MODIFYING TANK LAYOUTS TO IMPROVE PROCESS EFFICIENCY

The Merit Partnership is a joint venture between U.S. Environmental Protection Agency (EPA) Region 9, state and local regulatory agencies, private sector industries, and community representatives that was created to promote pollution prevention (P2), identify P2 technology needs, and accelerate P2 technology transfer within various industries in southern California. One of these industries is metal finishing, which is represented in the Merit Partnership by the Metal Finishing Association of Southern California (MFASC). Together, MFASC, EPA Region 9, and the California Manufacturing Technology Center (CMTC) established the Merit Partnership P2 Project for Metal Finishers. This project involves implementing P2 techniques and technologies at metal finishing facilities in southern California and documenting and sharing results. Technical support for this project was provided by PRC Environmental Management, Inc. The project is funded by the Environmental Technology Initiative and EPA Region 9, and is implemented, in part, through the National Institute of Standards and Technology with CMTC.

INTRODUCTION

The layout of metal finishing process tanks and rinse tanks plays an important role in overall process efficiency as well as in waste generation. At most metal finishing facilities, process lines evolve as tanks are added, removed, or become obsolete because of production demands and development of new process chemistries. Over time, process changes can result in inefficient tank layouts, which often limit or complicate many P2 opportunities, particularly closed-loop recycling technologies.

This case study illustrates the benefits of evaluating conditions at your facility and considering tank layout changes before pursuing other P2 opportunities. Modifying tank layouts can significantly improve production efficiency in terms of raw material use, water use, and throughput; reduce waste generation; and facilitate application of chemical recovery technologies.

ALL METALS PROCESSING COMPANY

All Metals Processing Company (All Metals) is a small job shop in Burbank, California, that performs cadmium, bronze, and zinc electroplating and black oxide coating for aerospace and other industrial customers. All Metals employs 15 workers, and its facility has about 8,000 square feet of space for plating operations.

All Metals uses about 7,800 gallons of water per day, most of which is used for rinsing operations. Wastewater containing metals and cyanide flows from rinse tanks to the on-site wastewater treatment system (WWTS). In addition, dragout and water from rinse tanks that spill onto the floor drain to a sump from which they are pumped to the WWTS. The WWTS currently generates about 680 pounds of filter cake per month, which is disposed of in an off-site hazardous waste landfill. Treated wastewater is discharged to the publicly owned treatment works (POTW). At the beginning of the project, **All Metals indicated that its goals were to reduce water use and eliminate wastewater discharges by installing chemical recovery systems.** In cooperation with the Merit Partnership, All Metals agreed to evaluate its process tank layout in order to reduce the contaminant load and wastewater flow from rinse operations before consulting with technology vendors.

"Bottom Line" Impacts of Dragout

High process solution losses through dragout will:

- ✗ Increase the quantities of plating chemicals used
- ✗ Increase rinse water use or decrease rinsing quality
- ✗ Increase wastewater generation
- ✗ Increase the quantities of WWTS treatment chemicals used
- ✗ Increase the quantity of filter cake generated
- ✗ Potentially increase the metal concentration in the WWTS discharge

These process inefficiencies increase shop operating costs and decrease profits!

