobbying, the key customer allowed ACC to move to an alternative oil, thus reducing solvent usage to less than 5 tonnes/year. This allowed the company to fall below the LAPC (and future LAPPC) authorisation threshold, avoiding the yearly monitoring and council registration charges of £790, and saving around £1 500/year in total.

> “*It is the aim of the company to pursue excellence in all areas and this aim extends to the impact the company has on the environment. With this vision, ACC often finds itself ahead of environmental legislative requirements, and gains the benefit of a competitive advantage from efficiency programmes. The introduction of an EMS and the associated costs has paid for itself through the waste identification programmes.*”
>
> **Andrew Barcroft, Operations Manager, Advanced Colour Coatings**

4.3 Link Lockers saves £140 000 by changing to powder coating

Link Lockers produces lockers for factories, leisure centres and various other customers, and is one of the leading manufacturers in the UK.

Four years ago, the company became concerned about a number of environmental, economic and quality issues surrounding its solvent-based wet paint process. To maintain its competitive edge and address all these issues, Link Lockers decided to move over to powder coatings. The change has realised extensive benefits, including:

- net cost savings of £140 000/year;
- the elimination of solvent use;
- a reduction of rework from 15% to virtually zero;
- a payback period on investments of three years.

Moving quickly to maintain a competitive edge

Link Lockers is based in Telford and is one of the largest locker manufacturers in the UK, producing 3 000 lockers/week on average. The company was established approximately 25 years ago, has a turnover of £9 million and currently employs 120 staff. Customers range from factories and leisure centres to Government departments, and about 25% of the lockers are exported.

The lockers are produced in a variety of sizes, colours and door configurations. Of the lockers, 85% by turnover are manufactured from steel, with others being constructed from aluminium and timber. Until recently, the lockers were mostly coated using a one-pack wet paint, which was electrostatically applied using automated banks of spray guns within booths.

In the mid-to-late 1990s, Link Lockers became increasingly concerned about the implications for its business of:

- tightening legislation surrounding solvent use;
- increasing waste disposal costs;
- pressure from customers with regard to environmental performance;
- the expense of maintaining the existing plant;
- the increase in the number of rejects;
- the consistency of product quality.

At this time, paint utilisation was only 53% (due to high levels of overspray) and rework rates had reached 15%. In addition, the overspray collection sumps under the paint booths required monthly clean-outs, costing £40 000/year in special waste disposal costs.

The company realised that to maintain its competitive edge it needed to quickly address these issues. After undertaking a cost-benefit analysis of alternative processes, and discussing the situation with equipment and material suppliers, Link Lockers decided to switch from wet paint to powder coatings in 1998.

Product quality improves with the powder coating process

Two automated booths and guns were replaced with those designed for the application of epoxy powder coatings. At the same time, Link Lockers fitted a new conveyor system to improve throughput. The equipment replacement work took around two weeks. One of the booths is now used to apply the main colour. The second booth is used to apply the various other colours needed, involving around eight powder colour changes each day.

The same ovens are used to cure the powder as were used to bake the wet paint. Oven temperature is slightly higher than before, but energy costs have only marginally increased. The costs for the epoxy coating are slightly higher than those for the solvent-based wet paint, but this increase in costs has more than been outweighed by the many improvements.

- The coating booths collect overspray and recycle it back into the system, resulting in 90% material utilisation.
- Coating thickness has increased from 18 microns to at least 30 - 35 microns, eliminating the need for a second coat with most colours, and virtually eliminating the need for rework and touch-up.
- Powder coating coverage, at around 14.5 m^2/kg, is almost identical to that achieved with previous solvent-based wet paint, but the powder coating goes on to the product rather than disappearing as waste.

