Trivalent Chromium Plating Conversion Case Study

Independent Plating, Worcester, Massachusetts

Faced with new regulations restricting emissions of hexavalent chromium (hex-chrome) from various plating operations, and increasing requests from its customer base for products that are environmentally preferable, Independent Plating (Independent) decided to explore converting one of its plating lines from hexavalent to trivalent chromium. Such a conversion is consistent with Independent's overall approach, which relies on substitution and prevention as their principal techniques for toxics use reduction. Their philosophy emphasizes source reduction, drawing heavily on research and implementing new safer and greener alternatives. With a commitment to providing safer, high-quality metal finishing in an environmentally sound manner, Independent plans to continue its proactive approach to growth well into the future.

Background

Independent Plating is an employee-owned metal finishing company that has been in business since 1941. For more than 70 years, Independent has been finishing an array of primarily aluminum and stainless steel tubing and wire products for a variety of products – from school furniture to high end retail displays to medical devices to law enforcement tools.

Metal finishing processes conducted at Independent include zinc plating, electroless nickel plating, black oxide, nickel chrome plating, phosphating, pickling and powder coating. These processes contain various heavy metals, acids and other hazardous substances, which pose potential negative impacts on the environment and workers. Consequently, Independent's metal finishing operations are subject to many environmental and occupational regulations, including new emission standards recently finalized by the US Environmental Protection Agency[1].

The specific processes used by metal finishers for various products are traditionally dictated by the demands of their customers. This often limits a finisher's choices when it comes to selecting the highest quality finish while reducing potential impacts on human health and the environment. Ten years ago Independent attempted to switch its nickel chrome line to

[1] US EPA National Emissions Standards for Chromium Emissions from Hard and Decorative Chromium Electroplating and Chromium Anodizing Tanks

trivalent chromium, but found that the technology available at the time did not achieve the quality their customers required. However, Independent continued to stay informed about new technological advances in metal finishing and, when customer demands for products with a lower environmental footprint began to increase, they made another concerted effort to find an alternative.

Assessment of Trivalent Chromium

Independent Plating took a systematic approach to exploring its options for implementing a trivalent chromium (tri-chrome) system. The first step was to conduct research into the technologies now available, and the experience of their peers with the various options. One area of particular interest to them was corrosion resistance. Because Independent primarily does plating on tubular products, they were concerned with assuring that their plating treatments minimized corrosion on the insides of tubes.