California Manufacturing Technology Center

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

MFASC

OCTOBER 1996

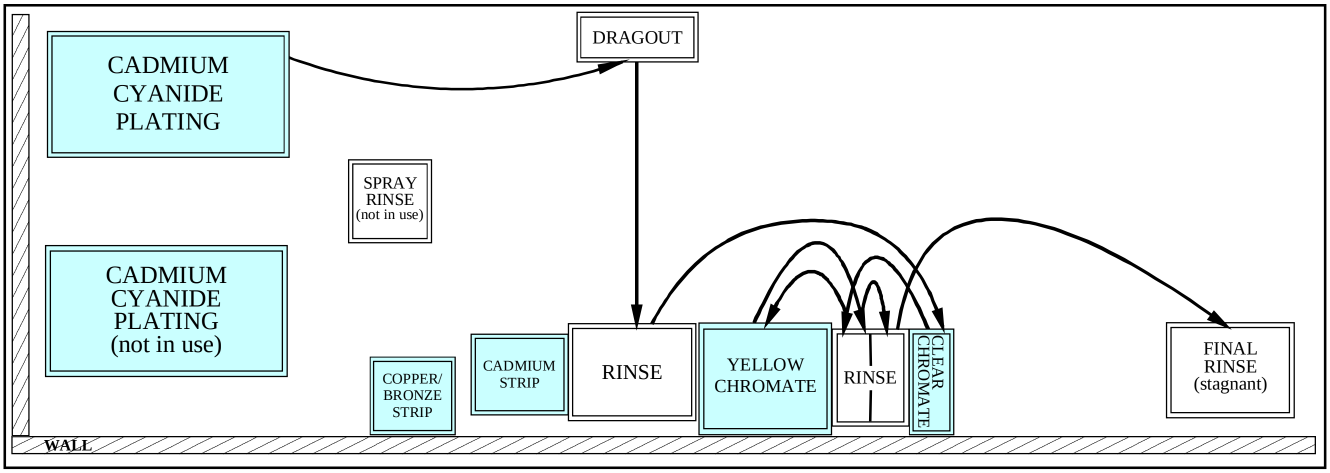


Figure 1. Original Tank Layout with Work Flow Indicated by Arrows

CADMIUM ELECTROPLATING LINE: ORIGINAL LAYOUT

All Metals selected the cadmium electroplating line for a tank layout evaluation because it is the most frequently used process line and because dragout from this line contributes the largest quantity of metals to the wastewater. The original cadmium electroplating line layout and work flow are shown in Figure 1. After alkaline soak cleaning and acid etching, the cadmium electroplating line consists of the following three processes: (1) cadmium cyanide electroplating, (2) bright dip (chromic acid-based), and (3) chromate conversion. Each process bath is followed by one or more rinses.

Based on its evaluation, the Merit Partnership determined that the original tank layout resulted in the following:

High Dragout Losses: Only one dragout tank and no spray rinses were used in the original tank layout to recover process solution dragout. Consequently, dragout was lost to single-stage rinses that discharged to the WWTS. Dragout was also lost to the floor because of large spaces between tanks.

High Rinse Water Use: The single-stage rinses required a high rinse water flow rate to maintain adequate rinse quality.

Inefficient Work Flow: Work flow overlap and backtracking increased worker fatigue, decreased process throughput, and contributed to dragout loss to the floor.

Process Solution Mixing in a Shared Rinse Tank: A shared rinse tank resulted in process solutions from two operations mixing in the rinse tank, which negatively impacted rinse quality and prohibited potential recovery and recycling of the process solutions.

CADMIUM ELECTROPLATING LINE: MODIFIED LAYOUT

The Merit Partnership used a computer program called *Perfect Rinsing* to (1) model the effects of adding tanks to the cadmium electroplating line and changing tank configurations, (2) estimate the benefits of these changes, and (3) determine the preferred tank layout. *Perfect Rinsing*, which is produced by Finishing Technology of Kennelon, New Jersey, is designed to simulate metal finishing rinsing operations. Specifically, the program computes key rinsing parameters, including

Features of the Modified Cadmium Electroplating Line

- A spray rinse tank after the cadmium plating tank
- A spray rinse tank after the chromate conversion tank
- Two-stage counterflow rinse tanks in place of single-stage rinse tanks
- A counterflow rinse tank after the bright dip tank
- Straight line process flow for plating and rinsing operations
- No unused tanks

