National Occupational Health and Safety Commission

ELECTROPLATING

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Foreword

The National Occupational Health and Safety Commission, Worksafe Australia, is a tripartite body established by the Commonwealth Government to develop, facilitate and implement a national approach to occupational health and safety.

The National Commission comprises representatives of the peak employee and employer bodies - the Australian Council of Trade Unions (ACTU) and Confederation of Australian Industry (CAI) - as well as the Commonwealth, State and Territory governments.

Since its establishment, the National Commission has produced occupational health guides. Before the National Commission was established, a series of similar guides was published by the National Health and Medical Research Council.

This Guide has been reviewed and endorsed by a working group of the National Commission as part of the co-ordinated effort by the Commonwealth, State and Territory governments and employee and employer organisations to make Australian workplaces safe and healthy.

Although this Guide has been endorsed by the National Commission, it is an advisory document only. It is produced and distributed in the interests of providing useful information on occupational health and safety for employers, employees and others. This document does not replace statutory requirements under relevant State and Territory legislation.

This Guide is aimed primarily at workers and managers but should also be useful to occupational health and safety personnel and others. It may be used in conjunction with appropriate training and consultation, in line with good management practice.

Contents

Introduction

This Guide discusses the processes and solutions used in electroplating and anodising, together with associated hazards and their management.

Other Worksafe Australia Guides that should be consulted for further information include:

- *Arsenic and its Compounds;*
- *Cyanide Poisoning;*
- *Occupational Health Services;* and
- *Solvent Vapour Degreasing.*

The National Commission publication, *Exposure Standards for Atmospheric Contaminants in the Occupational Environment* (latest edition), should also be consulted.

Australian Standards which are relevant to this Guide include:

- AS 1319 *Safety Signs for the Occupational Environment*;
- AS 1715 *Selection, Use and Maintenance of Respiratory Devices*; and
- AS 1716 *Respiratory Protective Devices*.

The monograph, *Industrial Ventilation - A Manual of Recommended Practice*, from the American Conference of Governmental Industrial Hygienists, is also useful.

Identification

Electroplating

When a metallic salt is dissolved in water it dissociates to form electrically charged ions. By passing a DC electric current through the solution, positive ions migrate to, and are deposited on, the negative electrode, causing the article to be plated. Such a process is known as electroplating. The most common metals used in plating are chromium, nickel, cadmium, zinc, copper, silver, gold and, more rarely, rhodium. In addition to the movement of ions, electric current also causes dissociation of water so that hydrogen formed at the cathode is released as a vigorous spray of gas carrying some electrolyte. Similarly, oxygen may be evolved at the anode in some processes.

For the metals below, the solutions used include:

Chromium:	Chromic acid with sulphuric acid;
Nickel:	Nickel sulphate with boric acid and nickel chloride;
Cadmium:	Cadmium cyanide with sodium cyanide and sodium hydroxide, Cadmium cyanide in alkaline solution;
Zinc:	Zinc sulphate with boric acid, Zinc cyanide with sodium cyanide, Zinc cyanide in alkaline solution, Zinc chloride with hydrochloric acid;
Copper:	Copper sulphate in weak sulphuric acid, Copper sulphate with sodium cyanide in alkaline solution, Copper cyanide with sodium cyanide in alkaline solution; and
Silver:	Silver cyanide in alkaline solution, Silver cyanide with potassium in alkaline solution.

Anodising

This process is related to electroplating. It uses similar plant and equipment and gives rise to similar hazards. The process involves the anodic oxidation of metals, usually aluminium. In this instance the metal concerned is the anode and undergoes surface oxidation by the oxygen liberated there. Two methods are employed: one uses sulphuric acid as the electrolyte, the other chromic acid.

Pre-treatments

Articles to be plated may be put through a variety of pre-treatment processes, including solvent degreasing, alkali cleaning and acid dipping which are described below.

Solvent degreasing

This process generally involves the use of chlorinated hydrocarbons in either the heated liquid or hot vapour form. The solvents commonly used are trichloroethylene, perchloroethylene and 1,1,1-trichloroethane. These compounds and their hazards are further considered in the Worksafe Australia Guide, *Solvent Vapour Degreasing*. The use of solvent degreasers should, however, be replaced with detergent-based water soluble degreasers, if practicable, as the latter are potentially less hazardous.