Far-reaching benefits realised by the switch to powder coating

Link Lockers has benefited in many ways from the switch to powder coating, helping the company to maintain its leading position in an increasingly competitive market. Among the many benefits are:

- improved aesthetic product quality, with the elimination of paint runs;
- improved product durability, due to an increase in film thickness of some 70%;
- improved material utilisation, up from 53% to 90%;
- near elimination of rework, from 15% down to virtually zero;
- increased production capacity, due to higher booth throughput and the elimination of rework;
- increased shop-floor space, due to the elimination of the paint mixing and touch-up areas, and the new booths being smaller than the original ones;

- elimination of solvent emissions and reduction in flammable material on site;
- elimination of the need for thinners, saving £4 000/year;
- elimination of special waste disposal costs associated with the overspray collection sumps, saving £4 000/year - a 15% reduction in total waste disposal costs.

Overall, Link Lockers has realised cost savings of around £140 000/year by making the switch. Based on capital costs of around £420 000, which includes the costs associated with staff training and production downtime, the payback period on investment is three years.

Further improvements enhance Link Lockers' position

To help address customers' increasing concerns with regard to environmental issues, Link Lockers has introduced an environmental policy. The policy informs customers of recent and planned environmental improvements, and a copy is included with all quotations provided to customers.

Link Lockers has also made energy efficiency improvements. High-pressure sodium oxide lamps are now used in the production area, in place of the less efficient fluorescent tubes. More efficient compressors have also been installed, which supply according to demand rather than running at a constant output.

The ovens used to cure the powder coating and dry the components after pretreatment are due for replacement soon. The company is seeking to replace these with more energy-efficient units.

> *"The switch from solvent-based paint to powder coating has been one of the best investments the company has made, improving quality, environmental and health issues."*
>
> **Terry Thompson, Operations Manager, Link Lockers**

4.4 Peatey's Coatings reduces solvent use and saves £90 000/year

Peatey's Coatings (Peatey's) coats a wide variety of products using powder and wet paints. Taking action to reduce solvent use has enabled Peatey's to maintain its position as one of the leading trade coaters, without compromising on quality, environmental performance or health and safety issues.

Three major improvements have been made at the company's Leeds site:

- a move from conventional to high volume low pressure (HVLP) spray guns, cutting paint use by 35% and saving £30 000/year, with a payback period of just two months;
- increased use of powder coatings, reducing coating energy use by 20%;
- use of an aqueous alkaline degreaser and phosphating spray unit in place of a vapour degreaser, saving around £60 000/year in chemical costs, with a net payback period of around 12 months.

The above improvements have reduced solvent use on site from 15 - 20 tonnes/year to below the 5 tonne threshold set under LAPC. The improvements have also contributed significantly to a 500% increase in productivity in the last ten years.

Staying ahead in a competitive sector

With an annual turnover of over £2 million, Peatey's is one of the largest trade coaters in the north of England. It was established in 1947 and currently employs 56 people at its Leeds site. The company holds Surfaqs Accreditation (relating to finish quality) from the Paint and Powder Finishing Association and has an accredited ISO 9001:2000 system. The company also has an environmental performance statement within its quality policy.

Finishes offered by Peatey's include powder coating and stove enamels, as well as two-pack paints. The company operates a 24-hour job turnaround and typically handles 50 to 70 jobs a day. These jobs can vary from coating only a few components to coating thousands at a time. The products coated also vary widely, ranging from shop shelving and light fittings, to architectural steel work and car components.

Three major improvements have been made at Peatey's over the last ten years, which have resulted in significant cost savings, as well as reducing environmental impact and realising major quality and health and safety improvements. Through these various improvements, the company has increased output by 300%, while moving from a three-shift system to a two-shift system. This equates to a 500% increase in productivity.

Change 1 - the move to HVLP spray guns

About five years ago, Peatey's changed from using conventional wet-paint spray guns to HVLP guns, which atomise the same volume of paint while keeping the dynamic tip pressure low. This switch has resulted in:

- a reduction in overspray, which has cut paint consumption by 35%, saving an estimated £30 000/year;
- improved product quality, due to more controlled paint application;
- improved productivity, due to reduced process time and labour requirements;
- a reduction in VOC and particulate emissions;
- a reduction in compressed air use and hence energy consumption.

