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Project Summary

Chromate Recovery from Chromating Rinsewater in the Metal-Finishing Industry

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The recovery system evaluated in this study combines various aspects of vacuum evaporation and flash distillation. It provides a continuous supply of good quality rinsewater to the chromating line at the Quality Rolling and Dehurring Co. (QRD). Recirculation prevents nearly 450,000 gal of water from going to waste every year. Contaminants removed from the circulating water include chromium, zinc, and other dissolved solids. Contaminants are concentrated in a tiny waste stream (one 55-gal drum) and disposed of. Because QRD uses three different chromate formulations on a single chromating line, this concentrate could not be reused. At plants that use a single formulation, reuse should be possible. Because wastewater (requiring treatment) is not generated, the recovery system reduces operating costs. At QRD, the return on investment was sufficient for the initial capital outlay to be recovered in approximately 4 yr.

This Project Summary was developed by EPA's National Risk Management Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The goal of the U.S. Environmental Protection Agency's (EPA) 33/50 Program is to promote voluntary reductions in the release of hazardous chemicals by 33% by the end of 1992 and by 50% by the end of 1995. One objective of the EPA 33/50 Program is to evaluate, in a typical workplace environment, examples of prototype or innovative commercial technologies that have potential for pollution prevention. Support for this program also was provided by the Connecticut Hazardous Waste Management Service (CHWMS). The goal of this study was to evaluate the technical, pollution prevention, and economic issues involved in using a recovery system to recover the rinsewater from the chromating line in a metal finishing plant. Chromium is a hazardous metal targeted for early reduction under the EPA's 33/50 Program. The recovery unit tested was manufactured and provided by Cellini Purification Systems, Inc.[1] Similar units with varying capabilities may be available from other vendors.

The site for the testing was QRD Co., a medium-size metal finishing plant, in Thomaston, CT. QRD has operated the chromating line with the recovery system for about 1 yr. The recovery system configuration at QRD is shown in Figure 1. QRD uses three different chromate formulations — blue, clear, and yellow — on the chromating line. The chromating line receives a variety of parts (from QRD's customers) that first are zinc-plated and then chromated.