Alkali cleaning

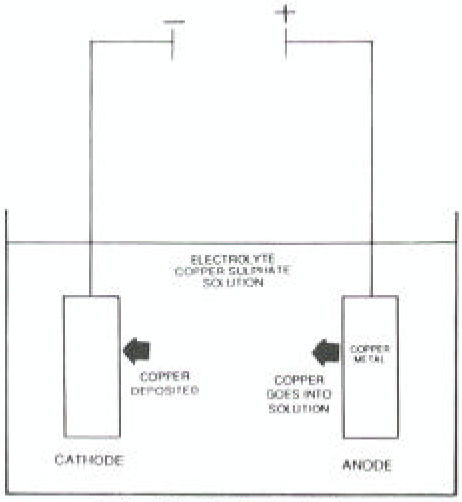
Electrolytic cleaning with alkalis may be used instead of vapour degreasing. Sodium carbonate is the common electrolyte used.

Acid dipping

This process involves the use of mineral acids - mainly hydrochloric and sulphuric acids.

Buffing and polishing

These processes are carried out on plated articles using cloth wheels impregnated with a variety of polishing compounds and waxes.



Principle of electroplating

Health Hazards

When considering the hazards associated with any workplace, it is essential to understand the relationship between 'hazard', 'exposure' and 'risk'.

'Hazard' is the potential for an agent or process to do harm. 'Risk' is the likelihood that an agent will produce injury or disease under specified conditions.

Health effects can only occur if a worker is actually exposed to the hazard. The risk of injury or disease usually increases with the duration and frequency of exposure to the agent, and the intensity/concentration and toxicity of the agent.

Toxicity refers to the capacity of an agent to produce disease or injury. The evaluation of toxicity takes into account the route of exposure and the actual concentration of an agent in the body.

While substances employed in electroplating are potentially toxic, poisoning and gassing are rare.

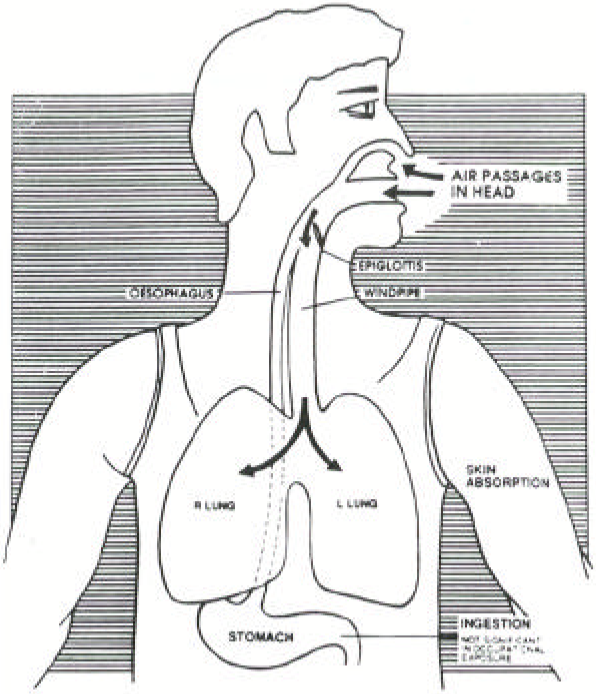
Exposure routes

The harmful effects of organic solvents follow inhalation of vapour, eye and skin contact with liquid or vapour, or ingestion, which are described below:

- Inhalation is the most significant route of entry by which harmful substances enter the human body at work.
- Toxic atmospheric contaminants may have local or systematic effects. Local effects harm only the part of the body they come in contact with, for example, inhalation of silica dust causing pneumoconiosis. Systemic effects, cause changes to the function of other organs, as in the case of inhaled particles that are soluble in the fluid of the tissues that line the lung, for example, lead and mercury fumes.
- Some atmospheric contaminants may be absorbed through the skin without any noticeable change to the skin, while others may cause serious damage to the skin itself.
- Ingestion is of relatively minor significance in occupational exposure to toxic materials.

