Sector Specific Best Practice Guide

BEST PRACTICES IN METAL PLATING AND FINISHING

Sectors Included:

Metal finishing processes involve treatment of a metal work-piece in order to modify its surface properties, impart a particular attribute to the surface, or produce a decoration. Plating is a subset of such finishing operations that involves putting a coating of metal over a base metal substrate to give various desirable properties to the object. Metal coating is another subset of such finishing operations and involves the application of a paint or powder coating to a metal work-piece. Products from metal finishing operations can range from structural steel to jewellery.

The reason(s) for carrying out metal finishing can include:

- decoration,
- protection against corrosion,
- providing resistance to oxidation, high temperatures, or UV radiation,
- imparting mechanical properties, such as resistance to fatigue, improvement of ductile strength, or longevity,
- resistance to the use of abrasives, and,
- imparting electrical & thermal properties such as semi-conduction, thermal resistance, fire resistance, etc.

Metal plating and finishing occurs in industries in Ireland from small indigenous metal working installations to large multinational companies such as the electronics industry. Some of the larger facilities fall under the Integrated Pollution Prevention and Control (IPPC) licensing system. However, this guide is aimed at the smaller metal finishers and mainly focuses on environmental best practices that are relatively simple and straightforward to implement in an existing facility. Therefore some of the more expensive best practice options (for example electrodialysis to concentrate drag-out; ultrafiltration for process bath maintenance, etc.) have been omitted from this guide.

Main Operations:

The main operations that can occur in metal plating and finishing are as follows:

- Cleaning: including solvent cleaning (either cold soaking or vapour phase), aqueous cleaning, abrasive cleaning, and other types of cleaning such as ultrasonic cleaning, chemical polishing and electropolishing. Cleaning is usually carried out before the main metal finishing operation and sometimes between operations.
- Chemical and electrochemical conversion coatings: including chromating, phosphating, anodising, and colouring, "Conversion" refers to the fact that these processes involve changing or converting the surface layer to impart various properties to the surface. These processes are usually applied before painting to improve coating adhesion and provide corrosion protection.
- Plating: electroplating of various types of metals onto metal surfaces.
- Other metallic coating: including hot dipping (such as galvanising) and mechanical plating (such as the peening process used for Dublin's 'spire').
- Organic and other non-metallic coating: covers organic and other non-metallic coating and includes powder and liquid paints, resins and enamels. The coatings that have been applied are subsequently dried. This can be by leaving to dry in ambient air or assisted drying using an oven.
- Stripping: used to remove previous metallic coatings from parts or to remove coatings from articles that have to be reworked.

Equipment Used:

The type of equipment in use usually falls into one of the following two categories:

- A series of process tanks and rinse tanks through which the work-pieces are passed, either contained in barrels in the case of bulk small items, or hung from racks or jigs in the case of bigger items. The majority of metallic coating operations and conversion coatings take place in such a set-up.
- Spray equipment. This is mainly used in painting and other non-metallic coating operations. The majority of spray equipment would be manually operated. Automated spray equipment is sometimes used in larger facilities. There are some applications involving flow or curtain coating, dip coating, or brush application.

Main Environmental Considerations:

The main environmental considerations in metal finishing are as follows:

- Heavy metals
- Volatile organic compounds (VOCs)
- Cyanides, chromates, phosphates, toxic organics, acids and alkalis, surfactants, complexing agents, solvent-containing materials, and other chemical substances.

The main effluent/waste streams from metal finishing are:

- Rinsewaters and other waters.
- Effluent treatment sludge.
- Various chemical wastes that can include spent process baths, cleaning liquors, etc.
- Air emissions of volatile organic compounds (VOCs) from processes using solvents - e.g. coating, cleaning, and degreasing.

Current Best Practices:

Current environmental best practices are split as follows:

Part I: Environmental best practices for metal plating and other finishing operations

Part II: Environmental best practices for metal coating operations utilising solvents

PART I: CURRENT BEST PRACTICES - METAL PLATING AND OTHER FINISHING OPERATIONS

Current environmental best practices for metal plating and other finishing operations can be broken down into general best practices and those that are specific to particular unit operations involved in metal plating and finishing,

1. General best practices applicable all metal finishing operations
2. Best practices applicable to all jig & barrel metal finishing operations
3. Degreasing or solvent cleaning
4. Plating
5. Chemical and electrochemical conversion coatings
6. Alternative stripping processes

GENERAL BEST PRACTICES APPLICABLE TO ALL METAL FINISHING OPERATIONS

1.1 Simple Resource Tracking in Metal Finishing

Tracking raw material and energy use on a regular basis, say monthly or even bi-monthly, and relating it back to product produced can highlight operations that are heavy on resources.

