U.S. Environmental Protection Agency
Region 9 Pollution Prevention Program

Extending Metal Finishing Bath Life

INTRODUCTION

This pollution prevention (P2) project was conducted as part of a joint venture between the U.S. Environmental Protection Agency (EPA) Region 9; the Arizona Department of Environmental Quality (ADEQ); the City of Phoenix; the American Electroplaters and Surface Finishers Association (AESF); and Astroplate, Inc. (Astroplate). This partnership was created to promote P2, identify P2 technology needs, and accelerate P2 technology transfer within the metal finishing industry. Technical support for the project was provided by Tetra Tech EM Inc. (Tetra Tech). The project was funded by EPA Region 9.

BACKGROUND

Spent process baths can be a significant and costly waste stream for metal finishing facilities to manage. Numerous factors can cause a bath's performance to degrade, such as depletion or imbalance of bath chemistries and buildup of contaminants from dragin or other sources. When a bath becomes spent, it is typically batch treated on site, bled into an on-site wastewater treatment system, or containerized for off-site treatment and disposal. Frequent bath dumps lead to excessive process chemical use, increased treatment chemical use and labor requirements, and greater sludge generation.

The life of a process bath can be extended through simple process control and bath contaminant reduction techniques, resulting in significant waste reductions and cost savings for a facility. The case study in this fact sheet describes techniques that extended the life of a nickel acetate seal bath at the Astroplate metal finishing facility in Phoenix, Arizona. However, **the concepts described in this fact sheet are applicable to a variety of types of process baths.**

Cost Factors for Spent Bath Disposal

- Process chemical purchases
- Treatment chemical purchases
- Treatment labor
- Sludge disposal

Bath Life Extension Techniques

A combination of these techniques can provide improved bath performance and increased bath life:

- ✔ Reduce dragin contamination
  - Increase draining time for parts
  - Modify rack position for parts
  - Add more rinses or a spray system
- ✔ Improve bath purity
  - Use deionized (DI) water for bath makeup
  - Filter bath continuously
- ✔ Maintain bath within control parameters
  - Measure pH, temperature, and concentration daily
  - Add chemicals only when needed
- ✔ Use a bath additive, or "enhancer"

CASE STUDY: ASTROPLATE, INC.

Astroplate operates a small metal finishing facility that performs sulfuric acid anodizing and chromate conversion (chemfilm) of aluminum parts for aerospace and industrial customers. Astroplate has 23 employees, runs two shifts per day, and uses a manually-operated hoist to move parts on racks through process steps. Anodizing process operations at the facility include alkaline cleaning, alkaline etching, acid cleaning, deoxidizing, anodizing, dying, and sealing.

As a result of bath life extension techniques, Astroplate decreased generation of spent bath solution by 74%. The resulting annual cost savings is $12,130.

Anodizing is an electrolytic process in which a porous oxide surface is formed on aluminum parts to provide wear- and scratch-resistance; corrosion protection; and a decorative texture, color, and appearance. Sealing, the final process step in aluminum anodizing operations, improves the corrosion resistance of anodized surfaces by penetrating and closing the pores of the oxide layer. A good seal is clean and clear, whereas a poor seal may leave a fine film layer (known as "smut") or yellow tint on the part. Before sealing, color is

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often imparted to anodic coatings for decorative or identification purposes by impregnating the pores with dyes or mineral pigments. Nickel acetate solution is the most commonly used seal for dyed anodic coatings because of its ability to retain the color of the dye.

Tetra Tech performed a P2 assessment at the Astroplate facility in August 1996 and identified spent nickel acetate solution as a frequently generated and costly waste. Astroplate operates a single, 560-gallon nickel acetate seal bath. Nickel acetate sealing follows dye operations (primarily black dye) and is the final process step on Astroplate's anodizing line. Astroplate dumps the nickel acetate bath when smut begins to form on sealed parts. On-site batch treatment records indicated that the nickel acetate bath was dumped an average of 2.3 times per month, resulting in about 1,290 gallons of spent nickel acetate solution being generated each month. Because spent nickel acetate baths were treated more often than other process baths, they accounted for a significant portion of the facility's wastewater treatment costs and sludge generation. Each month, Astroplate spent about $470 for process chemicals, $380 for treatment chemicals, $450 (nine hours) for labor, and $80 (150 pounds) on sludge generated from treating spent nickel acetate baths (see Figure 1).

