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## **How to comply with your environmental permit**

**Additional guidance for: The Surface Treatment of Metals and Plastics by Electrolytic and Chemical Processes (EPR 2.07)**

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Additional guidance for:

The Surface Treatment of Metals and Plastics by Electrolytic and Chemical Processes (EPR 2.07)

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## Introduction

In “Getting the basics right – how to comply with your environmental permit” (GTBR) we described the standards and measures that we expect businesses to take in order to control the risk of pollution from the most frequent situations in the waste management and process industries.

This sector guidance note (SGN) is one of a series of additional guidance for Part A (1) activities listed in Schedule 1 of the Environmental Permitting Regulations (the Regulations). We expect you to use the standards and measures in this note in addition to those in GTBR to meet the objectives in your permit.

Sometimes, particularly difficult issues arise such as problems with odour or noise. You may then need to consult the “horizontal” guidance that gives in depth information on particular topics. Annex 1 of GTBR lists these.

The IPPC Directive requires that the Best Available Techniques (BAT) are used. When making an application, explain how you will comply with each of the indicative BATs in this sector guidance note. Where indicative BAT is not included, where you propose to use an alternative measure or where there is a choice of options you should explain your choice on the basis of costs and benefits. Part 2 of Horizontal Guidance Note H1 Environmental Risk Assessment (see GTBR Annex 1) gives a formal method of assessing options which you should use where major decisions are to be made.

We will consider the relevance and relative importance of the information to the installation concerned when making technical judgments about the installation and when setting conditions in the permit.

Modern permits describe the objectives (or outcomes) that we want you to achieve. They do not normally tell you how to achieve them. They give you a degree of flexibility.

Where a condition requires you to take appropriate measures to secure a particular objective, we will expect you to use, at least, the measures described which are appropriate for meeting the objective. You may have described the measures you propose in your application or in a relevant management plan but further measures will be necessary if the objectives are not met.

The measures set out in this note may not all be appropriate for a particular circumstance and you may implement equivalent measures that achieve the same objective. In cases where the measures are mandatory this is stated.

In response to the application form question on Operating Techniques, you should address each of the measures described as indicative BAT in this note as well as the key issues identified in GTBR.

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Unless otherwise specified, the measures and benchmarks described in this note reflect those of the previous Sector Guidance Note. They will be reviewed in the light of future BREF note revisions. In the meantime we will take account of advances in BAT when considering any changes to your process.

### **Installations Covered**

This note applies to activities regulated under the following section of schedule 1 of the Regulations:

Section 2.3, Surface Treating Metals and Plastic Materials, Part A(1)

(a) Unless falling within Part A(2) of this section, surface treating metals and plastic materials using an electrolytic or chemical process where the aggregated volume of the treatment vats is more than 30m<sup>3</sup>.

Section 4.2, Inorganic Chemicals, Part A(1)

(f) Unless falling within another Section of this Schedule, any manufacturing activity involving the use of mercury or cadmium or any compound of either element or which may result in the release into air of either of those elements or their compounds.

### **PPC Amendment in July 2003 (England and Wales only)**

In July 2003, the PPC Regulations were amended by SI 2003 No 1699, which inserted a new Section 2.3 A (2) (a), thus: Surface treating metals and plastic materials using an electrolytic or chemical process where the aggregated volume of the treatment vats is more than 30m<sup>3</sup> and where the activity is carried out at the same installation as one or more activities falling within -

- (i) Part A(2) or B of Section 2.1 (Ferrous Metals);
- (ii) Part A(2) or B of Section 2.2 (Non-Ferrous Metals); or
- (iii) Part A(2) or B of Section 6.4 (Coating Activities, Printing and Textile Treatments).

The amendment has the effect of moving some activities from Natural Resources Wales to Local Authority regulation, e.g. where pickling is carried out prior to galvanising, phosphating prior to painting and anodising prior to powder coating.

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This guidance note only covers those A (1) activities which will be regulated by Natural Resources Wales.

### **Determination of 30 m<sup>3</sup> threshold for surface treatment**

Only the vats specifically carrying out surface treatment count towards the 30 m<sup>3</sup> threshold.

Note that there is no volume threshold for cadmium processes covered under section 4.2(f). When these cadmium processes are carried out on a site with more than 30 m<sup>3</sup> of surface treatment, the cadmium processes are included within the 30m<sup>3</sup> and are not considered a separate activity.

Examples relevant to installations with surface treatment activities might be:

- A site has a number of separate surface treatment lines undertaking different types of process, none of which exceeds 30m<sup>3</sup> of treatment volume on its own. If the total aggregate volume of all the tanks making chemical changes to workpiece surfaces exceeds 30m<sup>3</sup> then there will be an IPPC installation (and only one IPPC installation) which includes all associated activities on site which are technically connected with any of the surface treatment lines.
  - A site includes two >30 m<sup>3</sup> surface treatment shops operated by separate companies, but they share a common effluent treatment facility. The installation will include both main surface treatment activities and some or all of the associated activities listed above. Although there is only one installation, each operator is required to be separately permitted (with linked permits) for operation of that installation.

### **Directly associated activities**

The installation will also include **directly associated activities** which have a technical connection with the main activities and which may have an effect on emissions and pollution. These may involve activities such as:

- storage and handling of input chemicals and anode metals
- water treatment
- mechanical, chemical, liquid or vapour preparation of the work to be treated
- rinsing and drying of the work being treated
- post-treatment of the work (where necessary to complete the surface treatment)
- fume extraction and fume abatement system
- effluent treatment
- handling of spent process fluids
- handling of wastes.