This tracking can be achieved through looking at energy bills and purchase receipts for different material types, and keeping a tight inventory of materials. Information on products can be obtained from suppliers, for example, the solvent content of cleaners.

These usage figures should be related back to production throughput, e.g. tonnage of work processed, or if possible, estimated square metres of work processed. While the latter is not regularly calculated, it is recommended that the surface area of everything being finished is calculated.

In addition to this, tracking of waste production in terms of amount (say number of skips) and costs should also be undertaken regularly. Again these should be related back to production throughput.

If possible, putting water meters on individual processes/areas and breaking down material usage according to such processes will provide even more information on the efficiency of resource use.

1.2 Housekeeping Measures

Keeping process areas clean and painted, and keeping bunds free of rubbish, scrap parts, etc., will make any leaks from tanks or piping become apparent more readily.

In the event of liquid entering bunds, ensure that it is removed.

If using mobile pumps make sure they have an adequately sized container under them during use.

BEST PRACTICES APPLICABLE TO ALL JIG & BARREL METAL FINISHING OPERATIONS

2.1 Improve Operating Procedures

This section sets out improvements that can be made in operating practices. A significant factor in the success or otherwise of these procedural improvements, which cannot be overemphasised, is the training and familiarisation of staff with such practices.

2.2 Reducing Drag-out

Drag-out is a term which refers to the removal of process solution from a bath as a result of its adherence to the work-pieces and the jig or barrel. If the amount of drag-out formed in the first place is reduced, this will consequently reduce rinsing requirements, effluent treatment requirements and prolong the life of process baths. There are a number of ways that drag-out can be reduced:

- Better positioning of work-pieces on racks: parts should be placed on the rack so that the largest surface or plane is nearly vertical and the longer dimensions are horizontal. The lower edge should be inclined, so that run-off will occur at a corner rather than the entire edge. Avoid positioning parts directly over one another where possible.
- Better operation of racks: The rack should be positioned/inclined so that horizontal surfaces on the rack are minimised. Immerse the rack twice in the rinse tank when rinsing.
- Better operation of barrels: barrel holes should be kept clear to permit maximum drainage. Make sure barrel doors face upwards during withdrawal (usually less holes on doors). Intermittently rotate the barrel during draining and hold for 10 seconds in each position of rotation. Immerse the barrel twice in the rinse tank when rinsing.
- Slower work-piece withdrawal from tanks. The faster the work-piece is withdrawn from the process bath, the thicker the film on the work-piece surface and the greater the drag-out volume. The effect is so significant that most of the time allowed for draining a rack could instead be used for withdrawal only. This is obviously easier to achieve with electrically operated systems than manual systems.

Drainage time. Allow as much time as is feasible to drain above the process tank, except in the case of processes that require a rapid cessation of a reaction on the surface, such as passivation. Some guide values for minimum withdrawal and drainage times are:

Jigs/racks		
Process type	**Minimum withdrawal time (seconds)**	**Minimum drainage time (seconds)**
Plating & passivation	10	10
Cleaning & pickling	8	7
Seals/lacquers	10	5

Barrels			
Process type	**Minimum withdrawal time (seconds)**	**Minimum drainage time (seconds)**	**No. of 90^0 rotations & length of stationary period (seconds)**
Plating, cleaning, pickling, seals	5	24	3 rotations x 8 sec
Passivation	5	16	2 rotations x 8 sec

- Choice of barrel: use barrels with as high a proportion of the surface covered in perforations as is possible. Use barrels with draining ledges within the barrels. Use barrel arms made of fibreglass or reinforced polypropylene to minimise drag-out.

- Spray rinses can be installed over heated process tanks that will remove drag-out and make up for evaporative losses. These rinses can be automated to only be in operation when the jig is being lifted, or for manual systems a switch with a timer could be used.
- Compressed air jets can be used to blow off drag-out from work-pieces.
- Choice of solution chemistry. The higher the concentration of the solution, the larger the amount of drag-out (in terms of volume and concentration). Chemical product manufacturers may recommend an operating concentration that is higher than necessary. The operator may be able to determine a lower concentration that does not compromise product quality. Fresh baths can often be operated at lower concentrations than used baths. Make-up chemicals can be added to the used bath to gradually increase the concentration to maintain effective operation.
- Wetting agents can also reduce drag-out, but obviously do involve additional chemical use.
- Operating temperature. A higher operating temperature will reduce drag-out as viscosity will be lower. This has to be off-set against increased energy costs.