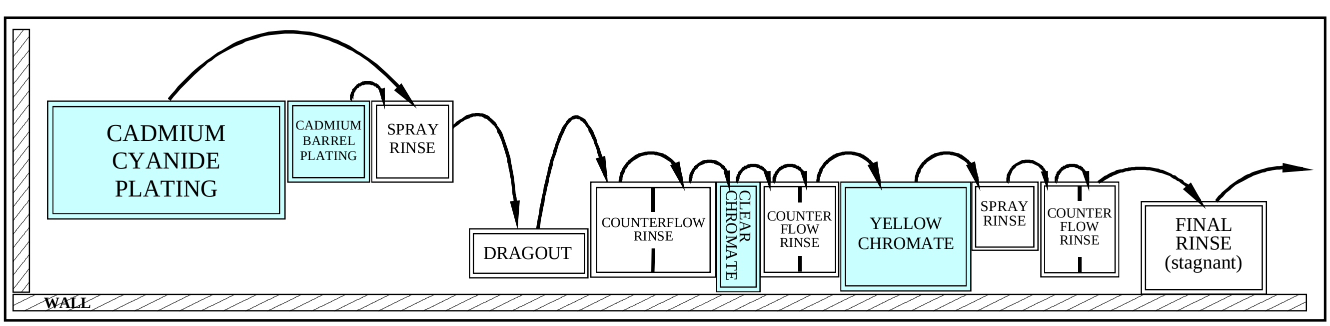


Figure 2. Modified Tank Layout with Work Flow Indicated by Arrows

concentrations of process chemicals in the rinse tank and the process chemical discharge rate, based on input parameters such as the dragout rate, process bath chemical concentration and evaporation rate, rinse water flow rate, and number and configuration of rinse tanks. The Merit Partnership determined the dragout rate on the cadmium electroplating line by measuring the increases in the metal concentrations in the rinse tank for each rack of parts plated. *Perfect Rinsing* assumes complete mixing and steady-state conditions of water in the rinse tank.

The Merit Partnership modeled several alternative rinse tank configurations for the cadmium electroplating line by changing the type and number of rinse tanks used and the rinse water flow rates. Comparisons were then made of the total rinse water flow rates, the total dragout losses, and the rinse quality in the rinse tanks of the original and alternate configurations. With allowance for the physical constraints at All Metals, such as available floor space, and the nature of the production processes on the cadmium electroplating line, the preferred tank layout was selected, and tank layout modifications were made (see Figure 2).

ESTIMATED IMPACT OF TANK LAYOUT MODIFICATIONS

The modified tank layout allows All Metals to (1) recover and reuse process solution dragout, (2) reduce rinse water flow, (3) improve rinsing, (4) implement more efficient work flow, and (5) lower concentrations of metals being discharged to the POTW. *Perfect Rinsing* results for the original and modified layouts are shown in Figures 3 and 4 for cadmium plating and chromate conversion, respectively, and are discussed below.

Recovery and Reuse of Process Solution Dragout: The spray and dragout rinse tanks collect concentrated solutions that are used to replenish process baths. The spray rinse tanks added after the cadmium cyanide plating and chromate conversion tank are expected to reduce process solution losses 50 percent by (1) removing dragout left on parts before they reach the running rinses and (2) using the dragout to replenish the process baths. Process solution recovery will also be improved because less dragout is lost to the floor between tanks. The reduction of process solution dragout is expected to result in a 50 percent decrease in the quantity of WWTS filter cake generated by treating wastewater from the cadmium electroplating line.

