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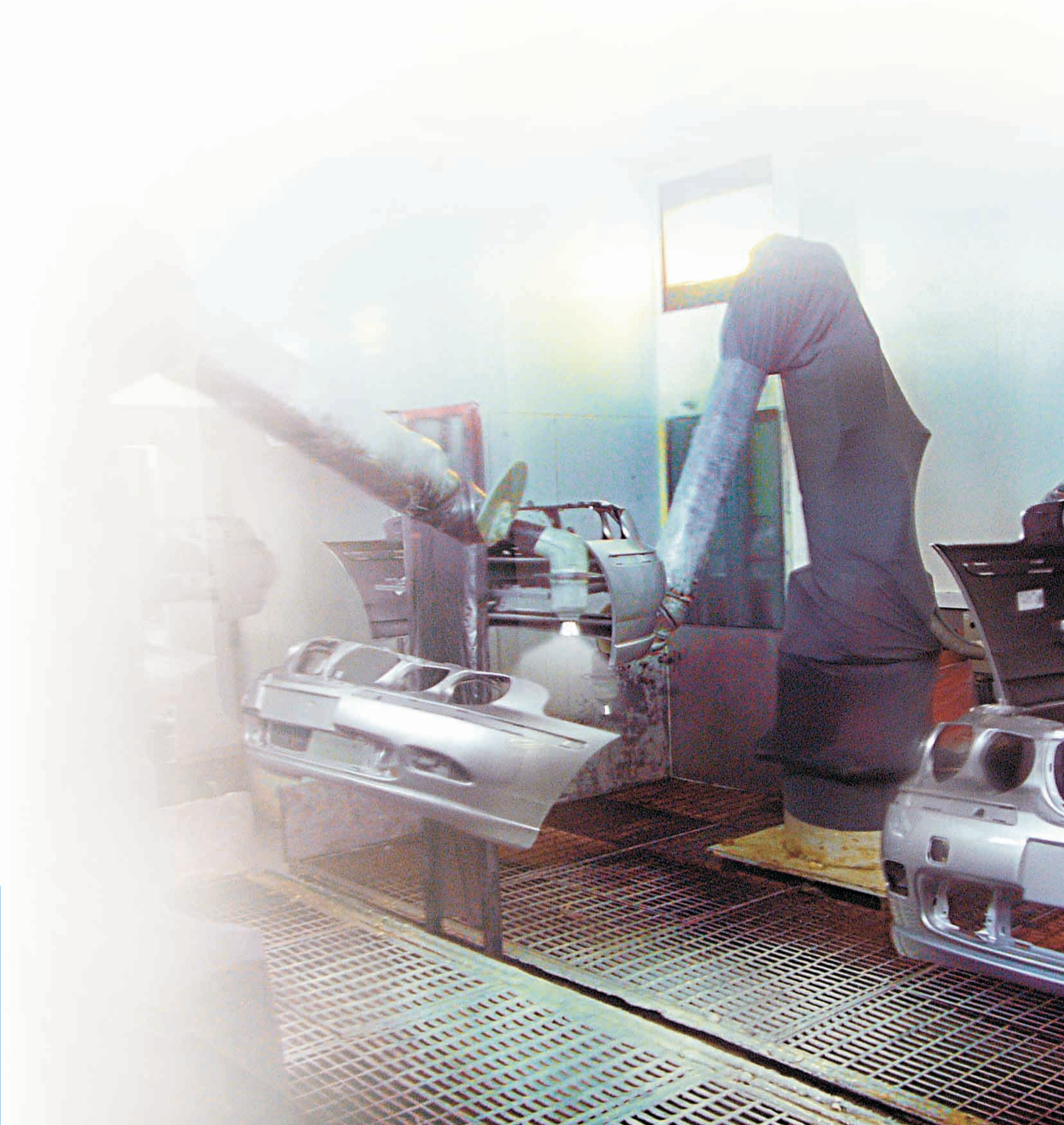
GG387

Cost-effective paint and powder coating: application technology



Cost-effective paint and powder coating: application technology

This Good Practice Guide was produced by Envirowise

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Summary

This Good Practice Guide is one of four complementary guides providing advice on cost-effective paint and powder coating. It is aimed at paintshop and production managers whose operations use paint and powder coating materials.

Transfer efficiency - the percentage of coating that actually ends up on the workpiece - is an important performance criterion for any method of applying a coating. This Guide explains how a company can reduce its costs and volatile organic compound (VOC) emissions by using efficient methods of applying coatings. The Guide describes good practice for:

- dipping;
- spraying;
- powder coating;
- equipment cleaning;
- automation.

Industry examples illustrate the cost savings and other benefits that can be achieved by switching to more efficient application methods.

The ideas highlighted in this Guide will:

- save money;
- save time;
- use less paint and solvent.

Use of more efficient application methods will also help companies that are regulated under Local Authority Integrated Pollution Prevention and Control (LA-IPPC) or Local Air Pollution Prevention and Control (LAPPC) to comply with the regulations in a cost-effective manner.

There is an action plan at the end of the Guide to help you focus on the ideas that are most relevant to your company.

The other guides in the series cover materials management, surface cleaning and preparation, and coating materials. All are available free of charge through the Environment and Energy Helpline on freephone **0800 585794** or via the Envirowise website (**www.envirowise.gov.uk**).

This Guide builds upon GG53, first printed in 1997, and contains up-to-date legislation and industry examples.

Contents

Introduction

The four complementary guides to cost-effective paint and powder coating in this series are:

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)

These guides and other Envirowise publications mentioned herein are available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

These guides are intended to help a range of companies, including:

- metal finishers;
- fabricators;
- component and assembly manufacturers for original equipment manufacturers;
- original equipment manufacturers.

The guides are applicable to companies using paints and powders to coat in:

- predominantly manual operations, eg degreasing baths and hand-spraybooths;
- partially automated operations;
- fully automated operations.

Some sections of the Guide are more applicable to smaller, manual operations and others to larger, automated operations. Companies considering automation of tasks may also find this Guide useful.

Coating material applied to anything but the job in hand is wasted.

1.1 Selecting an alternative application technology

This Guide includes information on the following application technologies:

- dipping:
  - electrodeposition/autodeposition;
- flow coating;
- barrelling;
- spraying:
  - HVLP;
  - airless;
  - air-assisted airless;

- centrifugal (electrostatic);
- disc (electrostatic) for automatic systems;
- electrostatic systems for manual spray guns;
- hot spraying;

- powder coating:
  - corona electrostatic charging;
  - tribo-charging;
  - combination charging;
  - powder bell;
  - fluidised bed.

When considering the possibility of changing to a different application technology, it is important for companies to decide the aims in carrying out the change and then prioritise them.

The prioritised aims should be matched against all available application technologies to determine the best possible match. Such aims might include:

- reducing application costs;
- reducing the consumption of coating materials;
- reducing solvent emissions;
- improving production capacity through reduced processing time;
- maintaining or improving finish quality;
- ensuring required coating thickness is achieved easily;
- meeting requirements for Local Air Pollution Prevention and Control (LAPPC) compliance.

Many of these aims and priorities will limit the number of alternative application technologies that are suitable. The capital cost of the change may also impose constraints on the choice of technology. However, the capital cost may be offset against the savings made by any gains in transfer efficiency.

The change to a different application technology may be taking place at the same time as - or be driven by - a change in the type of coating material used. *Cost-effective paint and powder coating: coating materials* (GG386) describes the range of paints and other coatings now available.

Automation (see section 8 of this Guide) may also have an impact on, or be forcing, the change in application technology.

Reductions in material use may be maximised if the change in application technology is combined with a change in coating material.

More efficient application saves time and money

Plastic Omnium, which employs 275 people at its Measham site in the Midlands, manufactures high quality car bumpers for a range of vehicle manufacturers.

In 1998, the coating of the car bumpers involved robotic spraying of primer using pneumatic guns, robotic spraying of the first basecoat using pneumatic guns, manual spraying of the second basecoat using pneumatic guns and finally, manual spraying of the first and second clear coats using electrostatic guns.

The various stages of the coating process were investigated and the transfer efficiencies calculated for each stage. The robotic basecoat guns had a very low transfer efficiency of around 35%, with 65% of the coating being lost to the air extraction wash bath beneath the booth.

To reduce paint wastage, the company undertook a number of measures including fitting electrostatic bells to the existing basecoat robots. The cost of the bells, including installation and optimisation, was just under £88 000 and the total cost of the improvement project, including staff time, downtime and spare parts, was approximately £150 000.

Having installed and optimised the system, paint and solvent use was monitored on a monthly basis and the net cost saving calculated. Over the first year of operation, with the plant running at about 8 000 to 9 000 bumpers per week, the company saved approximately £231 000 on basecoat paint, giving a payback period on materials alone of under eight months.

Reducing material consumption

Companies that are more efficient and produce less waste are more profitable and competitive. This Guide compares the performance of currently available technologies for applying coatings, and highlights ways of reducing waste in coating operations.

2.1 Improving transfer efficiency

Transfer efficiency is a measure of how well a technology applies a layer of paint, ie how much applied paint actually ends up on the job. It is defined as the percentage of coating used that becomes attached to the workpiece.

Coating material that is not applied to components being coated is a major source of waste, eg overspray caused by the properties of the spray gun and the way the spray gun is used. Overspray can be reduced by good operator practice.

Transfer efficiencies quoted by spray gun manufacturers are measured under ideal conditions and against large, flat surfaces. In practice, these ideal transfer efficiencies cannot be achieved when coating relatively small, irregular objects. However, the relative transfer efficiency performance of the spray gun equipment can be used to choose the best equipment for a given application.

Transfer efficiencies for dipping and brushing are not normally quoted, but can be assumed to be nearly 100%.

2.2 Reducing solvent losses

Organic solvents are widely used in UK industry for a range of processes. In the metal coating industry, trichloroethylene can be used for cleaning and a range of organic solvents including xylene, white spirit and butyl acetate may be part of the paint formulation or used for thinning.

These, and other organic solvents, give rise to volatile organic compound (VOC) vapours, and 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.

The EC Solvent Emissions Directive was implemented by the Pollution Prevention and Control (Solvent Emissions Directive) (England and Wales) Direction 2002, which places strict controls on VOC emissions from industry and defines emission limit values for new and existing installations. Prescribed coating activities (those with solvent consumption above prescribed thresholds) must comply fully with the requirements of the Solvent Emissions Directive by 2007. Note that the emission limits for those VOCs carrying risk phrases (such as trichloroethylene) are mandatory.

The Pollution Prevention and Control (PPC) Regulations require the operators of prescribed processes to submit a detailed application for a permit to operate to the regulator. Most paint and powder processes fall within Part A(2) for Local Authority Integrated Pollution Prevention and Control (LA-IPPC) or Part B for Local Air Pollution Prevention and Control (LAPPC).

There are transitional arrangements for existing installations which are authorised as Part B processes under the Local Air Pollution Control (LAPC) regime.

The relevant Secretary of State's Process Guidance Notes applicable to metal coating in the general industrial sector are PG6/23 *Coating of metal and plastic*, PG6/31 *Powder coating*, PG6/34 *Re-spraying of road vehicles* and PG6/40 *Aerospace coatings*. There are other Process Guidance Notes applicable to particular industries and processes.

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

Even if your process does not use enough solvent to be prescribed under the PPC Regulations, using good practice will still enable you to achieve significant cost savings. Companies approaching the relevant threshold may also be able to postpone or avoid the need for a permit to operate under LAPPC by improving their operating practices.

Emission reductions can be achieved by means of abatement plant, by the 'reduction scheme' using coating materials with a reduced solvent content and increased efficiency in the use of solids, or during the transition period, by the use of 'compliant coatings'.

Operators of prescribed processes are also required to prepare a solvent management plan to determine the 'annual actual solvent emission' and compare it with the 'Target Emission'.

Ways of reducing solvent consumption are described in *Good housekeeping measures for solvents* (GG28) and *Cost-effective solvent management* (GG13).

Cost-effective paint and powder coating: materials management (GG385) describes how coating operations can save money through good housekeeping.

Dipping

Dipping is probably the oldest and least technical method of applying coatings.