HVLP spray guns are slightly more expensive than conventional spray guns, and require additional staff training to ensure their correct use, but these costs are significantly outweighed by the resulting financial savings. Indeed, payback on investment was achieved in just two months.

Change 2 - increased use of powder coatings

Peatey's introduced a powder coating process on its site in the early 1970s. This move required the purchase of new spray guns, but existing spray booths could still be used. Powder coating commissions now represent 80% of turnover and demand continues to increase as more customers recognise the benefits that powder coating brings, for example, in terms of improved corrosion resistance.

Applying powder coatings in place of solvent-based paints has resulted in:

- the elimination of the need for a primer coat, thereby improving productivity and reducing material costs;
- a reduction in energy consumption of around 20%, due to the recirculation of air within the workspace which reduces heat loss;
- the elimination of VOC emissions.

At the moment, the company is rarely able to recycle overspray and surplus powder, as it is constrained by the very large number of one-off colours used.

Change 3 - a new approach to metal degreasing and preparation

Peatey's has completely changed its approach to the degreasing and preparation of products. Like many in the sector, the company used to use trichloroethylene in a manually operated vapour degreaser. The tank was cleaned out manually every six weeks or so, which involved draining the tank into drums and then digging out the sludge. This was a very unpleasant and potentially dangerous job, and drums were often left in the yard for some time before being collected as special waste.

Blasting is now used in place of mechanical (manual) preparation, while a fully enclosed and automated aqueous degreasing and phosphating spray unit has replaced the vapour degreaser. These changes have resulted in:

- a reduction in chemical costs of £60 000/year;
- the elimination of VOC emissions;
- a reduction in job rejects/rework, as the new process ensures the consistent degreasing of products, improved corrosion protection and better coating adhesion;
- improved productivity - a product batch that previously took two hours to degrease and involved two men, now takes 20 minutes with minimal labour input;

- reduced waste disposal costs, saving around £1 500/year, as effluent from the new process can be discharged to sewer with the agreement of Yorkshire Water;
- a reduction in health and safety risks through the elimination of trichloroethylene, a Category 2 carcinogen.

The equipment capital costs were high, and energy use in the ovens has increased due to the need to dry wet components, but the savings made have resulted in a payback period of approximately 12 months.

The additional benefits of lower solvent use

The reduced VOC emissions resulting from the changes made at Peatey's have improved workplace air quality. Solvent use has come down from around 15 - 20 tonnes/year to below the 5 tonne LAPC authorisation threshold, which has saved £790/year in annual authorisation subsistence fees, plus the associated monitoring and management costs.

> *"The trade coating business is highly competitive and profit is made through continually improving processes and reducing costs. It is a matter of pride to all of us at Peatey's that we can continue to keep our position as one of the leading companies in the industry by improving quality and value for money whilst providing a far safer working environment for our employees and significantly reducing our environmental impact."*
>
> **Ruth Chapman, Managing Director, Peatey's Coatings**

4.5 Plasma & Thermal Coatings Ltd makes continuous improvement in environmental performance and saves over £6 000/year

Plasma & Thermal Coatings Ltd (PTC) has developed and applied coatings for a wide variety of customer applications since 1995, and in 1999 became one of the first thermal spray companies in the UK to be awarded ISO 14001.

PTC continues to demonstrate its commitment to improving its environmental performance, and has implemented many measures to help control any impacts at source. The company has adopted an integrated management system (IMS) and, in addition to environmental and financial benefits, the approach is also having a positive impact on employee motivation and customer satisfaction. Among the many benefits realised at PTC are:

- a 50% reduction in degreasing solvent use, from around 2 500 litres/year to around 1 200 litres/year;
- special waste disposal costs reduced by around £3 000/year;
- exemption from LAPC/LAPPC authorisation, saving the annual fees of around £800;
- energy savings of £2 000/year, equivalent to some 3% of the electricity bill;
- a significant improvement in workplace air quality and noise levels.