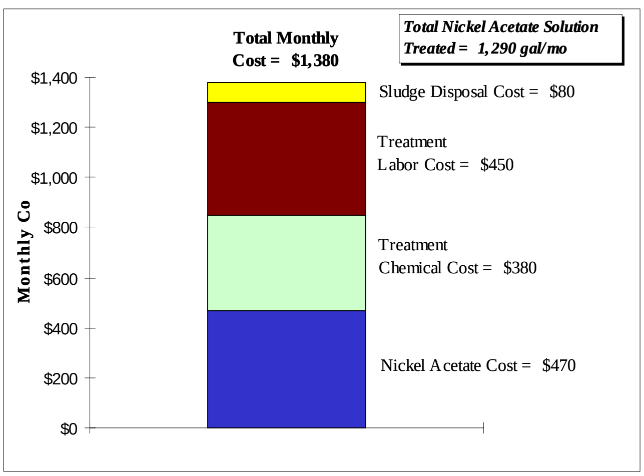

Figure 1. Nickel Acetate Bath Monthly Costs

Based on an evaluation of facility process operations, Tetra Tech and Astroplate determined that frequent nickel acetate bath dumps were the result of (1) inadequate process control, and (2) dragin from preceding process operations that contaminated the bath. Consequently, the strategy for extending nickel acetate bath life focused on (1) maintaining process bath control, (2) decreasing bath contamination, and (3) using a bath additive.

MAINTAINING PROCESS BATH CONTROL

A process bath that is maintained "in control" performs better and longer than a bath whose operating parameters are not maintained within specific ranges. Operating parameters that may affect bath performance include (1) concentration, (2) pH, and (3) temperature. Astroplate uses Anoseal 1000, which is manufactured by Novamax Technologies, Inc., of Atlanta, Georgia, as the nickel acetate bath chemical. At the time of the P2 assessment, Astroplate performed nickel acetate bath dumps based on visual observation of sealed parts, did not measure any bath parameters, and did not make any chemical additions to the bath.

Following the P2 assessment, Astroplate began to monitor and record the concentration, pH, and temperature of the nickel acetate bath. Initially Astroplate maintained these parameters within the chemical manufacturer's recommended ranges, but the facility eventually determined the best operating parameters for its own process application. Astroplate maintained the concentration of the bath at 1.5 to 2.5 percent nickel acetate by making chemical additions as needed. Astroplate determined that maintaining the concentration in this range resulted in acceptable seal quality while reducing nickel acetate chemical use.

Astroplate maintained the bath pH between 5.8 and 6.0 by lowering the pH with acetic acid and raising it with dilute ammonium hydroxide. Astroplate also maintained the temperature of the bath at 155 to 165 °F. The facility operated the bath below the temperature range recommended by the chemical manufacturer to reduce evaporative water loss and minimize part heating, which reduces streaking and spotting on parts as they are transferred to the rinse.

DECREASING BATH CONTAMINATION

At the time of the P2 assessment, Astroplate's nickel acetate bath was being contaminated by black dye dragin and city water used for bath makeups and additions. To decrease bath contamination, Astroplate (1) installed a continuous filtration system on the nickel acetate bath, (2) used DI water to make up new nickel acetate baths, and (3) modified the rinse system on the preceding black dye operation to include spray rinses. Each of these techniques is described below. The tive

Nickel Acetate Seal Process Bath Control

Parameter	Chemical Manufacturer's Recommended Range	Astroplate's Control Range	Measurement Frequency	Measurement Method
Temperature	185 to 190 °F	155 to 165 °F	Daily	Meter
pH	5.8 to 6.0	5.8 to 6.0	Daily	Meter
Concentration	3.0 to 4.0%	1.5 to 2.5%	Every 2 days	Titration

Figure 2. Nickel Acetate Bath Filtration System

costs of implementing each of these techniques are included in the Costs section on the last page of this fact sheet.

