ELECTROPLATING

A FOCUS ON CHROME PLATING

What is electroplating?

Electroplating is a chemical or electrochemical process of surface treatment. A metallic layer is deposited on the base material. Common plating metals include: cadmium, chromium, copper, gold, nickel, silver and their alloys. This information bulletin focuses on chrome plating.

Why is electroplating important?

Electroplating is used for components and equipment in all fields of technology to:

a) protect the material against corrosion
b) improve the surface properties
c) achieve optimum decorative effects

What are the sources of exposure in chrome plating?

The main source of exposure is to tank contents (for example, mists, gases, vapours) that become airborne due to tank agitation, tank temperature, dipping of parts, parts moving along on hanging conveyors as well as batch changing activities and tank recharging.

How are the metal parts cleaned prior to chrome plating?

Before plating, most metal surfaces are cleaned in a degreaser, conditioned for the plating process in a series of acid and caustic baths and then rinsed to remove remaining bath liquids.

What are the hazards of acid baths?

Acid baths are widely used in electroplating. The most common of these acids are hydrochloric, nitric, nitric-hydrofluoric and sulfuric acids. Also, in what is called a "bright dip," nitric and sulfuric acids are combined to give a shiny, mirror-like surface to metals and alloys such as cadmium, copper, nickel and silver.

Direct contact with these acids can result in:

- severe skin burns
- repeated skin contact will cause scarring and open, ulcerated wounds which are slow to heal
- burns on the eye can result in impaired vision and even blindness

Among the acids, concentrated sulfuric acid causes unusually severe burns and eye damage. Hydrofluoric acid in contact with skin destroys tissue. It penetrates deep where it can destroy soft tissues and bone, and cause electrolyte imbalance (particularly with calcium).

These acids can release vapours, gases and mists which can cause serious damage to the eyes, nose, throat and lungs. The extent of vapours and mists depends on the temperature of the bath and air circulation in the room.

Vapours and mists released by acid baths can dissolve in the moist tissue of the eyes, nose, throat and lungs, and cause irritation and burns of the tissues. At relatively low vapour levels, the vapours dissolve before they get deep into the lungs, and the irritation is felt in the upper respiratory system, the nose and throat, and on the eyes. If such exposures persist, the irritation and burning give rise to nosebleeds and sinus problems in the case of hydrogen fluoride exposure (can be a by-product of fluoroboric acid which is used in some plating baths). Hydrogen fluoride vapours also cause digestive symptoms, including nausea, vomiting, abdominal cramps and diarrhea.

Also, chronic (long-term) exposure can discolour, damage and even dissolve the surface enamel of the teeth. In particular, hydrogen chloride, fluorine and nitric acid vapours can discolour the teeth, and both sulfuric and hydrochloric vapours can also cause erosion of the enamel in exposed teeth.

In case of sudden, extreme over-exposure, these vapours can reach deep into the lungs and cause severe lung reactions and even death, usually from pulmonary edema (build-up of fluid in the lungs).

How can acid bath hazards be controlled?

A number of effective control measures can be taken to reduce the dangers of acid baths. These include:

- good local exhaust ventilation to remove mists, vapours and gases above the tanks; experience has shown that bright-dip baths of nitric and sulfuric acids need closer fitting hoods and more effective exhaust than other types of acid baths; the rinse baths may need ventilation as well;
- mist reducing agents and foam blankets on the surface can reduce misting;
- baths should be covered when not in use;
- chemicals should be added to the baths carefully to reduce splashing;
- full protective clothing should be provided and worn at all times, including full face shield, chemical-type goggles, rubber gloves, boots and aprons;
- eating, drinking and smoking near tanks should be prohibited;
- emergency wash facilities, including shower and eyewash station should be located nearby.

What are the hazards of caustic baths?