Taking a continuous improvement approach

PTC is based in Newport, South Wales. The company employs 30 people and has a turnover of £2.6 million. The facility at Newport offers an extensive range of thermal spray processes - including plasma, high velocity oxy-fuel (HVOF), wire and combustion spraying - all using a wide variety of coating materials. All spray cells are fully automated with sound-attenuated booths and robotics. Spray and coating parameters are recorded to ensure continued quality and repeatability. PTC has customers worldwide, covering the aerospace, automotive, oil and gas exploration, and industrial land-based turbine industries.

While the company had always taken environmental issues seriously, further legislative and commercial (supply chain and cost reduction) pressures led PTC to introduce an ISO 14001 environmental management system (EMS) in 1999 and subsequently an IMS covering health, safety, environment and quality.

These moves have led to the company becoming more proactive, taking a continuous improvement approach with a clear focus on process and procedural improvements driven by realistic objectives and targets. Introduction of the systems, coupled with good working relations with external bodies such as the Carbon Trust, Welsh Water and the Environment Agency, has also helped PTC with pollution control work, ensuring legislative compliance and reduced risks.

Getting staff on board

To support the implementation programme, competency requirements were identified and appropriate staff training was organised. Management commitment to training, education and consultation has led to a positive culture within PTC, which helps to assist the continuous improvement process. Maintaining high standards in housekeeping is just one area where shop-floor staff have played a major role.

Taking action to reduce solvent use

PTC has always used raw materials which are inherently VOC-free. Applying low-VOC coatings, and using less than 5 tonnes/year of solvent, meant that the company did not need to register under the LAPC regime, avoiding the yearly authorisation fee of £790.

However, PTC did use around 2 500 litres/year of trichloroethylene for manual and vapour degreasing. Concern over this chemical being defined as a Category 2 carcinogen, coupled with the harmful environmental effects of it as a VOC, led the company to look for less wasteful practices and less harmful substitutes.

As an initial measure, tighter control was taken over solvent housekeeping. Solvent is now decanted into smaller containers, each fitted with a trigger pump to control solvent delivery. Minimum quantities are dispensed onto cotton rags for manual degreasing, reducing consumption and eliminating the risk of spillage.

After involved research and customer consultations, trichloroethylene has been replaced with a water-based cleaner with very low solvent content. There has been no reduction in the quality of component cleaning, as verified by subsequent customer approvals. While the new cleaner is a little more expensive per litre than trichloroethylene, less is used and the overall cost per component is approximately the same as before.

Together, these measures have allowed trichloroethylene use to be reduced to around 1 200 litres/year, just over a 50% reduction. Trichloroethylene is still used for vapour degreasing in a fully enclosed system, which reduces unnecessary emissions and exposure.

Reducing special waste

Special waste disposal was a big issue for PTC. Prior to the environmental improvement programme, it was costing the company around £3 900/year to dispose of waste solvent and laboratory chemicals.

PTC has lowered the volume of special waste for disposal by:

- taking action to reduce the use of trichloroethylene;
- introducing strict control over the storage and use of laboratory chemicals;
- improved identification and segregation of wastes (ie stopping general wastes from being mixed with special wastes).

These measures have cut disposal costs to around £900/year, saving £3 000/year.

Realising the value of energy

Some of the largest long-term savings at the Newport site have been realised through a rigorous energy management programme, which has involved:

- regular reviews of energy usage and costs;
- internal benchmarking of building and process energy efficiency;
- installation of a power factor corrector and high frequency lighting;
- regular checking/calibration of equipment controls;
- keeping staff informed, trained and well-motivated to save energy.

These initiatives will save the company around £2 000/year, some 3% of the energy bill.

Not forgetting health and safety

Staff welfare has always been important to PTC. Low-VOC manual degreasing has improved the workplace environment. In addition, the company has installed further soundproofing and abatement equipment on each of its spray booths to reduce noise and particulate levels, to ensure compliance with the Environmental Protection Act 1990 and Noise at Work Regulations 1989.

Forthcoming developments look set to save £50 000/year

PTC is developing coatings that have been proven to reduce the level of trace water impurities in applications for the water treatment industry. The company hopes to expand the market for these coatings to the air treatment and food manufacturing sectors.