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## Key Issues

The key issues are:

### Management systems

The sector has a significant number of small to medium enterprises (SMEs), with limited technical resources. Hence, management systems are a critical issue, particularly written procedures, training and maintenance. You should have an Environmental Management System (EMS) in place, preferably with external certification. The Surface Engineering Association 'Health, Safety and

Environment Code of Practice for the Surface Finishing Industry 2001' forms a good basis for such a management system.

### Accident prevention and control

It is recognised in this sector of industry that the most significant environmental impact may result from an accident and, as such, this aspect is of key importance. You must have written procedures for emptying vats and transferring and storing liquors and chemicals. In addition to the potential for spillage or leakage of treatment fluids, some sites may have historically leaky drainage systems that will need attention. Secure storage arrangements for raw materials and chemicals must also be provided.

### Process selection and raw materials

As far as practicable, you should use the least harmful metals and chemicals. You should also use techniques which aim for near-zero emissions to water and the minimum amount of waste. You can achieve this by techniques such as cascade rinsing, evaporation, recovery and recycling. If you use a particularly toxic metal, particularly cadmium, you may require special techniques to prevent its release. Use proprietary plating electrolytes that have a low concentration of dissolved solids and operate with minimum energy requirements for heating or cooling, which avoid cadmium wherever practicable and which require relatively simple effluent treatment.

### Minimising the use of water and other raw materials

You should minimise your water consumption. Much of the water input is used for rinsing purposes and is discharged after treatment as trade effluent. Where rinsing techniques are poor, not only is water use per unit of output high but metal can be wasted as it is carried out into effluent treatment. In order to minimise water and metal use, you should optimise rinsing systems and use recirculatory or low flow systems as appropriate. Examples of these include counter current or spray rinse systems, or treatment systems such as ion exchange, the choice of which should be justified on a site-specific basis. If rinse waters are recycled to replace water lost to evaporation from process tanks, essentially zero liquid discharge can be achieved.

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### **Minimising hazardous wastes**

The bulk of the chemicals used in the processes are lost through drag-out and final discharge of spent process fluids. The metals are usually removed in an effluent treatment plant resulting in the production of hazardous wastes comprising metal hydroxide sludge and filter cake. In some electroplating processes a significant proportion of the input anode material is lost as sludge, generally ending up as hazardous waste but this depends on the process - some, like copper plating, leave no sludge, and some use inert anodes.

### **Emissions to sewer and controlled waters**

Normally, discharges to water in this sector are to foul sewer. You should discuss any process discharges directly to surface water with us at the preapplication stage, as they will require special attention. Significant detail is required in assessing rinsing and metal recovery systems used within the installation and you should provide a full justification for current techniques and planned improvements based on the use of Best Available Techniques (BAT). Emission of metals to water should generally be very low. Note also that you should take care to prevent or minimise the release of persistent organic substances that may be present in some of the chemicals you use (e.g. proprietary additives).

### **Solvent emission regulations**

The Solvent Emissions (England and Wales) Regulations, SI 2004 No107, require companies to meet the Solvents Emissions Directive 67/548/EEC (SED). This may affect operators in the surface treatment sector who use solvents, e.g., for component degreasing or in paint shops.



## 1 Managing your activities

### 1.1 Energy Efficiency

Indicative BAT

The following should be used where appropriate:

- 1 High efficiency dewatering techniques to minimise drying energy.
- 2 Minimisation of water use and closed circulating water systems.
- 3 Using spent cooling water (which is raised in temperature) for rinsing purposes.
- 4 Automated control for DC rectifiers.
- 5 Electrolytic processes that operate under thermally stable conditions without the need for heating or cooling.
- 6 Minimum use of fume extraction consistent with COSHH Regulations.
- 7 Inverter speed control or flow damper for fume extraction centrifugal fans.

## 1.2 Efficient use of raw materials and water

Indicative BAT

The following should be used where appropriate:

### Indicative BAT

The following should be used where appropriate:

- 1 Effluent treatment facilities should be designed to process spent process fluids and recover anode metals for reuse, e.g. cadmium, copper and nickel.
- 2 Spent alkaline cleaners and acid pickles should be used for pH control in the effluent treatment facility.
- 3 You should evaluate the use of phosphating sludge as a filler for agricultural and horticultural use.
- 4 Filter cake may have uses, and these should be investigated in preference to landfill disposal.
- 5 Filter cake presses should be operated at not less than 7 bar and preferably 10-15 bar to reduce its mass, volume and water content.
- 6 Consider use of a low temperature biological cleaner system in place of the traditional alkaline soak cleaner for a long production life, low waste and low energy consumption.
- 7 Consider use of ion exchange or other treatment unit to re-circulate rinse waters.
- 8 Consider use of closed loop operation with three to four stage cascade rinsing, so that drag-out can be returned upstream to balance the evaporative loss and minimise waste.
- 9 Minimise drag-out by maximising the drainage time of the work over the tank or in a separate drainage tank.
- 10 Use electrochemical metals recovery technology for unreturned drag-out.
- 11 Use electrodialysis technology for the re-oxidation of hexavalent chromium [chromate, or Cr(VI)] degraded to trivalent chromium [Cr(III)] in chromic acid anodising electrolytes.