In its simplest form, items to be coated are immersed in a reservoir of liquid coating and then pulled out. Excess coating material is allowed to drain and the applied coating is then dried. The excess coating material is returned to the reservoir.

The advantages of dipping are:

- much less waste is produced compared with spraying;
- transfer efficiency is nearly 100%;
- complex objects can be coated easily;
- high production rates.

Dipping does, however, have several significant limitations.

The reservoir has to contain sufficient liquid for the largest possible item to be completely submerged, and have sufficient capacity to accommodate the increase in the liquid level as the object is dipped.

This accommodation problem can be overcome by using a secondary, overflow reservoir coupled with a mixing system to ensure agitation of the coating material. However, the need to maintain a reservoir of liquid coating ties up money in material stocks and removes flexibility in changing colour or coating type. Large volumes of flammable coatings can also constitute a major fire hazard.

The choice of coating material is fairly limited. The need for the coating material to possess the liquid properties necessary to provide an acceptable finish tends to favour low viscosity materials. High solids paints and 2K systems (see section 8.4) are usually not suitable. Although ultraviolet-cured coatings can be used, no light can be allowed to enter the reservoir of coating material.

Solvent evaporation from the reservoir surface not only increases the viscosity of the coating material, but also creates a health hazard. Measures that minimise solvent losses include:

- using low volatility solvents;
- careful design of the dipping plant;
- avoiding extraction systems and draughts;
- incorporating deep headspaces (freeboard) to retain a solvent-saturated atmosphere above the reservoir;
- fitting and using lids and/or flexible baffles.

The reservoir of coating material has to be carefully managed to achieve the desired coating quality, for example:

- contamination of the coating material with residual pretreatment chemicals may lead to a poor quality finish;
- the coating material may require agitation to ensure the desired quality of coating finish.

In dipping, the quality of the resulting coat depends on:

- the choice of coating material;
- the shape of the items to be coated.

Coating thickness is affected by:

- the speed of dipping and withdrawal from the bath;
- the temperature difference between the coating material and the items to be coated.

Care should be taken when considering whether or not to dip coat an object. Dipping processes are most suitable for primer coating or where colour changes are not required and where surface finish is not a prime consideration.

Complex objects with small holes or close faces can let the coat 'web' across the holes or faces, resulting in a poor quality coating. Pockets that hold liquid material may also create problems in the finish quality.

Dipping is relatively easy to automate. Automation of dipping can result in improvements in the quality of finish because accurate control of immersion, holding and withdrawal times can be achieved. Evaporation control using baffles, flexible doors, etc, is also easier, as frequent access to the paint reservoir is not required.

Dipping can be cost-effective, particularly when compared with the losses of coating materials from spraying operations.

3.1 Electrodeposition/autodeposition dipping

Two modern versions of dipping - more often found in medium-to-high volume coating operations - are electrodeposition and autodeposition.

These systems involve dipping components in special polymer-based coatings. In the case of electrodeposition, the workpieces have to be connected to the electrodes of the bath - usually through the jig. In autodeposition, electrical connection is not required. The mechanisms of electrodeposition and autodeposition are outlined in section 3 of *Cost-effective paint and powder coating: coating materials* (GG386).

In both cases, the workpieces have to be rinsed after coating to remove the 'cream' of excess polymer which forms during the coating process. The coating is then baked to remove water and volatile compounds, ie to cure the coat.

A major advantage of autodeposition over electrodeposition is that the curing temperature of the coat is lower, ie 100°C rather than 170 - 180°C. The lower curing temperature enables manufacturers to coat assemblies that have heat-sensitive parts, eg plastics, instead of coating metal parts prior to assembly.

Both electrodeposition and autodeposition systems use water-based coating materials, with little or no VOC content - an advantage if a company wishes to reduce its VOC emissions.

These systems are used mainly for corrosion-resistant coating of automotive and aerospace components, where finish quality is not of paramount importance.

3.2 Flow coating

Flow coating is suited to large or oddly shaped parts that are difficult or impossible to dip coat. An ample supply of coating material is pumped through perforated tubes or non-atomising nozzles that flood the part with the coating material. As in dipping, excess coating material is allowed to drain and is collected for re-use. The advantages and limitations of the dipping process generally also apply to flow coating.

3.3 Barrelling

This technique is used in coating processes, such as coating fasteners, where only a low quality finish is needed.

The items to be coated are loaded into a mesh or perforated drum/barrel. The barrel is then immersed in a bath of coating material, where it may be rotated to ensure adequate coverage of all the items. The barrel is then withdrawn from the bath and allowed to drain. It is sometimes spun to remove excess coating material. The coated items are then tipped out of the barrel onto a suitable drying surface, eg a mesh or perforated plate, and allowed to dry.

The benefits of such a system are:

- less wastage than spraying;
- no need for time-consuming loading onto hooks or jigs as for conventional dipping.

However, the finish quality is low.

Spraying systems

The main factors affecting the transfer efficiency of a spray gun are the mechanisms by which the:

- coating material is atomised;
- atomised material is projected or attracted to the workpiece.

The relatively low efficiency of conventional spray guns compared with newer types is targeted in UK environmental legislation governing the industrial application of coating materials containing VOCs. Earlier editions of the Secretary of State's Guidance for Processes prescribed for LAPC by local authorities specified the use of an application method with a solids transfer efficiency of 65% or better. Users of industrial coatings regulated under LAPC were required to change to spray guns with improved transfer efficiencies not later than 1 April 1998.

Although many low volume users of industrial coatings fall below the threshold for regulation under the current LAPPC regime, and are not covered by this requirement, use of higher efficiency spray guns saves money through reduced wastage of coating materials.

4.1 Higher efficiency spray guns

The significant savings that can be achieved by switching to higher efficiency spray guns for both small and medium-to-high volume users are illustrated in the example shown in Table 1 overleaf.

The example assumes that:

- all of the coating material was originally applied using conventional spray guns;
- all of the wastage occurs through overspray and not through spillages, overmixing, etc;
- higher efficiency spray guns are used under the same conditions as conventional spray guns.

In practice, paint is wasted in other ways, leading to an overall reduction in paint use of typically 30%. The net cost saving would be lower due to the cost of buying the higher efficiency spray guns.

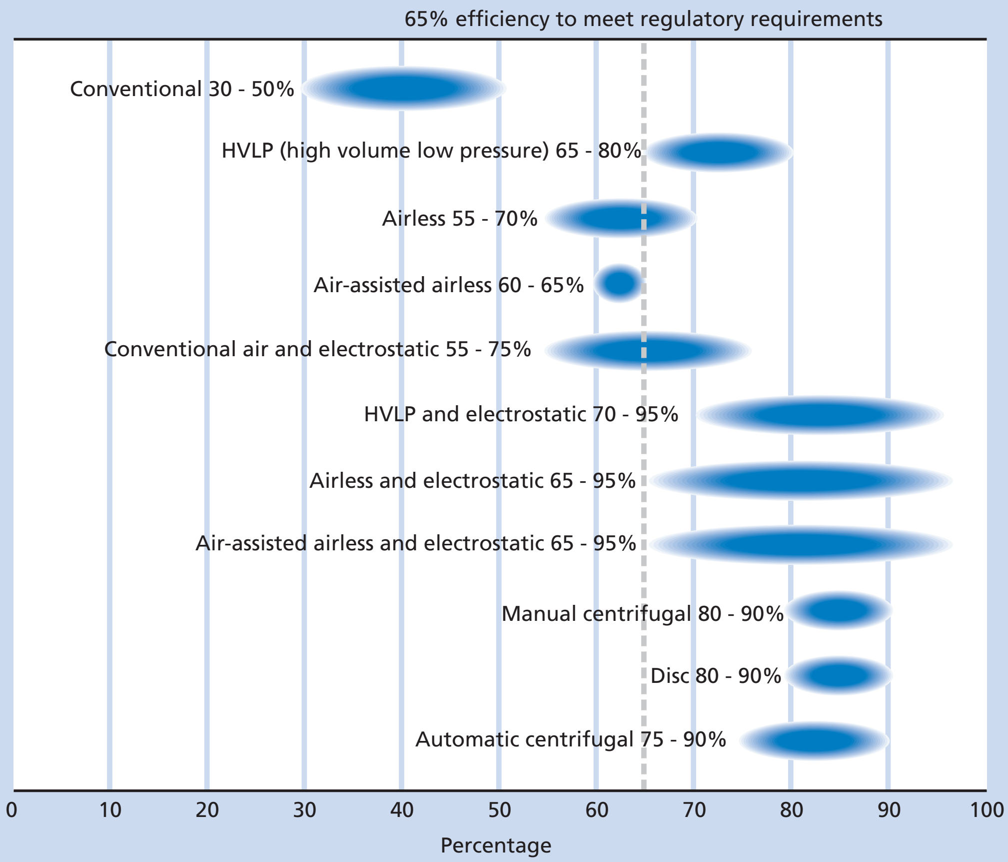
If a company sold its products at a gross margin of 10%, then to generate an equivalent profit to the saving calculated in Table 1, the small user would have to sell additional product worth £190 000 and the medium-to-high user, product worth £950 000. Many companies would find this difficult to achieve due to limitations in production capacity, lack of suitable sales outlets, inadequate investment capability or some other factor. A small investment in higher efficiency spray gun equipment is much more attractive.

Table 1 Example savings through use of higher efficiency spray guns

	Small volume user	Medium-to-high volume user
Coating material sprayed	9 000 litres/year	45 000 litres/year
Typical transfer efficiency of conventional spray guns	40%	40%
Wastage through overspray	5 400 litres/year	27 000 litres/year
% wasted through overspraying	60%	60%
Applied coating material requirement	3 600 litres/year	18 000 litres/year
Minimum transfer efficiency of higher efficiency system	65%	65%
Amount of coating used in higher efficiency spray guns	5 540 litres/year	27 700 litres/year
Reduction in coating material purchases	38%	38%
Coating material purchases	£50 000/year	£250 000/year
Typical savings	£19 000/year	£95 000/year

The higher transfer efficiencies now obtainable for coating operations with different types of spraying system are shown in Fig 1.

Fig 1 Transfer efficiencies of different spraying systems



Note: The systems are ranked (roughly) by cost of hardware, starting at the top with the least expensive.

4.2 Spray guns

This section explains how the different types of spray gun work. Table 2 summarises their advantages and disadvantages.

Table 2 Advantages and disadvantages of different types of spray gun

Type	Advantages	Disadvantages
Conventional spray guns	Unskilled sprayers can use. Variable spray pattern. Variable spray flow. Inexpensive and easy to maintain. High quality atomisation.	Low transfer efficiency. Easily mis-used. Do not meet requirements of LAPPC.
HVLP spray guns	High transfer efficiency, giving less waste and lower costs. Easy to operate. Low spray fog. High quality atomisation. Inexpensive and easy to maintain. High application rates possible.	Require trained, skilled sprayer.
Airless spray guns	Very high application rates. Lower overspray and fog. Good for viscous coating materials. Particularly suitable for coating large areas. Good coverage in recesses.	Need skilled sprayer. Spray 'tails' are difficult to eliminate. Small nozzle orifice blocks easily. Inflexible liquid hose due to high pressure liquid. Finish quality not as good as with conventional spray guns.
Air-assisted airless spray guns	Very high application rates. Lower overspray and fog. Good for viscous coating materials. 'Tails' easier to eliminate than with airless spray guns. More controllable application flow than airless spray guns.	Unskilled sprayers find guns difficult to use. Small nozzle orifice blocks easily. Finish quality not as good as with conventional spray guns. Limited to large area applications.
Manual centrifugal spray guns (electrostatic)	Very high transfer efficiency. Portable (no need for compressed air). Very little overspray and no bounce back.	Low application rates. Relatively poor finish quality. Need coating material with correct conductivity. Workpiece must be earthed. Incompatible with metallic or water-based paints. Cannot be used with high viscosity paints.