Contamination accumulates mainly in the Rinse 1 Tank, which functions as a

[1] Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

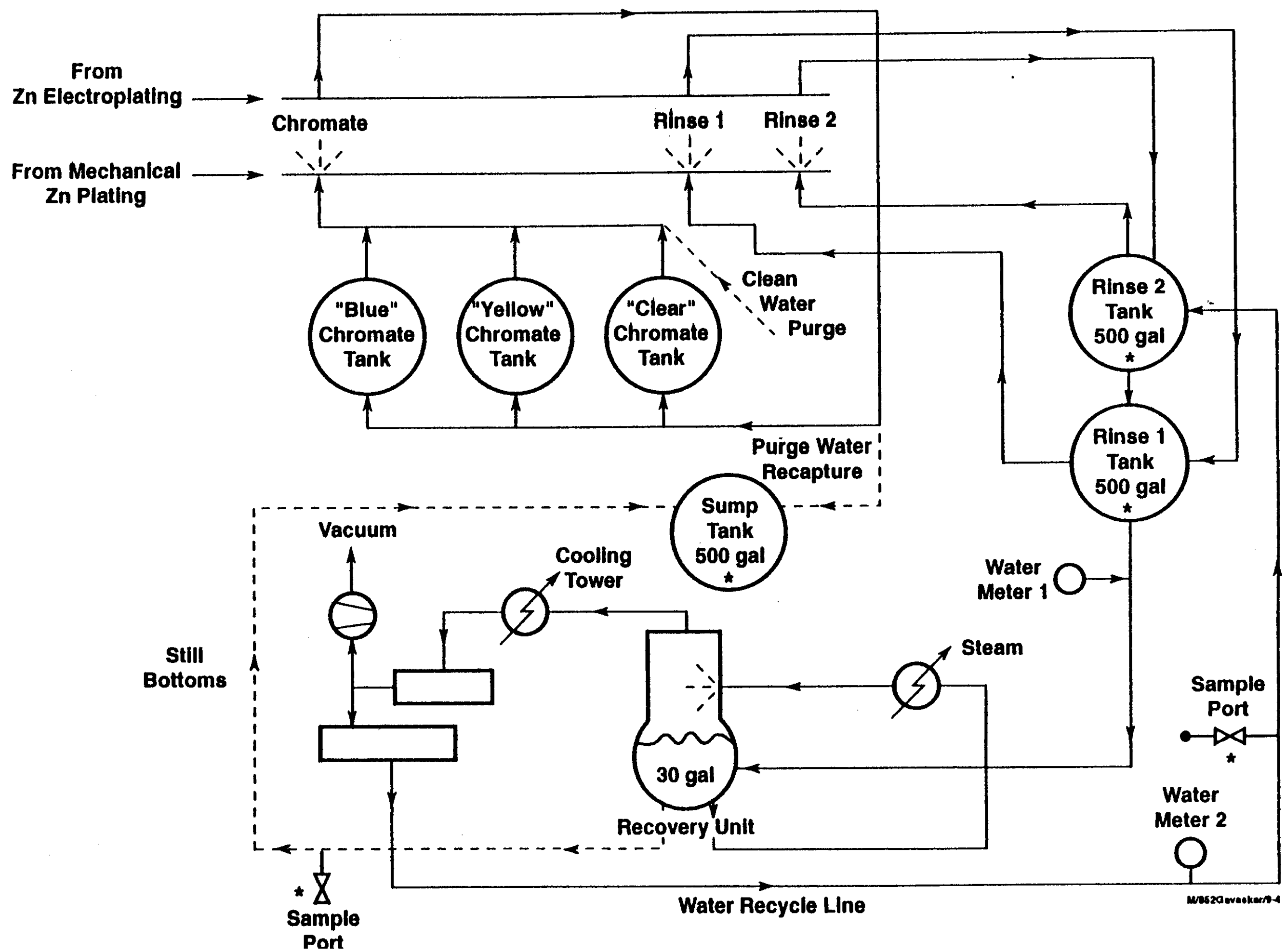

Figure 1. *Chromating rinsewater recovery system. (Sampling locations marked by an asterisk.)*

dragout rinse. This contaminated water is processed through the recovery unit at an average rate of 1 gal/min. The water is first drawn into the recovery unit still. The contents of the still are recirculated through a steam heat exchanger and a spray nozzle back into the column of the still. The water is heated to 110°F before it goes through the spray nozzle and is flash-distilled under vacuum. In the column, the down-flowing liquid returns to the bottom of the still and the distillate vapor rises upward and is later condensed by a water-cooled condenser. The condensate is stored in a small side tank, from which it is returned periodically by level control to the Rinse 2 Tank, which is the clean, final rinse. The recovery system is fully automated and integrated into the chromating line and requires very little operator attention.

The chromating line operates for 1 shift/day, but the recovery unit remains on 24 hr/day so that the rinsewater gets additional cleaning after the contaminant contribution from the chromating line stops. Approximately 50 gal/day of fresh tap water is added into the Rinse 2 Tank to make up for evaporative losses. Once every 3 or 4 wk, the still bottoms are evacuated into the sump tank. The sump tank also stores the rinsate generated when the chromate lines are purged before a formulation switch. When the sump tank is full, QRD plans to process its contents through the recovery unit and concentrate it down to around 55 gal. This 55 gal of concentrate containing chromates can be either reused or disposed of as hazardous waste. QRD does not reuse it because it contains a mixture of three different chromate formulations. Other plants that use only a single formulation may be able to reuse the concentrate.

Testing was conducted over one shift (6 hr of continuous chromating line operation) and on the following morning before the next day's shift. Samples were collected periodically from the locations shown by asterisks in Figure 1.

Product Quality Evaluation

Rinsewater quality was monitored throughout the shift, and the results are shown in Table 1. Water quality in Rinse 1 continues to deteriorate as the contribution from the dragout increases. Contamination in the Rinse 2 Tank is maintained at very low levels by the periodic influx of clean processed water from the recovery unit. As the Rinse 2 Tank gets full, some water is transferred manually into Rinse 1 to simulate a countercurrent flow through the rinses. Overnight processing, while the chromating line is not operating, helps to reduce contamination further, as observed in the 8:00 a.m. sample collected the next morning. Plants that operate the chromating line three shifts per day will not have the benefit of this additional overnight processing, and contaminants may accumulate to levels slightly higher than those shown for Rinse 2 in Table 1, until an equilibrium state is reached.

