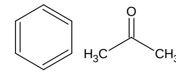
QBE Regional



Recognition, Evaluation & Control

Environmental Health Newsletter September 2009

Metal Finishing

The focus of this EH Newsletter is metal finishing and EH related health hazards associated with metal finishing. Most loss control staff are familiar with common metal finishing processes involving painting. Staff are probably less familiar with other metal finishing processes involving electroplating, anodizing and conversion coating. We currently write some of these types of operations and have looked at others. Loss control staff need to understand the various metal finishing processes and their associated hazards so exposures can be adequately assessed during surveys.

There are two main steps in finishing metal parts. These include surface preparation and surface treatment. Surface preparation is required to ensure that the surface treatment is done properly. Surface treatment improves the lifespan and qualities of metal parts. Surface treatment may also improve bonding of adhesives and coatings during further processing. Some properties of metal finishes include:

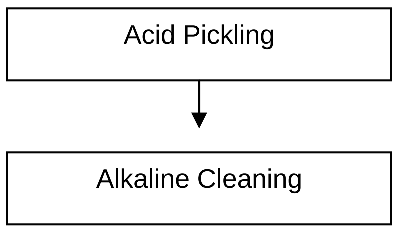
- Corrosion resistance
- Wear resistance
- Electrical properties
- Brightness/color
- Chemical resistance
- Hardness

The processes that we are focusing on include.

- Surface preparation
- Electroplating
- Anodizing
- Conversion coating
- Painting

Surface Preparation

Surface preparation involves removing grease and oils, dirt, oxides and other surface contaminants from the parts before the coating process. These contaminants must be removed before coatings are applied or the finish may be defective. Surface preparation is similar for all metal finishing processes.

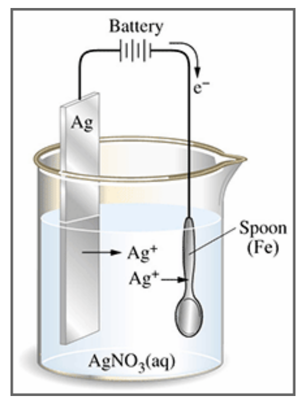


Acid pickling involves the use of a strong acid, usually hydrochloric acid, to remove scale and rust. Pickling time is dependant on the base metal, its thickness and degree of contamination. Pickling is always followed by a water rinse to remove residual acid from the part. An alkaline solution (sodium hydroxide or potassium hydroxide) is used to neutralize any remaining acid as well as to remove any remaining contaminants from the surface of the part. In some operations electrocleaning is performed at this stage in the process. Electrocleaning involves using an electric current passing through the part in the alkaline solution. This enhances the cleaning process. These alkaline solutions can be fairly strong and may be heated.

Electroplating

Electroplating is a process where a metal is deposited on an object by passing a solution through the product is an electrolyte solution of the desired metal. It should be noted that most electroplating is done on metal parts, but there are methods of plating onto plastic and rubber parts as well.

A low-voltage dc power supply (4-12V) supplies electricity from an anode, which is a piece of metal that will be plated onto an object, through the electrolytic bath to the object to be plated which is the cathode. As you may remember from your chemistry classes, oxidation occurs at the anode and reduction occurs at the cathode.



If the anode is an inert electrode, the bath is maintained by periodically adding metallic salts of the desired metal to the bath.

Numerous metals can be plated onto parts. These include:

- Cadmium
- Chromium
- Copper
- Gold
- Nickel
- Silver
- Tin
- Zinc

When surveying an account that does electroplating it is important to identify the types of plating that are conducted. Most platers specialize in one or two types of plating such as tin and zinc or chrome. Different chemicals are used in the various plating processes and it is important to identify the type of plating since there are different health concerns with each type of plating.

Plating can be done by two primary methods. These include rack plating where individual pieces are hung from racks with the entire rack being immersed in the bath. Employees hang the parts on the racks and remove them after they are plated. Small parts like washers or bolts may be plated in rotating barrels and this process is called barrel plating.

Rack Plating

Loading Parts on Rack

Automated Barrel Plating

Both types of plating can be done manually or automatically. In the manual process employees move the racks or barrels of parts from one bath to the next and use a hoist to raise and lower the racks or barrels into the baths.

Manual Barrel Plating

In the automated process the racks and barrels move through the series of baths automatically. The plating process is controlled by regulating the voltage and amperage, temperature, residence times and concentration of the plating baths. Parts are dipped into a hydrochloric acid bath for a few seconds to remove any thin smut films and to activate the surface for electroplating prior to plating. The general electroplating sequence involves dipping the parts in a series of baths that include the plating solution and rinse tanks.