## 1.3 Avoidance, recovery and disposal of wastes

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# **2 Operations**

## **2.1 Material storage and handling**

## **2.2 Surface preparation**

## **2.3 Surface treatment**

## **2.4 Rinsing**

## **2.5 Drying**

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## 2 Operations

### 2.1 Material storage and handling

Small quantities are usually stored in 25, 30, 50 and/or 205 litre special plastic containers supplied by chemicals distributors, often on a returnable basis. High consumption acids, e.g. 32% w/v hydrochloric acid or concentrated sulphuric acid, are stored in the larger installations in dedicated bulk stock tanks or in 1000 litre returnable Intermediate Bulk Containers (IBCs). Dilution of strong acid to the operational concentration is usually carried out at the process tanks.

### 2.2 Surface preparation

#### **Mechanical**

Prior to surface treatment, some types of work may require finishing to remove rust or heatscale before chemical preparation

#### **Indicative BAT**

1. You should ensure that emissions from the local exhaust ventilation do not have an adverse environmental impact.

#### **Degreasing using organic solvents**

The use of vapour phase degreasing has significantly diminished. It is not a process that can easily be integrated into an automated surface treatment plant. It is used

#### **Indicative BAT**

1. You must comply with the requirements of the Solvent Emissions Directive, as implemented by the Solvent Emissions (England and Wales) Regulations 2004. Compliance with the SED goes beyond the technical measures described in this guidance.
2. The main control measures are:
  - control of point source emissions to air (from the degreaser vents system)
  - control of fugitive emissions to air
  - recovery of solvent in spent solvent waste
  - disciplined use of properly positioned and closed lids, except when loading and unloading conventional degreasers
  - the use of top-loading multiple door facilities
  - the use of totally sealed end-loading degreasers with solvent vapour condensation and condensate recycle.

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only for low-volume high-value components that require a high level of cleanliness, e.g. in the aerospace and specialist electronics industries.

### **Chemical cleaning using aqueous cleaners**

Alkaline cleaning is the most common first process step. It is usually carried out as an immersion (in tank) operation, but spray cleaning is sometimes used. The cleaning process usually comprises two consecutive operations:

- A hot alkaline oil emulsifying soak cleaner at 60-90°C
- A hot electrolytic alkaline cleaner at 50-70°C which utilises the ‘scrubbing’ effect of liberated hydrogen or oxygen

It is not now usual to provide a water rinse between the two alkaline cleaning stages. Alkaline cleaners become spent after a period of time and require partial or total replenishment, but many plants use flotation oil separation equipment on the alkaline soak cleaner as a means of prolonging the life of the cleaning fluid.

#### **Indicative BAT**

1. The key areas of control are:

- energy consumption
- fugitive emissions to air
- rinse water efficiency
- cleaning fluid lifetime
- disposal of spent cleaners.

2. Consider use of ion exchange or other treatment unit to re-circulate rinse waters.

3. Closed loop operation with three to four stage cascade rinsing, so that drag-out can be returned upstream, is a particularly effective way to balance the loss of water by evaporation and minimise waste of costly process chemicals.

4. Where appropriate, generate turbulence by means of an eductor to provide improved cleaning, and maintain particulates in suspension so that they can be removed continuously by external filtration.

5. Where appropriate, use membrane filtration to remove oil and grease, emulsions and dispersants

6. Where possible, maintain adequate freeboard above the cleaner level (minimum of 150 mm) to minimise entrainment of liquid and subsequent emissions to air.

Extraction lip ducts should be mounted at least 50mm above the top of the tank lip angle, and you should use the minimum air flow consistent with satisfactory extraction.

7. Where appropriate, use “hexagons” or “croffles” to reduce evaporative loss and reduce energy consumption. Use automated lids on large cleaner tanks to reduce fume extraction energy costs as well as to reduce consumption for process heating.

8. Consider the use of proprietary cleaners that allow a lower operating temperature.

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9. Consider use of a low temperature biological cleaner system in place of the traditional alkaline soak cleaner for a long production life, low waste and low energy consumption.

### **Pickling**

15-30% hydrochloric acid at ambient temperature is the most common pickling agent used in the surface treatment sector. 10% sulphuric acid at up to 70 °C is also used, as are mixtures of hydrochloric and sulphuric acids. Corrosion of the work is likely with acid pickling unless an inhibitor is incorporated. A mixture of nitric and hydrofluoric acids at elevated temperature is used for the descaling of high alloy steels prior to electropolishing.

Proprietary dry acid salts are available for small-scale work where the use, storage and handling concentrated acids is undesirable. There are also proprietary alkaline derusting salts which enable iron and steel work to be rapidly descaled without the danger of attack on the basis metal, and are especially suitable for precision components where etching of the surface must be avoided. Alkaline derusting is also employed for the treatment of high tensile and hardened steels which are susceptible to hydrogen embrittlement under acid conditions. The performance of pickling solutions deteriorates as the level of dissolved iron and other metals increases. Partial or total replenishment then becomes necessary.

### **Indicative BAT**

1. The key areas of control are:
  - rinse water economy
  - prevention and control of point source and fugitive emissions to air
  - pickle efficiency
  - acid regeneration
  - acid recycling
  - use of inhibitors which are readily biodegradable.
2. There should be two or three stage cascade pickling with continuous pickle acid feed and continuous discharge to the effluent treatment facility.
3. There should be a minimum of two stages of cascade rinsing with agitation.
4. Consider ion exchange or other treatment unit to re-circulate rinse waters.
5. Consider use of spent pickle acid for pH control in the effluent treatment facility.