Acid and caustic baths complement each other. Acid baths are best for removing scale, rust and oxide coatings from metals, caustic (or alkaline) baths for removing oil, soils, buffing compounds and paints. The most common caustics are sodium hydroxide and potassium hydroxide (also called caustic soda and caustic potash, respectively). Most caustic baths also contain a variety of special purpose additives.

Many baths use electrodes and pass electric current through the fluid to improve the cleaning effects. These electrodes also release gas bubbles, which increases the mist above the tank.

Caustics in concentrated solutions are even more corrosive to the skin and eyes than acids.

Direct contact with caustics can result in:

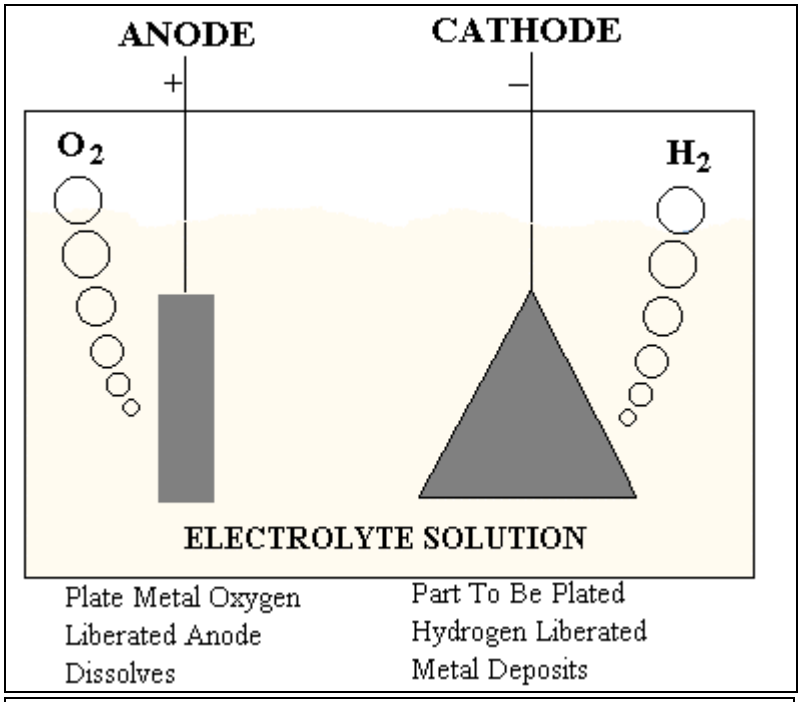
- deep, painful burns to the skin
- destroying the eye tissue if splashed into the eyes

Like acids, caustic vapours, mists and sprays irritate the eyes, nose, throat and lungs. Persistent vapour exposure can cause a hole to form in the cartilage between the nostrils of the nose (called a "perforated septum"). Lower mist levels can cause dermatitis. Also, like acids, very high vapour expsures can cause pulmonary edema and death.

How are caustic bath hazards controlled?

The control measures for acid baths apply to caustic baths as well. However, because of the rapid action of caustics on the eye, the need for eye goggles which fully cover the eye and protect it from splashes in all directions is very important. A face mask is no substitute for these goggles unless the mask encloses the face or head. Also, emergency shower and eyewash fountains must be located nearby the caustic bath. In case of a splash, the eye should immediately be washed for a full 15 minutes.

What actually happens during the chrome plating process?



Source: Burgess WA. Recognition of Health Hazards in Industry - A Review of Materials & Processes, 2nd edition. John Wiley & Sons Inc., 1995.

During the electroplating process itself, the workpiece is immersed in a solution containing the metal to be plated. The appropriate electrode of a low voltage, direct current power supply is connected to the workpiece so that usually it becomes the cathode during electroplating. The other electrode, usually an inert bar or the metal being plated, is also placed in the solution. When the current is turned on, the metal in the solution becomes plated on the workpiece. Hydrogen gas is released at the cathode and oxygen at the anode (Figure 1). These gases are released as bubbles at the liquid surface.