Health effects

Exposure to hazardous material may be acute or chronic. *Acute exposures* generally refer to single dose, high concentration exposures over short periods while *chronic exposures* involve repeated or continuous exposures over long periods. These exposures may have acute, immediate effects or chronic, long term effects.



Routes of entry of atmospheric contaminants

Chromic acid

Chromic acid is a strong irritant and corrosive. The hazard usually arises either as the result of splashes, or as a mist of chromic acid-coated bubbles of hydrogen or as chromic acid contaminated dust. It affects the skin, nasal and bronchial mucosal linings. On the skin, especially abraded skin over joints, chromic acid can cause punched-out, penetrating, chronic ulcers (‘chrome holes’). Chromic acid solution can cause allergic contact dermatitis.

Chrome ulceration of the nose affects the anterior area of the nasal septum where the mucous membrane is adherent to the septal cartilage. Early effects are undue sneezing, redness of mucosa, bloodstained or watery discharge from nose and bleeding. Crusting, ulceration and perforation of the septum may follow. Discomfort may occur in the early stages but healed perforations are without symptoms except for nasal whistling in some cases.

Chromic acid, when inhaled as mist or contaminated dust, may cause nasal irritation, rhinitis and bronchitis. Data from experiments with animals support the view that water insoluble hexavalent chromium compounds, for example, zinc chromate, are carcinogenic, whereas the soluble forms are not.

Nickel solutions

Contact of nickel solution with the skin is a common cause of dermatitis. Sensitisation to nickel can also occur.

Cyanide solutions

Cyanide solutions are corrosive to skin and eyes and may also cause dermatitis if allowed to remain in contact with the skin. Cyanide can be absorbed through the skin. A hazard can result if the pH of cyanide plating baths falls below approximately pH10. At lower pH the air above cyanide solutions can contain high levels of hydrogen cyanide. A considerable hazard from the evolution of hydrogen cyanide gas results if cyanide solutions are allowed to come into contact with acid. The evolved hydrogen cyanide has the smell of bitter almonds. Proper control of effluent assists in minimising exposure. For information on cyanide poisoning, refer to the Appendix.

Hydrogen cyanide gas and its simple salts are among the most rapidly acting of all known poisons. Even small concentrations are extremely hazardous. Not all people are able to recognise the bitter almond smell of hydrogen cyanide. Therefore smell should not be relied upon as a warning signal.

Arsine

Arsine gas is formed when acid comes into contact with most solutions containing an inorganic arsenic compound and, in rare instances, may cause severe or fatal poisoning. Arsenic may be present as an impurity in metals and in commercial grades of sulphuric and hydrochloric acids. These compounds are further considered in the Worksafe Australia Guide, *Arsenic and its Compounds*.

Solvent degreasing

All solvents used for this purpose have a powerful defatting action on the skin and may cause skin redness, dermatitis and predispose the skin to infections. In addition, the inhalation of vapour may have profound anaesthetic and toxic effects. For further information on solvent degreasing, refer to the Worksafe Australia Guide, *Solvent Vapour Degreasing*.

Alkali cleaning

In alkali cleaning, sodium carbonate with other alkalis may form a mist which can be irritating to the skin, eyes and respiratory mucosa.

Acid dripping

The mineral acids used in acid dipping, including hydrochloric, hydrofluoric and sulphuric acids, are corrosive to skin and eyes. If high concentrations, air agitation or elevated tank temperatures are used, substantial quantities of acid mist may be evolved. Acid mist may irritate skin, conjunctivae (lining of the eye), nose and throat. Acid mist may also result in the delayed onset of chest pain, cough and shortness of breath. These latter symptoms signal the need for immediate medical attention.

In addition to its corrosive effects, nitric acid requires particular care because of the potential for liberation of nitrogen oxides. Water-soluble nitrogen oxides can cause respiratory tract irritation, including chemical pneumonia. Nitrogen oxides with low water solubility can penetrate deep into the lungs and may result in delayed serious injury.