Table 2 Advantages and disadvantages of different types of spray gun (continued)

Type	Advantages	Disadvantages
Automatic centrifugal spray guns (electrostatic)	High transfer efficiency. High application rates. Reduced overspray and bounce back. High quality atomisation and coating finish. Compatible with solvent-based and water-based paints. Easy to use.	Only suitable for automatic, high volume applications. Need coating material with correct conductivity. Workpiece must be earthed. High quality compressed air required.
Disc spray guns (electrostatic)	Very high transfer efficiency. High application rates. Very little overspray and no bounce back. High quality atomisation and coating finish. Compatible with solvent-based and water-based paints. Compressed air not required.	Need coating material with correct conductivity. Workpiece must be earthed. Only suitable for automatic systems.

4.2.1 Conventional spray guns

The coating material and high pressure compressed air (2 - 3.5 bar) are brought together within the spray gun at a common nozzle, where the compressed air speeds up as it expands to atmospheric pressure. The relatively slow moving liquid coating material is broken up (atomised) and propelled forward as droplets by the high speed compressed air. Air-atomised spray guns typically have application rates of 250 - 700 ml/minute.

When this high speed spray reaches the workpiece, it tends to bounce back carrying some of the droplets of coating material with it. This reflected material interferes with the forward motion of compressed air and coating material from the spray gun nozzle, creating further disturbance of the spray. This is the cause of the characteristic spray fog associated with conventional spray guns.

The less than 50% efficiency of conventional spray guns means that, for every litre of paint reaching the surface being coated, at least one litre of paint is wasted in overspray.

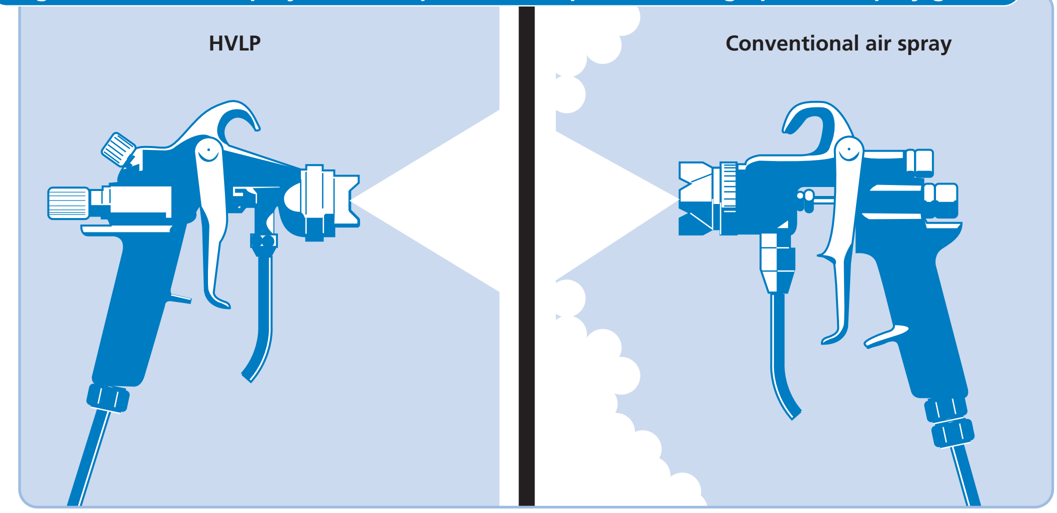
Some newer gun designs allow improved control of the direction of the emerging air jets, reducing bounce back.

4.2.2 HVLP spray guns

High volume low pressure (HVLP) spray guns are recognised as being one of the most efficient ways of applying coatings to surfaces.

HVLP spray guns atomise the liquid coating in a similar way to conventional spray guns, but use much slower air. This reduced air velocity is achieved by using low pressure air, ie less than 0.7 bar, at the aircap of the spray gun. HVLP spray guns use a 2 bar compressed air supply with air flow rates of up to 100 m^3/hour. Despite using high volumes of air, the use of lower velocity air means that the bounce back and resulting spray fog from HVLP spray guns are considerably less than for conventional guns (see Fig 2).

Fig 2 Reduced overspray from low pressure compared with high pressure spray guns



The much higher transfer efficiency of HVLP spray guns (see Fig 1) means that for each litre of paint applied, only 0.2 - 0.35 litres is wasted. Application flow rates can also be higher where finish quality is less critical. With a trained sprayer, atomisation and finish quality can match conventional spray gun finishes. High quality finishes can be achieved, as demonstrated by the use of HVLP spray guns in automotive refinishing, where finish quality is of paramount importance.

Reducing overspray also increases the lifetime of spraybooth filters - saving time and money.

For companies close to the threshold for regulation under LA-IPPC or LAPPC, improved transfer efficiencies could mean avoiding regulation - again saving both time and money. For companies below the threshold, using HVLP spray guns may help to avoid reaching the threshold in the future, eg if output increases.

These savings can be realised only if operators are trained to get the most out of HVLP spray guns. All major spray gun manufacturers offer training courses, as do many paint manufacturers.

Switch to HVLP spray guns produces significant cost savings

Peatey's Coatings is one of the largest trade coaters in the north of England, employing 56 people. About five years ago, Peatey's changed from using conventional wet-paint spray guns to high volume low pressure (HVLP) guns. The paint shop manager estimated that this switch resulted in a 35% saving in total paint use, resulting in cost savings estimated at £30 000/year. Although HVLP guns are slightly more expensive than conventional spray guns and require additional staff training to ensure correct use, the costs are significantly outweighed by the financial savings. This change resulted in an estimated payback period of two months.

Air turbine systems

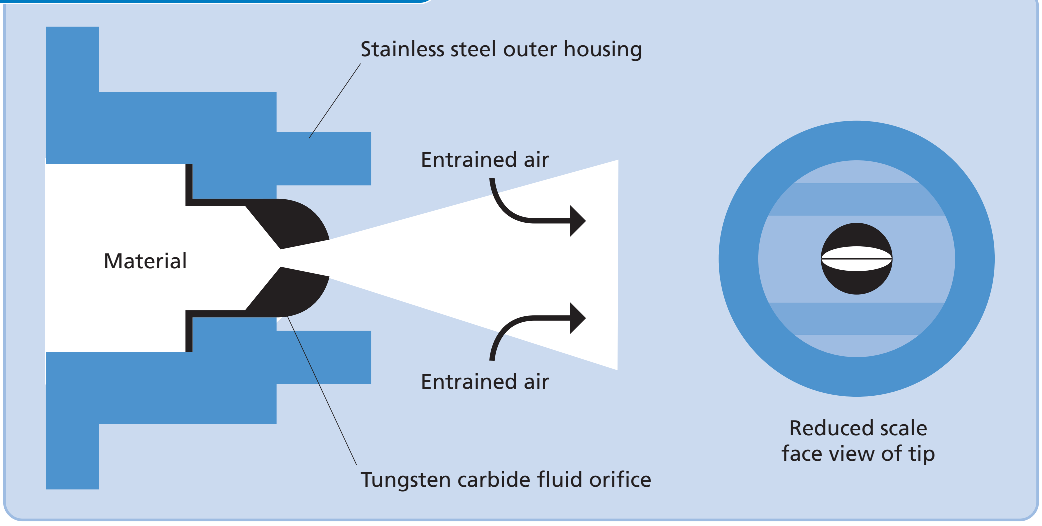
These systems, which deliver air to the spray gun at 0.2 - 0.4 bar and volumes up to 100 m^3/hour, offer an alternative to compressed air. The atomisation quality - and hence finish quality - and application rates of these systems are not as high as conventional or compressed air HVLP spray guns. However, they do have the advantage of being portable, as the electrically powered air turbine units are relatively small compared to air compressors.

4.2.3 Airless spray guns

Airless spray guns rely on the atomisation of high pressure liquid coating passing through a very small nozzle orifice, typically 0.1 - 1.5 mm (see Fig 3). The high liquid pressures, which vary according to the application, range from 50 - 400 bar. They are achieved by using small piston pumps, usually powered by compressed air.

Although there is no air at the spray gun nozzle, some air is entrained into the spray through the atomisation and forward velocity of the liquid coating. This entrained air creates a very small amount of bounce back from the workpiece.

Fig 3 Section through an airless tip



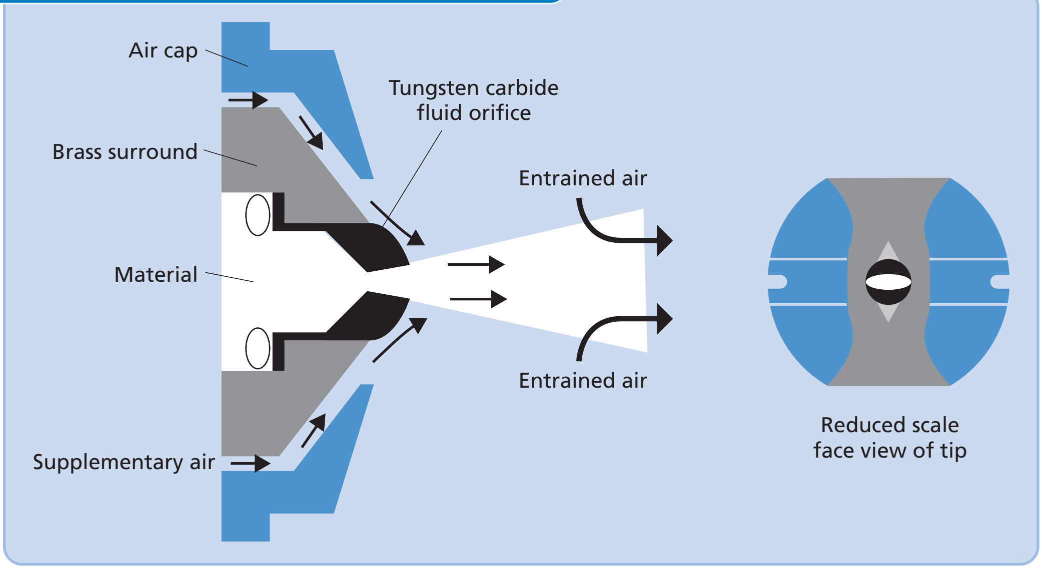
The spray rate, which can be very high, can only be adjusted at the pump and not at the spray gun. This means that airless spray guns cannot be used on work which needs flow control or a light touch. Because of the high application rate, a good spray technique is required to eliminate spray 'tails'. Airless methods are suitable for coating large areas and can spray high viscosity, high solids coatings.

Airless methods are used for application of coatings to commercial vehicles and in the application of high-solids, heavy-duty coatings to structural steel used in civil and marine engineering. The transfer efficiency is up to 80%.

4.2.4 Air-assisted airless spray guns

This is a hybrid of the airless and conventional types of spray gun (see Fig 4). Coating material is still pumped to the spray gun nozzle, but at lower pressures (typically 25 - 100 bar) than the airless spray gun. Compressed air, which is also fed to the spray gun nozzle, is used to enhance atomisation and to shape the spray fan. The greater control achievable with air-assisted airless spray guns compared to airless spray guns reduces the 'tails' problem.

Fig 4 Section through an air-assisted airless tip



Adding air to the spray reduces the maximum transfer efficiency compared to the airless spray gun (see Fig 1). Although this additional air creates a small amount of bounce back and fogging, it is much less than with conventional spray guns. Transfer efficiency is typically about 30% higher than conventional spray guns.

4.2.5 Centrifugal spray guns

Both manual and automatic centrifugal spray guns rely on electrostatic attraction to make them work - but in different ways.

