State of Ohio Environmental Protection Agency

Office of Pollution Prevention

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Pollution Prevention Opportunities for PBT Chemicals

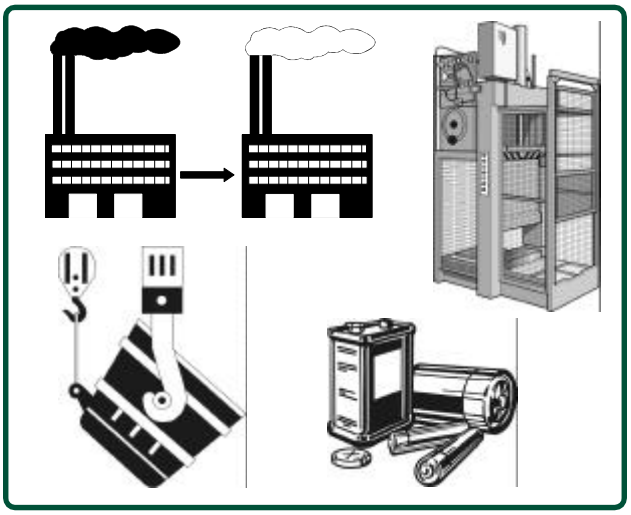
Chromium and Chromium Compounds

Chromium is present in the environment in several different forms. The most common forms are chromium(0), chromium(III) (or trivalent chromium) and chromium(VI) (or hexavalent chromium). Chromium(III) occurs naturally in the environment and is an essential nutrient that helps the human body utilize sugar, protein and fat. Chromium(VI) and chromium(0) are generally produced by industrial processes. Chromium compounds are tasteless and odorless.

Hexavalent chromium or chromium(VI) is a recognized carcinogen. Exposure to chromium (VI) in dust is associated with increased incidence of lung cancer and is known to cause inflammation of the skin (dermatitis). In contrast, trivalent chromium or chromium (III) is considered relatively safe.

Where are Opportunities for Pollution Prevention?

The metal chromium, or chromium(0), is a steel-gray solid with a high melting point. It is used mainly for making steel and other alloys. The naturally occurring mineral chromite in the chromium(III) form is used as brick lining for high-temperature industrial furnaces, for making metals, alloys and chemical compounds. Chromium compounds, mostly in chromium(III) or chromium(VI) forms,



produced by the chemical industry, are used for chrome plating, the manufacture of dyes and pigments, leather tanning and wood preserving. Smaller amounts are used in drilling muds, rust and corrosion inhibitors, textiles and toner for copying machines.

What is Pollution Prevention?

Pollution prevention means using source reduction techniques in managing waste problems and, as a second preference, environmentally sound recycling. The benefits of practicing pollution prevention include reduced operating costs, improved worker safety, reduced compliance costs, increased

- ✓ **One casting company replaced a sand which contained chromium compounds with a zircon-based sand.**
- ✓ **A producer of colorants, adhesives and dispersions for the plastics industry replaced lead chromate pigment with organic compounds.**

productivity, increased environmental protection, reduced exposure to future liability costs, continual improvement, resource conservation and enhanced public image. For more details, see Ohio EPA's Office of Pollution Prevention fact sheet, *What Is Pollution Prevention?* at **www.epa.state.oh.us/opp/fact1_web.pdf**.

Chromium Pollution Prevention in Industries

Pollution prevention in a manufacturing setting generally means material substitution, process improvement and product change or redesign. Often, pollution prevention practice involves applying one or more of these strategies in tandem.

Material Substitution is the use of different materials that are less toxic or non-toxic. This may include the use of a non-chromium containing raw material or different equipment that does not require chromium.

A manufacturer of electric lift trucks and antenna rotators removed lead and chromium from most paint formulations, eliminating paint waste as a hazardous waste stream. Paint sludge is now recycled into building materials such as quarry tile, asphalt, mastic and binder.

Process Improvement means to improve the operational process, thereby reducing or eliminating the need for chromium usage. This includes increasing the operating efficiency of an equipment or a process, good maintenance programs and training to reduce the risk of waste generation.

For hexavalent chromium plating baths, the technique of porous pot plating has been used to extend bath life, thereby reducing the discharge of pollutants. During plating, the concentrations of iron and other cationic impurities build up in a hexavalent chromium bath to the extent that plating becomes unsatisfactory. If this bath is placed in a porous pot in which a semipermeable membrane separates cathode from anode, and power is applied, the iron and other contaminant metal ions pass through the membrane and accumulate in the cathode chamber from which they are periodically removed for disposal. Chromate ion remains in the anode compartment as part of the solution which, after purification, may be returned to the plating tank for further use. Less chromium is wasted by using this technique.