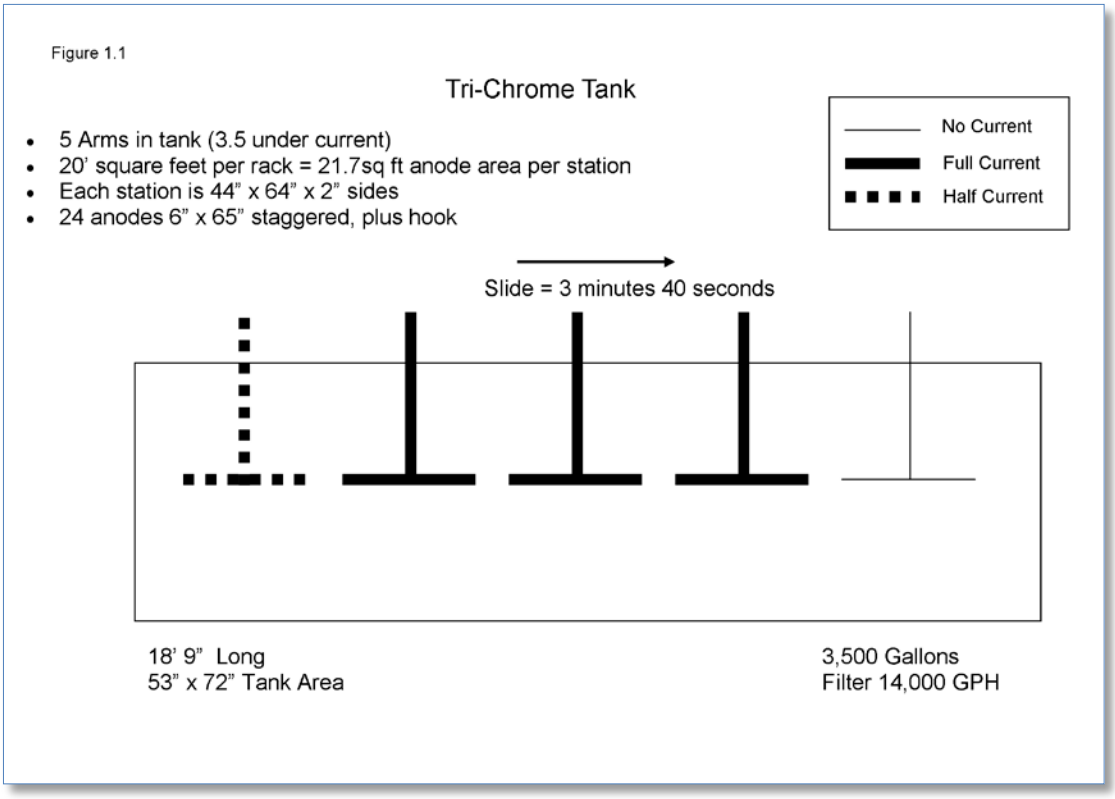
Research - Independent spent considerable time researching different tri-chrome systems to decide which would best meet all of their needs as well as the needs of their customers. They paid particular attention to the uniformity and thickness of coverage and the color achievable by the various options, as well as ease of system maintenance and the level of support expected from the vendor. They visited several plating shops that are currently using various tri-chrome systems, to learn about the operational requirements of their tri-chrome lines and to get feedback from these platers about their experiences with various vendors.

Based on this research, Independent identified the following benefits and challenges of converting to a tri-chrome system:

Benefits of Trivalent Chromium	Challenges with Trivalent Chromium
Improved quality: superior throw, better coverage around holes, less burning and whitewash, easier cleaning. Need for color buffing is nearly zero.	Cost: implementation and chemical costs are higher than hex-chrome.
Increased throughput: larger load sizes are possible. Increased rack density possible	Appearance; although generally acceptable, tri-chrome colors are not quite identical to hex-chrome
Less hazardous waste generated. Lower cost of hazardous waste management	Technical capabilities: tri-chrome is not capable of replacing every hex-chrome requirement and/or specification.
Lower toxicity (hex-chrome is a carcinogen)	
Minimizes employee exposure: potential employee exposure to toxic air emissions reduced	Bath control: tri-chrome baths require increased testing and maintenance, and operate with higher current requirements
Less likely to trigger future regulatory restrictions	Still contains very small amount of hex chrome in solution