Processed water coming out of the recovery unit (before it reaches the Rinse 2 Tank) was also sampled and analyzed (Table 2). A tap water sample was collected and analyzed for comparison. The recovery unit reduced contamination of chromium and zinc in the processed water to levels slightly above levels in the fresh (tap) water supply. Because tap water at QRD normally is high in dissolved solids, the recovery unit was able to reduce the total dissolved solids (TDS) level to below that in the tap water. Small amounts of acidic components in the chromate solution transfer over into the distillate as seen from the low pH of the processed water. This, in turn, progressively reduces the pH in the Rinse 2 Tank (Table 1). The low pH is not a concern in this operation.

Table 3 shows the characterization of the still bottoms and the chromate solutions. The contaminants that are removed from the rinsewater can be noticed accumulating in the still bottoms. From this table, it can be seen that if the still bottoms materials is concentrated further, the chromate concentrations would ultimately reach those in the chromate tanks. If only one formulation were being used, the final concentrate could have been returned to the chromate tanks. Zinc and dissolved solids levels in the still bottoms are still relatively low to be of concern during reuse.

Pollution Prevention Evaluation

Without the recovery system, QRD would maintain a continuous 5 gal/min flow of fresh water to Rinse 2 (clean final rinse). The overspray in Rinse 2 would be collected and sprayed in Rinse 1 (dragout). After Rinse 1, the water would be taken to the on-site wastewater treatment plant. For one 6-hr shift/day, 5 days/wk, 50 wk/yr operation, 450,000 gal of wastewater

Table 1. *Water Quality in Rinse Tanks*

Sample No.	*Time*	*Cr mg/L*	*Zn mg/L*	*TDS* mg/L*	*Cond. µmhos/cm*	*pH*
<u>Rinse 1 Tank</u>						
W-R1-1	*9:30 a.m.*	*2.57*	*4.5*	*48*	*60*	*4.39*
W-R1-2	*11:00 a.m.*	*12.0*	*23.5*	*162*	*200*	*4.20*
W-R1-3	*12:30 p.m.*	*29.5*	*61.0*	*372*	*475*	*4.08*
W-R1-4	*2:00 p.m.*	*14.6*	*32.5*	*273*	*340*	*4.30*
W-R1-5	*3:30 p.m.*	*24.7*	*53.2*	*374*	*450*	*4.14*
W-R1-6	*8:00 a.m.†*	*8.91*	*26.1*	*196*	*312*	*4.46*
<u>Rinse 2 Tank</u>						
W-R2-1	*9:30 a.m.*	*0.21*	*0.4*	*42220*		*280 6.47*
W-R2-2	*11:00 a.m.*	*0.435*	*1.15*	*174*	*190*	*7.11*
W-R2-3	*12:30 p.m.*	*0.589*	*1.50*	*141*	*180*	*6.85*
W-R2-4	*2:00 p.m.*	*0.843*	*3.28*	*119*	*160*	*5.22*
W-R2-5	*3:30 p.m.*	*1.35*	*3.97*	*88*	*130*	*4.56*
W-R2-6	*8:00 a.m.†*	*0.593*	*2.42*	*28*	*55*	*3.90*

** Total dissolved solids.*
† Next day.

Table 2. *Processed Water Quality*

Sample No.	*Time*	*Cr mg/L*	*Zn mg/L*	*TDS* mg/L*	*Cond. µmhos/cm*	*pH*
W-PW-1	*9:30 a.m.*	*0.235*	*0.338*	*30*	*55*	*3.88*
W-PW-2	*11:00 a.m.*	*0.348*	*0.592*	*32*	*60*	*3.76*
W-PW-3	*12:30 p.m.*	*0.437*	*0.793*	*42*	*80*	*3.63*
W-PW-4	*2:00 p.m.*	*0.445*	*0.796*	*31*	*80*	*3.68*
W-PW-5	*3:30 p.m.*	*0.482*	*0.870*	*9*	*80*	*3.71*
W-TW-1†	*12:30 p.m.*	*0.079*	*0.291*	*250*	*400*	*6.39*