An electroplating tank is usually constructed of rigid plastic or steel with a plastic, rubber or lead lining. The anodes and cathodes, hung from copper rods and immersed in electrolyte are electrically connected to a dc power supply with heavy copper bus bars.

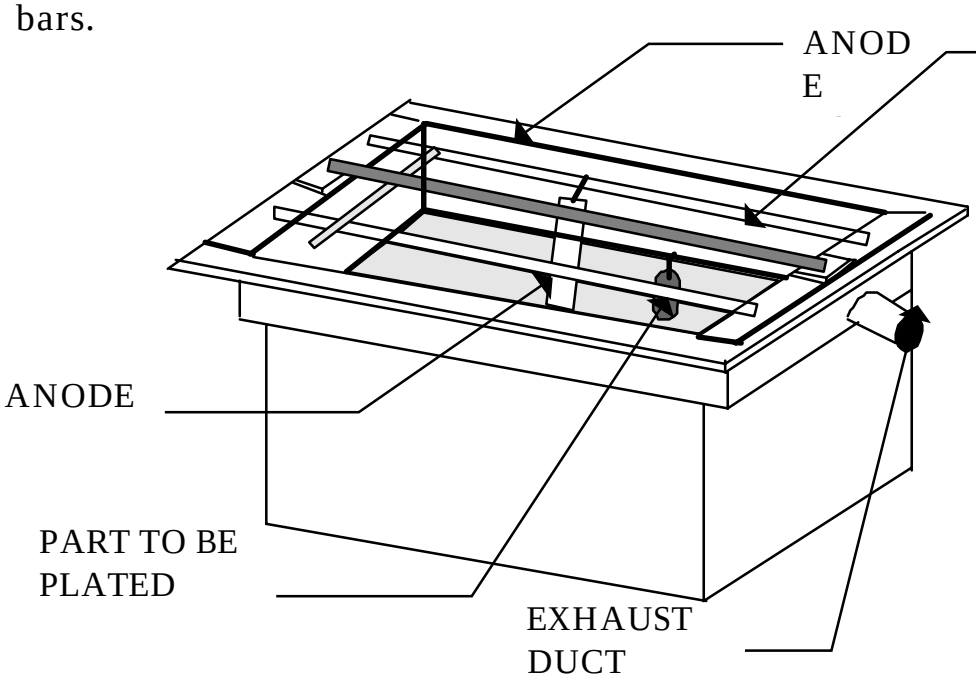


Figure 2: Main components of an electroplating tank. Air is exhausted with a perimeter slot exhaust. ***Source:*** *Burgess WA. Recognition of Health Hazards in Industry - A Review of Materials & Processes, 2nd edition. John Wiley & Sons Inc., 1995*

What are the air contaminants produced in the electroplating process?

The main source of vapours, mist and gases during electroplating is the small gas bubbles which form at the electrodes when the electric current is on. The bubbles rise to the surface and burst, creating a fine mist above the bath. The speed with which bubbles are formed varies greatly from one type of metal to another. For example, copper plating generates few bubbles and little mist while chromium plating generates bubbles rapidly with heavy misting (Figure 3).