As part of its on-going environmental programme for 2002/3, PTC embarked on a major project in association with students from Cardiff University. The work aims to identify spray particulate levels, measure risk and hence improve staff wellbeing.

In 2003, a £50 000 investment in gas management was made, which is expected to reduce gas usage, reduce fire/explosion risk, produce space savings and significantly increase productivity. Overall, the benefits are expected to be worth around £50 000/year to the company.

> *“The benefits of the IMS have gone straight to the bottom line. The environmental and quality initiatives have been incredibly good business, while implementation of a health and safety system has led to considerable improvements to the working environment for employees. The company will continue to make progress through enterprise and innovation.”*
>
> **Plasma & Thermal Coatings Ltd**

4.6 Quality and efficiency initiatives save SMP Playgrounds over £40 000/year

SMP Playgrounds (SMP) manufactures and installs children's playground equipment. The company has built its reputation on delivering high quality and safe play equipment. The company has made environmental improvements, driven mainly by concerns over legislation, product quality and production efficiency, all of which have benefited from the measures taken to date. The specific improvements include:

- a halving of the coating quantities used by the company, saving around £40 000/year;
- the elimination of solvent use, thereby avoiding the need for authorisation under LAPC, saving £790/year in fees alone;
- a 25 - 30% reduction in labour costs;
- improved product quality, particularly in terms of consistency and corrosion resistance.

Overall, the measures introduced have realised a payback period of around two years.

Company move prompts coating change

SMP is a medium-sized company based in Egham, Surrey, and was established over 35 years ago. It employs around 64 staff and has an annual turnover of about £8 million. The company specialises in the production of innovative playground equipment for children, including climbing frames, swings, roundabouts and all-in-one play centres.

Strict safety standards are required for the equipment to be deemed suitable for children. With customers worldwide, SMP ensures that all its products meet the latest European safety standards and UK legislation, including extra precautions for equipment to be used by under 36-month old children. It is, therefore, important that any coatings used are very durable and non-toxic.

SMP originally employed a three-coat solvent-based system, using a primer, undercoat paint, and coloured finishing paint. Spraying was carried out with conventional electrostatic manual spray guns, which continually caused production problems and affected product consistency and quality. The process was also very labour-intensive.

In 1999, SMP started planning a move to new premises. The company was already authorised under LAPC, but realised it would have to apply for a new authorisation when relocated. SMP seized the opportunity offered to change to a cleaner, less labour-intensive process. Powder coating was examined, as it offered clear cost, quality and environmental benefits.

The original process used grit blasting to prepare surfaces, with hot zinc spray used as an undercoat on products destined for extremely corrosive conditions. Products were then coated with a thick paint film, capable of meeting the 2 000 hours protection requirement in ASTM (American Society for Testing and Materials) B 117 for *Salt Spray [Fog] Testing*. The key challenge was to find a powder coating system that would give the same or better quality performance as the old paint system, at an acceptable cost.

After many trials and considerable testing, SMP selected a system that uses a 'green' cured zinc-rich epoxy powder coating, over-coated with a polyester super-durable coloured finish. New plant was installed at a cost of around £130 000.

Benefits of the powder coating process

Prior to the installation of the new powder system, SMP was spending around £80 000/year on paint. In addition, the old paint process was releasing over 7 tonnes/year of VOCs to the atmosphere, making it subject to authorisation under LAPC.

Converting to powder coatings has approximately halved the company's previous spend on coating materials, saving around £40 000/year, and has eliminated the need to use solvents. The company now avoids the costs of LAPC compliance, including the authorisation fee of £790 and associated management time. In addition, SMP has a safer working environment for its employees and has reduced its environmental impact.

Productivity has also increased dramatically, with the new coating system requiring 25 - 30% less labour input. Overall, taking the productivity improvements and material savings into account, payback on investment in the new powder coating plant has been achieved in around two years.