## **2.3 Surface treatment**

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### ***Electroplating***

Most plating electrolytes incorporate proprietary additives, usually of organic formulation which assist in the deposition process and provide desirable surface properties such as grain refinement, ductility levelling, and brightness. Certain additives are consumed in the electrochemical reaction, others act as "carriers" and are lost from the electrolyte by drag-out. Similarly the salts, alkalis and/or acids that comprise the basic electrolyte are lost by drag-out. The dragout losses are balanced by regular additions of the appropriate proprietary and commodity chemicals. Mass drag-out is minimised by operation at the lowest acceptable dissolved solids concentration.

Cadmium plating is carried out in an alkaline cyanide-based electrolyte. Release of cadmium to sewer has effectively to be **prevented** (not just minimised and rendered harmless) and your consideration of BAT for drag-out minimisation and cadmium recovery should aim to minimise cadmium release to landfill.

The operational temperature is dependent on the nature of the electrolyte, the metal being plated, and the volatility of the organic additives. There is a substantial energy input from the DC plating supply, necessitating a similar energy demand for cooling in the case of ambient temperature processes. In other processes the plating current energy needs to be augmented to achieve operating temperatures in the order of 50-65°C (e.g. nickel plating). Thermally stable processes that do not require the intervention of continuous process heating or cooling are desirable but not yet commonplace.

Fume extraction is often used for plating electrolytes. For tanks carrying out many different plating operations, and especially for chromium (VI), fume extraction was previously thought to be essential. However, many techniques have been developed that eliminate or minimise the need for fume extraction and still meet COSHH requirements.

### **Indicative BAT**

1. The main areas of control are:
  - rinse water economy – see Section 1
  - mass drag-out reduction
  - return of drag-out
  - recovery of higher value metals from drag-out which cannot be returned
  - energy consumption – see section 1
  - prevention of fugitive emissions to air – see section 3
2. You should give full consideration to using substances other than cadmium, chromium(VI) and other hazardous materials. Where alternatives are not available, you must provide proper controls.

Where appropriate for the process you should:

3. Maximise stages of cascade rinsing, with agitation where appropriate.
4. Use ion exchange or other treatment units to re-circulate rinse waters.
5. Use proprietary plating electrolytes that have a low concentration of dissolved solids and operate with minimum energy requirements for heating or cooling. These should avoid cadmium where possible and should require relatively simple effluent treatment.
6. Replace EDTA by QUADROL in autocatalytic copper systems.
7. Minimise drag-out by maximising the drainage time of the work over the tank or in a separate drainage tank.
8. Use ECO-rinse tank(s) to reduce mass drag-out and subsequent rinse-water consumption.
9. Use electrochemical metals recovery technology for unreturned drag-out.
10. Use evaporation technology in conjunction with 3-5 stage cascade rinsing to allow



11. Generate turbulence by hydraulic power and eductors.
12. Use electro dialysis technology for the re-oxidation of chromium (VI) reduced to chromium (III) in chromic acid anodising electrolytes.
13. Use hydrogen peroxide in the pickling tanks to reduce NO<sub>x</sub> emission and acid consumption.
14. Employ low temperature processes consistent with good metal deposition rate. You should use lids on process tanks operating at 60°C and above, and you should consider hexagons or croffles for all manually operated tanks.
15. A minimum of 4 and preferably 5 stages of cascade rinsing after chromic/sulphuric acid etch, with techniques for minimising drag-out. Consider alternatives to chromic/sulphuric acid as an etchant.
16. Provide jig or barrel supports whilst draining for manually operated process tanks.
17. Use continuous filtration and removal of sludge from phosphating process tanks.

## Anodising

Aluminium, and to a lesser extent, magnesium and titanium, are anodised to provide surface properties which include improved corrosion protection, hardness, and decorative appeal. The three main processes used for aluminium work are:

- Sulphuric acid anodising at 18 to 22 °C for decorative work
- Sulphuric acid anodising at -5 to 5 °C for hard, thick films
- Chromic acid anodising at 38 to 42 °C for corrosion protection

Following the preparation stages, the work is then etched in a sodium hydroxide-based etchant or chemically/electrolytically polished, depending on the finish required. The removal of smut with dilute nitric acid generally follows. The work is then anodised in the appropriate electrolyte.

Post-anodising, the anodic film requires sealing in hot water, or in a proprietary metal salt solution prior to hot water sealing, though for decorative applications, the work may be immersed in dye solution prior to sealing. The issues relating to drag-out, anodising current, process heating/cooling are similar to electroplating. Close temperature control of the anodising electrolyte is important, and it is necessary to provide vigorous turbulence through air agitation or, preferably, through the use of hydraulic eductor systems. The use of fume extraction should be considered, although many techniques have been developed that eliminate or minimise the use of fume extraction and still meet COSHH requirements.

### **Indicative BAT**

1. The main areas of control are:

- rinse water economy – see Section 1
- mass drag-out reduction – see electroplating
- energy consumption – see Section 1
- prevention of fugitive emissions to air – see Section 3
- removal of dissolved aluminium for the anodising electrolyte
- chromium (VI) plating.

### **Electropolishing**

Stainless steels and related alloys are electropolished on a considerable scale as a means of improving corrosion resistance, as well as enhancing appearance.