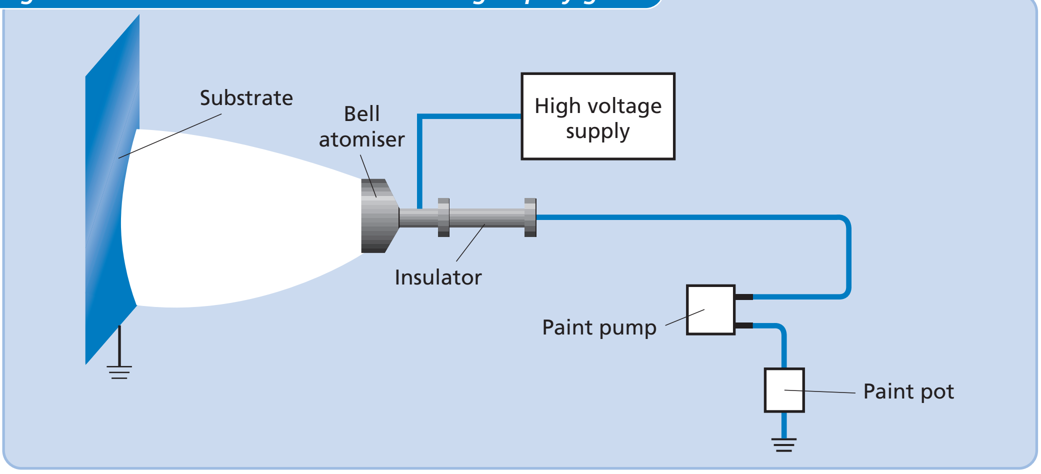
Manual centrifugal spray guns
With these guns the coating material is fed to a spinning bell or cup rotating at around 600 rpm. Centrifugal action forces the coating material to the outer edge of the spinning bell; the liquid spins off the bell as a conical thin sheet which breaks up as it expands into an atomised spray.

A charge is imparted to the liquid coating by applying an electrostatic charge to the rotating bell. This electrostatic charge atomises the liquid coating droplets as they spin off the cone leaving the rotating bell. As the charged molecules of coating material repel each other, the larger droplets break up into smaller droplets.

Because no air is required, there is no bounce back and high transfer efficiencies are achieved. The slow application rates (100 - 150 ml/minute) also mean that air is not entrained into the spray fan. The quality of atomisation and coating finish are adequate for some applications, eg decorative paintwork and wrought ironwork.

Automatic centrifugal spray guns
These operate at much higher rotational speeds than manual types. The spinning bell rotates at up to 60 000 rpm when unloaded, the speed falling to 20 000 - 35 000 rpm when coating material is being applied. The speed of the bell and the force applied to the coating material, spin the thin liquid film off the outer edge of the bell as an atomised spray (see Fig 5). Electrostatically charging the bell improves the atomisation of the coating material and gives the coating material droplets a negative electrostatic charge. Compressed air is used in the spray gun to produce a low velocity air shroud, which helps to project the atomised coating material towards the earthed workpiece.

Fig 5 Electrostatic bell automatic centrifugal spray gun



These spray guns can only be used in automatic, high volume applications, as the high speed of the bell presents a safety hazard and provides a gyroscopic effect, which would make the gun unwieldy for a sprayer to use.

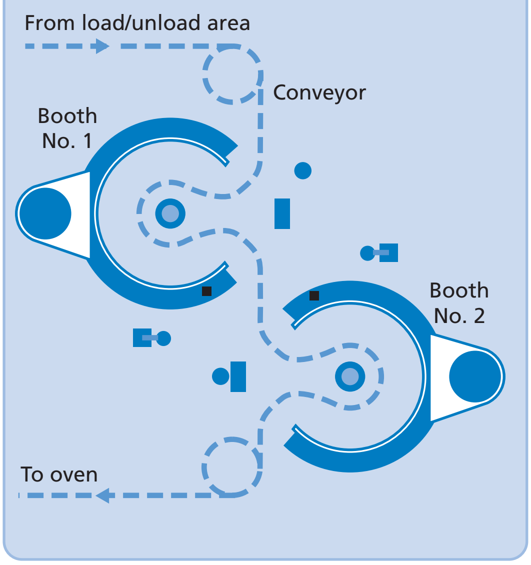
Automatic centrifugal spray guns can be used to apply both solvent-based and water-based paints, although there are some quality issues with metallic paints. Their advantages are demonstrated by the guns' almost universal acceptance by car manufacturers for production line painting.

Disc spray guns

These guns, which are used exclusively in automatic systems, are a hybrid of the manual and the automatic centrifugal spray gun. Instead of a bell, these spray guns have a disc that rotates at up to 40 000 rpm. The disc is oriented to point either upwards or downwards, the spray being thrown out in a horizontal plane. The disc atomises the paint in two ways: by spinning the liquid off the edge of the disc, and through electrostatic forces.

Disc spray guns are often used in omega conveyor loop applications, where the workpieces move round a fixed spray gun (see Fig 6). In some systems, the spray gun moves vertically up and down on a track to enable painting of tall workpieces.

Fig 6 Typical omega loop floor plan for a disc spray gun system



4.3 Enhancement techniques

The following section explains how techniques such as electrostatic spraying and hot spraying help to achieve high coating efficiencies. The advantages and disadvantages of these techniques are summarised in Table 3. Transfer efficiencies are shown in Fig 1.

Table 3 Advantages and disadvantages of different enhancement techniques

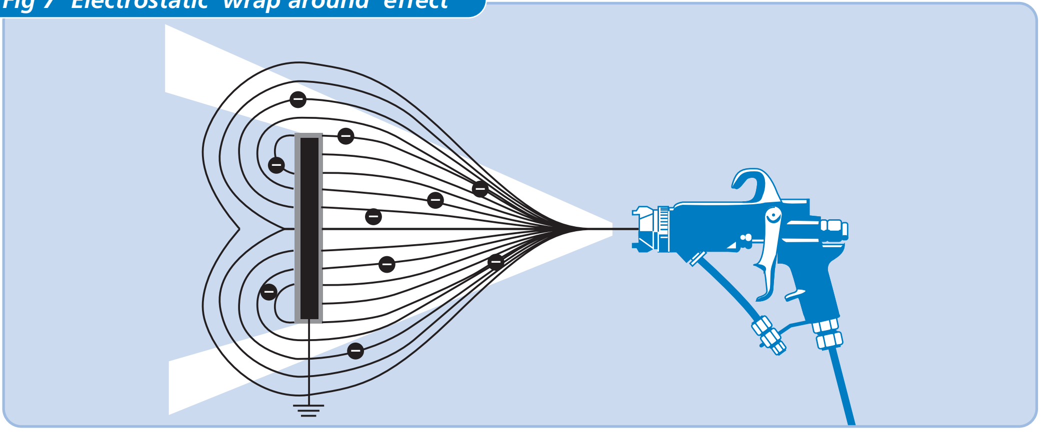
Type	Advantages	Disadvantages
Electrostatic systems	Very high transfer efficiencies possible. High application rates possible. Reduced overspray and bounce back. Spray wraps round objects. High build-up of coats possible. High quality atomisation and high finish quality possible.	Require skilled sprayers. Good earthing of workpiece required. Correct conductivity of coating material required. Good cleanliness standards needed to avoid airborne dust reducing finish quality. Faraday Cage Effect can affect finish quality.
Hot spraying	Viable alternative to solvent thinning. Shorter drying and curing times. Essential for some solvent-free coating systems.	

4.3.1 Electrostatic systems

Electrostatic spraying can be applied to any of the spraying technologies described in section 4.2. However, care should be taken to avoid damaging parts that may be sensitive to electrostatic charges, eg items containing electronic components.

The technique involves applying a charge, usually negative, to the coating material as it is atomised. The negatively charged spray droplets are attracted to any earthed surface; if the workpiece is earthed, the negatively charged droplets are attracted preferentially to it. This effect is so powerful that, with some objects, coating spray can be observed to 'wrap around' (see Fig 7). This effect means that electrostatic spraying works particularly well with frameworks, tubular metals and fabricated sections.

Fig 7 Electrostatic 'wrap around' effect



In practice, not all the charged droplets reach the workpiece. The increase in transfer efficiency depends on a number of factors, including:

- The efficiency with which the droplets are charged. Poor charging results in poor attraction of droplets to the workpiece.
- The efficiency of atomisation of the spray gun. The more efficient the atomisation, the smaller the droplets and the more likely that electrostatic forces will attract them to the workpiece.
- The quality of the earthing of the workpiece. The better the earth, the better the power of the electrostatic forces. If there is no earth, there will be no electrostatic attraction and no enhancement of the spraying efficiency. Poor - or even non-existent - earthing is a common fault with spraying operations using electrostatic systems.
- The shape of the workpiece. Free ions that have not been attracted to the coating material droplets are also attracted to the earthed workpiece, where they tend to build up on leading edges and in crevices or hollows. These charged areas can attract too much paint (in the case of leading edges) or repulse paint (in the case of crevices or hollows). This may lead to uneven paint thickness and poor finish quality. This effect is known as the Faraday Cage Effect.
- The need to use a conductive coating material. Not all coating materials are suitable for electrostatic application.

4.3.2 Hot spraying

This technique enhances both coating efficiency and finish quality. Some types of solvent-free coatings have to be applied hot.

Applying heat reduces the viscosity of most coating materials and thus increases the application rate and/or improves the surface finish of the applied coat. Temperatures of up to 60°C can be used. Heating can be achieved by either pre-heating the coating material before putting it in the spray gun pot or fitting in-line heaters on pump-fed coating systems and paint circulation systems. The technique can be applied to conventional, airless and electrostatic spray guns.

Pre-heating the coating material improves drying and curing times by:

- improving solvent flash-off from the spray;
- increasing the applied coat temperature and enhancing solvent flash-off and drying;
- increasing the curing rate of catalysed coating systems, such as 2K coats.

Cold paints do not spray well. Therefore, spraying can also be enhanced by simple measures such as:

- moving the paints from a cold paint store to the paintshop some hours before use, to allow them to reach room temperature before spraying;
- having a correctly heated paint store.

Powder coating

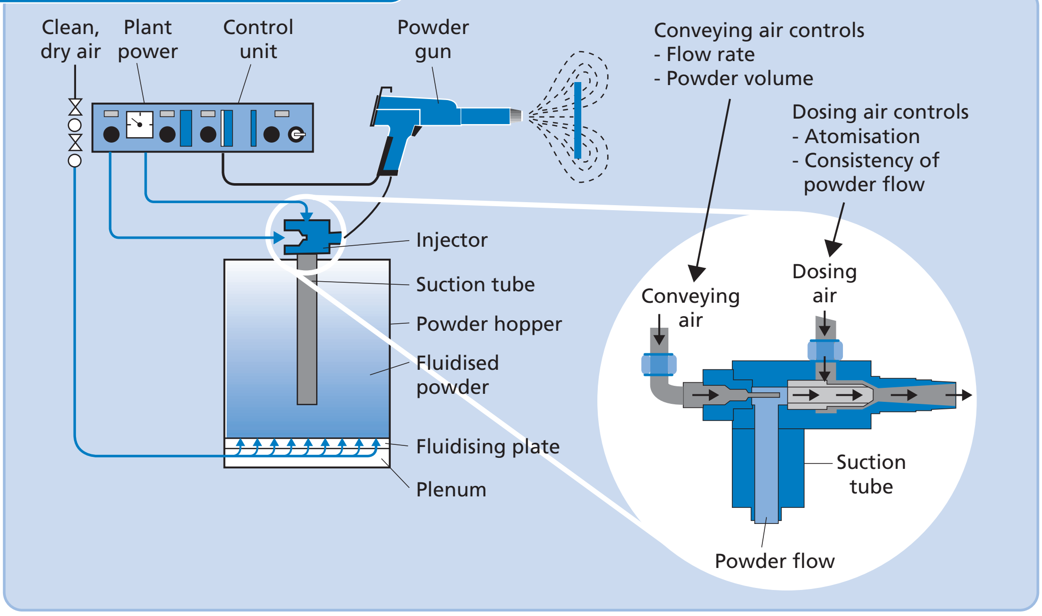
This is essentially an electrostatic coating process. In simple terms, the powder is 'atomised' by compressed air in a spray gun and given an electrical charge. The workpiece to be coated is earthed so that it attracts the charged powder particles. The powder particles then stick to the metal surface, until the workpiece is placed in an oven to cure the powder coating.

Powder coatings are usually a thermosetting or thermoplastic plastic or resin material. Transfer efficiencies of 60 - 70% can be achieved with powder coating. However, efficiencies can increase to 97% if the oversprayed powder is recovered. The process is relatively simple, but does raise some worker safety issues[1] concerning exposure to total inhalable dust.