Filtration: Filtration is used to remove suspended solids in the process solution that may gradually build up and impair the nickel acetate seal. A filtration system also circulates the process solution, which maintains a uniform bath temperature and concentration. Filtration systems are sized according to solids loading and flow rate and are available with in-tank and external configurations. Astroplate installed an external filtration system manufactured by Serfilco, Ltd., on the nickel acetate bath (see Figure 2). The filtration system housing holds six cartridge filters, and a centrifugal pump continuously circulates solution through the system. To prevent pump damage when the cartridges become fully loaded, Astroplate installed a pressure-sensitive, automatic shutoff switch on the filtration system. Astroplate uses 20-micron cartridge filters in the system that are replaced about once per week. Spent filters are cleaned in an acid strip bath and disposed of appropriately.

Installing an automatic shutoff on the filtration system prevents the pump from burning out when the filters become heavily loaded or clogged.

DI Water: Originally Astroplate used city water to make up new nickel acetate baths. However, using DI water for bath makeups minimizes the introduction of compounds often found in city water that can decrease bath quality. For example, laboratory analysis indicated that tap water in Phoenix had an average concentration of 14 milligrams per liter of silicate, a compound that can decrease nickel acetate bath life. After the P2 assessment, Astroplate installed a DI water system manufactured by Pure Rain Technologies. About 420 gallons of DI water is used to make up each new bath. In addition, DI water is added to the bath in order to make up for evaporative losses.

Spray Rinses: Dragin of process chemicals from preceding operations was a major source of nickel acetate bath contamination. The P2 assessment determined that dragin could be reduced by improving preceding rinse operations. Originally, after anodizing, parts were processed in the black dye tank and rinsed in a single, flowing rinse before being sealed. Although the rinse water flow rate was 3.6 gallons per minute, black dye was dragged in at a rate high enough to discolor the nickel acetate bath and give it a gray tint. Following the P2 assessment, Astroplate added a spray rinse tank before the black dye flowing rinse to reduce black dye dragin (see Figure 3). The spray rinse also allows Astroplate to (1) collect concentrated black dye rinse water for return to the black dye bath, which reduces black dye chemical use, and (2) operate the flowing rinse at a lower flow rate, which reduces water and sewer fees. Spray system components were obtained from Ewing Irrigation and Industrial Products of Phoenix, Arizona. The spray system features recessed nozzles whose configuration protects them from damage by racks. In addition, check valves are used to maintain water pressure in the pipes connected to the nozzles so that the spray pattern develops quickly when the system is turned on. The spray system is activated by a foot pedal.

USING A BATH ADDITIVE

Additives are available for some process baths to replenish lost chemicals and to introduce chemical agents that boost bath performance. After the P2 assessment at the facility, an additive was identified that is specifically designed to prolong the life of nickel acetate seal baths. The additive, which is called Novaseal Enhancer and is manufactured by Novamax Technologies, Inc., adds wetting and dispersing agents to improve seal quality and prevent smut and white powder formation on parts. The additive also produces a hydrophobic anodic coating that helps water to run off parts, thus minimizing water spotting. Astroplate adds an average of 1.3 gallons of this additive to the nickel acetate bath every week; the exact amount added in a given week depends on the observed seal quality.

COSTS

The capital and operation and maintenance (O&M) costs associated with modifying Astroplate's nickel acetate seal operation are shown in Table 1. These costs are representa-