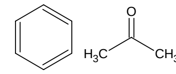
Electroless plating is a newer metal finishing process that does not use electricity for depositing metal on parts. The bath solution itself and chemical reactions in the bath supply the electrons for the deposition reaction. The baths are complex and use chelating agents, citrates, oxalates and cyanides. Nickel, copper, cobalt and gold are the most common metals plated by this process.

Anodizing

Anodizing is another common surface treatment that is often confused with electroplating. Anodizing involves applying a surface oxide coating to a metal. The object acts as the anode rather than the cathode. Oxygen forming at the surface of the part reacts with the part forming a harder more durable surface. Anodizing is commonly done on parts made of aluminum but magnesium and titanium can also be anodized. There are three types of anodizing. These are:

- Type I
- Type II
- Type III

Type I anodizing uses chromic acid and is therefore the most hazardous type of anodizing from an exposure standpoint. Type II uses sulfuric acid while Type III anodizing uses sulfuric acid and organic acids. Anodizing leaves aluminum with hardness, corrosion resistance, and increases paint adhesion properties. The part surface can also be easily dyed and anodizing is often done in association with dying processes where the aluminum is dyed gold,



red, yellow, black or green. The general anodizing process includes the following baths:

1. Hot soap wash
2. Water rinse
3. Caustic etch with sodium hydroxide
4. Water rinse
5. Anodizing bath
6. Water rinse
7. Colorant dye
8. Water rinse
9. Sealer bath

Conversion Coating

In conversion coating the metal substrate participates in a coating reaction and becomes a component in the coating. This is a chemical reaction of the metal surface. Conversion coatings are used to:

- Increase corrosion resistance
- Absorb lubricants
- Enhance appearance
- Promote adhesion
- Provide wear resistance

The most common conversion coating is phosphating which involves reaction of the metal with phosphate ions in an acidic solution. Zinc phosphate is used to provide a rust preventative coating. Manganese phosphate is used for wear resistance. Iron phosphate is the most common phosphating process and is used to enhance adhesion of paints on the metal surface. Application of the phosphates is by spraying or immersion in automated processing lines and equipment.

Chromating is another conversion process that has been done more recently. Chromating is often performed on zinc die castings, hot dipped galvanized parts and aluminum. The chromate coating provides electrochemical protections of the metal surface and is done by spray application or immersion.

Potential Health Hazards of Surface Preparation, Electroplating, Anodizing and Conversion Coating

Surface preparation, electroplating, anodizing and conversion coating operations all involve the use of acid and alkaline baths. Acids may include boric, hydrochloric, nitric, sulfuric or chromic. Alkaline baths include sodium hydroxide and potassium hydroxide. Acids and alkalis are most hazardous in concentrated forms and when heated. Acids and alkalis cause skin burns and severe eye injuries. Contact can be through direct dermal contact or splashes to the face and eyes especially when chemicals are added to baths or when handling racks or barrels during plating. Proper dermal protection is required to prevent contact. Chemical splashes are also a potential hazard so eye and face chemical splash protection is important. Eyewash and shower stations should be located in close proximity to the baths and be in good working order.

The chemical hazards related to electroplating depend on the type of plating that is conducted. The majority of plating baths are alkaline baths based on cyanide salt solutions. Cyanide salts are used because they can deposit the metal coatings in remote recessed areas of the work piece better than other plating methods. Cadmium, copper, silver, brass, zinc and bronze plating use cyanide baths. Chromium, copper, nickel and tin are commonly plated in acidic baths.

It is extremely important to have tight chemical controls when cyanides are used in plating operations. Cyanide salts release highly toxic hydrogen cyanide gas when they contact an acidic material. Acids and cyanides must be segregated and stored where they cannot come in contact. There must also be no chance of cyanides and acids coming in contact in floor drains or process equipment.

Chrome (chromium) plating and aluminum anodizing or Type I anodizing are a particular concern from a chemical standpoint. Chromic acid is a dermal hazard but also poses a respiratory hazard since chromium is in the hexavalent form which is a carcinogen. There are two types of chrome plating that loss control should be familiar with. Hard chrome plating is a process where a thick chromium coating is applied to the part. It is used to provide wear resistance and oil retention to parts. Hard chrome is not harder than other forms of chromium but is called hard chrome due to the heavy thickness of the chromium. The other type of chrome plating is decorative chrome plating. This is a thin layer of chromium plated over a nickel coating that provides a very shiny and reflective surface. Chrome wheels and car bumpers are examples of decorative chrome plating.

