Board of Public Works
HTM project
City of Los Angeles

FACT SHEET

Plating with Trivalent Chrome

BACKGROUND

Much has been written in recent years about replacing environmentally hazardous hexavalent chromium electroplating solutions with trivalent ones for decorative chrome applications. Although hexavalent processes have been used for electroplating for over 65 years, they have serious environmental and performance problems associated with them.

Hexavalent chromium is a highly toxic material as well as a suspected carcinogen. Its uses poses a danger to human health, particularly to shop personnel, as well as to the environment. Hexavalent chromium can escape the plating line through spills, leaks, in discarded baths, rinses, and in a form of mist associated with hydrogen bubbles generated during plating operations.

There are also performance deficiencies associated with hexavalent chromium use that result in many reject parts and other problems that cost a shop owner money. These deficiencies include:

- Poor covering power (especially around holes and slots)
- Burning
- White-washing
- Sensitivity to ripples in power supply
- Low energy efficiency: 85 to 90% of the electric power applied goes for the generation of hydrogen

Hexavalent chromium wastes need to be chemically reduced to trivalent chrome in the shop's treatment plant. This necessitates the use of expensive chemicals such as sulfur dioxide, sodium metabisulfite or sodium borohydride. Also considerable hazardous sludge is generated during the neutralization step of the treatment process due to the high chromium concentration of the plating solutions. Hazardous waste haulage and disposal costs are rising dramatically each year. Thus, it's becoming harder to use hexavalent systems profitably.

Advantages Offered By Trivalent Chrome Systems

Trivalent systems can save an electroplating shop money in a number of ways:

1. ***Lower Metal Concentrations.***

Chromium concentrations in trivalent plating baths are typically less that 1 ounce per gallon (oz/gal). Hexavalent chromium concentrations are 15 to 40 oz/gal. Lower heavy metal concentrations mean less chrome dragout, and thus, lower waste treatment costs and less hazardous sludge generated in trivalent systems. Reducing sludge quantities also saves you money in haulage and disposal fees.

2. ***No Reduction Step.***

By installing a trivalent system, you avoid the need to reduce hexavalent chrome wastes to their trivalent state. Since three pounds of sodium metabisulfite are required to reduce each pound of chromic acid, significant quantities of chemicals, as well as equipment and labor costs, are eliminated by switching to a trivalent system.

3. ***More Parts Can Be Placed on a Rack.***

Trivalent chrome chemicals produce a high quality plate even when rack densities are increased 15% above those for hexavalent chrome systems.

4. ***Lower Current Density.***

Lighter weight, less expensive racks can be used to carry the lower currents. Simple hooks made out of hard drawn copper wire have also worked well in trivalent systems. Use of such hooks eliminates the expense of designing and special ordering custom parts racks.

5. ***Fewer Rejects.***

The throwing power of trivalent chrome is excellent. It is almost impossible to burn parts, too, according to satisfied shop owner, even with current densities above 100 amp/sq.ft. Trivalent systems do not experience the white washing problems that hexavalent systems do.

6. ***Reduced Dragout.***

Tri-chrome baths are far less viscous than hexchrome. Less solution clings to the parts that are withdrawn from the bath. This reduces both treatment expenses and material costs for the makeup chemicals.

7. ***No Fumes.***

When you stand next to a trivalent chrome plating tank, you notice an immediate difference. There are none of those eye-stinging, throat-irritating fumes that are emitted from a chromic acid bath. The hexavalent chromium in those fumes is a suspected carcinogen. Besides being unpleasant to breathe, the fumes present a danger to personnel and to the environment surrounding the shop.

8. ***Reduced Liability.***

Use of hexavalent chromium constitutes a liability to the shop due to the dangerous nature of the chemical. Spills and other accidental releases of hazardous wastes can lead to lawsuits that might have been avoided if safer chemicals were used.

TABLE 1. ***Comparison of Plating Bath Operating Characteristics***

	HEX	TRI
Temperature	110° F	120° F
Parts area per rack	12 ft^2	13.8 ft^2
Plating time per part	20 sec	100 sec
Current Density	200 amp/ft^2	68 amp/ft^2
Amperage for entire tank	2400 amp	2100 amp
Tank voltage	12 volt	8 volt
KWH/shift @ 85% rectifier efficiency	196 KWH	114 KWH

So Why Haven't All Shops Converted to Tri-Chrome?

While tri-chrome systems offer some distinct advantages over hex-chrome for decorative chrome plating applications, there are potential problems associated with their use. In the past, color was a big problem. The plate was darker and not as shiny. This problem has been greatly reduced. The tri-chrome system developed by Canning Materials produces plates that are as shiny and as of high a quality as hex-chrome plates. If the tri-chrome parts are placed side by side with hex-chromed parts, however, there is a noticeable color difference, the first shop was forced to switch back to a hexavalent system.

The cost of chemicals for a trivalent system is currently higher than for a hexavalent set-up, although this might change as trivalent systems become more common.

Trivalent chromium systems are new, but have already shown tremendous potential for the future. As waste management costs continue to rise, the savings that trivalent systems offer will increase markedly. Specific characteristics of a trivalent system that has been in operation for approximately one year are included in the case study given on Page 5.