Buffing and polishing

There are specific hazards related to buffing and polishing which are generally associated with the generation of dusts. For further information, refer to the Worksafe Australia Guide, *Atmospheric Contaminants.*

Prevention and Control Measures

To establish appropriate prevention of significant health effects, an evaluation of work practices and conditions must be undertaken by qualified health and safety personnel. These practices should be considered an integral part of management. Good occupational hygiene promotes elimination of hazards, where practicable. Engineering controls to minimise the hazard at the source, where practicable, and administrative controls should be adopted.

The following prevention and control measures should be adopted with a view to evaluating and eliminating or controlling hazards associated with electroplating. Although the electroplating environment may expose workers to a variety of hazards, a comprehensive approach to health and safety will substantially reduce the risk of injury or disease by minimising hazardous exposures. Education to promote knowledge about relevant hazards is essential if safe working procedures are to be followed. Material safety data sheets (MSDS) should be made available to all personnel.

Evaluation

Environmental sampling and analysis should be undertaken at regular intervals by qualified occupational health and safety professionals in accordance with the methods recommended by the appropriate occupational health authority.

Control measures

Prevention and control measures include, but are not limited to, the following:

- elimination/substitution and process modification;
- engineering controls;
- administrative controls; and
- use of personal protective equipment.

Engineering controls

Engineering controls should be such that the concentrations of atmospheric contaminants given off by the plating tanks do not exceed National Commission recommended exposure standards. While many plating operations may not require mechanical ventilation, chromium plating processes invariably do. For these, the ventilation of tanks should preferably be by lip or slot ventilation systems, design details of which may be obtained from *Industrial Ventilation - A Manual of Recommended Practice*.

The evolution of mist from tanks can also be reduced by the use of patented surfactants or plastic chips, placed on the surface of the plating solution. Surfactants should be used in addition to mechanical ventilation and not as a substitute for it.

Solvent degreasing

Vapour degreasing tanks should be positioned in an area free from draughts to prevent fugitive emission of vapour. Vapours emitted should not be allowed to come into contact with high temperature sources, for example, welding processes, as harmful decomposition products may result. Local exhaust ventilation and maximal enclosure of process are essential. Tanks should have efficient heat and vapour condensation controls and be provided with an overhead lifting device operating at a controlled rate to minimise exposure of the operator to vapour.

Cyanides

These require special attention. They should be clearly labelled, and stored in a secure, dry place completely separate from acids. A notice, a cyanide poisoning kit (refer to the Appendix) and a self-contained breathing apparatus or canister respirator complying with Australian Standards AS 1715 and AS 1716 should be provided.

Articles treated in acid baths should be thoroughly rinsed with water before placing them in a cyanide tank. Drainage should be such that floors can be readily hosed in the event of spillage, with no possibility of overflow into other areas. Drainage should also be so designed that there is complete separation of acid spillage or effluent from cyanide spillage or effluent.

Buffing and polishing

Control of dust hazards may be accomplished by equipping polishing wheels with local exhaust ventilation systems.

Personal protective equipment

In certain circumstances, personal protection of the individual employee is necessary. Personal protective devices should be regarded as being supplementary to substitution and engineering control and should not be used in preference to the latter because they do nothing to eliminate the hazard.

Personal protective equipment must be appropriately selected, individually fitted and workers trained in their correct use and maintenance. The equipment must be regularly checked and maintained to ensure that the worker is being protected.

For wet process (electroplating), personal protective equipment/clothing should consist of:

- a waterproof apron;
- suitable protective footwear;
- safety goggles or a face shield; and
- suitable mid-arm gloves (such as PVC for alkali and acidic solutions, nitrile rubber for solvent degreaser).

For dry process (polishing/buffing), personal protective equipment/clothing should consist of safety glasses or a face shield.

The selection, use and maintenance of respiratory protective devices should be in accordance with the requirements of Australian Standard AS 1715.

Signs

Tanks, pipelines and supply valves should be clearly labelled in appropriate languages, in accordance with the provisions of Australian Standard AS 1319. Labels should indicate, where appropriate, the nature of the contents, the strength and temperature and also the nature of the hazard and its emergency treatment.