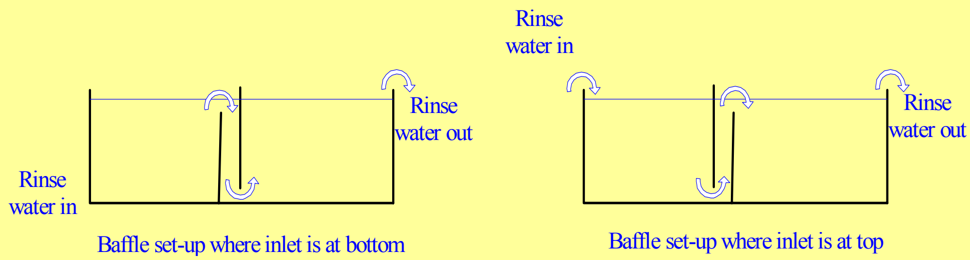
2.3 Improvements in Rinsing

Improvements that can be made to improve the efficiency of rinsing which will reduce water use, reduce the amount of rinsing water generated, and reduce subsequent treatment requirements are as follows:

- Where there is no space or capital available for additional rinse tanks, a simple but very effective improvement in rinsing is to dip twice in the same rinse tank. This is far more effective than leaving parts submerged in the rinse tank.
- Using static rinse tank in both directions. If a static rinse tank is in place, use it just *before* parts go into the process bath as well as when they come out of the process bath. This will help stabilise the concentration of chemicals in the rinse tank at approximately 50% of the bath concentration. This is because it will drag in rinse water on parts into the static rinse tank, and it will drag in a more concentrated solution rather than rinse water into the process bath. Particularly suitable for ambient process tanks. This is sometimes referred to as an eco-rinse.
- Controls on rinse water flows:
  - Flow restrictors on flow-through rinses. These simple mechanical flow control valves give constant flow independent of pressure and are very cheap. This eliminates variations in water flowrate arising from water line pressure changes or operators adjusting valves in error.
  - Control valves on rinse water flows with timers delivering a fixed amount of water triggered by programming or a switch.
  - Conductivity control in the flow-through rinse tank. This will deliver fresh rinsewater only when a preset level of conductivity, indicating contamination, has been exceeded.
- Adjustments to existing rinse tanks to avoid short circuiting:
  - Put the water inlet at the bottom of the tank and run-off at the top.

– Put a water distribution line (e.g. perforated plastic tubing) on the bottom of the tank rather than a single inlet.

– Install baffles to maximise the use of the tank volume (if not restricted by work flow) See diagram



- Static rinse tank. These are rinse tanks without a flow of water. Water from the static rinse tank can be added back into the process tank to make up for evaporative losses. They should be used in conjunction with other rinsing systems. Combinations of multiple static rinse tanks can also be used.

- Counter-current rinsing. If there is room for more than one rinse tank set up a counter-current rinse system, i.e. have the fresh water entering the last tank that the work-pieces go through. Let the overflow from this last tank be the feed for the earlier rinse tank. A two-stage counter-current rinse system will drastically reduce the amount of water needed to clean a part to the same degree of cleanliness – water reduction can be 90% or more (see appendix).
  With a certain number of counter-current rinse tanks it may even be possible to reduce rinse water flow such that the rinse water can be used to make up for evaporative losses, even in ambient process tanks.

- Spray rinses. Spray rinses can be installed over rinse tanks. These act like a second rinse step. These rinses can be automated to only be in operation when the jig is being lifted, or for manual systems a switch with a timer could be used. Spray rinses can also be used on their own as outlined in section 2.2.

- An overall master control valve on the main water supply to the finishing process with a switch convenient for the operator (e.g. beside door or on main control panel) for stopping water loss during breaks, overnights and weekends. Avoids having to change settings on individual valves on tanks.

- Air agitation. This keeps the rinse tank stirred and also has a scrubbing effect in removing process solution from parts.

- Photosensor on an automated line. This can detect when dripping stops.

2.4 Minor Process Bath Improvements

Some relatively inexpensive modifications can be carried out on existing process baths:

- Drain boards. These can be installed between tanks and angled to allow drips to return to the process bath when parts are transferred between tanks. They also help to keep the area in and around the tanks clean.

- Drip trays. These can be inserted either manually or automatically under the parts suspended from the jig to prevent contamination of other process baths when the jig is being moved.