Following conventional aqueous alkaline cleaning, there is usually a descaling process based on a mixture of hydrofluoric and nitric acids. The work is then anodically electropolished in a concentrated phosphoric/sulphuric acid mixture at a temperature of 60-90°C. Following rinsing, the work is treated in 20% nitric acid at 50°C to remove phosphate smut. The issues relating to drag-out, rinsing, DC supply, process heating etc. are similar to electroplating. Fume extraction is necessary with NO<sub>x</sub> abatement.

### **Indicative BAT**

1. The main areas of control are:

- rinse water economy – see Section 1
- mass drag-out reduction – see electroplating
- energy consumption – see Section 1
- prevention of fugitive emissions – see Section 3
- prolongation of the descaling and electropolishing process fluids by basis metal removal

### **Plating on plastics**

Plating on ABS and a few other plastic materials is generally carried out in large automated plants. There are two stages in the overall process. In the first (pre-treatment) stage, the work is etched in chromic/sulphuric acid (400g/l CrO<sub>3</sub>) at 60°C, and then autocatalytically plated with a thin layer of nickel which provides a conductive surface for the second stage conventional electroplating treatment. This will generally comprise copper and nickel substrates (bright or satin) followed by a decorative chromium finish. The first stage comprising etching, activation, acceleration and autocatalytic nickel requires a high level of process control. Generally, the issues relating to drag-out, rinsing, DC supply, process heating, fume extraction, etc. are similar to electroplating.

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### **Indicative BAT**

1. The main areas of control are:

- rinse water economy – see Section 1
- mass drag-out reduction and return of drag-out – see electroplating
- energy consumption – see Section 1
- prevention of fugitive emissions – see Section 3
- prolongation of the life of process fluids in the pre-treatment stage.

### **Autocatalytic plating**

Autocatalytic (electroless) plating of nickel is used for complex shaped engineering components where an even coating is required. The process (usually based on the supply of proprietary chemicals) depends upon an autocatalytic effect whereby the nickel ions in solution are reduced to the metal only on the surface of the component. The deposit is an alloy of nickel and phosphorus (or occasionally of boron). The phosphorus content is typically 8%. Autocatalytic nickel is also used to provide an electrically conductive surface in the plating of plastics.

Autocatalytic copper plating is used in the printed circuit board industry. It provides the electrically conductive surface for drilled holes in copper clad laminate prior to electroplating.

Autocatalytic nickel-plating systems generally operate at a temperature of 85- 95°C so fume extraction is essential. The process fluid has a relatively short life due to the build-up of decomposition products, with 6-8 turnovers typically being achieved before replacement is necessary. The spent fluid requires considerable treatment before it can be discharged as trade effluent due to the presence of complexing agents and, in some proprietary formulations, a trace quantity of a brightener based on a cadmium salt. If this cannot be accomplished in-house it has to be consigned to a licensed waste disposal contractor for treatment and disposal off-site.

Autocatalytic copper systems are based on QUADROL or EDTA and formaldehyde, and generally operate at 45°C.

### **Indicative BAT**

1. The main areas of control are:

- rinse water economy – see Section 1
- mass drag-out reduction – see electroplating
- energy consumption – see Section 1
- prevention of fugitive emissions – see Section 3
- prolongation of process fluid life
- avoidance of the use of cadmium salt as a brightener in autocatalytic nickel systems
- disposal of spent process fluid
- avoidance of the use of EDTA in autocatalytic copper systems.

There are several treatments that do not involve electrolytic or autocatalytic processes. These include (but are not necessarily limited to):

- bright dipping
- chemical blacking
- chromating
- stripping (removal of plated metal)
- etching
- oxidation (decorative)
- phosphating
- chemical milling

All the above require post treatment rinsing, and drying unless followed by another process.

### **Indicative BAT**

1. The main areas of control are:

- rinse water economy – see Section 1
- mass drag-out reduction – see electroplating
- energy consumption – see Section 1
- prevention of fugitive emissions – see Section 3
- prolongation of process fluid life.

## 2.4 Rinsing

Rinse systems must be properly designed to prolong process fluid life and save water. They must also ensure that the finished work is chemically clean, especially when the final treatment, whether plating or passivation, uses Cr(VI). Single stage rinse tanks are ineffective unless they use a very large volume of water, or the rinse water is recirculated via an ion exchange (or other treatment) unit. You should use cascade (counterflow) rinsing in two or more stages to reduce your water use while achieving satisfactory rinsing.

### Indicative BAT

1. The main areas of control are:
  - water economy – see Section 1
  - mass drag-out reduction – see electroplating.

You should use the following techniques where appropriate:

2. Multistage cascade rinsing.
3. Closed-loop or recirculation systems with rinse water treatment (ion exchange, reverse osmosis, electrodialysis, air swept evaporation or vacuum evaporation).
4. Conductivity probes.
5. Water meters on each line.
6. Flow restrictors.
7. Minimised drag-out by employing a drainage time over the process tanks of at least 20 seconds for rack work and 30 seconds for barrelled work.
8. Drag-in – drag-out tanks (ECO rinse system) to reduce mass drag-out and subsequent rinse water consumption.
9. Continuous filtration and removal of sludge from phosphating process tanks.
10. Recycling of trade effluent to less critical rinsing stages.

## 2.5 Drying

Surface treated work generally requires drying to prevent possible tarnishing and corrosion of the coating in storage. The drying temperature is generally 60 - 80°C, but a maximum of 60°C for passivated zinc-plated work. Small work which is treated in barrel plants is usually dried in batch centrifugal driers. Manually operated lines frequently use a final static water rinse at 60-90°C to heat the work so that it will flash dry after withdrawal.