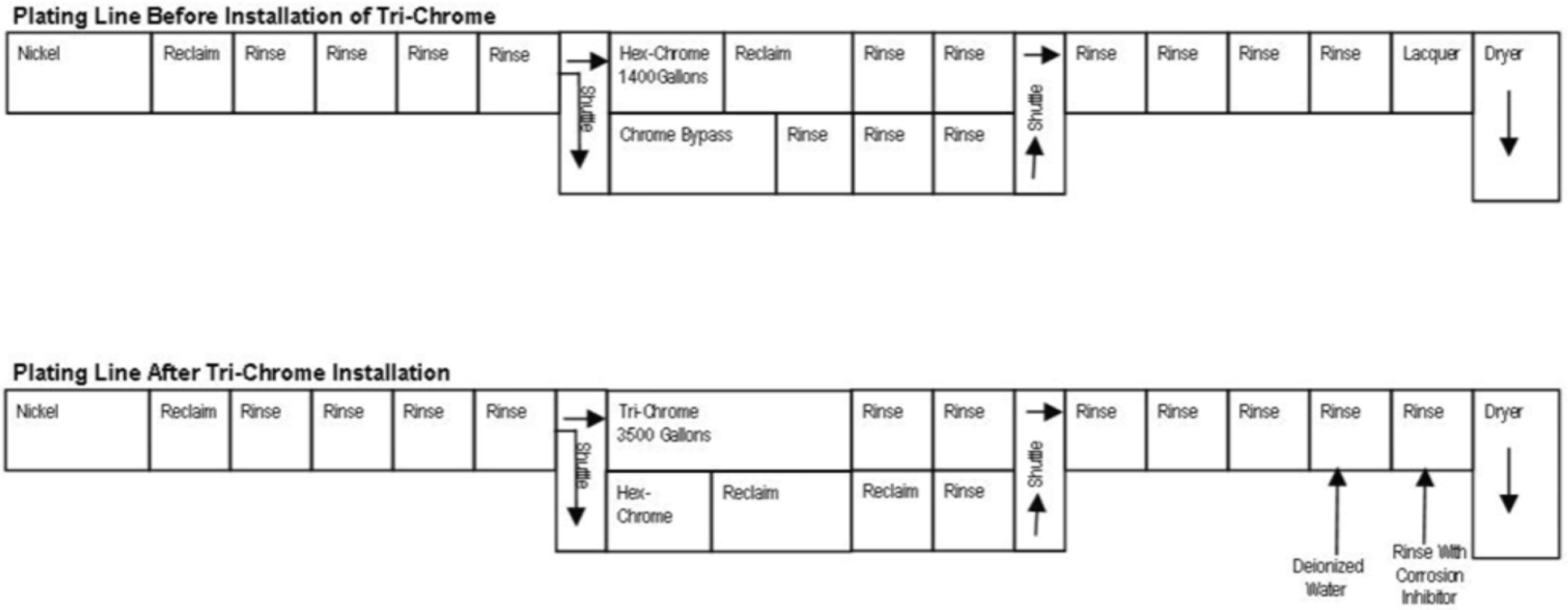
Decisions – After six months of research, Independent chose three vendors for further consideration. They sent each vendor parts that represented a range of products with which they typically work to assess the uniformity and thickness of coverage achieved, as well as their ability to closely match the bluish color of hex-chrome plated parts. Eventually, Independent decided on the vendor that provided a sulfate-based electroplating system (PAVCO, Inc.). Important factors in this decision included consistency of coverage, ability to most closely match the color of their customer's parts, operating cost savings (the sulfate system uses approximately one half the electric energy required for the chloride-based system), and vendor support.

Design – Compared with hex-chrome, tri-chrome takes approximately three times as long, at a reduced electric current (i.e., 3 minutes at 50 ASF) to achieve the desired thickness. Independent was able to modify one of its plating lines for the tri-chrome installation in a way that allowed them to meet the requirements of their customers and get the proper thickness of coverage. Specifically, the process flow was redesigned by moving from a 1400 gallon tank (for the hex-chrome system) to a 3500 gallon tank for tri-chrome (see Figure 1.1).



The new tank was built in-house, which resulted in significant savings and allowed them to control the design and installation process. In addition, Independent was able to modify an existing line to run either hex-chrome or tri-chrome (see Figure 1.2), thereby cutting down on the time and costs of the project. This also allowed them to pilot the tri-chrome system without any interruption to service for their customers.