** Total dissolved solids.*
† Field blank consisting of tap water supply at QRD.

Table 3. *Characterization of Distillation Still Bottoms and Chromate Tanks*

Sample No.	*Time*	*Cr mg/L*	*Zn mg/L*	*TDS* mg/L*	*Cond. µmhos/cm*	*pH*
Still Bottoms						
C-SB-1	*9:30 a.m.*	*162*	*258*	*2,280*	*2,700*	*3.52*
C-SB-2	*12:30 p.m.*	*168*	*277*	*2,240*	*2,500*	*3.59*
C-SB-3	*3:30 p.m.*	*216*	*385*	*3,170*	*3,200*	*3.80*
C-SB-4	*8:00 a.m.†*	*224*	*420*	*3,610*	*4,000*	*3.95*
Chromate Tanks						
Blue	*2:00 p.m.*	*1,254*	*1,739*	*16,740*	*12,000*	*2.57*
Yellow	*2:00 p.m.*	*1,471*	*15*	*3,590*	*15,000*	*1.55*
Clear	*2:00 p.m.*	*3,860*	*0.743*	*25,110*	*28,000*	*2.87*

† Next day.
** Total dissolved solids.*

(requiring treatment) would be generated annually. Not only would QRD have to accommodate this new influx of wastewater; the sludge generated in their treatment plant would have to be handled and disposed of as hazardous waste because of the presence of chromium. By using the recovery system, QRD not only saves nearly 450,000 gal of water, but also prevents the creation of a large, new, hazardous waste stream. Instead, it generates only about four drums of still bottoms concentrate that has to be disposed of. This waste concentrate can be avoided through reuse by plants that use only one formulation. QRD adds approximately 50 gal of fresh water to the Rinse 2 Tank daily to make up for evaporative losses in the system.

Economic Evaluation

Table 4 lists the major costs of operating with and without the recovery system. The recovery unit provides a savings in annual operating costs of $23,082. QRD's recovery unit cost $78,000 with an additional $9,000 cost for installation and auxiliary equipment (such as cooling tower, piping, etc.). A payback period of 4 yr was estimated at QRD for the investment.

Conclusions

The recovery system at QRD prevents the generation of large volumes of wastewater and hazardous sludge that otherwise would result from the chromating operation. Further pollution prevention would be possible at plants that use only one formulation, through potential reuse of the chromium contained in the still bottoms concentrate. Rinsewater quality is maintained at acceptable levels throughout the shift without adding large volumes of fresh water. By eliminating wastewater treatment costs, considerable savings are realized at QRD that result in a reasonable payback period.

This system has potential for use in many applications that generate wastewater. One concern is the relatively high energy (steam) consumption of the recovery unit. Future versions of this system are focusing on reducing this energy requirement.

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Table 4. *Major Operation Costs Comparison*

Item	Annual Amount	Unit Cost, $	Annual Cost, $
Without Recovery System			
Water (rinse)	450,000 gal	4.65/1,000 gal	2,093
Wastewater treatment	450,000 gal	88.00/1,000 gal	39,600
		TOTAL	41,693
With Recovery System			
Water (rinse, makeup)	12,500 gal	4.65/1,000 gal	58
Water (cooling, makeup)	12,500 gal	4.65/1,000 gal	58
Waste disposal	55 gal	350.00/55 gal	350
Energy			
- electricity	60,950 kW hr	0.068/kW hr	4,145
- steam	3,000,000 lb	0.004/lb	12,000
Maintenance	—	—	1,200
Labor	100 hr	8.00/hr	800
		TOTAL	18,611

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***Lisa Brown** is the EPA Project Officer (see below).*
The complete report, entitled "Chromate Recovery from Chromating Rinsewater in the Metal-Finishing Industry," (Order No. PB95-243044; Cost: $17.50, subject to change) will be available only from:
National Technical Information Service
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Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
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