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### **Indicative BAT**

You should consider using the following techniques in order to save energy:

1. Centrifugal drying for small work.
2. Providing lids for hot water tank driers.
3. Providing a continuous bleed-off from hot-water driers as supply for the preceding cascade rinsing system, with equivalent water feed to hot water tank driers to make-up for evaporative loss and the bleed to the rinsing tanks.

# **3 Emissions and monitoring**

**3.1 Point source emissions to water**

**3.2 Point source emissions to air**

**3.3 Fugitive emissions to air**

## 3. Emissions and monitoring

### 3.1 Point source emissions to air

Both inorganic and organic chemicals are used in surface treatment but the effluent is predominantly inorganic. Most of the organic content is the oil and grease from alkaline cleaning. Trace quantities of substances such as emulsifying agents, surfactants, de-foamers and other organic additives may also be present, and you should check whether any of these may persist in the environment.

Surface treatment activities in the printed circuit industry may involve the release of complexing agents and formaldehyde used in autocatalytic copper plating and water soluble resists. The effluents can be complex mixture of substances and the impact of these, both individually and synergistically, needs to be assessed.

Most surface treatment operations employ a dedicated effluent treatment facility to minimise their releases.

#### **Indicative BAT**

The following should be used where appropriate:

##### **Handling**

1. You should normally use buffer storage tanks to contain process fluid dumps (e.g. spent alkaline cleaners, pickles, passivates), which are preferably treated in the effluent treatment facility rather than removed by a licensed waste disposal contractor. You will usually have a dedicated storage tank for alkaline, acidic, and Cr (VI) dumps. In such cases you should be able to release the spent materials to the effluent treatment facility at a slow, controlled rate.
2. For larger surface treatment operations where there are several process lines, the effluent flow will vary in accord with the number of lines in operation. You should ensure that peak loads do not exceed the capacity of the effluent treatment facility.
3. Small effluent treatment facilities are preferably operated on a batch basis, only releasing trade effluent to the sewer after confirmation that it is within the Sewerage Undertaker's consent limits. Larger facilities may be operated on a continuous basis provided that adequate monitoring is in place.
4. The effluent system should be designed so as to prevent process effluent by-passing the effluent treatment plant.

##### **Treatment objectives**

5. You should justify the choice and performance of the effluent treatment facility against the following objectives:
  - the removal of dissolved metals including basis metals, e.g. iron, aluminium, copper, and zinc, and plating metals e.g. chromium, copper, nickel, lead, tin, silver, and zinc
  - the control of the trade effluent pH within the Sewerage Undertaker's consent limits
  - formal consent limits may also be set for suspended solids, oil and grease, sulphate, detergents, COD, and cyanide
  - your permit may also set limits on the discharge.

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### **Primary treatment**

12. Whether multistage cascade or rinse water re-circulation with ion-exchange (or other treatment unit) is used for water conservation, the primary stage of effluent treatment is the precipitation of the dissolved metals from the effluent. Any Cr (VI) present, must first be reduced to the trivalent state in a turbulent tank reactor. Any effluent stream containing cyanide requires a cyanide oxidation step, again in a turbulent tank reactor. The dissolved metals in the combined effluent stream are then precipitated in a turbulent tank reactor by adjusting the pH within the range 6-10 depending on the metals present. Mixing in circular tank reactors is preferably promoted by slow speed propellor or turbine agitation and wall baffles. PID control rather than on-off control systems for dosing chemicals may improve pH stability.
13. The next step is the separation of the precipitate in a void tank settler or a lamellar clarifier, often with chemical pre-treatment (e.g. polyelectrolytes, inorganic coagulants and bentonite) to enhance the removal of colloidal solids, and/or to reduce the settlement time. Settling equipment works best with a steady continuous flow. Pumping tanks should preferably be fitted with a level sensing device with a proportional output that is used to control the flow. The settled sludge containing 2-3% solids is periodically discharged to a secondary settlement tank where the solids level is allowed to attain a level of around 8%.
14. The sludge is then filtered in a high pressure batch filter press for further water removal. The discharged filter cake containing 20-30% solids is removed by a licensed waste disposal contractor to landfill. The filtrate is recycled to the precipitation reactor. Filter press pumps providing an operational pressure of 10-15 bar will increase the solids content of the filter cake to 35-40%.
15. The clean water flow from the settler/clarifier is usually discharged directly to the foul sewer as trade effluent.

### **Secondary/tertiary treatment**

16. Filtration to remove fine suspended solids to achieve trade effluent consent limits for metals of 1-3mg/l is common.
17. Trade effluent, whether filtered or not, may be recycled to the less critical rinsing steps and thus reduce input water usage by up to 30%.
18. Where multistage cascade rinsing is in place, the effluent flow may be very low. "End of pipe" treatment with such techniques as activated carbon, bone charcoal, selective cationic ion-exchange, membrane filtration technology, and reverse osmosis may be considered, thus enabling a further reduction in water usage.

## 3.2 Point source emissions to air

You may have emissions to air from the following sources:

- particulates from mechanical preparation equipment
- VOCs from vapour degreasing equipment
- humid air from hot aqueous alkaline cleaning tanks
- humid air containing hydrochloric acid gas from hydrochloric acid pickle tanks
- humid air containing sulphuric mist from hot sulphuric acid pickle tanks
- humid air containing process fluid mists from surface treatment process tanks. Volatile organics may also be present from electroplating tanks
- humid air containing process fluid mists from post treatment tanks
- humid air containing NO<sub>x</sub> from nitric acid oxidation and stripping processes.