Basic powder spraying equipment (see Fig 8) consists of:

- A powder feed system, which supplies powder to the spray gun. This usually consists of equipment to fluidise the powder and transport the compressed air. This equipment need not be complicated - many units simply have a suction tube that fits into a box of powder paint, others hold the powder in tanks. Gravity cup spray guns used for sampling could also be used for small production runs.
- A spray gun, which is connected to the air-conveyed powder, a second 'atomising' air supply and a low voltage electrical supply.
- A control unit that controls the powder feed flow rate and the electrostatic system.
- A spraybooth and a powder recovery and recycle system.
- A convection or infrared oven, in which to cure the powder coat.

Fig 8 Powder spraying equipment



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[1] See the following:

Health and Safety Executive (HSE) guidance: *Controlling exposure to coating powders*. Ref HS(G)203.

HSE employee leaflet: *Working safely with coating powders.* Ref IND(G)319.

Available from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA. Website: www.hsebooks.co.uk

British Coatings Federation (see section 10) publication: *Application of powder coatings by electrostatic spraying (code of safe practice).*

Material Safety Data Sheets.

Powder spraying equipment is available in various sizes and designs, ranging from stand-alone powder spraying equipment through to fully integrated coating units for small and large items.

More sophisticated powder spraying equipment may include:

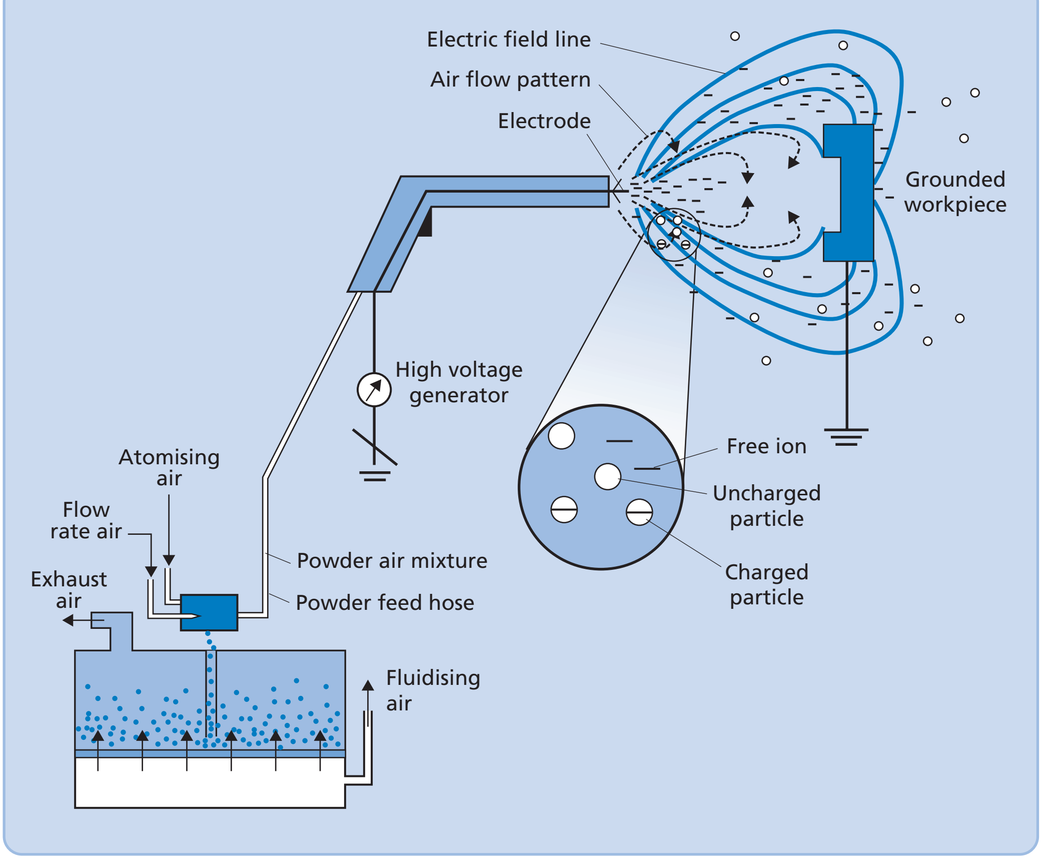
- spray-shaping attachments;
- automated coating units with workpiece conveyors;
- powder recovery equipment;
- combined powder spraybooths and ovens.

The three main methods for charging powders are described below.

5.1 Corona electrostatic charging

Corona charging works by applying a high voltage to a corona discharge point - a needle - near the air-blown powder. Most spray guns have an external corona discharge point. Negatively charged ions created by the corona discharge from air molecules attach to powder particles being discharged from the spray gun. Discharge ions and charged powder particles are pushed down the lines of force created by the corona discharge to the nearest electrical earth, the workpiece (see Fig 9).

Fig 9 External charging corona spray gun



Several factors should be considered when using corona charging:

- Overspray is created by uncharged powder particles carried along in the air stream from the spray gun which do not hit the workpiece due to their trajectory. This overspray reduces the transfer efficiency.

- Free ions that are not attached to powder particles can build up in the recesses of the earthed workpiece, creating pockets of negative charge - the Faraday Cage Effect (see section 4.3.1). These pockets repel the charged powder particles. Similarly, back ionisation can occur as the film thickness increases and free ions build up. A poor surface finish, eg orange-peel effects, can also be created.
- The size distribution of the powder particles is important to finish quality.

  The presence of too many small particles can lead to overcharged particles being attracted preferentially to the nearest part of the earthed workpiece - the leading edge. This creates a disproportionately thick coat on this part of the workpiece.

  Large particles tend to attract a disproportionate share of the charge. This increases overspray and reduces the thickness and finish quality of the applied coating.

5.2 Tribo-charging

In tribo-charging, the powder particles are passed over a plastic surface, eg polytetrafluoroethylene (PTFE), in the spray gun. Friction rubs electrons off the powder particles, giving them a positive charge. To ensure good charging, the powder passages in the spray gun are narrow and maze-like. The spray gun is earthed to prevent a build-up of negative charge. The positively charged powder particles are then blown towards, and attracted to, the earthed workpiece.

Overspray is again created by uncharged particles. The powder particle size distribution has the same effects as with the corona discharge spray gun.

Tribo-charging has the following advantages over corona charging:

- the Faraday Cage Effect is minimised because free ions are not created;
- thicker coats can be applied.

However, there are also some disadvantages:

- application rates with tribo-charged spray guns are slower;
- wrap around is poorer;
- tribo-charged guns are more difficult to clean due to their construction.

5.3 Combination charging

This novel method is a combination of the corona discharge and tribo-charging methods. In combination charging, the tribo-charged spray gun is modified to apply a positive charge to the powder, rather than relying on friction to charge it.

Combination charging overcomes the Faraday Cage Effect of the corona charging and the slowness of tribo-charging. This method also produces a heavier coat than corona discharge spray guns and has better wrap around than tribo-charged spray guns.

5.4 Powder bell spray guns

Powder bell spray guns use a spinning disc to produce a wide fan pattern of charged powder.

The charge is applied to the powder through a combination of conduction and corona discharge from the edge of the disc.

These spray guns can apply powder at transfer efficiencies of over 80% (without powder recovery) and are particularly suitable for large flat areas in volume finishing lines, eg white goods' manufacture.

Powder bell spray guns are only suitable for automatic systems due to their size, spray fan pattern and the gyroscopic effect of the spinning disc.

5.5 Fluidised bed coating process

This process is suitable for large workpieces, such as pipeline valves and fence posts.

Dry air is forced through a porous membrane into a tank, which is about half-filled with powder, fluidising the powder. The item to be coated is preheated to above the fusion point of the powder, then dipped in the powder for a few seconds.

Electrostatic methods can also be applied to the fluidised bed coating process. In this case, the workpiece is not preheated and curing takes place in an oven in the usual way.

5.6 Powder recovery and recycle system

There are two types of collector for powder recovery:

- cyclone collectors;
- cartridge collectors.

Cyclone collectors have a recovery efficiency of 85 - 95%; the recovery efficiency being less for finer powders. A cartridge filter is usually required downstream of the cyclone, to prevent discharge of fine powder to atmosphere.

Cyclone collectors can be cleaned easily and may also have removable cones and hoppers to facilitate colour changes.

A variety of types of cartridge filter are available. The build-up of powder on the filter is periodically removed by reverse air jet blowing. The powder released from the filter drops into a hopper, from where it is returned to the feed hopper of the powder spraying equipment.

Good spray gun techniques

Good practice during setting up and when using spray guns can:

- save money by reducing paint waste;
- save energy costs by reducing the amount of energy used for pumping paint and producing compressed air;
- save time by reducing rework caused by poor quality finishes.

Poor operator practice can produce high rework rates and high material consumption from a good spray gun system. This is true for both automatic and manual spray systems. In automated systems, the skill and knowledge of the operators who set up and operate the equipment are just as important as in manual systems, where operators directly control the spraying.

The difficulties many sprayers encounter with high efficiency spray guns stem from the forgiving nature of conventional spray guns. Bad habits may have developed. When a new spray gun technique is introduced into a paintshop, it is essential for the sprayers to be:

- trained to use this new equipment;
- given time to practice and perfect the proper techniques before production starts.

Many spray gun manufacturers and paint manufacturers operate training courses. The benefits from investment in training include improved material use and productivity, ie reduced losses and rework.

Spraying techniques can be learned and are not complicated. The following suggestions for good practice are applicable, to a greater or lesser degree, to all types of spray gun.

6.1 Setting up

- Maintain spray guns properly. Worn parts, eg nozzles and needle valves, produce poor atomisation and will result in poor finish quality and the need for rework.
- Assemble the spray gun correctly for the job at hand, according to the paint manufacturer's recommendations. This may include selecting the correct nozzle size to ensure the appropriate application flow rates.
- Test spray before starting on the job to check that the spray pattern is correct for the particular job.
- Use the correct size compressed air hose, according to the spray gun manufacturer's advice.
- Good quality compressed air, at the correct supply volume and pressure, is vital for good quality spraying. Problems with poor air supply should be tackled at source. Further information and guidance on good compressed air management is given in the appendix. In addition:
  - Check that the air supply to the spray gun is at the correct pressure and the line can supply the correct air flow rate for the spray gun. Excessive air pressures result in over-atomisation, leading to poor finish quality due to dry spray and excessive overspray from increased bounce back.

- With HVLP spray guns, use an aircap pressure tester to ensure the air supply is delivering the required pressure at the aircap (according to the spray gun manufacturer's advice). Do not exceed this pressure. A common mistake among sprayers, even with conventional spray guns, is to set the aircap pressure too high.

- Follow the manufacturer's instructions when setting up spray guns that use compressed air. The techniques can be learned.

- Increasing the fluid flow rate in an attempt to increase paint application rates can be counterproductive. Excessive fluid flow rates can lead to poor atomisation, causing finish quality problems and excessive overspray.

- With electrostatic spray systems, ensure that electrical connections are sound and clean.

6.2 Operation

Spray guns should be held at right angles to the surface being painted and at the specified distance. This depends on:

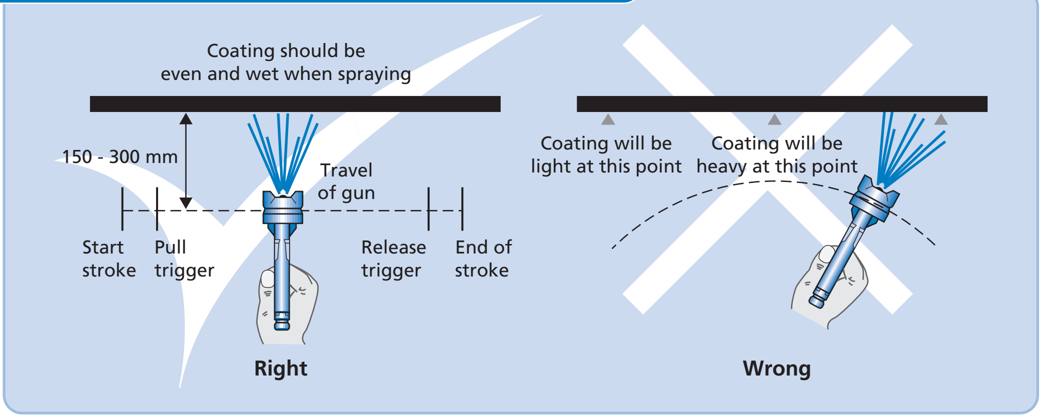
- the job at hand;
- the type of spray gun;
- the type of coating being applied.