> *"I believe that this process is far better than the old dirty process and gives our products better corrosion properties and right first time quality with less manpower."*
>
> **Bob Wilson, Works Director, SMP Playgrounds**

4.7 Wellington Garage benefits by using water-based paints in vehicle respraying and saves £28 000/year

Wellington Garage is an independent car repair body shop. In 1999, the company decided to replace two drying ovens and, instead of opting for a straight replacement, took the opportunity to switch to water-based paints and ovens capable of dealing with the associated drying requirements. This course of action has paid dividends, with significant benefits resulting from the change, including:

- a reduction in VOC emissions of 55%;
- better workplace air quality;
- a 12% increase in throughput, worth £74 000/year in extra business;
- reduced courtesy car needs, saving £28 000/year;
- an 18% reduction in oven gas usage, saving the company around £420/year.

Recognising an opportunity to make savings

Wellington Garage is a medium-sized independent car repair body shop based in Bury, Greater Manchester. It employs 22 people, 14 working in the body shop, and has a turnover of around £750 000. The company is a member of the Motor Vehicle Repairers Association and operates

within an ISO 9002 quality management system, and is an approved Accident Repair Centre for a number of insurance companies. For the past 12 years, the company has specialised in body repairs and refinishing, although it also provides a full range of vehicle maintenance and MOT testing services.

In late 1999, the company decided to replace two drying ovens in its repair centre, as they were getting old and uneconomic to run. Initially, the company obtained quotations for the direct replacement of the existing ovens, which were used to dry solvent-based coatings. Wellington Garage's annual VOC emissions were then 0.6 - 0.8 tonnes. New requirements under Local Air Pollution Prevention and Control (LAPPC) and the Solvent Emissions Directive would bring this threshold down from 1 tonne/year to 0.5 tonnes/year of VOCs for vehicle refinishers, with obvious compliance implications. The company, therefore, decided to investigate the possibility of switching to water-based coatings where possible.

The move to water-based paints

Wellington Garage carried out various investigations into the cost and quality implications of changing coating materials. This research led to the conclusion that water-based primers and basecoats should be used, even though they were slightly more expensive per litre than the equivalent solvent-based coatings. However, the company deduced that it would still have to use solvent-based clearcoats, due to perceived limitations with current water-based lacquers. Coating selection had implications for the ovens, which needed to be capable of drying water-based coatings efficiently. The speed and efficiency of the drying process relies on the humidity, temperature and flow rate of the drying air. Various systems were considered, keeping these factors and energy efficiency very much in mind.

The oven units chosen are fully enclosed and airtight, with double-skinned, insulated walls. Spraying is carried out within the booth/ovens under slight positive pressure to prevent dust ingress. Finished jobs are baked in the ovens for typically 20 - 30 minutes. Overspray is carried away and trapped in filters, which are occasionally replaced. The booths have a very high recirculating airflow, and incorporate a heat exchanger system which recovers heat from the extracted air and hence reduces gas consumption. The units are fully galvanized to protect the steelwork from corrosion, often a problem with humid airflows. The ovens also incorporate a light management system that switches off unnecessary lights.

To replace the original drying ovens like-for-like would have cost in the region of £22 000. The chosen ovens cost £50 000, but have enabled higher throughput and use less energy. Gas usage has dropped by around 18%, saving £420/year, despite a 12% increase in vehicle throughput, giving a specific energy consumption drop of over 27%. The higher throughput has added £74 000/year to the business's turnover.

Falling below the VOC threshold

Despite the fact that the clearcoats are still solvent-based, the change to water-based primers and basecoats has significantly reduced VOC emissions at Wellington Garage. Further emission reductions have been made possible through the use of HVLP spray guns, which reduce paint overspray and hence reduce wastage. The garage management has also implemented tighter control over paint allocations. Paint quantities are now mixed to the nearest tenth of a litre required for the particular type of job.

Overall, VOC emissions have been reduced from around 0.7 tonnes/year to 0.31 tonnes/year, a reduction of nearly 56%. This brings the company below the 0.5 tonne VOC threshold that will apply to existing installations from October 2007 under LAPPC. Reduced use of VOCs has also significantly improved the workplace air quality, which has contributed to better staff wellbeing and helped with staff retention.