Material losses and pollution are negligible from well-designed extraction systems. However, where there is a need, cross-sectoral guidance on abatement techniques for point source emissions to air can be found in the BREF for Waste Water and Waste Gas treatment.

It is usual for there to be a common fume extraction manifold, fan and stack for the chemical preparation, surface treatment process and post treatment tanks.

Where the surface treatment process tanks contain cyanide substances, the overall extraction system is divided for safety purposes into two parts: an alkaline system to which the alkaline and cyanide tanks are extracted, and an acid system to which the acidic process fluids are extracted.

Many plants employ a wet mist eliminator upstream of the extraction fan(s) and stack(s). This is usually the case when an extraction system is used for Cr (VI) plating tank. Wet abatement scrubbers are not generally necessary unless there are significant levels of gases present which are soluble in water or aqueous solutions e.g. NO<sub>x</sub>. Scrubbers are generally placed after the extraction fan and there is then no need for a wet mist eliminator prior to the extraction fan.

### *Extraction above tanks and meeting Health and Safety (COSHH) Requirements*

Certain process tanks will need fume extraction due to the nature of the chemical processes, such as chemical brightening, bright dipping in aqua fortis. However, in other cases there may, or may not, be a need for extraction depending on the way that the process line is operated and in particular other methods of reducing the emissions at source have been employed as detailed below. For example, although extraction was once thought essential for process tanks containing Cr (VI), methods now exist to reduce the emissions at source. This eliminates or reduces the need for extraction leading to a both a lower environmental impact and significant cost savings.

In general, a two stage approach should be adopted.

#### **Stage 1.** Techniques to minimise air emissions at source

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Health and Safety and the environment both benefit if you minimise air emissions at source. You can use a combination of techniques to achieve this depending on the process requirements of each process tank, including:-

- use of hexagons or croffles
- use of chemical suppressants (surfactants) with appropriate control of their levels
- use of eductors or mechanical agitation in place of air agitation where appropriate
- maximise the free-board height between process solution level and top of the tank.

This should not be less than 150 mm and should normally operate at about 300 mm. However, in all cases you should be able to justify the freeboard used based on the size of the tank and nature of the plating process, and the use of the other techniques mentioned in this section. (Note that for Cr (VI) plating, chromic acid anodising and chromic/sulphuric acid etch tanks we strongly recommend the use of 300 mm freeboard)

- controlling the speed of insertion and withdrawal of the workpiece to minimise any wave effects
- regular measurement of solution surface tension.

When introducing these techniques you should carry out regular COSHH monitoring to ensure that health and safety requirements are being met and also to establish the optimum combination of the techniques. It may be necessary to introduce the techniques in a staged manner in order to ensure that product quality is not compromised.

These Stage 1 actions will often reduce air emissions to below required levels for air quality within the factory, and in some cases this will allow you to switch off the fume extraction system currently in use. This will provide the following environmental benefits:-

- reduced air emission from fans
- reduced process interruption due to maintenance of fans.

### **Stage 2.** Techniques involving the use of minimum fume extraction to meet COSHH requirements

Even after introducing all the techniques in stage 1 you may still need to use fume extraction systems to meet COSHH requirements. In this case you should use the minimum extraction rate to minimise the draw of air over the tanks, reducing both evaporation and the entrainment of process solutions in the extracted air. The following factors should be considered in minimising the extraction rate:-

- use the minimum extraction rate that gives an adequate extraction rate across entire surface area
- local extraction rates should be capable of regulation by local dampers
- as well as the free-board between the process solution and top of tank mentioned above, the bottom of the extraction duct should be at least 50 mm above the top of the tank
- installation of push-pull extraction system.
- Even if it is not possible to maximise the free-board as described in Stage 1, it should be possible to implement a push-pull extraction system. This involves installing an air blowing assembly, using drilled pipework, along the opposite side of the tank to the edge extraction. The extraction rate in the edge extraction can then be reduced by about 30%

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as long as it is matched by an exhaust rate in the air blower. This can enable the minimum free-board height to be reduced by up to 30%

#### **Indicative BAT**

1. If you use local exhaust ventilation (LEV) to control harmful substances, you should use the minimum extraction rates that enable COSHH requirements to be met; and where possible extraction should not be used at all, as described above.
2. Process tank lip ducts should be located with at least a 50mm gap between the top of the tank and the bottom of the lip duct.
3. Fume extraction through the upper sides of process tanks is not recommended.
4. A mist eliminator should be installed in the suction side of the extraction fan, with mist-eliminator drainage and washings being discharged to the effluent treatment facility.

### **3.3 Fugitive emissions to air**

#### **Indicative BAT**

1. Where there are opportunities for reductions, your permit may require you to submit a regularly updated inventory of fugitive emissions.
2. A simple water scrubber should be fitted to the vent outlet of hydrochloric acid tonnage storage vessels (for use during filling operations).
3. You should regularly clean fume extraction ducting and mist eliminators.

# **4 Annexes**

**Annex 1 Emission benchmarks**

**Annex 2 Other relevant guidance**

## 4. Annexes

### Annex 1- Emission benchmarks

#### Emissions to air

The emissions quoted below are daily averages based upon continuous monitoring during the period of operation.