TABLE 2. ***Comparison of Hexavalent and Trivalent System Costs***

	HEX			TRI		
	Unit Cost	Qty Used Per Shift^	Cost Per Shift	Unit Cost	Qty Used Per Shift^	Cost Per Shift
Plating Chemicals						
Chromic acid	$ 1.08/lb	28.8 lb	$31.10			
Chrome catalyst	15.00/lb	0.3 lb	4.32			
Trichrome additive #1				$28.75/gal	1.9 gal	$54.63
Trichrome additive #2				28.25/gal	1.5 gal	42.38
Trichrome base salts				1.97/lb	18.0 lbs	35.68
Boric acid				0.36/lb	10.0 lbs	3.60
Trichrome wetter				12.75/gal	0.6 gal	7.65
Hydrogen peroxide				8.00/gal	0.5 gal	4.00
Treatment Chemicals						
Sodium metabisulfite	0.33/lb	86.4 lbs	28.51			
Lime	0.09/lb	28.8 lbs	2.71			
Energy Usage						
Electrical	$0.085/kwh	196.0 kwh	16.66	$0.085/kwh	114.0 kwh	9.69
Natural Gas	$0.65/therm	6.9 thms	4.47	$0.65/therm	9.6 thms	6.24
Operating Variables						
Rejects		1.5 %	81.00*		0.5 %	27.00*
Operating Costs			168.77			190.87
Gross Profit Per Shift (Calculated at $0.20 per sq ft of parts plated)	0.20	7200 ft^2 **	1440.00	0.20	8220 ft^2 **	1644.00
Net Proftit Per Shift (= Gross Profit - Oper. Costs)			**$1271.23**			**$1453.13**
Difference in Profits Per Shift (= Trivalent - Hexavalent)						**$181.90**

^ Shifts are eight hours in length.
* Cost for rerunning rejected parts.
** Trivalent Process is able to plate 15% more parts per shift, due to higher parts densities on racks.

Case Study of a Trivalent Chromium System

Shop X is a medium sized chrome, nickel and zinc automated plating shop in the Los Angeles area. The shop converted an automated chrome line to a trivalent system approximately a year ago at a cost of $70,000. The owners of the shop felt that the increased production rate they could achieve with a trivalent system would increase their profits as well. The results of their switch to trivalent chrome are documented below.

The plating line that was converted uses a 3,000 gallon chromium bath, preceded by a nickel bath. The production rate is 75 racks per hour, and with the old hexavalent system, 12 sq.ft. of parts could be stacked on each rack.

Shop X found that at least 15% more surface area of parts could be placed on each rack in the new trivalent system. The additional production rate increases profits by $216 per shift. It is the nickel plating that precedes the chrome bath, however, that limits the number of parts per rack from being even higher. When the parts density is increased too much, nickel plates poorly in the recesses and crevices of the parts. A good chrome plate cannot be achieved unless there is a good nickel plate underneath it.

The shop is currently trying to control nickel concentrations in the plating bath more closely. By keeping concentrations at 8 oz/gal, greater parts densities on the racks should be achievable. Nickel densities often get up to 10 to 14 oz/gal, due to a closed loop recovery system that recycles nickel from the rinse tanks back into the plating bath.

The reject rate for poorly plated parts for the hexavalent system was 1.5% of all parts, while for the trivalent system, it is only 0.5% and possibly lower. This means that with the new trivalent system, almost one more rack of good parts is produced every hour. In terms of dollars, an additional $54 of profit per eight hour shift is realized because of avoided rerun costs due to the lower reject rate.

Because trivalent waste streams do not need to go through a reduction step, no sodium metabisulfite or lime is needed. This saves the shop $31 per shift.

The biggest disadvantage of the trivalent system is that the plating chemicals are considerably more expensive. Before the new system was installed, it was estimated by the supplier that trivalent chemicals would cost $70 more per eight hour shift than hexavalent chemicals. In actuality, the cost for the trivalent chemicals is $113 more per shift. More chemicals have had to be used than originally estimated in order to obtain a high quality plate.

A detailed comparison of the costs of the two systems is given in Table 2.

ADDITIONAL PUBLICATIONS

Some additional publications available from the Hazardous and Toxic Materials Project that may be helpful are:

Hazardous Waste Management and Minimization Guidelines for Los Angeles City Departments

California Requirements for Generators of Hazardous Waste

Hazardous Waste Haulers and Facilities in Los Angeles

The EPA Manual for Waste Minimization Opportunity Assessments

EPA's Waste Minimization: Environmental Quality with Economic Benefits

Additional Fact Sheets for: Paint Formulating Industries; Pesticide Formulating Industries; Automotive Repair Shops; Asbestos Handling, Transport, and Disposal; Aerosol Containers; Electroplating Sludge

FURTHER INFORMATION

For further information and assistance or to request additional publications please contact the HTM Project at:

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The Board of Public Works Hazardous and Toxic Materials Project was established by the Los Angeles City Council in 1988. The purpose of this program is to promote the National policy of minimizing hazardous waste generation and ensure citywide compliance with hazardous materials and waste requirements. Technical assistance is provided to City agencies and industry through on-site consultation, information dissemination, and waste assessments.

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