If the spray gun is held too far from the workpiece, transfer efficiency is lost due to excessive fog and losses to gravity. Finish quality will also be affected, as too much solvent may evaporate from the spray before it reaches the workpiece, causing common faults such as orange-peel effects and dry spray.

If the spray gun is too close to the workpiece, the applied coat may be too wet. This can cause sagging and runs that spoil the finish quality.

Fig 10 shows the correct distance for HVLP spray guns.

Fig 10 Correct spray technique with HVLP spray guns



The painting action should ensure that the spray gun is kept parallel to the surface at all times. Arcing the gun alters the spray gun to workpiece distance throughout the stroke (see Fig 10), leading to patchy finish quality.

The spray gun should be moved at a speed that gives a full wet coat to the surface. Each stroke should overlap the previous stroke by about 50%.

At the beginning and end of each stroke, the trigger should be used to feather the applied paint. This prevents sagging from over-application of paint where strokes overlap.

Edges should be sprayed first. Paint should then be applied working away from the edge to the main area of the workpiece.

If poor technique is contributing to poor finish quality or high material consumption, then a refresher training course will help to bring operators back to standard.

6.3 Minimising overspray

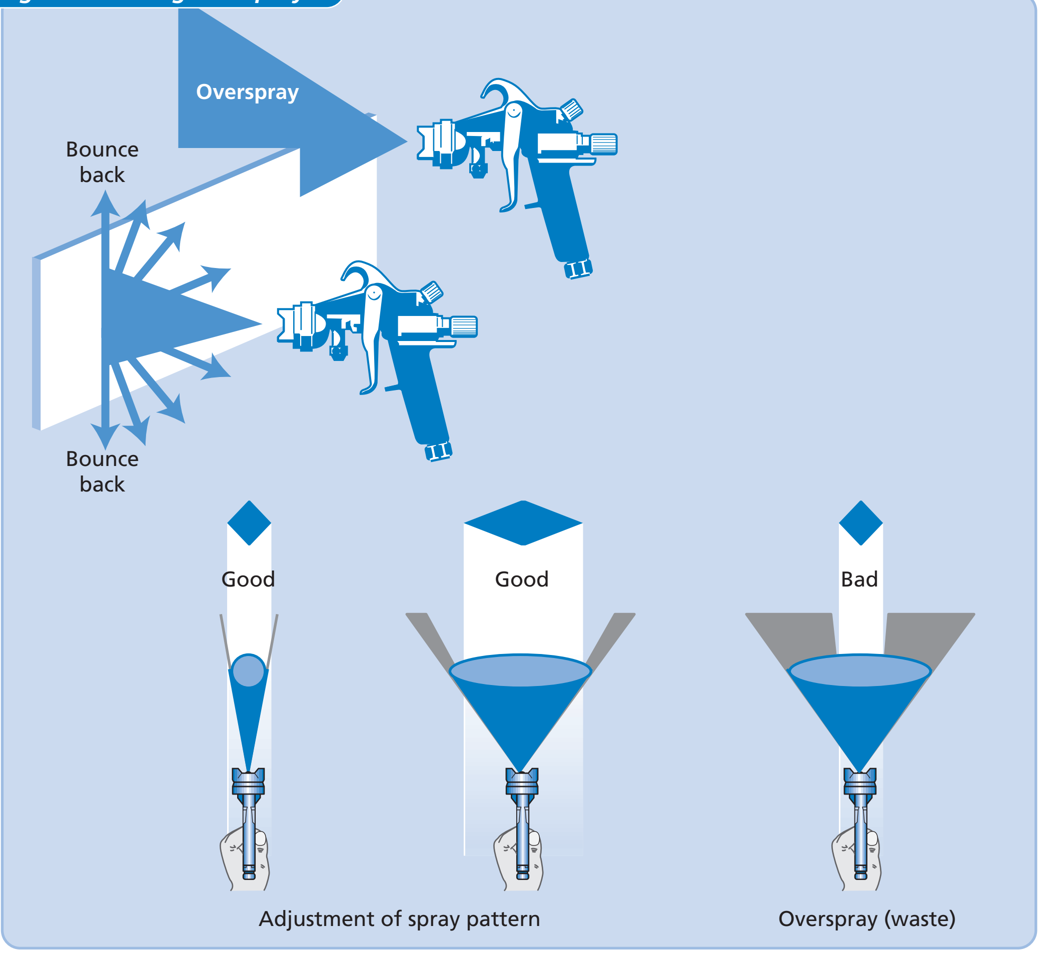
When painting flat sheets, overspray occurs as the spray gun passes over the edges of the workpiece at the beginning and end of each stroke. The first and last passes only partially hit the workpiece. When coating frameworks manufactured from relatively small tube sections, the nature of the workpiece increases the problem. With complex three-dimensional workpieces, overspray may be even worse.

Although overspray is unavoidable in most jobs, it can be minimised if care is taken in setting up the spray gun before starting a job.

Overspray can be substantially reduced by simply:

- Feathering - or triggering - the spray gun at the end of each stroke. This entails rapidly turning the spray gun off and then on again to start the next stroke. This conserves paint when the spray gun is not pointed at the workpiece and reduces excessive application at edges - the cause of sagging and runs (see Fig 11).
- Adjusting the spray pattern to match the job at hand (see Fig 11). Adjusting the spray to match the smallest of a batch of objects will minimise overspray on all the objects. Using the largest spray pattern to gain speedy application is wasteful.

Fig 11 Reducing overspray



6.4 Selecting a paint delivery system

Paint delivery systems include:

- pumped supply;
- remote paint pot;
- paint cup (gravity or syphon) on spray gun.

Paint pots use compressed air to deliver paint to the spray gun.

6.4.1 Remote paint supply versus paint cup on spray gun

This choice depends on individual paintshop requirements. Many paintshops have a selection of both.

Paint cups suit jobs where:

- small amounts of paint are used for each job;
- frequent colour changes are required.

Remote paint pots suit jobs where large quantities of paint are required for application to large areas. Remote paint pots also reduce sprayer fatigue.

6.4.2 Remote paint pot versus pumped supply to spray gun

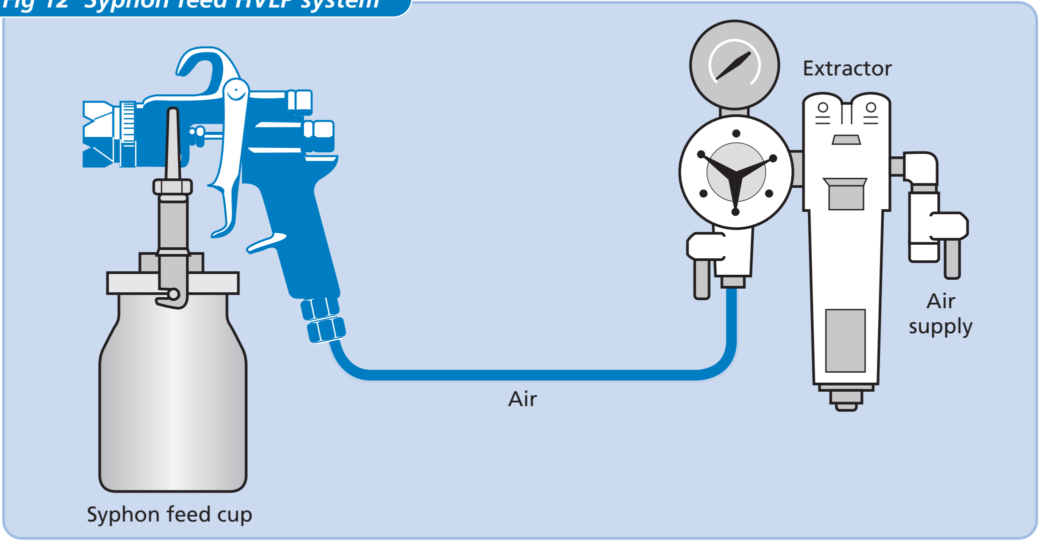
While remote paint pots hold more paint than a cup-on spray gun, they still require refilling. This involves de-pressurising the paint pot, refilling it and then re-pressurising. During this time, the sprayer has to stop spraying. Pressurised paint pots, like traditional syphon cups, always leave a residue of paint in the cup that cannot be pushed out of the pot. This is because the paint flow depends on the mouth of the syphon tube being below the surface of the paint.

Pumped systems have the advantage that the paint pot can be refilled while spraying continues. A carefully designed pumped system also drains the paint pot completely, leaving a minimum of waste.

6.4.3 Gravity cup versus syphon cup

Traditional syphon paint cups (see Fig 12) waste paint. At the end of each job, there is always approximately 25 ml of paint, which cannot be sucked up, left in a 0.5 litre cup.

Fig 12 Syphon feed HVLP system



The paint wasted by a paintshop performing 100 jobs a week using primer and top coat is:

100 x 2 x 25 ml = 5 litres/week. Assuming a 48-week working year, the minimum total amount of paint wasted is 240 litres/year.

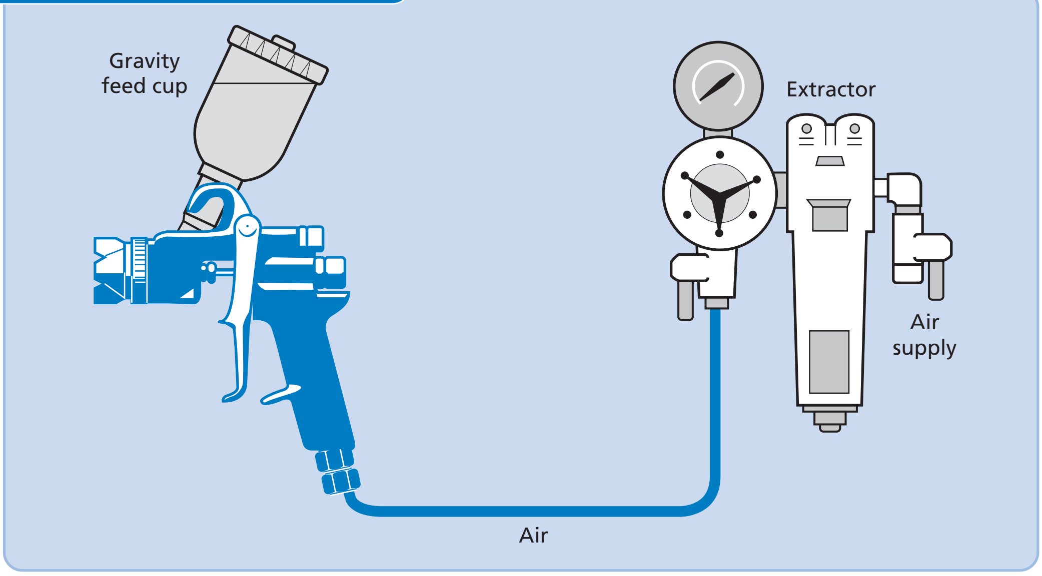
A good way of avoiding this waste is to use gravity paint cups (see Fig 13). No paint is wasted in this type of cup, as long as the correct amount of paint is mixed or measured out for each job. When the gun runs out of paint, the only paint left in the cup will be the small amount which adheres to the sides of the cup.

Gravity cups tend to be smaller than syphon cups, thus reducing the top-heavy effect disliked by many sprayers. However, this feature - coupled with the fact that gravity feed increases paint delivery rates - has the disadvantage that the cup has to be refilled more often.

Gravity cup spray guns also have the advantage that they weigh less, thus reducing operator fatigue. On average, a gravity cup HVLP spray gun weighs 250 g (8 oz) less than the equivalent syphon cup spray gun.

A relatively new development is a plastic-bodied gravity feed HVLP spray gun weighing up to 500 g (1 lb) less than a metal syphon cup HVLP spray gun.