Where emissions are expressed in terms of concentrations and where continuous monitors are employed, it is recommended that limits are defined such that:

- not more than one calendar monthly average during any rolling twelve month period shall exceed the benchmark value by more than 10%;
- not more than one half hour period during any rolling 24 hour period shall exceed the benchmark value by more than 50% (for the purpose of this limit half hourly periods commence on the hour and the half hour).

Where spot tests are employed:

- the half hour limit above shall be applied over the period of the test;
- the mean of three consecutive tests taken during a calendar year shall not exceed the benchmark value by more than 10%.

#### Reference conditions for releases to air

The reference conditions of substances in releases to air from point-sources are:

- temperature 0 °C (273K);
- pressure 101.3 kPa;
- no correction for water vapour or oxygen.

To convert measured values to reference conditions, see the **Monitoring Guidance**<sup>1</sup> for more information.

<sup>1</sup> Environment Agency Technical Guidance Notes M1 and M2 provide extensive guidance on the monitoring of stack emissions to air. The conversion referred to is given in TGN M2

<b>Table 4.1 Indicative BAT standards for emissions to air</b> Emission	Benchmark Level	Techniques which may be considered to be BAT	Comment
Chromium (VI) and its compounds as chromium	1.0 mg/m <sub>3</sub>		Surface treatment BREF
Hydrogen chloride	10 mg/m <sub>3</sub>	Scrubbers/Absorption columns	Surface treatment BREF
Hydrogen cyanide	5 mg/m <sub>3</sub>		Surface treatment BREF
Hydrogen fluoride	2 mg/m <sub>3</sub>	Scrubbers/absorption columns	Surface treatment BREF
Nickel and its compounds (as nickel)	2.0 mg/m <sub>3</sub>		Surface treatment BREF
Oxides of nitrogen (total acid forming as NO <sub>2</sub> )	200 mg/m <sub>3</sub>	Scrubbers/absorption columns	Surface treatment BREF
Particulate matter	50 mg/m <sub>3</sub>		Surface treatment BREF
Oxides of sulphur (as SO <sub>2</sub> )	100 mg/m <sub>3</sub>	Absorption columns	Surface treatment BREF

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## Emissions to water and sewer

Where automatic sampling systems are employed, limits may be defined such that not more than 5% of samples shall exceed the limit.

Where spot samples are taken no individual spot sample in a range of samples, shall exceed the limit by more than 50%.

**Table 4.2 Indicative BAT standards for emissions to water and sewer**

Substance	Level (mg/l)
Aluminium	As trade effluent consent
Cadmium	0.01
Free Cyanide	0.2
Chromium VI	0.1
Chromium, total	1.0
Copper	1.0
Lead	0.5
Nickel	1.0
Silver	0.1
Tin	2.0
Zinc	2.0
BOD	As trade effluent consent
COD	As trade effluent consent
Hydrocarbons	0.1
Halogenated hydrocarbons	0.1

Notes:-

For cadmium the level represents an accepted limit of detection, and there should be no detectable level of cadmium in any discharge from the installation.

You should note that cadmium and lead are List I substances.

## Process efficiency

Solid waste releases such as sludge or filter cake comprise the largest source of pollution. Plating sludge and filter cake comprise hydrated iron hydroxide (from the work) and the plating metals, together with soil, oil and greases from the chemical preparation processes. Solid waste from the aluminium anodising process is largely made up of hydrated aluminium hydroxide. Phosphating process waste is mainly iron, manganese or zinc phosphate. Drag-out reduction, drag-out recovery and other appropriate techniques should enable the achievement of the following process efficiencies with respect to input material.

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<b>Table 4.3: Typical process efficiencies Process</b>	<b>Benchmark efficiency</b>
Zinc plating	(all processes) 90%
Nickel plating (closed loop)	95%
Autocatalytic nickel plating	95% (excluding losses spent solutions)
Copper plating (cyanide process)	95%
Tin and tin alloys	95%
Chromium plating (closed loop)	96%
Precious metal plating	98%
Cadmium	99%
Phosphating	90%
Anodising	90%

## Annex 2 – Other relevant guidance, abbreviations and glossary

For a full list of available Technical Guidance and other relevant guidance see Appendix A of GTBR.

In addition to the guidance in GTBR the following guidance is relevant to this sector:

- BREF – Surface treatment of metals and plastics
- The Categorisation of Volatile Organic Compounds, 1995 HMIP Research Report No DOE/HMIP/RR/95/009
- IPPC SG5 - Secretary of State's Guidance for the A2 Galvanizing Sector - published 2003
- AA1 Review of current status of chromic acid use in electroplating and related processes: Report of the hexavalent chromium working party of the Surface Engineering Association HSE Committee.

### Abbreviations and Glossary

**Drag-out** Process fluid carried out with the work on its withdrawal from a process tank

**DTPA** Diethylenetriaminepentaacetic acid

**EDTA** Ethylenediamine-tetracetic acid.

**Levelling** The ability of a plating electrolyte to deposit a level coating on an irregular surface

**Linishing** Mechanical linear abrasion of work by a moving abrasive belt

**NTA** Nitriloacetic acid

**PID** Proportional, integral and derivative control action

**QUADROL** NNN'N'-tetrakis-(2-hydroxy-propyl) ethylenediamine

**Smut** Fine deposit appearing on the surface of the work after a pickling operation

**Work** The components, articles, material being surface treated.

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