2.5 Improve Maintenance Procedures

Routine removal of sludges/soils and other contaminants from baths should be carried out. This can be as simple as a perforated ladle or intermittent/continuous filtering systems can be used. Reusable filters are preferable. Installation costs are relatively small. Oil can be removed from process baths and degreasing solvent or solutions by skimmers, gravity separators and centrifuges. Ion exchangers can be used in some applications to remove various contaminants (for example, removal of copper/zinc/nickel contaminants from trivalent chromium plating baths). Certain salt contaminants can be removed by cold crystallisation – the bath is cooled down and the salts precipitate out (such as sodium carbonate from plating baths that use caustic). Such a process can be incorporated into a normal shut-down when baths will cool anyway. Carbon filtration of organic contaminants can be achieved by either adding carbon to the process bath and removing it in the filter or else having a carbon filter installed in the same line as the solids filter (for example, removal of organic contaminants which can cause dullness in the finish from a nickel plating bath).

Minimising drag-out means that more systematic methods for regular removal of contaminant build up will be required. This is because drag-out does assist in the removal of contaminants (along with the valuable process solution).

Maintenance of racks/barrels to prevent products of corrosion entering the process baths:

- Check barrels regularly to see that holes are not being closed off through the tumbling action during processing. Any holes in polypropylene barrels that are starting to close off can be drilled back to normal size.
- Periodic checking of jig insulation (if present) for cracks which would trap process solution.

2.6 Process Control

The process solution should be regularly checked to see that it is maintained at the desired strength.

The correction of solution strength by making small and frequent additions is much more effective than making a few large additions.

An accurate log of all checks and additions should be kept.

Make use of chemical suppliers to advise on addition rates and which parameters should be used for control purposes.

Conductivity probes may assist in maintaining a constant concentration.

For ease of control it is preferable, where possible, to use inert electrodes combined with metals in solution rather than using metal electrodes alone (for example a nickel solution together with inert anodes rather than nickel electrodes on their own). This is because it is easier to maintain the appropriate concentration of metal in the bath using solutions rather than relying on dissolution of metal from the electrode alone.

Use a deioniser on your water supply for additions to process baths as well as for rinse water used in static baths and in closed loop rinses. This will help to reduce contaminant build-up. Standard deioniser packages can be fairly easily incorporated into your water supply.

2.7 Product Storage

Try to store products prior to processing them away from the humid and acidic conditions of processing areas for as long as possible. This will reduce corrosion formation. Corrosion on products might need additional cleaning before they are processed.

DEGREASING OR SOLVENT CLEANING

3.1 Reduce or Eliminate the Need for Cleaning

The subsequent processes a work-piece is to be subjected to will have a bearing on whether it needs to be cleaned and what degree of cleaning is required. This should always be asked - work-pieces should not always automatically be cleaned.

Careful storage may reduce cleaning requirements. Protective packaging may help reduce the amount of cleaning required. This does need to be considered against the additional resource use as a result of such packaging. Reusable packaging or coverings may be applicable.

3.2 Use Alternative Cleaning Processes

If you operate a degreaser or use solvent to clean parts by cold soaking, the need to use these processes in every case should always be assessed. In many cases they are used all the time just because they are there. Consider the following alternatives for cleaning:

- Use water for cleaning. Clean hot water at 80 – 90 ^{0}C without any chemicals can remove the majority of oil and grease that comes on metal finishing work-pieces.
- Carry out some initial cleaning with dry rags or paper for larger parts prior to use of the degreaser. This will extend the degreaser's working life (although it will generate waste soiled rags/paper).
- Mechanical cleaning such as power wire brushing or shot blasting may be applicable.
- Use water-based solutions. There are a wide variety of cleaners available for different types of soiling, different types of substrate and for the different types of follow on processes. Work-pieces are soaked in the solution. The solutions do require regular replenishment. Exhausted solutions will need to be either treated or properly disposed. Specialised equipment is available for using such solutions but is not always necessary. Some such equipment would be relatively simple and inexpensive. Some have integral brushes and heating to assist the cleaning process.
- Use a biological degreasing system. Specialised equipment is needed. Uses microorganisms to break down the oil and grease on the surface of work-pieces. These are closed systems so only very small amounts of sludge need occasional disposal. Only very small amounts of cleaning chemical need to be added occasionally. Has the advantage of there being no oil or solvent for disposal. May not be suitable for all types of oil. It has also been reported to eliminate the need for parts etching. Such systems are commercially available.

- Ultrasonic cleaning can be used to enhance cleaning systems, but specialised equipment is needed. An ultrasonic cleaning unit is a tank that has an attached transducer capable of generating sound waves. High frequency sound waves are transmitted through the cleaning solution, causing formation and collapse of small vapour bubbles at the solid surface, called micro-cavitation. This agitation assists in the removal of soiling, especially in hard to reach areas. Hence the efficiency of the cleaning process is enhanced. Tanks are usually operated with aqueous and other non-volatile media.
- Alternative solvents that are less hazardous are available which could be used instead of chlorinated solvents and aromatic hydrocarbons. These include terpenes, aliphatic hydrocarbons, alcohols, esters, and glycol ethers.