Monitoring

Monitoring may be used for the evaluation of a hazard and for assessing the effectiveness of control measures. The design and implementation of a monitoring program should be carried out by, or in consultation with, a properly qualified person.

Monitoring of the work environment involves the measurement of atmospheric contaminants at selected locations in the workplace (static, positional monitoring). Personal monitoring involves the measurement of atmospheric contaminants in the breathing zone of the individual worker.

Biological monitoring involves measurement of the concentration of a contaminant, its metabolites or other indicators in the tissues or body fluids of the worker. In some cases, biological monitoring may be required to supplement static or personal monitoring.

In the control of health hazards due to a specific contaminant, where it has been demonstrated that the exposure of the employee to the contaminant is approaching the relevant exposure standard, or where biological monitoring indicates that an unacceptable exposure is occurring, *immediate action must be taken to reduce the health hazard* and intensive monitoring should continue.

The exposure standards represent airborne concentrations of individual chemical substances which, according to current knowledge, should neither impair the health of, nor cause undue discomfort to, nearly all workers. Additionally, the exposure standards are believed to guard against narcosis or irritation which could precipitate industrial accidents.

Except where modified by consideration of excursion limits, exposure standards apply to long term exposure to a substance over an eight hour day for a normal working week, over an entire working life.

The exposure standards do not represent 'no-effect' levels which guarantee protection to every worker.

Records of the results of any monitoring should be maintained and employees should be informed of these results.

Health assessment

In some occupations, health assessment may form part of a comprehensive occupational health and safety strategy. Where employees are to undergo health assessment, there should be adequate consultation prior to the introduction of any such program. Where medical records are kept, they must be confidential. In some cases, it is valuable to be able to relate employee health and illness data to exposure levels in the workplace.

A periodic examination of the hands and forearms of employees is recommended. Employees should be encouraged to undertake, with appropriate guidance, self examinations. Irritation should be reported to a suitably qualified medical practitioner.

Education and training

All employees working in electroplating processes must be informed of the hazards from exposure to the contaminant and the precautions necessary to prevent damage to their health. They should be made aware of the need to carry out their work so that as little contamination as possible is produced, and of the importance of the proper use of all safeguards against exposure to themselves and their fellow workers. Adequate training, both in the proper execution of the task and in the use of all associated engineering controls, as well as of any personal protective equipment, is essential.

Employees exposed to contamination hazards should be educated in the need for, and proper use of, facilities, clothing and equipment and thereby maintain a high standard of personal cleanliness.

MSDS should be obtained for all potentially hazardous substances from the suppliers of such materials before handling.

A management representative should be nominated as responsible for personal protective equipment supply, maintenance and training.

First Aid

First aid facilities should be at least in accordance with the requirements of the Worksafe Australia Guide, *Occupational Health Services*.

Provision for the immediate irrigation of splashes in the eyes, using copious quantities of water, is essential. Where body splashes are likely to occur, a deluge shower in close proximity to the work area should be provided. All cuts and abrasions of the skin of employees should be treated immediately. This is particularly important in chromium plating operations.

For information on cyanide poisoning, refer to the appendix.

Appendix

Cyanide poisoning

While cyanide poisoning is uncommon, all personnel where cyanide or cyanide compounds are used should be well versed in first aid treatment and have kits on hand.

The signs and symptoms of fear of cyanide poisoning are similar to that of mild poisoning, namely, nausea, headache, sense of suffocation and agitation. Cyanide poisoning is uncommon and, unless there is firm evidence to show that cyanide contamination has occurred, a patient is most likely to be suffering from something else.

Kelocyanor (dicobalt edetate), which is used to treat cyanide poisoning, may make the situation worse if it is given to someone who is not suffering from cyanide poisoning.

Mild or early cyanide poisoning

Onset of symptoms after exposure is very rapid. Symptoms and signs of mild cyanide poisoning include headache, giddiness, nausea and vomiting (if the cyanide has been ingested). The person has difficulty breathing with a sense of suffocation and a feeling of general weakness with heaviness of arms and legs. Cyanide causes irritation of the nose, mouth and throat.