Figure 3. *Perfect Rinsing* Results: Cadmium Plating

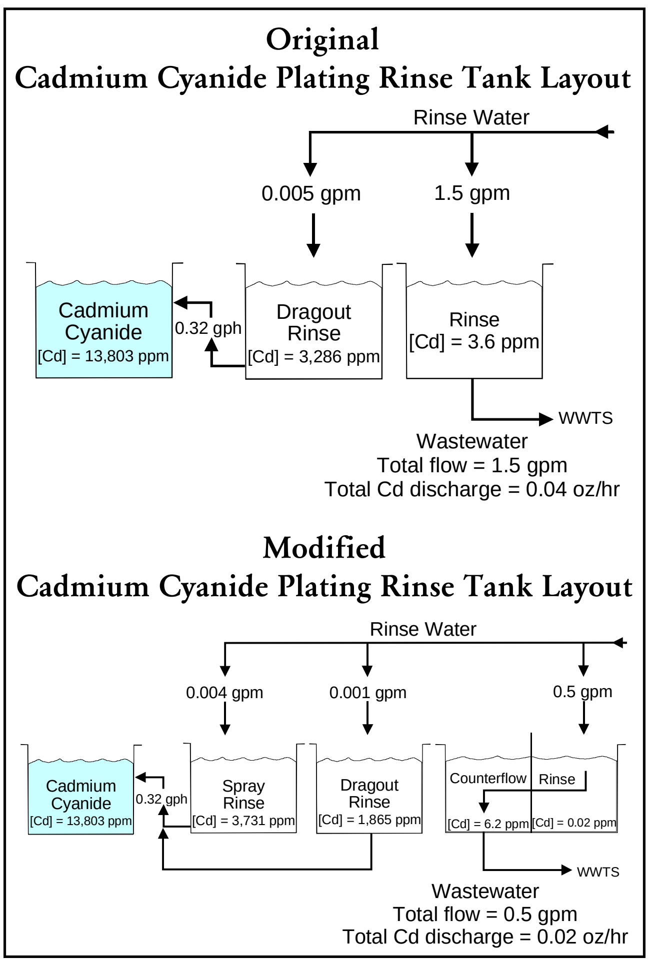
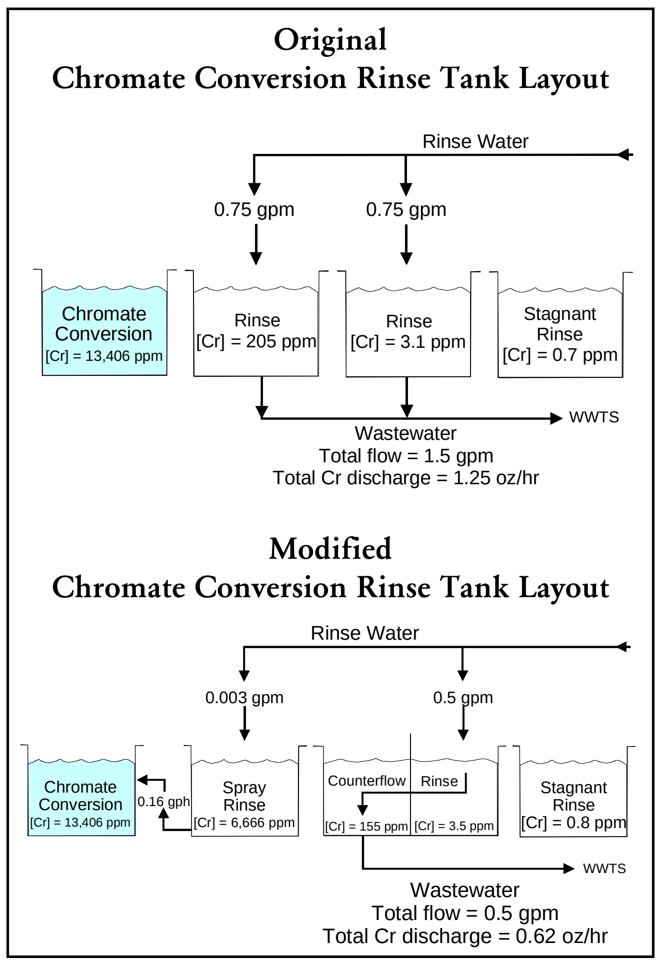


Figure 4. *Perfect Rinsing* Results: Chromate Conversion



Tank Layout Modification Results			
	Before Modification	After Modification	Cost Savings
Cadmium Cyanide Dragout	18 gal/mo	9 gal/mo*	$400/yr
Chromate Conversion Dragout	123 gal/mo	62 gal/mo*	$180/yr
Rinse Water	31,700 gal/mo	15,800 gal/mo	$360/yr
Sewer Fee	31,700 gal/mo	15,800 gal/mo	$1,440/yr
WWTS Chemicals		Not Quantified	
WWTS Filter Cake	200 lb/mo	100 lb/mo*	$240/yr