3.3 Improve the Operation of Conventional Vapour Degreasers

There are a number of operational procedures that should be observed to minimise the loss of vapour from conventional vapour degreasers:

- When inserting or withdrawing components, speeds greater than 3 metres per minute (11 feet per minute) should be avoided to minimise the amount of solvent vapour lost. A power-operated hoist is recommended for all degreasing plants to control the speed of entry and exit of the work-pieces.
- Avoid heavy loads that will result in the collapse of the vapour blanket and infiltration of air into the unit. This solvent saturated air will then be expelled when the vapour layer re-establishes.
- Ensure that the parts have reached the temperature of the vapour before removal so that condensation has ceased. Look to see that there is no liquid on the parts.
- Rim ventilation should be high enough to protect operators, but excessive extraction results in unnecessary solvent consumption. An extraction rate of 640-915 m^3/hr per m^2 of bath surface is recommended. For any degreaser with a specific rim vent slot design, extract fan specification and ductwork configuration, there will be a specific rim vent slot velocity. Some users may find it easier to check this measurement rather than the total volume of air extracted. The degreaser supplier should be contacted for the appropriate figure.
- To ensure the degreaser functions efficiently, the solvent temperature should be maintained at a level adequate for vapour production.
- Improvements that can be made to conventional vapour degreasers that will reduce solvent emissions are as follows:
- Locate the degreaser away from drafts or use baffles to prevent upset. Proper location can reduce solvent loss by up to 30%. Features that create air currents that can disturb the vapours include doors, windows, heating and ventilation systems and busy passages.
- Install support frames within the condensation zone to allow work that is mounted on jigs to be supported while degreasing is in progress. This enables the lifting device to be raised and the lid closed over the work during the degreasing process.

- Install covers to eliminate drafts and reduce diffusion. These lids should be fitted below the rim ventilation slot, otherwise this can allow the extraction system to pump the system dry, and should be fitted at the top of the freeboard zone. A roller or a slide design should be used rather than lift-out panels as this is less likely to disturb the vapour. Double-door systems can be used, which are more expensive to install, but reductions in solvent consumption of up to 80% have been claimed. Such systems can have timed interlocks.
- The use of baskets having an area less than 50% of the degreaser opening will limit vapour dragout due to the piston effect.
- Increase freeboard height. A freeboard ratio (freeboard height divided by the width of the tank) of at least 0.75:1 and preferably 1:1 is recommended.
- Install fixed pipework, connected to the sump, for topping up with new solvent, rather than manually pouring new solvent into the degreaser from drums or buckets.
- Install refrigerated coils, which will condense solvent from the air leaving the degreaser and return it to the unit.
- A rapid-response temperature sensor installed immediately below the condensation zone acts as an energy saving device. The sensor cuts the energy input to the sump in response to the vapour temperature. The cooling effect of the new load being placed in the unit reactivates the main heating system.

3.4 Use a Low-Emission Vapour Degreaser

The Low-Emission Vapour Degreaser, by contrast to conventional degreasers, is a completely sealed unit. It incorporates both refrigerated condensation and carbon adsorption/desorption to trap and regenerate solvent.

PLATING

4.1 Electrolytic Metal Recovery

Electrolytic recovery of metals from static or closed loop rinse systems can be used for precious metals as well as nickel, copper, zinc, and chromium. Commercially produced packages are available in different sizes. Electrolytic recovery is usually used as one step in a treatment system as recovery from very dilute solutions cannot be achieved using this method.

A heated solution is desirable to overcome electrode polarisation and low diffusion rates. Mechanical mixing is also necessary to improve plating, this is achieved by a moving or rotating cathode or a high solution velocity over fixed cathodes.

In some cases a high surface area is used where the metal is deposited onto a fibrous or filamentous substrate. This can be sold as a low volume residue or the deposited metal can be stripped chemically or electrochemically so that the end result is a concentrated solution of the metal which is recovered for reuse.

If inert anodes are used the metal can be reused as anode material. These anodes can be reused several times as the inert base metal will not be dissolved during plating. The process also has the advantage of destroying any cyanide in the solution in parallel with the electrolytic recovery of the metal.

4.2 Alternative Plating Processes

The use of alternative coatings that will provide the same degree of protection, decoration, etc. should always be assessed.

Developments in the area of alternative plating processes will be accelerated by Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (ROHS Directive). This Directive requires the removal of lead, mercury, cadmium, and hexavalent chromium in such equipment, from 1 July 2006, except for certain applications where there are no feasible alternatives (for example cadmium plating).