Fig 13 Gravity feed HVLP system



Equipment cleaning

Thorough cleaning of equipment that has been used to apply paint and powder coatings - jigs, spray guns, paint pots, dip baths and other ancillary equipment - is necessary to ensure good applied coat quality. The cleaning process avoids colour contamination and helps to maintain good equipment performance, but it does not add value to products. Cleaning also creates waste.

In most cases, removal of waste coating material requires the use of:

- cleaning materials;
- energy;
- manpower.

Minimising these inputs will save money and leave operators free to concentrate on applying coatings.

7.1 Spray guns

Cleaning spray guns is a time-consuming process that produces:

- waste solvent, ie gunwash contaminated with paint;
- VOC emissions to the atmosphere.

The Secretary of State's Process Guidance Note PG6/23 *Coating of metal and plastic* requires metal coaters to use fully enclosed cleaning systems wherever possible. If this is not possible, VOC emissions should be contained and vented to suitable abatement equipment.

Many smaller companies, which are below the threshold for regulation under LAPPC, do not possess enclosed machines; gunwashing is often carried out manually in poorly ventilated equipment by simply using a can of solvent, a brush and a scraper.

Enclosed cleaning machines reduce operators' exposure to potentially harmful solvent vapours. Companies without enclosed cleaning machines should consider buying one.

Manual machines allow the operator to control and optimise the amount of solvent dispensed for cleaning. This reduces solvent use and controls VOC emissions to the workplace. Those companies that already possess manual machines could consider investing in an automatic machine. Fully automatic machines have a number of advantages:

- the machine can be loaded and left to run, leaving sprayers free to do other work while the equipment is being cleaned;
- the machine uses the correct amount of solvent to clean the spray gun, thus avoiding possible wastage;
- reduced risk of impact on operators' health and the environment, due to much lower VOC emissions.

The ability to clean the spray gun manually, eg for dried-on paints, is still required. A good automatic machine should provide this option.

Another requirement is the facility to 'spray out' the spray gun with clean solvent at the end of the cleaning cycle. This sprayout should be recovered by the machine to minimise VOC emissions and conserve gunwash solvent. Some machines still have the sprayout facility linked into the extraction system, where the solvent will not be recovered. Companies using machines with the sprayout facility linked to the extraction system should ask their supplier if it can be modified to capture sprayout.

If both water-based and solvent-based paints are used, then two gunwashing machines will be needed - one for each type of paint. Never mix machine use by putting spray guns used with solvent-based materials in a machine used to clean water-based guns, or vice versa, as this may cause contamination.

- For water-based paints and cleaning fluids, use a gunwashing machine with a plastic or a stainless steel chamber. Do not use a mild steel chamber as the cleaning fluid will corrode it.
- For solvent-based paints, use a gunwashing machine with a metal chamber. Choose one with a stainless steel chamber if possible. Never use a plastic gunwashing machine, as the solvent may damage the plastic.

For optimum performance, gunwashing machines need to be kept clean. Pouring paint into the machine makes the solvent dirty faster. This costs money, as more gunwash is used. In addition, the guns may not come out clean enough to use, causing time delays or maybe even rework, if the dirty gun is not spotted in time.

- Encourage sprayers to pour excess paint into a separate container before cleaning their spraying equipment.
- Use a plastic or wooden spatula to scrape out any residue from the paint cup or pot to reduce contamination of the gunwash.

The latest gunwashing machines, which set a new standard for solvent emissions, work by reducing the pressure and increasing the flow of the washing solvent to minimise spray mist. The spray mist is extracted from the machine. Manufacturers claim that emissions from this new generation of gunwashing machines are less than 10% of those from previous models.

In many automated plants, automatic gun cleaning is fitted to minimise start-up, shutdown and colour changeover times. This facility can result in excess consumption of washing solvent unless it is optimised and maintained properly.

7.2 Spraybooths

Overspray which is not captured by filters or water curtains, or which is not sucked out through the exhaust ventilation, ends up on the walls of the spraybooth. Removing this layer of paint takes time and cleaning agents, ie more solvent.

If product specifications require spraybooths to be kept relatively clean, eg to avoid possible contamination of the coating with dry paint dust, then cleaning of spraybooths frequently adds extra costs.

The following are two simple ways of reducing the cleaning requirements:

- Taping paper - or a similar cheap and easily disposed of material - to the walls of the booth. This material can be simply replaced and thrown away during cleaning. However, this method may represent a fire hazard. This practice is not advised for electrostatic spraying, where there may be a risk of an electrostatic discharge if insulating material is introduced.

- Spraying the walls of the booth with a strippable booth coating (proprietary brands are available), which traps overspray. The trapped paint is easily removed by stripping it off or, in the case of water-based paints, washing it off using a bucket of water and a cloth or a water spray.

With automatic spraying, there are often definite areas which receive overspray. Such areas can be covered with a strippable coating to aid cleaning.

7.3 Jigs

There are always exposed parts of the jig which receive a coating of paint every time it is used. This paint eventually makes it difficult to use the jig or causes problems with cross-contamination of colours or electrical earthing. The jig then has to be cleaned.

Jig design affects the extent to which paint builds up on the jig and, thus, the amount of cleaning required.

- The length of time between jig cleaning is increased if the jigs are designed so that the parts are self-seating, ie they always fit on the same place and effectively cover that place.
- There is less build-up of paint if empty positions on jigs are capped off or masked.

The three different approaches to jig cleaning - mechanical, chemical and thermal - give rise to different issues in the workplace, as discussed below.

7.3.1 Mechanical cleaning

This may involve the use of shotblasting equipment or simply a wire brush. The main drawback to using shotblasting equipment is that the dislodged paint will contaminate the shotblast medium. If the same shotblast medium is used for surface preparation, contamination can be transferred.

Brushing is labour-intensive, but does solve the problem of contamination of shotblast media.

Suitable ventilation and operator protection should be provided to reduce the risks of dust inhalation.

7.3.2 Chemical cleaning

Chemical cleaning can be carried out using either an organic solvent or a chemical stripper. The solvent is generally the same as the original paint thinner, while the chemical stripper is often acid-based.

This is a useful technique, but it does lead to a potential problem with waste disposal. Gloves and further personal protective equipment may be needed for operators.

Surface cleaning and preparation: choosing the best option (GG354) describes alternative chemical cleaning materials. Some of these materials can also be used for paint stripping.

7.3.3 Thermal cleaning

Thermal cleaning involves the combustion of the paint material adhering to the jigs. Thermal cleaning can involve the use of:

- a dedicated burn-off oven (often fitted with an afterburner to reduce fume emissions);
- a fluidised bed system.

Simply using a blowtorch is not desirable from a health and safety viewpoint.

With dedicated thermal cleaning units, parts are usually loaded by hand before the cleaning cycle is initiated. Fluidised bed systems require parts to be suspended in a heated, buoyant cloud of sand - or similar temperature-resistant material. A metal basket is usually used to hold the parts.

If the thermal input of the burner used to remove paint residues is more then 0.2 MW, then the process must be authorised under LAPPC. Secretary of State's Process Guidance Note PG2/9 *Metal decontamination processes* applies. For advice about legislation governing your operation, contact the Environment and Energy Helpline on freephone 0800 585794.

Automation

Automation of coating can be applied to almost all industrial situations. While this section is more applicable to medium-to-high volume coating operations, it may also be of interest to companies seeking to increase capacity or looking for ways to achieve closer control of their coating process.

Although this section focuses on spraying, many of the benefits of automation can be obtained with other coating methods. Automation of dipping is briefly discussed in section 3.

8.1 Benefits and costs of automation

These depend on individual company circumstances, including size and the extent to which coatings are applied.

The benefits of automation include:

- improved coating efficiency;
- consistent/improved finish quality;
- reduced materials costs;
- improved processing capacity;
- reduced labour costs;
- less need for rework and its associated costs;
- improved efficiency of existing employees;
- continuous production at a consistent rate (given proper maintenance);
- ability to provide optimum transfer efficiency using a standardised technique.

The cost benefits resulting from automation have to be offset against the capital cost and the costs of operating the automated system.

The operating costs of automated plant depend on the complexity of the system. Few automated plants operate without human interaction, since people are needed to:

- receive raw materials and load them into the plant;
- remove and dispatch the finished goods;
- check on finished product quality (difficult to automate) and adjust the plant accordingly;
- maintain the plant.

The cost of spares should also be taken into account when assessing the feasibility of automation.

8.2 Plant design

Automation of coating requires careful planning and programming. The results obtained from an automated plant are only as good as the care taken over the plant's specification, design, construction, operation and maintenance. With automated plant, coating errors may not be discovered until the finished coat is inspected; unlike manual operations where the sprayer usually self-corrects.

8.2.1 Specification

Before initiating the design and purchase of automated plant, a company should consider its reasons for automation. These reasons may include some of the benefits listed in section 8.1 but the extent of the benefits will depend on the particular application.

The technical specification of the plant should be considered once you have:

- determined current performance;
- identified existing production bottle-necks.

An easy trap to fall into is to replace a manual operation with an automated plant, which is cheaper in terms of operating costs but delivers no improvement in performance.

Before making a potentially expensive investment in automated plant, you should consider if there are alternative ways of improving performance, for example:

- use of alternative coating materials, eg high solids paints, which can give cost savings, as well as capacity improvements;
- changing to different application techniques, eg high transfer efficiency spray guns or electrostatic methods.

Such measures may avoid bottle-necks in the coating process and bring about sufficient capacity improvements and savings to at least postpone the need to invest in automation.

If the company's aims cannot be achieved in other ways and automation is seen as the only way forward, then the type of automation needed should be given careful consideration.

The degree of automation specified has to match the company's needs. Full automation may not be necessary to solve a particular problem.

8.2.2 Design and construction

Every company has unique coating requirements - coating material specification, finish specification, application rates, curing regime, etc. A company looking for equipment to meet its needs should talk to as many equipment and technology suppliers as possible, to ensure it obtains the best possible solution.

Ideally, a company should conduct field trials with a potentially suitable design - either on a demonstration plant or on an existing operational plant. The latter option gives the company the opportunity to talk to the user of a particular system to find out whether it works as well as the manufacturer claims. Manufacturers should be able to provide names of referees who can testify to their equipment's performance.

8.2.3 Operation

Production quality from automated plant relies on the quality of the set-up. This requires skilled and trained personnel, who understand spraying.

Many of the problems associated with automated plant are programming errors, coating material problems and spraying problems, rather than mechanical failures.

Robotic system saves time and money

Over 1 100 television cabinets are painted during every shift at the Sanyo Industries (UK) Ltd plant in Lowestoft, Suffolk. As the plant's robot sprays neared the end of their working lives, Sanyo began investigating new developments in robotic spray systems. Although computer-controlled robots are able to repeat a spray pattern accurately and reliably, early systems applied the paint at a consistent rate with wide sweeps. The limited control led to paint losses from overspray as the gun swept past the edge of the workpieces. This, coupled with bounce back from any spray which hit the workpiece, resulted in low transfer efficiencies.

Sanyo installed two six-axis robots, which have ten possible spray patterns or 'brushes', covering a band between 50 mm and 250 mm wide. Paint viscosity is continually monitored to ensure each brush operates at a constant flow rate. Air flow is also controlled to give consistent atomisation and spray power. Careful control of these parameters for each brush, coupled with the precise programmed motion of the robot arm, gives spray patterns which are accurate to within 1 mm.

This extra control in paint application has reduced paint consumption by 60%, while simultaneously reducing painting times by 54%. The material savings and increased output mean that the new robotic system has a very short payback period.