Hexavalent chromium is used extensively in decorative and functional plating applications as well as conversion coatings. Approximately 80 percent of the available power supplied to a hexavalent chromium bath generates hydrogen

gas. Evolution of the gas produces a mist of fine water particles with entrained hexavalent chromium. As hexavalent chromium is a carcinogen and a designated hazardous air pollutant, protection of worker health and safety as well as the environment requires control of its emission. Wastewater treatment incurs the cost of an added step to reduce hexavalent to trivalent chromium.

In some applications, especially decorative plating, the use of trivalent chromium has proven successful. Use of trivalent chrome eliminates both misting and the added step in wastewater treatment. Adherence, throw and coverage are all improved, and higher rack densities can be achieved. Because bath concentration is much lower than for hexavalent chromium, drag-out is less and the amount of sludge produced by wastewater treatment is substantially reduced. Plating thickness is limited to 0.1 mil because thicker coatings exhibit cracking and spalling. Thus the technique is usually unsuitable for hard chromium coatings, which may be 20 mils or more in thickness. Although the color tones of trivalent chromium coatings are different from those of hexavalent chromium, additives to the trivalent chromium bath can often ameliorate the difference. For more details, see *"A Pollution Prevention Resource Manual for Metal Finishers"* at **www.epa.state.oh.us/opp/mfrm.txt**.

Research by an Ohio firm using a trivalent chromium plating process to replace hexavalent chromium plating was a winner of the U.S. Environmental Protection Agency's (U.S. EPA) Small Business Innovation Research (SBIR) Program. This research used modulated reverse current (MRC) electrolysis in conjunction with a reduced cost trivalent chromium plating chemistry. The result was a reduced cost, performance based, functional trivalent chromium plating process to replace conventional hexavalent chromium plating. It is believed that the process can replace conventional hexavalent chromium plating for thick, hard and functional coatings.

In 1991, an Ohio steel products manufacturer committed to the U.S. EPA's 33/50 Program. The company's efforts focused on reducing off-site releases of chromium, lead and nickel, as well as heavy metal from electric arc furnace (EAF) dust. It recycled 50 percent (600,000 pounds) of one plant's EAF dust on site and sent the remainder to a reclaimer, along with the dust from a second steel plant, for high temperature metals recovery. Its two steel plants implemented new emission control systems and baghouses with higher efficiency, which are able to capture 99.5 percent of EAF dust generated from the steel melting process. These changes combined to decrease the company's Toxic Release Inventory releases more than 80 percent.

Product Change or Redesign may eliminate chromium altogether from the manufacturing process, especially where chromium is incorporated into the product. For example, a producer of colorants, adhesives and dispersions for the plastics industry replaced lead chromate pigment with organic compounds.

Systematic Approaches to Pollution Prevention

A systematic approach to pollution prevention establishes and maintains a systematic management plan designed to continually identify and reduce environmental impacts through pollution prevention. Many facilities are incorporating pollution prevention into their quality programs or environmental management systems.

An aluminum extruding facility in Ohio was able to remove hexavalent chromium completely through a series of projects:

First, it changed from an alkaline cleaner to a dispersion cleaner that was chromium-free. The new dispersion cleaner has an oil dispersion attribute which extends the life of the cleaner bath by allowing excess oil to be skimmed off. The new dispersion cleaner yields a longer tank life and lower oil and grease levels in the rinse water. The extended tank life saves $4,000 per year.

Then, the company substituted an iron phosphate conversion coating in the pretreatment process for the previous hexavalent chromium process. Hexavalent chromium was also removed from the paint line by switching to powder coating.

The removal of hexavalent chromium was completed in the anodizing line by implementing a totally non-chromium conversion coat process. This process proved to be the equal of the previous chromium process in areas of salt spray testing and paint adhesion properties. Long-term cost savings were also documented over the chromium process, especially in the waste treatment areas.

Contact OPP

For more information and assistance on pollution prevention, contact Ohio EPA's Office of Pollution Prevention (OPP) at (614) 644-3469 or visit OPP's Web site at **www.epa.state.oh.us/opp.**

Ohio's Materials Exchange (OMEx) at **www.epa.state.oh.us/opp/omex**, lists "*materials wanted*," including metal wastes, metal-bearing sludges and filter cakes. Users may also post their "*materials available*" on the listing. The exchange proves valuable in the reuse of materials and preventing them from becoming a waste.

www.epa.state.oh.us/opp

The Office of Pollution Prevention was created to encourage multi-media pollution prevention activities in Ohio to reduce risk to public health, safety, welfare and the environment. Pollution prevention stresses source reduction and, as a second choice, environmentally-sound recycling, while avoiding cross media transfers. The office develops information related to pollution prevention, increases awareness of pollution prevention opportunities, and can offer technical assistance to business, government, and the public.

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