4.3 Non Cyanide Plating Baths

There are several alternatives available in relation to the replacement of cyanide plating baths:

- acid zinc plating in place of cyanide zinc plating. Has the added benefit of reduced energy requirements. Needs good process control and work-pieces must be very clean for this process.
- Alkali cyanide-free zinc plating. Has disadvantage of a higher energy requirement. As for acid zinc plating, this process needs good control and well pre-cleaned work-pieces. It has been reported to achieve better metal distribution than cyanide plating.
- acid copper plating or pyrophosphate copper plating in place of cyanide copper plating.

4.4 Alternative to Hexavalent Chromium Plating Baths

Earlier problems with trivalent chromium as an alternative to hexavalent chromium plating such as colour differences and variations have been overcome with newer products. Such processes require a higher degree of control and some modifications will be needed to equipment. Product quality is reportedly better than with hexavalent chromium plating. Trivalent chromium cannot replace hard chromium processes.

CHEMICAL AND ELECTROCHEMICAL CONVERSION COATINGS (CHROMATING, PHOSPHATING, ANODISING, AND COLOURING)

5.1 Alternative Conversion Coatings

Trivalent chromium conversion coatings are available as an alternative to hexavalent chromium conversion coatings. These solutions can be used in existing equipment with only minor modifications, so they are relatively easy to retrofit.

There are chrome-free conversion coatings available but work-pieces may need additional coating to provide corrosion protection.

ALTERNATIVE STRIPPING PROCESSES

6.1 Cyanide-free stripping solutions

There are alternatives available for cyanide-free nickel stripping solutions. Tank lining may be needed.

PART II: METAL COATING OPERATIONS UTILISING SOLVENTS

SIMPLE RESOURCE TRACKING FOR METAL COATING

Tracking raw material and energy use on a regular basis, say monthly or even bi-monthly, and relating it back to product produced can highlight operations that are heavy on resources.

This tracking can be achieved through looking at energy bills and purchase receipts for different material types, and keeping a tight inventory of materials. Information on products can be obtained from suppliers such as the solvent and solids content of coatings.

These usage figures should be related back to production throughput, e.g. tonnage of work processed, or if possible, estimated square metres of surface coated. While the latter is not regularly calculated, it is recommended that the surface area of everything being coated is calculated.

In addition to this, tracking of waste production in terms of amount (say number of skips) and costs should also be undertaken regularly. Again these should be related back to production throughput.

If possible, breaking down material usage according to individual processes/areas will provide even more information on the efficiency of resource use.

RAW MATERIAL STOCKS

Try to keep your stock of raw materials to a minimum, as this will reduce the amount that will eventually become waste due to quality problems, obsolete materials, product changes, etc.

RAW MATERIAL STORAGE

Ensure raw materials are stored in a manner that prevents damage and spillage. Especially in the case of coatings, indoor storage, or even a smaller indoor day store for paints is recommended since outdoor storage or storage in unheated stores will reduce viscosity. Follow manufacturers instruction for storage of coatings to maximise their shelf-life.

OPERATING PROCEDURES

This section sets out improvements that can be made in operating practices. A significant factor in the success or otherwise of these procedural improvements, which cannot be overemphasised, is the training and familiarisation of staff with such practices.

- Ensure coatings are at room temperature before using.
- Use mobile pumps rather than pouring for transferring larger amounts of coatings. Such pumps are even available for 25-litre drum size. For smaller amounts, e.g. cleaning, use enclosed piston-type dispensers rather than pouring. This will reduce usage and emissions.

- Just the amount of coating sufficient for a given job should be measured out.
- When mixing two component coatings it is important to follow the correct mix rates as recommended by the supplier/manufacturer. Workers should be trained on this and have correct instructions available to them. Apart from reducing waste, this will also improve product quality and reduce reject rates. Use of two pack mixing systems that mix the two components just prior to the spray gun can be beneficial (see 2.7).
- Only carry out spraying within spray booths.
- Keep lids on coatings tins before and after use and during handling/transport around the premises to reduce solvent emissions. This will also improve product quality since the coating will remain at its designed solvent content. Lids should also be kept on part-empty drums and on drums containing waste. Lids can be designed to cover containers during pumping. Transfer solvent-containing material out of containers that do not seal properly, e.g. are damaged or dented.
- Keep any solvent impregnated wipes in enclosed containers, and when they are used place in a bin with a self-closing lid.

PROCESS CONTROL

Try to maintain a relatively consistent coating shop temperature throughout the year so the viscosity of the coatings is at the recommended levels. This will improve coating finish.