Total Cost Savings = $2,620/yr
Total Cost = $4,520
Payback Period = 1.73 years

*Estimated from *Perfect Rinsing* results

Reduced Rinse Water Flow: All Metals significantly reduced rinse water flow by installing counterflow rinse tanks. Two-stage counterflow rinses theoretically require 97 percent less water than single-stage rinses to achieve comparable rinse quality. Spray rinses and dragout tanks also reduce the total rinse water flow required for effective rinsing. Although *Perfect Rinsing* results indicated that flow rates of less than 0.25 gallon per minute (gpm) could be used for the counterflow rinses, All Metals conservatively installed 0.5-gpm flow restrictors on its three rinse tanks in place of the 1.5-gpm flow restrictors originally used on the two rinse tanks of the original layout. The combined reduction in dragout and rinse water flow results in a reduction of the quantities of wastewater treatment chemicals used.

> ***"Since implementing the tank layout changes, our wastewater treatment chemical use has declined by 60 percent."***
>
> Tim Roach
> Manager, All Metals

Improved Rinsing: As shown in Figure 3, the concentration of cadmium in the last cadmium cyanide rinse tank is estimated to have decreased by 99 percent, which results in a dramatic increase in rinsing quality. Such a change improves overall process efficiency, reduces the numbers of reject parts, and reduces dragin to other process baths.

More Efficient Work Flow: Repositioning the tanks decreased the amount of worker time and effort required to move parts through the cadmium electroplating line. As a result, All Metals has the capacity for increased process throughput.

Number of Footsteps Needed for Cadmium Line Electroplating

Before Modification:	58
After Modification:	21

Lower Concentrations of Metals in WWTS Discharge: The concentrations of cadmium and chromium discharged from the WWTS to the POTW are expected to decrease as a result of dragout reduction and process chemical recovery. This will help All Metals consistently meet its cadmium and chromium discharge limits, which will result in a cost savings by reducing paperwork and fines paid for permit violations.

COSTS

The capital costs for the tank layout modifications included $2,000 for two used counterflow rinse tanks and $600 for two new spray rinse tanks. Costs for ancillary materials such as plumbing hardware were not recorded; however, these costs were not significant. Therefore, the total capital cost for the tank layout modification was $2,600. Modifications were performed by three shop workers in about 8 days and the total labor cost for modifying the tank layout was $1,920. No operation and maintenance (O&M) activities are needed for the modified tank layout beyond those required for the original layout. Therefore, no additional O&M costs are being incurred as a result of the tank layout modifications.

THE NEXT STEP: CHEMICAL RECOVERY TECHNOLOGIES

By reducing dragout and rinse water flow rates through tank layout modifications, metal finishing facilities can more cost-effectively apply chemical recovery technologies. By modifying its tank layout for the cadmium electroplating line, All Metals reduced dragout and rinse water use at the point of generation, segregated rinses, and maximized production efficiency. All Metals is now evaluating technologies to recover process chemicals from wastewater for reuse in the process tanks. In addition, these technologies also usually generate clean water that can be recycled into the rinse tank for reuse. Potential chemical recovery technologies include reverse osmosis, ion exchange, vacuum evaporation, and electrowinning.

Chemical Recovery System Design Parameters		
	Before Modification	After Modification
Cadmium Loading	0.04 oz/hr	0.02 oz/hr
Chromium Loading	1.25 oz/hr	0.62 oz/hr
Wastewater Flow Rate	3.0 gpm	1.0 gpm

Dragout and wastewater flow reductions resulting from tank layout modifications will enable All Metals to purchase a smaller chemical recovery system, which will require less capital costs.

For more information on this case study or the Merit Partnership, contact the following individuals:

Laura Bloch (EPA Region 9)	at	(415) 744-2279
John Siemak (CMTC)	at	(310) 263-3097
Dan Cunningham (MFASC)	at	(818) 986-8393
Tim Roach (All Metals)	at	(818) 846-8844

Assistance for this fact sheet was provided by
PRC Environmental Management, Inc.