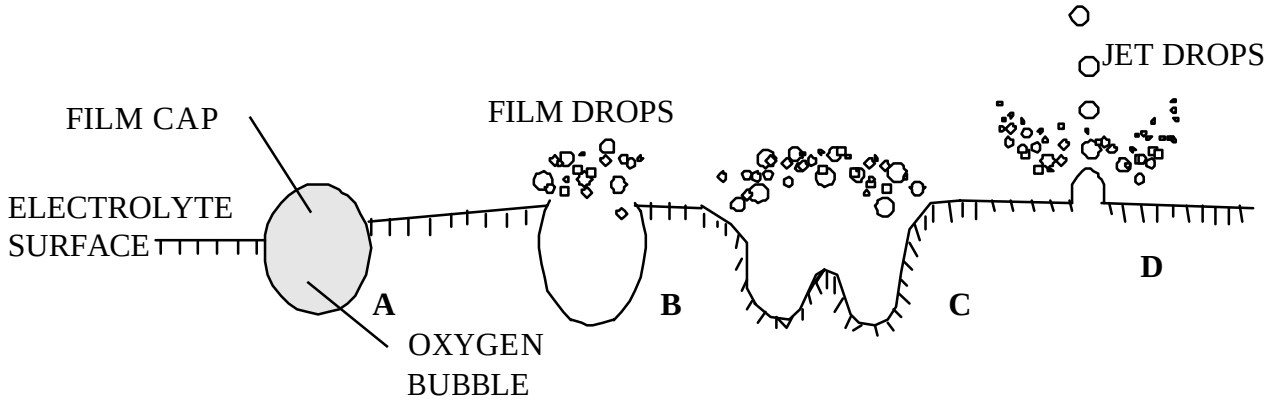


Figure 3: (a) The gas bubble shown just before release from the bath, (b) small diameter mist droplets are formed as the film cap of the gas bubble breaks, (c) a liquid jet is formed in the crater, (d) larger droplets formed and released from the jet. ***Source:*** *Burgess WA. Recognition of Health Hazards in Industry - A Review of Materials & Processes, 2nd edition. John Wiley & Sons, Inc., 1995.*

Contaminant generation rate also varies with metal ion concentration, current density, bath additives and bath temperature. Air or mechanical agitation of the bath used to improve plating quality, may also result in the release of mist.

The health significance of the mist generated by the electroplating processes depends on the contents of the bath. In considering the nature of airborne contaminants released from the bath, it is convenient to class the bath electrolyte as alkaline or acidic. Chromium, copper, nickel and tin are commonly plated from acidic baths.

Chromium metal is electroplated from a chromic acid bath. Hexavalent chromium causes lung cancer in humans. Evaluations by the California Department of Health Services, the U.S. Environmental Protection Agency, and the U.S. Agency for Toxic Substances and Disease Registry indicate that the risk of lung cancer to exposed workers is extremely high. Also mists from chromium plating solutions cause burns on the moist tissues of the eyes, nose and throat. These can cause scarring of the cornea of the eye and of the nose and throat, with frequent nosebleeds. After many

years of exposure, burns in the nostrils are especially slow to heal and may develop into open, oozing sores (ulcers). Eventually, some workers develop a hole in the cartilage that separates the two nostrils ("perforated septum").

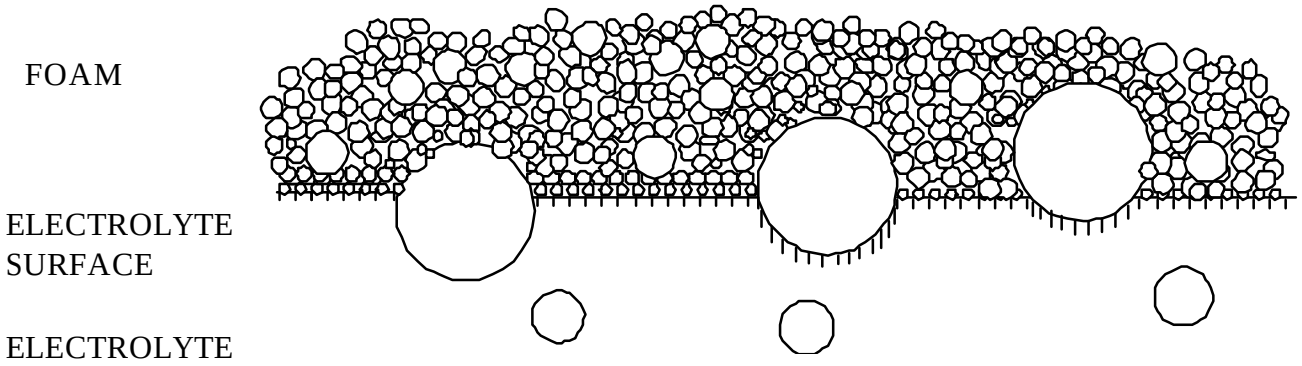
Finally, nickel plating can release nickel sulfate fumes. Nickel compounds are highly potent skin sensitizers and frequently cause a chronic skin condition called "nickel itch". Nickel compounds can also irritate the eyes, nose and throat.