MAINTENANCE PROCEDURES

All spray equipment moving parts should be lubricated frequently so as to extend their life and improve their performance (specialised lubricants are available from spray gun suppliers). Spray equipment moving parts should be properly adjusted. Certain parts of spray guns, such as the nozzle and valves, should be checked regularly and replaced if worn.

Regularly maintain spray booths. For dry booth filters: regularly change the filter – follow the manufacturer's recommendations on frequency. For water wash spray booths: perform periodic disposal of the water and where appropriate periodic solids removal from the water. Spray booth fans and ducts will need periodic maintenance.

Drain air compressors of condensate and clean air intake filters on a regular basis. Repair leaks on compressed air lines.

ALTERNATIVE COATINGS

Using alternative coatings will help reduce solvent emissions from painting and coating processes. The use of alternative coatings may be able to bring a site below the solvent consumption thresholds under the 2002 Solvents Regulations and exempt the site from meeting emissions limits or targets under the Regulations and from having to obtain an annual certificate of compliance from their local authority. These thresholds differ depending on the type of material being coated. The use of alternative coatings may even be able to bring a site below the solvent consumption thresholds under the IPPC Directive and eliminate the need to hold an Integrated Pollution Prevention and Control licence (IPPCL) from the EPA.

Conventional coatings typically contain 60 - 80% solvent, or in the more common units used by the industry, between 720 – 960 grammes of solvent per litre of coating. Two component coatings are usually somewhat lower in solvent content, typically about 50%. Alternative coatings include conversion to aqueous coatings, low solvent content coatings, high solids content coatings or powder-based coatings.

Both the solvents Directive (1999/13/EC) and a planned "deco paints" Directive are likely to eventually force coatings suppliers to reduce solvent content of paints.

Do not automatically dismiss trying out alternative coatings as a result of any historical trials that may have been unsuccessful. This is an area under continuous development with both technical and cost improvements regularly being made.

It should be remembered also that a reduced usage of solvent will translate to a lower fire risk for your premises. This can in some cases be translated into lower insurance premiums.

Water-based Coatings

Aqueous coatings available today meet the performance requirements in various applications including in the electronics and vehicle refinishing industries. Aqueous coatings have the added benefits of better application rates and the ability to use water for gun cleaning. Aqueous coatings can usually be applied with conventional equipment, although the equipment materials should be checked to ensure they are suitably corrosion resistant. Aqueous coatings can be more expensive than conventional coatings but the higher cost can be off-set by the improved application rates – often less coats are necessary to achieve the same finish. Additional pre-treatment of work-pieces may be required to improve adhesion. A high level of pre-cleaning will be necessary. Curing or drying facilities may also need to be improved as drying times will be longer. Some of the more recently available water based coatings have lower curing energy requirements. It should also be remembered that a licence to discharge to sewer or waters from the local authority will be necessary if disposing of aqueous washings to drain.

Low Solvent Content Coatings

There are coatings available that have reduced solvent content as compared to conventional solvent-based coatings. These typically contain 30 - 40% solvent.

High Solids Content Coatings

High solids content coatings typically contain 50% or less solvent. A lower amount of high solids coating is needed to cover a given area. Coating equipment cleaning requirements may increase somewhat.

Powder-based Coatings

Powder-based coatings is also an alternative to solvent based coatings. However, plant investment is significant and it is usually more suitable to high volume throughput facilities.

HIGH TRANSFER EFFICIENCY EQUIPMENT IN PAINTING AND COATING

Change to high volume low pressure (HVLP) spray equipment that is more efficient in the amount of paint needed to spray a given area, i.e. has a higher transfer efficiency. For conventional high-pressure, air assisted spray equipment (3 - 6 bar) only 25% - 40% of paint reaches the surface. For high volume low pressure (HVLP) spray equipment (typical line pressure about 2 bar) 40% to 65% or more of paint reaches the surface. HVLP also offers improved finish quality and reduced paint costs due to overspray reduction. Spray booth cleaning is also reduced due to an increased amount of the coating going onto the product rather than the walls of the spray booth.

At present there has been little take up of such equipment by Irish industry. The typical cost of a high quality spray gun is €400. These spray guns can be connected to the existing conventional pressurised air supply systems. Newer models also have a similar feel in use to conventional guns.

There are also other types of spraying equipment available that offer improved transfer efficiency for specific applications. Airless spray and air assisted airless spray are suitable for coating of large areas.

PROPER OPERATION OF SPRAY EQUIPMENT & TRAINING OF OPERATORS

The importance of operator training in the techniques and use of spray equipment cannot be emphasised enough. A properly trained person using conventional equipment could possibly have a better transfer efficiency than an untrained person using HVLP equipment.