The main airborne exposures in plating operations involve contaminants released from the plating baths themselves. During the plating process water is dissociated at the electrodes in the baths. Oxygen generated at the anode and hydrogen at the cathode form bubbles that rupture on the surface of the bath releasing mist. The mist generation at the tanks can be an inhalation concern and is a function of the type of plating that is being conducted and its efficiency. Copper plating is about 100% efficient so very little energy is wasted in the formation of oxygen and hydrogen. Chrome plating is very inefficient with up to 90% of the electric energy going to the dissociation of water. Large amounts of chromic acid mist can be created and since chromic acid involves chromium in the hexavalent state there is high risk for overexposures and health concerns.

There are two means of controlling acid mists at plating baths. Mist suppressants can be used to reduce the surface tension of the bath and the associated mist generation. A layer of floating plastic chips, beads or balls can be used in the baths. Tank covers can be used in some instances. Local exhaust ventilation hoods are also used to control emissions from the baths. Slot hoods or back-draft hoods work the best. Canopy hoods are not recommended.

Slotted Hood

All chromium and cyanide baths should be exhausted due to the potential hazards of mists generated at these baths. Remember that many of the baths in a plating line involve water rinses or detergent washes. These do not need to be exhausted.

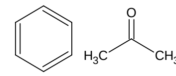
Ergonomic related concerns at surface preparation, electroplating, anodizing and conversion coating operations are primarily related to repetitive motion injuries in the racking process and manual material handling associated with lifting the racks onto the conveyor line. Large heavy parts are more of a concern. Hoists are usually used to move barrels or racks into and out of the baths but smaller racks or barrels are sometimes lifted by hand.

Parts Handling

Manual Material Handling

Painting

Painting is the most common metal finishing operation. Paint is used to provide protection against corrosion, for appearance and other improved qualities. There are two paint systems. These are liquid paint systems and powder paint systems. Liquid paints can be classified as solvent based or water based. Liquid paints have three main components. These include the vehicle which is all the liquid components, filler materials which include the pigments, and



additives which increase the speed of drying, control fungus and provide other roles in specialty paints.

Solvent based paints use common organic solvents including aromatics, alcohols, and ketones. The solvents are used to thin the resin and adjust paint viscosity. They also aid in film formation during evaporation. Water based paints use water to perform these functions. Water based paints are being used more and more for environmental reasons and because they are less hazardous than solvent based paints.

Paint resins form the paint film upon drying. There are a number of resin systems. These include:

- Acrylic
- Alkyd
- Amino
- Epoxy
- Phenolic
- Polyurethane
- Vinyl

The epoxy and polyurethane paints are two component systems that pose a more significant hazard than the other paint. Polyurethanes contain a polyurethane prepolymer containing a reactive isocyanates and a polyester. These two chemicals react with a catalyst to form a chemical resistant polymeric coating. Unreactive isocyanates such as toluene diisocyanate (TDI) can cause respiratory sensitization and occupational asthma. Epoxy paints are resistant to chemicals and high temperature. The two part system is composed of bisphenol A and epichlorohydrin with an amine catalyst. Epoxy paints are moderate skin irritants and are a common cause of dermatitis.

Powder Coat Painting

Powder coat painting is a method of applying dry paint to a part. In liquid paint systems the liquid carrier evaporates leaving the paint coat. In powder coating the paint is negatively charged and sprayed onto the part that is positively charged. This eliminates all the environmental concerns associated with organic solvents. After the paint has been applied, the paint is cured in an oven forming a continuous film. The powder coat paint can be applied by manual spraying or by an automated gun station or a robot. Parts usually pass through the spraying booth or enclosure on a conveyor. Powder is collected by a recovery system so up to 99% of the paint is used.

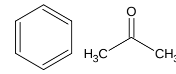
Potential Health Hazards of Painting

The primary hazard associated with liquid paints is solvent exposure from solvent based paints. There is a wide variety of solvents with differing toxicity. MSDSs of the most common paints used at a facility should provide a good basis of potential exposures. Water based paints do contain organic solvents so potential hazards are minimal.

Pigments and fillers have been historic health hazards in painting. Pigments included heavy metals such as lead, antimony, cadmium, chromium and zinc. Due to their high toxicity, these pigments have been replaced by organic pigments in most instances. Lead and chromate paints are still used in certain situations where high durability and weather resistance is required.

The main chemical hazard with powder coat painting is from exposure to a compound known as TGIC (triglycidylisocyanurate or 1,3,5-triglycidyl-s-triainetrione). This is a very common polyester-epoxy resin coating used in powder coat paints. The substance is a skin, eye and respiratory system irritant. It is also a skin sensitizer. There is little human exposure data for the substance, but animal studies have resulted in liver and lung damage as well as possible male reproductive system damage.