Nickel fumes have been proven to cause nasal and sinus cancers among nickel refinery workers. In electroplating operations, the nickel compounds are different than those encountered in a nickel refinery, however, nickel vapours in plating shops should be treated with great caution and unnecessary exposure avoided.

How are hazards controlled in chrome plating?

Bath additives are available to reduce the surface tension of the electrolyte and, therefore, to reduce misting. Additives are available to provide a thick foam that traps mist released from the bath. These agents are best used for tanks that operate continuously. A layer of plastic chips, beads or balls on the surface of the bath will also trap the mist allowing it to drain back into the bath (see Figure 4 below).

MIST RELEASE WITH FOAM LAYER



Source: *Burgess WA. Recognition of Health Hazards in Industry - A Review of Materials & Processes, 2nd edition. John Wiley & Sons Inc., 1995*

Figure 5 shows three exhaust hoods that are commonly installed for open-surface tanks in plating shops. All are identified as lateral exhaust hoods since they bring the air across the surface of the tank to the hood opening. Providing partial and total

enclosures along with these hoods is frequently possible, providing excellent control of air contaminants at modest flow rates.

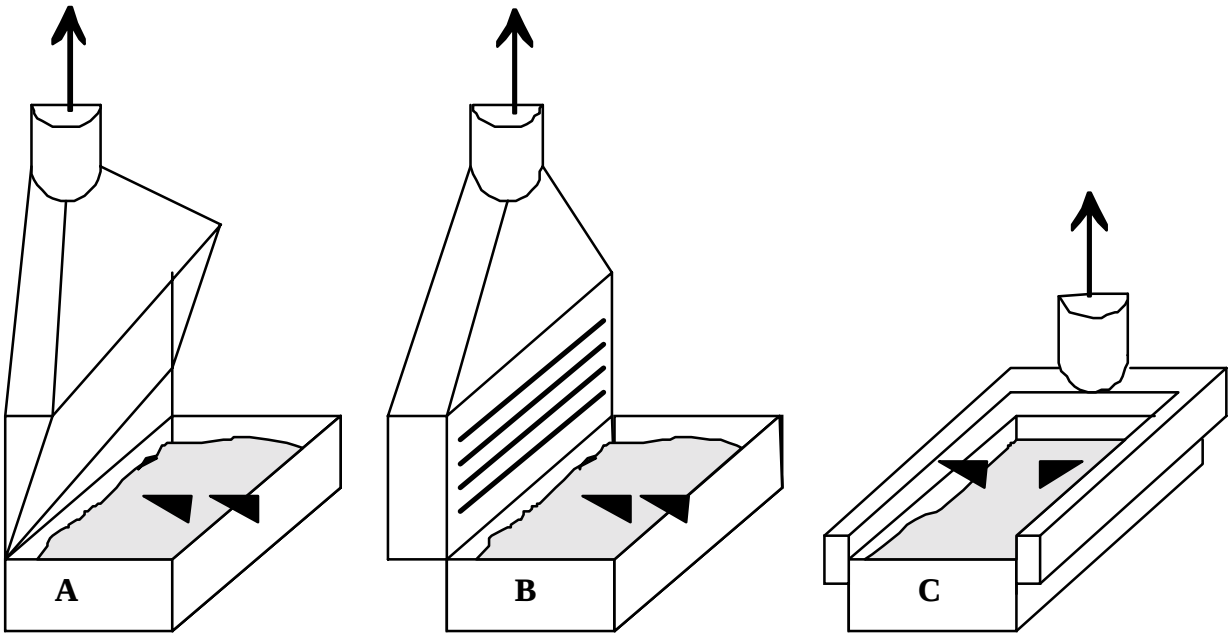


Figure 5: Conventional open-surface tank exhaust hoods: (A) open fishtail, (B) slotted plenum fishtail and (C) lateral slot. ***Source:*** *Burgess WA. Recognition of Health Hazards in Industry - A Review of Materials Processes, 2nd edition. John Wiley & Sons, Inc., 1995.*