Figure 1.2


Plating Line Before Installation of Tri-Chrome
Nickel
Reclaim
Rinse
Rinse
Rinse
Rinse
Shuttle
Hex-Chrome 1400 Gallons
Reclaim
Rinse
Rinse
Chrome Bypass
Rinse
Rinse
Rinse
Shuttle
Rinse
Rinse
Rinse
Rinse
Lacquer
Dryer
Plating Line After Tri-Chrome Installation
Nickel
Reclaim
Rinse
Rinse
Rinse
Rinse
Shuttle
Tri-Chrome 3500 Gallons
Rinse
Rinse
Hex-Chrome
Reclaim
Reclaim
Rinse
Shuttle
Rinse
Rinse
Rinse
Rinse
Rinse
Dryer
Deionized Water
Rinse With Corrosion Inhibitor

Equipment Specification – Independent worked closely with PAVCO to choose the appropriate process operating and control equipment. Specifically, the choice of automatic amp meter feeder and bath filter was vital to assure consistent quality and uniformity of the new plating process, and reduced much of the guesswork in maintaining correct process parameters. Much of the equipment required for the new tri-chrome system (e.g., filters, rectifiers, etc.) was already available in-house at their Worcester facility, which helped keep costs down.

Installation – With the dedication and hard work of Independent's facilities staff and finishing line operators, installation of the new tank and equipment into the existing plating line went as anticipated and was completed without any interruption of service. The total time required to redesign the process flow and complete tank fabrication and installation was approximately 8 weeks.

Training – Independent worked closely with PAVCO to train its lab personnel and metal finishing managers. The new system uses a dual pump amp meter feeder for automatic bath make-up additions. It was essential for operators to know how to properly use the automatic pH and temperature controllers, and analyze the tri-chrome bath for contaminant drag out and build up in the tanks. Operators were also trained in use of the new rectifier settings to improve the current density of the tri-chrome process. Performance training focused on maximizing the throwing power of tri-chrome, visually inspecting parts to detect potential chrome burn (characterized by white or yellow spots on the plated surface) and modifying racking procedures to maximize rack densities. Overall, Independent found that their line operators required very little training to master the new tri-chrome system.

Results

Product Quality

Upon implementation of the new tri-chrome system Independent immediately noticed a reduction in rejects associated with whitewash and chrome burning. With tri-chrome they were able to virtually eliminate the need for color buffing. In addition to the reduction in reject rate, the superior throwing power and coverage of the tri-chrome system resulted in improved quality. The key factor, however, has been their ability to closely match the color of final products required by their customers. This color matching allows customers to easily commit

Typical product with nickel trivalent chromium plating

to the switch from the hex-chrome plated parts to the new tri-chrome plated parts. Additionally, the increased throw of the tri-chrome bath means better plating coverage on part crevices, internal openings and penetrations, thus improving overall product quality.

A unique capability of this new line is its ability to run a variety of parts through at the same time and to increase the overall racking density without fear of developing chrome burn. Although not yet realized due to the large size of parts currently being finished, Independent anticipates that they may be able to increase the number of parts per load by 15% or more once the size range of parts processed in this system expands. In addition, the superior rinsing characteristics of the tri-chrome system allow them to reduce most of the cleaning steps further improving process throughput potential.

O&M Costs

Independent has experienced increased costs associated with maintenance and analysis with the new tri-chrome line. The filters on the tri-chrome line turn over 3500 gallons of solution five times an hour, resulting in the need for frequent filter maintenance and cartridge replacement. In addition, although an automatic amp meter feeder is used for additions to the tri-chrome bath, analysis of the bath concentration and make-up needs to be performed twice daily (as opposed to the weekly analysis associated with the previous hex-chrome system).

Impurities

Trivalent chromium baths tend to be more sensitive to metallic impurities than hexavalent chromium baths. One of Independent's main concerns was its ability to minimize metal impurities, specifically iron, in the tri-chrome bath. They also needed to watch for a buildup of hex chrome, which can result from ionic conversion of tri chrome in the bath from the anodes. Impurities are removed from the Independent system using hydrogen peroxide as a precipitating agent followed by filtration. However, addition of too much peroxide in the bath can lead to an increase in sludge formation that impacts subsequent waste treatment steps.

New tri-chrome line showing movable isolation wall

In addition, due to the configuration of the Independent line with hex- and tri-chrome baths running in parallel (see Figure 1.2), they were concerned about the possibility of hex-chrome carrying over into the tri-chrome bath. To reduce the potential for this contamination they designed a movable isolation wall that was installed between the two tanks.