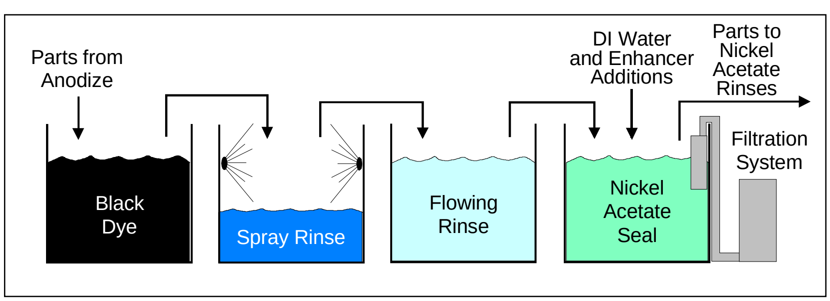

Figure 3. Modified Black Dye and Nickel Acetate Seal Process Operations

Capital Costs				O&M Costs	
Filtration System		**Spray System**		**Spray System**	
Housing	$1,100	Tank liner	$911	Labor	$50/week
Filters (6)	$59	Nozzles (30)	$225	**Filtration System**	
Pump	$870	Check valves (6)	$17	Labor	$25/week
Pressure switch	$115	Piping	$112	**Bath Additive Addition**	
Motor starter	$101	Pressure reducer	$46	Chemical	$30/week
Hose and fittings	$258	Foot valve	$133	Labor	$25/week
Installation labor	$300	Installation labor	$1,200		
Total	$2,803	Total	$2,644		
DI Water					
System and installation	$403	***Total Capital Costs = $5,850***		***Total Annual O&M Costs = $6,760***	

Table 1. Nickel Acetate Bath Life Extension Costs

implementation costs for the P2 techniques used by Astroplate, except for the cost of the spray system tank liner. Astroplate needed the tank liner to reinforce an old plastic tank used for the spray rinse. Therefore, the total cost for Astroplate's spray system may be higher than for a typical spray system.

RESULTS

Before implementing bath life extension techniques, Astroplate dumped its nickel acetate bath an average of 2.3 times per month (or about once every 2 weeks), resulting in a 1,290-gallon spent nickel acetate solution waste stream each month (see Figure 4). Astroplate implemented bath life extension techniques in two phases. Phase 1 involved process bath control and bath additive use. These techniques were implemented first because of their low capital costs and ease of implementation. The Phase 1 efforts decreased the average bath dump frequency to 1.5 dumps per month (or about once every 3 weeks).

Phase 2 involved filtration system, DI water, and black dye spray rinse system use. These techniques required more time to implement because they involved equipment selection, purchasing, and installation. After Phase 2 implementation, the average bath dump frequency decreased to 0.6 dump per month (or once every 7 weeks); the total amount of spent nickel acetate solution generated each month decreased by 950 gallons to an average of 340 gallons per month. As a result of the Phase 1 and 2 efforts, the facility's generation of spent nickel acetate solution decreased by 74 percent. During Phase 1 and 2, no major changes in facility production levels occurred. The decrease in nickel acetate chemical use, treatment chemical use, treatment labor, and sludge disposal resulted in an annual cost savings of $12,130 for Astroplate. The resulting environmental benefit is a decrease of 56 pounds per year of nickel released in treatment sludge or discharged in wastewater.

Astroplate will realize additional cost savings through return of black dye spray rinse water to the black dye bath and reduced rinse water use in the black dye flowing rinse. The cost to make up the 550-gallon black dye bath at the facility is $930. Astroplate can reduce its black dye purchase cost by as much as $150 per month by returning the spray rinse water to the process bath.

As a result of bath life extension techniques, Astroplate decreased generation of spent nickel acetate solution by 74%. The resulting annual cost savings is $12,130.

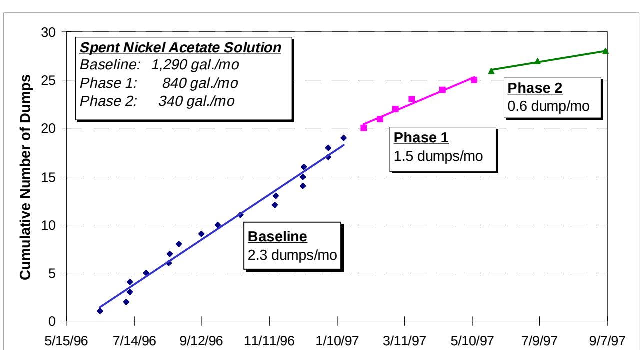

Figure 4. Nickel Acetate Bath Dump Frequency and Volume

Bath Life Extension Results

	Per Month Before	Per Month After	Annual Savings
Nickel Acetate Chemicals	26 gal	6.8 gal	$4,140
Treatment Chemicals	$380	$100	$3,360
Treatment Labor	9 hours	2.4 hours	$3,960
Sludge Generated	150 lb	39 lb	$670

Annual Savings = $12,130/yr

Capital Cost = $5,850

Annual O&M Cost = $6,760/yr

Payback Period = Capital Cost/(Savings-O&M Cost)**= 1 yr**

For more information on this case study or EPA Region 9 P2 projects, contact the following individuals:

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