In addition to proper design and installation of good local exhaust ventilation, adequate replacement air, backflow dampers on combustion devices to prevent carbon monoxide contamination of the workplace and suitable air cleaning, must be provided.

The effectiveness of exhaust ventilation may be evaluated by air sampling at the workplace and direct ventilation measurements at the bath. Because of severe corrosion of the duct work, periodic checks of the exhaust systems in plating shops are necessary. Airflow rates from each tank should be determined and compared with the recommended exhaust rate. Qualitative assessment of ventilation is possible using smoke tubes or other tracers. The effects of room drafts on the local exhaust ventilation should be identified. Ventilation efficiency may be improved by using partitions to minimize the draft effects.

An extensive review of the usefulness of various control technologies including local exhaust ventilation, mist control additives, plastic chips and foam blankets has been conducted by NIOSH (1985). Chips and mists suppressants were adequate for certain baths, but for hard chrome plating and other critical control situations, these measures should be used with local exhaust ventilation. The single most important feature affecting worker exposure was whether a cover was in use on the tanks. In one case

study the use of a cover resulted in a reduction of air concentrations by a factor of 20. In several cases recommended minimum exhaust rates were found to be too high, resulting in wasted energy. Also, the study indicated that push-pull ventilation was an effective approach for tanks over 4 feet in width.

The educated use of protective equipment by electroplaters is extremely important for preventing contact with various sensitizers and corrosive materials encountered in the plating shop. Know what to wear and when! Minimum protective clothing should include:

- rubber gloves
- aprons (should come below the top of boots)
- boots
- chemical handler's goggles and face shields
- respirators

If respirators are required it is important that an appropriate respirator be chosen to ensure adequate protection. Workers should also be trained on the respirator's capabilities and limitations. Instruction should also include the care and maintenance of the respirators.

The following should also be available in the workplace:

- A shower and eyewash station serviced with tempered water
- All personnel should have a change of clothing available
- Trained “first responders” (those trained in emergencies and decontamination)

A wide range of chemicals handled in an open fashion does present a major dermatitis hazard to the plater and skin contact should be avoided. Nickel is a skin sensitizer and may cause "nickel itch", developing into a rash with skin ulcerations. If solutions are splashed on work clothing it should be removed, the skin should be washed and the worker should change into clean garments. The hands should be washed frequently and eating, drinking and smoking should be prohibited in the work area.

Protect yourself in case of accident!

- Know where the eyewash fountains are in the event of splashes of chemicals into the eyes.
- Know where the emergency showers are.
- Know who to call if help is needed.
- Make sure electrical control panel padlocks are used for electrical lockout.
- Make sure location of emergency stop cables is known.

Due to the nature of the contaminants found in electroplating, first-aid instruction is essential. The first-aid principles and treatments of greatest importance to the plating industry are as follows:

- Act immediately
- Call 911
- Restore breathing and maintain circulation
- Never administer liquids to an unconscious person
- If the eyes are chemically affected, immediately flush with plenty of water for at least 15 minutes
- If any skin surface is affected or the person's clothing saturated, get the worker to a source of running water immediately (emergency shower, water hose). Dilute the chemical with large amounts of water. Flush clothing thoroughly before attempting to remove it.
- Stop bleeding if serious

If workers are suffering symptoms from electroplating hazards they should see a doctor and inform the Joint Health & Safety Committee.

The Occupational Health Clincs for Ontario Workers Inc. can assist in medical, occupational hygiene and ergonomic evaluations for electroplating operations.

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