Severe cyanide poisoning

Severe cyanide poisoning may be characterised by gasping for breath and loss of consciousness. After loss of consciousness, the breathing may be weak or absent and may result in cardiac arrest and possibly death.

Rescue

It is essential that rescuers have been trained in the procedures to be followed and in the use of protective equipment.

Before entering an area contaminated by cyanide gas, rescuers must wear breathing apparatus complying with Australian Standard AS 1716.

Care should also be taken in handling a patient whose clothing is contaminated with cyanide, as cyanide can be absorbed through the skin or the vapour may be breathed in. The clothing should be carefully removed and placed in a receptacle for decontamination.

First aid

To be effective, first aid must be prompt. Immediately:

- remove patient from source of contamination, to fresh air if hydrogen cyanide gas (HCN) is present;
- if patient is not breathing, start artificial respiration. If mouth-to-mouth resuscitation is used, the lips and mouth should be wiped clean of vomitus or other material and an approved airway used if available;
- if pulse is absent, start external cardiac massage;
- give oxygen if available;
- remove contaminated clothing promptly and wash the skin thoroughly;
- avoid contact with contaminated clothing or vomitus; and
- arrange for the urgent transfer of the patient, accompanied by an attendant with the cyanide emergency kit, to medical care.

Professional care

Treatment should include the following measures:

- Breathing and circulation should be supported.
- Oxygen should be given. In the majority of cases, oxygen, rest and supportive care is sufficient to ensure recovery. Particular attention should be given to the monitoring of the level of consciousness.
- If cyanide has been swallowed, gastric lavage should be considered.
- If the patient is known to have been exposed to cyanide and is unconscious or lapsing into unconsciousness:
  - insert indwelling cannula into vein,
  - take blood in a fluoride heparinised tube for confirmation of diagnosis,
  - slowly inject one 20 mL ampoule of Kelocyanor (300 mg dicobalt edetate), and

- if there is no response, repeat, taking care to avoid adverse drug reactions.

Oxygen, respiratory and circulatory support should continue, if necessary, for hours.

Emergency kit for cyanide poisoning

At all places where there is a risk of cyanide poisoning, the following items should be kept in an accessible and convenient position:

- an oxygen resuscitator and a source of oxygen;
- a clearly marked cyanide antidote box containing:
  - an approved airway,
  - an elasticised tourniquet,
  - disposable indwelling intravenous cannulae,
  - 20 mL sterile disposable syringes and needles,
  - fluoride heparinised blood sample tubes,
  - surgical swabs, dressings and adhesive tape, and
  - ampoules of Kelocyanor (dicobalt edetate), including the prescribing information outlining side-effects and precautions*;
- a copy of the appropriate MSDS; and
- a copy of the Worksafe Australia Guide, Cyanide Poisoning.

*** *Note:* An adverse reaction can result from the cyanide antidote being given in the absence of cyanide poisoning. Reported adverse reactions include oedema of the face and neck, urticaria, palpitations, hypotension, collapse, convulsions, vomiting, chest pains and difficulty in breathing. The cyanide antidote should be administered only when cyanide poisoning is beyond doubt and only by a professional health attendant. NOTE EXPIRY DATE. Procedures should be in place to ensure that Kelocyanor supplies are replaced before the expiry date.**

Further Reading

American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation, *Industrial Ventilation - A Manual of Recommended Practice*, 20th Edition, American Conference of Governmental Industrial Hygienists, Lansing, Michigan, 1989.

Department of Employment and Industrial Relations, *Occupational Safety and Health in Commonwealth Government Employment*, Code of Practice 703, Electroplating, Australian Government Publishing Service, Canberra, 1979.

Standards Australia, AS 1319-1983 *Safety Signs for the Occupational Environment*, Sydney.

- AS 1715-1982 *Selection, Use and Maintenance of Respiratory Protective Devices*, Sydney.
- AS 1716-1984 *Respiratory Protective Devices*, Sydney.
- AS 2661-1983 *Vapour Degreasing Plant, Design, Installation and Operation Safety Requirements*, Sydney.