Wastewater Treatment and Hazardous Waste Generation

There are important advantages associated with converting from hex-chrome to tri-chrome. Trivalent chemistries use lower concentrations of chromium in the bath, generally 5-7.5 g/L of trivalent chromium compared to 130-225 g/L for hexavalent chromium. Therefore, much less chromium enters the wastewater treatment process. Potential exposure of workers to toxic chemistries is also significantly reduced.

Moreover, the reduction step associated with converting the highly toxic hexavalent chromium to trivalent chromium in wastewater treatment process is not required. This eliminates the need for reducing agents like sodium bisulfate and additional acid for pH control, and significantly reduces the volume of sludge produced. In addition, anodes in hex-chrome systems deteriorate over time, creating an additional source of hazardous solids in the waste stream. The tri-chrome process produces approximately one-tenth the sludge volume of the hex-chrome system, which significantly reduces associated hazardous material handling and disposal costs.

Comparison Data

The following table summarizes key data associated with the two systems:

	Trivalent Chrome	Hexavalent Chrome
Chromic Acid (oz/gal)	1.15	30.73
Current/Duration	50 ASF for 3 min	150 ASF for 1 min
Operating Temperature (range)	126° F (122° to 136°)	105° F (86° to 122°)
Plating Time Per Part	20 seconds	80 seconds
Treatment Chemical Costs: Sodium Metabisulfite Sodium Hydroxide	 N/A N/A	 $0.55/lb $0.55/lb
Estimated Chemistry Costs per Square Foot of Part Plated	$0.04	$0.02
Anode	Iridium-oxide coated titanium (40”x 65”)	Lead
Equipment/Maintenance: Anode Replacement Filter Cartridge Replacement Automatic Pump Feeder	 18-24 months Every 2 weeks Every 5 years	 40+ years N/A N/A
Reject Rate	Low (white wash and burning not likely)	As much as 15% (tendency to white wash or burn)

Conclusions

Independent Plating has a philosophy of staying ahead of regulatory restrictions, responding to customer demands, and optimizing the safety of its occupational environment while continuing to maintain its competitive edge. With an emphasis on source reduction and relying heavily on researching and implementing new safer and greener alternatives, they have successfully demonstrated the ability to shift their nickel chrome plating line from the use of hex-chrome to tri-chrome. As they continue to work with customers to convert specific product lines to the new tri-chrome process, Independent has had no customer complaints with respect to color or coverage quality.

Although the operational costs associated with tri-chrome are higher than those for hex-chrome, Independent is finding that as they gain more experience with tri-chrome, its costs are still coming down. Moreover, improved product quality, reduced reject rate, and the increasing desire for 'green' products among its customers is helping Independent gain an ever-more-important market advantage.

Independent intends to increase its use of tri-chrome and other potential alternatives to hex-chrome, with a goal of complete elimination of hexavalent chromium in the next several years. It is not a simple conversion, however, and requires the commitment and dedication of skilled operators and engineers to be successful. It also requires constant communication with customers to demonstrate that this safer process can produce the quality and reliability they demand. This is a challenge that Independent Plating has been willing to make – for its employees, for its customers, and for the environment.

To learn more about Independent Plating's metal finishing capabilities or to discuss how your facility might be able to implement similar process modifications to reduce your use of hexavalent chromium, contact Mike Nahorniak, General Manager, 508-756-0301 ext. 100, or mike@independentplating.com

For more information about the Toxics Use Reduction Institute Industry Incentive Grants program, contact Pam Eliason, Industry Research Program Manger, at 978-934-3142, pam@turi.org.

For information about the on-site confidential technical assistance services provided by the Office of Technology and Technical Assistance (OTA), contact Bill McGowan, Technical Services Chief, at 617-626-1078 or william.mcgowan@state.ma.us