Better quality and productivity gains

Wellington Garage had experienced various quality problems with its solvent-based coatings, such as lifting/shrinkage and metamerism, the latter resulting in apparent colour variation under different types of light. These problems led to rework and hence wasted coatings and ancillaries, such as masking materials. The associated delays also created difficulties with customers, who expected their vehicles back on time, and congestion in the workshop as new vehicles were brought in while old ones were being reworked.

Conversion to the water-based coatings has significantly improved product quality, with the vast majority of jobs now being 'right first time'. This factor, combined with the faster drying times provided by the new ovens, has helped to increase throughput by around 12%. As customers are given courtesy cars, the quicker turnaround has reduced the number of units required by some 20 cars, giving an unexpected cost saving of £28 000/year.

Making improvements across the board

Examining the process has enabled Wellington Garage to make changes in all areas, to improve its performance and work environment.

The fitting of skylights has allowed artificial lighting to be switched off during daylight hours on most days. Body shop staff are now able to match colours under natural lighting.

Modifications to the compressor have allowed it to run on a single phase when lightly loaded. This is preferable to it switching on and off on three-phases, which had the tendency to create occasional power surges.

> *"At Wellington we consider ourselves very proactive on issues such as waste, energy conservation, health and safety, and environmental protection. Adopting this approach has certainly contributed to the growth of the business."*
>
> **Dave Wardle, Body Shop Manager, Wellington Garage**

Further assistance

If you require further advice or have any specific questions about efficient paint and powder coating, the **Environment and Energy Helpline on 0800 585794** can put you in touch with relevant technical experts. The Helpline can also:

- provide free, up-to-date advice on environmental issues;
- tell you about relevant environmental and other legislation that could affect your business;
- send you copies of relevant Envirowise publications;
- suggest other sources of information;
- arrange for a confidential, on-site waste review (known as a *Fast*Track visit) from an environmental advisor to help you identify opportunities for resource efficiency and thus reduce costs.

Particularly relevant Envirowise guides include:

- *Cost-effective paint and powder coating: materials management* (GG385)
- *Cost-effective paint and powder coating: coating materials* (GG386)
- *Cost-effective paint and powder coating: application technology* (GG387)
- *Surface cleaning and preparation: choosing the best option* (GG354)
- *Reducing costs in vehicle refinishing* (GG36)
- *Reducing solvent use in the furniture industry* (GG177)
- *Cost-effective solvent management* (GG429)
- *Reducing solvent use by good housekeeping* (GG413)
- *Solvent management in practice: industry examples* (GG124)
- *Solvent capture for recovery and re-use from solvent-laden gas streams* (GG12)
- *Solvent capture and recovery in practice: industry examples* (GG100)
- *Monitoring VOC emissions: choosing the best option* (GG203)
- *Cost-effective reduction of fugitive solvent emissions* (GG71)

A wide range of case studies is also available, covering various sectors. All Envirowise publications are available free of charge through the Environment and Energy Helpline on **0800 585794** or via the Envirowise website (**www.envirowise.gov.uk**).

The website also carries other useful information, for example, on waste minimisation clubs and forthcoming events.

The Environment Agency general enquiries line (0845 9333 111) and website (www.environment-agency.gov.uk) can also provide advice and information on solvent management issues and legislative compliance.

Example cost saving worksheet

Area/department:

Cost-saving measure	Approximate reduction (%) **A**	Quantity affected/year (litres) **B**	Unit cost (£/litre) **C**	Projected yearly saving (£) **A×B×C/100 = D**	Approximate capital cost (£) **E**	Payback period (months) **12×E/D**
1. eg Spray guns	50	20 000	5	50 000	5 000	1.2
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
TOTAL	—	—	—			

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

Envirowise offers a range of free services including:

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

envirowise
Practical Environmental Advice for Business

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

For further information please contact the

Environment and Energy Helpline 0800 585794