Operators should be trained on factors such as:

- Holding the spray gun perpendicular to the workpiece surface
- Holding the spray gun 15 to 20 cm (6 to 8 inches) from the workpiece
- Ensuring each stroke overlaps the previous stroke by 50%
- Triggering the gun at the beginning and ending of each pass (i.e. release the trigger just before the stroke ends while the gun is directly over the product)
- Maintaining a consistent gun speed — general recommendation is 1.3 m/s (250 ft/min)

- Choice of the correct coating flow rate (common practice is to use too high a flow, resulting in poor finishing)
- Maintaining the correct air pressure for spraying, and use of the air-cap pressure tester in checking this (using too high a pressure is again common practice, and also leads to poor finish results)
- Choice of the appropriate nozzle to suit the item being coated
- Adjusting the spray pattern to suit the item being coated
- Establishing the recommended thickness of coating on the product
- The frequency and method of cleaning spray guns.

Proper training and operation will obviously also improve product quality and reduce reject rates. Spray training courses are available in Ireland.

Spray guns should be cleaned after use or whenever there will be an appreciable interval between uses. Avoid the practice of cleaning by spraying solvent into the water curtain or dry filter. Instead use enclosed units (see below) or else spray solvent directly into a container for possible reuse.

ELECTROSTATIC ASSISTANCE IN SPRAYING

An electrostatic charge is introduced to the surface being coated. This attracts the particles of paint to the surface, which in turn improves the efficiency in the amount of paint that is transferred during spraying. Electrostatic assistance can provide transfer efficiencies from 65% to 80%. Electrostatic assistance is the method used in powder coating but it can also be used with liquid coatings. A negative charge is applied to the coating as it is sprayed via a power supply connected to the spray equipment. The workpiece needs to be earthed in order to attract the charged coating particles. It is particularly suited to metal workpieces. Electrostatic assistance can be used with HVLP, airless and conventional spray equipment although electrostatic versions of these systems are more expensive. The coating must be conductive. In the case of water-based coatings the paint holding container must be insulated in order to prevent the charge going to earth through the paint supply (and also the container must be protected from passers-by touching it and receiving a shock due to this insulation). Training of operators in the use of the electrostatic system would be required. Electrostatic assistance is not suitable for anything that contains electronic components as they could be damaged by the electrostatic charge. Some problems can also be encountered in coating recessed areas.

USE OF RECOMMENDED MIX RATES

For coating products supplied as components to be mixed prior to use rather than ready to use, it is important to follow the correct mix rates of the components from the supplier/manufacturer. Workers should be trained on this and have correct instructions available to them.

ENCLOSED GUNWASH STATIONS

Spray guns can be washed in enclosed equipment designed for the purpose. This reduces the release of solvent as well as reducing solvent consumption due to cleaning. Such manually operated or automated equipment is readily available on the market.

USE OF PAINT MIXING EQUIPMENT

Enclosed paint mixing equipment that reduces release of solvent is available on the market. Systems are available which mix two component coatings just prior to entering the spray gun. This also reduces the amount of waste coating generated through mixed coating hardening before being used.

Appendix: Water Reduction in Counter-current Rinses

The following example illustrates the water savings that are possible through operating a counter-current rinsing system (see section 2.3 for rinse improvements in metal finishing).

The flowrate of rinse water required is calculated as follows for counter-flow rinsing:

$$\begin{array}{c}\text{Rinse Water}\\ \text{Flowrate}\\ \text{(litres/hr)}\end{array} = \left(\begin{array}{c}\text{number of}\\ \text{rinses}\end{array}\right)\left(\begin{array}{c}\text{Dragout}\\ \text{volume}\\ \text{(litres/hr)}\end{array}\right)\left[\left(\begin{array}{c}\text{Dilution}\\ \text{ratio}\end{array}\right)^{\left(\frac{1}{\text{Number of rinses}}\right)}\right]$$

Where,

Number of rinses: the number of rinse tanks in the counter-current system.

Dragout volume: the volume in litres that is dragged out from the process tank into the rinsing system every hour. A typical value of 2 litres per hour will be used for this example.

Dilution ratio: is the concentration in the process bath divided by the concentration in the final rinse, e.g. dilution ratio of 5000 means a dilution of 1 in 5000. This value will be used for this example.

For a single stage rinse, the required flowrate is as follows:

Rinsewater flowrate (litres/hour) = (1) (2) $(5000)^{(1/1)}$

= 10,000 litres/hour for a single stage rinse

For a two stage counter-current rinse, the required flowrate is as follows:

Rinsewater flowrate (litres/hour) = (2) (2) $(5000)^{(1/2)}$

= 283 litres/hour for a two stage counter-current rinse