Only spray painting results in potential exposure to all paint components. Hand painting and dipping do not create aerosols so consequently only solvent vapors are a potential airborne hazard. There are a number of paint spraying methods and the spray painting hazard depends on the transfer efficiency during paint application. Airless spraying eliminates the need for compressed air. Paint is pressurized and forced through a small orifice. This method produces the least amount of overspray. High volume-low pressure systems use air at 3-6 psi. The low air pressure results in transfer efficiency over 65%. The next most efficient painting method is Low Pressure-Low Volume. A special atomizing gun achieves 60-80% transfer efficiency. The lowest efficiency painting method is air atomization. This is the traditional paint spraying method where a siphon picks up paint created by negative pressure caused by air flow through the gun. Atomization takes place outside the gun between the horns of the gun. Transfer efficiency is only 25-30% which results in a large amount of overspray and potential worker exposure.



The preferred control method for paint spraying is to use a paint spray booth. There are a number of different types of booths. These include open booths where the operator stands outside the booth and sprays into the booth and enclosed booths where the operator paints within the booth itself. Booth depth is the most critical factor in contaminant capture efficiency. Rebound from flat surfaces in shallow booths is a common cause of elevated exposures.

This figure shows painting outside of a booth that is too shallow. Notice the large amount of overspray outside the booth.

Clutter in the back of the booth often results in painting too near the face opening. Painting should be done as far back in the booth as possible. Adequate airflow across the entire face of the booth is important. OSHA requires air flow of at least 100 ft/min at booth face openings. Clutter and equipment in front of the booth or at the face opening can have a drastic impact on face velocity and result is elevated worker exposures.

Work practices are import when spraying in a booth. General practices that should be followed include:

- Do not spray toward another employee
- Do not spray outside the booth face opening.
- Do not spray from the back of the booth toward the face opening.
- Do not position the work so that the operator is between the exhaust and the spray gun.
- Allow parts to dry in the booth or in a drying room rather than in general production areas.

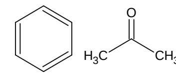
This figure shows an employee standing between the work piece and the exhaust of the booth. This results in overspray blowing back toward the operator. If the booth is shallow, overspray may also be blown out of the booth.

PPE should also be used as a control measure when painting. All dermal contact with paints and solvents should be avoided. It is especially important to avoid contact with urethane and epoxy paints because they are skin and respiratory sensitizers. Gloves, disposable suits and boot covers should be used when spray painting. Hoods should also be used for urethane, epoxy and powder coat paints. The level of respiratory protection depends on the paint system, application method and ventilation controls. The minimal respiratory protection usually required for paint spraying is a half-face air purifying respirator with mist-organic vapor cartridges. Supplied air hoods or helmets should be used where epoxy or urethane paints are spray painted or where employees apply powder coat paints while standing past the booth face opening.

This figure shows an employee applying powder coat paint inside a paint booth wearing a supplied air hood.

Evaluating Metal Finishing Operations

A good description of operations is the most important piece of the loss control survey when evaluating metal finishing operations. Describe all the metal finishing processes. What are the base metals and what are the metal finishes applied to the base metal? What types of plating are done (rack, barrel, manual or automated)? Does the account do any chrome plating, anodizing or chromating? Do they use hexavalent chromium? Does the account use cyanide baths? What types of painting are conducted (spray, dip, electrostatic)? Are more hazardous types of paint applied (epoxy or urethane)? Are painting operations automatic or manual?



Chemical

How are chemicals handled and how are they stored? How does the insured store cyanides and acids? Are they stored so they cannot come in contact with each other? What are the quantities of chemicals? Is chemical access controlled? Are chemicals transferred to baths by hand or are they pumped? Are chemical containers properly labeled? Is chemical and hazard communication training conducted? Do loss runs show chemical burns or inhalation related illnesses or injuries? Has the account ever had air testing done? If so, get a copy.

PPE

What PPE is worn by employees adding chemicals to baths? What PPE is worn by employees at the plating baths? Is chemical splash protection (face shields, splash suits) worn around acid or caustic baths? Are there eyewash and safety showers near the baths? Have these devices been maintained and are they regularly tested? Do employees applying spray paint or powder coat paint wear respirators and what type?

Local Exhaust Ventilation

Are there slot hoods or other local exhaust ventilation hoods around plating baths, especially any cyanide or hexavalent chromium baths? Are mist suppressants used in plating baths especially chromium tanks? Is painting conducted in paint booths? Are the booths fully enclosed or do painters stand outside the booth and spray into the booth? Is there evidence of overspray on surfaces outside the booth? Are the booths clean and maintained properly? Are parts air dried in the booth after spraying or are them moved onto the production floor to dry?

Ergonomics

Is barrel plating or rack plating performed? What are the sizes and weights of parts placed on racks? Are parts manually dipped into the plating baths or is a hoist system in place? Are there any automated plating lines? What are the weights of parts placed on or removed from overhead conveyors in automated paint lines? Has there been a history of manual material handling or ergonomic related losses?