8.3 Automated spraying

Automation in coating operations ranges from simple stand-alone plant, to complex integrated plant. For automated spraying, the main categories include:

- Transport of the workpiece to and from a manual spraying operation. This is the simplest form of automation. It can improve process capacity as the sprayer is free to set up and spray work, rather than having to fetch and carry loads.
- Transport of the workpiece through a manual spraying operation. Here the sprayer is free to concentrate on spraying. This form of automation maximises spraying time by eliminating the time the sprayer spends moving the workpiece or moving around the workpiece. This type of automation includes:
  - conveyor systems where the workpiece moves past the sprayer;
  - turntables where the workpiece revolves to allow the sprayer to coat the entire workpiece without having to move.
- Automated spraying, with manual loading and unloading of the workpiece. The process can be either batch (the workpiece is loaded into a booth, painted and then removed) or continuous (workpieces travel through a continuous plant), with manual loading and unloading of workpieces. The often complex and time-consuming job set-up, eg putting items on jigs, is still carried out manually. The advantages of automated spraying include:
  - minimisation of overspray, rework, etc, due to the consistent spraying technique;
  - possible increase in processing capacity;

- the ability to use a spraying technology that is not suitable for manual spraying, eg electrostatic bell spraying;
- the possibility of continuous spraying, with no need for rest-breaks, shift changeovers, etc.

- Fully automated transport and spraying of the workpiece, where manual intervention is minimised. Such operations are usually continuous, with the workpieces carried on conveyors.
- Automated paint mixing and delivery systems can be used to minimise paint changeover times and waste. They include:
  - continuous 2K paint mixing (see section 8.4);
  - paint circulation systems.

8.3.1 Automated spraying equipment

The four general categories of automated spraying equipment are:

- Fixed spray gun, fixed workpiece. The workpiece is loaded into a spraybooth, sprayed and the coated workpiece removed. A stoving step may be also included. This type of automation, which is limited to batch operations, is typically found in small batch powder coating plants.
- Fixed spray gun, moving workpiece. Workpieces pass by one or more spray guns in a tunnel system or around a single spray gun, eg an omega loop system where the workpiece rotates as it passes the gun (see Fig 6).
- Fixed workpiece, moving spray gun. The best example of this category is a robot spray arm programmed to paint a fixed workpiece. The workpiece can be either manually or automatically loaded. Robot sprayers come in varying degrees of sophistication, ranging from single colour/single job, through to robots equipped for quick colour change and shape recognition for a variety of jobs.
- Moving workpiece, moving spray gun. To reduce the number of spray guns required to coat workpieces in a continuous plant, the spray gun can be moved to cover a larger area. This is usually achieved by using spray guns mounted on reciprocators moving on a single axis. Multi-axis reciprocators and robots can also be used.

8.4 Automatic 2K mixing

Two-pack (2K) paint systems contain two components - a resin-based material and a catalyst or hardener - that, when mixed, react to form the final coating. The mixed paint has to be used within a certain time, otherwise the paint sets in the spraying equipment.

In some paintshops, batches of 2K paint are mixed for each job and then sprayed. This can create waste because batch sizes are often:

- mixed to a standard volume;
- deliberately over-estimated to make sure the sprayer does not run out of paint before the job is complete.

One way of eliminating this waste is to mix the 2K paint as it is sprayed. This method is only applicable to paintshops using a pumped paint delivery system to the spray gun.

Mixing is carried out in two ways:

- At the spray gun. These devices mix the paint components either immediately before spraying or in the spray fan itself, ie two spray fans are mixed. The two components are pumped separately to the gun from either containers (cans, drums or tanks) or ring mains. Mixing spray guns are complex devices that are particularly useful for spraying 2K paints with an extremely short ‘pot life’.
- At the paint pump. The two components are pumped into a static mixing device, which pre-mixes them. The mixed 2K paint is then delivered to the spray gun, using the mixing pump pressure. Mixed 2K paint hoses can be as long or short as required. However, ‘pot life’ has to be taken into account or the paint will set before it is sprayed.

Relatively sophisticated controls are needed on the pumps used for mixing 2K paints to ensure the components are mixed in the correct ratios. This is not as critical on 2K paints with a mixing ratio of resin:catalyst of around 1:1, but becomes important as mixing ratios increase to typically 20:1 or higher.

Action plan

IF YOU WANT TO IMPROVE YOUR PERFORMANCE AND SAVE MONEY:

- Switch to a coating technology with a high transfer efficiency.
- Use higher efficiency spray guns, eg HVLP spray guns.
- Insist on good spray gun technique:
  - provide training and refresher courses for sprayers;
  - use good quality compressed air at the correct supply volume and pressure;
  - keep electrical connections clean when using electrostatic enhancement;
  - maintain correct spraying distance and movement relative to the workpiece;
  - minimise overspray;
  - use the most efficient paint delivery system.
- Minimise the use of cleaning materials, energy and labour during equipment cleaning.
- Consider ways of automating your process.
- Contact the Environment and Energy Helpline on freephone **0800 585794** to obtain free copies of the Envirowise publications mentioned in this Guide or visit the Envirowise website (**www.envirowise.gov.uk**).

  Don't forget to ask for the three other guides in the series on cost-effective paint and powder coating, if they relate to your operation:

  Cost-effective paint and powder coating: materials management (GG385)

  Cost-effective paint and powder coating: coating materials (GG386)

  Surface cleaning and preparation: choosing the best option (GG354)

Sources of further information

The following organisations have websites carrying information which is useful to paintshop managers.

British Coatings Federation (BCF)
James House, Bridge Street, Leatherhead, Surrey KT22 7EP
Tel: 01372 360660
www.coatings.org.uk

The BCF offers a number of publications giving more detailed information on environmental and regulatory aspects, health and safety and particular coating systems.

Surface Engineering Association and Paint and Powder Finishing Association
Federation House, 10 Vyse Street, Birmingham B18 6LT
Tel: 0121 237 1123
www.sea.org.uk and www.finishes.org.uk.

The latter website includes a comprehensive buyer's guide.

Paint Research Association (PRA)
8 Waldegrove Road, Teddington, Middlesex TW11 8LD
Tel: 020 8614 4800
www.pra.org.uk

The PRA offers a number of periodicals and publications giving detailed information on coating systems.

Compressed air for spraying

Although compressed air is often regarded as a free and convenient resource, the compressor motor uses significant amounts of electricity. Leakage of compressed air is a major source of wastage. There are also costs associated with treating the compressed air to make it suitable for use in paintshop applications.

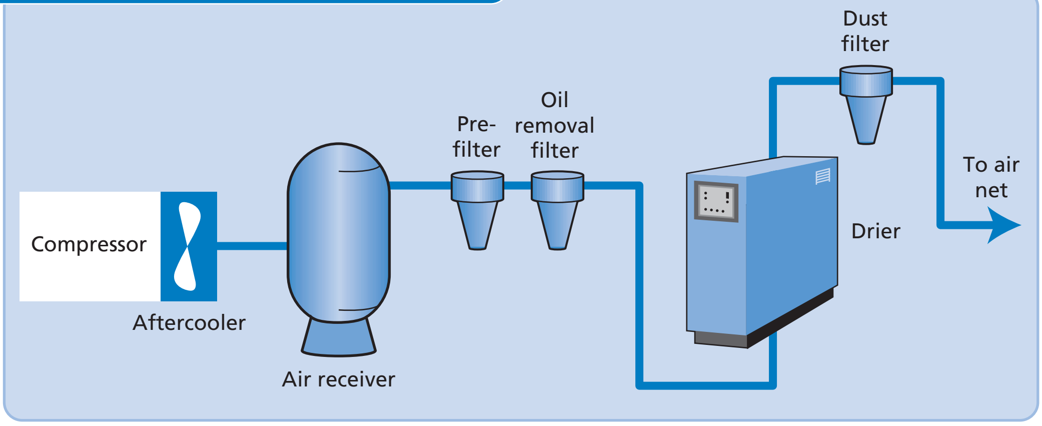
Information on how to reduce costs associated with compressed air can be obtained from the following Action Energy publications, which are available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the Action Energy website (www.actionenergy.org.uk).

- Fuel Efficiency Booklet (FEB4) *Compressed air and energy use*
- Good Practice Guide (GPG126) *Compressing air costs*
- Energy Consumption Guide (ECG40) *Compressing air costs: generation*
- Energy Consumption Guide (ECG41) *Compressing air costs: leakage*
- Energy Consumption Guide (ECG42) *Compressing air costs: treatment*

All spray guns that use compressed air, especially HVLP, require the right volume of compressed air of the right quality and at the right pressure. If there is insufficient air pressure at the HVLP spray gun, there will not be enough air to atomise the paint properly - the resulting coat may be too thick and could sag or run. Too much air pressure can result in too much air atomising the paint. This may result in strange spray patterns, poor coating of surfaces and similar rates of overspray to conventional spray guns.

Compressed air that is too hot can result in poor paint finishes as more solvent (or water) than usual will evaporate before the spray reaches the surface. Moisture (or oil) in compressed air can ruin paint surfaces and block compressed air filters, restricting the air flow and causing pressure/volume problems. Dust can also ruin the surface of paint coats (see Fig A1). For powder coating in particular, the compressed air must be scrupulously clean, as moisture can cause the powder to agglomerate, causing unevenness in the finish coating.

Fig A1 Compressed air treatment process



A simple way of checking the quality of your compressed air is to take a clean, dry HVLP spray gun and attach an air line to it without putting paint in the paint cup. Pull the trigger with the gun in front of you, pointing to your side. If the compressed air is wet, you may see a fine mist. Alternatively, pull the trigger with the gun pointing at a clean sheet of white paper. If the paper gets wet or dirty, you have a problem.

Poor compressed air supplies will result in:

- poor quality finish (leading to rework);
- overuse of coating materials;
- wasted energy in generating the compressed air.

It is also important to meet the health and safety standards for breathing air, as the same compressed air supply feeds the operator's mask.

- Always follow the spray gun manufacturer's recommendations with regard to air line sizes and pressures to ensure an adequate airflow to the operator's mask.
- Use good quality compressed air conforming to British Standard 4275. Further information is given in Health and Safety Executive Guidance Booklet HS(G)53 *Respiratory protective equipment: a practical guide for users*, (1990) (ISBN 0-7176-1198-1). This may save you money in the long-term.
- Table A1 (overleaf) provides a checklist for good compressed air management.

Table A1 Checklist for good compressed air management

Question	Reason for action	Yes	No
Is your compressor the right size for your operation? Is it able to meet the demands made by spray guns, breathing masks, air-powered tools, etc?	Over-stretching a compressor will result in poor performance of the tools you are using, eg poor quality paint finish with an HVLP spray gun, damage to the compressor and wasted energy (the compressor will be less efficient).		
Is your compressor housed in a dry, clean, open area with easy access all round and a good supply of fresh air?	Compressors need fresh air to keep cool and reduce the temperature of the compressed air. If the compressor gets hot, it will become less efficient and may even break down.		
Do you replace the air inlet filters on your compressor as often as stated in the manufacturer's instructions?	Blocked air inlet filters restrict the amount of air the compressor can suck in, making the compressor less efficient and thus wasting energy.		
If you have automatic blowdown fitted to your compressed air receiver, is it working properly?	Water builds up in any compressed air receiver. Routine drainage of this water will prolong the life of the receiver and improve the quality of the compressed air (by preventing dry compressed air from being moisturised by the water in the receiver).		
If not, do you blowdown the compressed air receiver as often as advised in the manufacturer's instructions?	This lets out any water which has collected in the receiver.		
If you have a refrigerant or desiccant compressed air drier fitted to your compressed air supply, do you check that it is working properly as often as is advised in the manufacturer's instructions?	Ideally, you should have a refrigerant or desiccant compressed air drier on the supply to your spraybooth or paintshop - it is not always necessary to dry all the air used in the paintshop. You can keep costs down by sizing the drier to meet the needs of your spraying operation, rather than supplying dry air to the whole paintshop.		
If you have any filters/coalescers fitted to your main compressed air system, do you check that they are working correctly as often as is advised in the manufacturer's instructions?	Filter/coalescers filter out dust and collect any water/oil mist from the compressed air. They do not dry the air completely - a desiccant drier is better for this purpose.		
If you use pressure regulators on the supplies to your HVLP spray guns, are these regulators fitted with working pressure gauges?	For good performance, HVLP spray guns need compressed air supplied at the right pressure and volume. Pressure regulators ensure that the required pressure is not exceeded.		
Are these pressure gauges checked for accuracy every month?	Working pressure gauges are essential to provide the correct pressure compressed air for your HVLP spray guns.		

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

Envirowise offers a range of free services including:

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

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For further information please contact the

Environment and Energy Helpline 0800 585794