U.S. Environmental Protection Agency

Concurrent Technologies Corporation

# ETV VERIFICATION STATEMENT

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| **TECHNOLOGY TYPE:** | **ELECTROCOAGULATION** | | |
| **APPLICATION:** | **METAL FINISHING WASTEWATER** | | |
| **TECHNOLOGY NAME:** | **Kaselco POSI-FLO Electrocoagulation Treatment System** | | |
| **COMPANY:** | **Kaspar Electroplating Company** | | |
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The United States Environmental Protection Agency (EPA) has created the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by substantially accelerating the acceptance and use of improved, cost-effective technologies. ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations, stakeholder groups consisting of buyers, vendor organizations, and states, with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

Concurrent Technologies Corporation operates the ETV Metal Finishing P2 Technologies (ETV-MF) Pilot, one of 12 technology focus areas under the ETV Program, in cooperation with EPA's National Risk Management Research Laboratory. The ETV-MF Pilot has evaluated the performance of a wastewater treatment system for processing of wastewater from metal finishing operations. This verification statement provides a summary of the test results for the Kaselco system.

## VERIFICATION TEST DESCRIPTION

The Kaselco Electrocoagulation Treatment System (Kaselco system) in combination with an ion exchange polishing system were tested, under actual production conditions, processing metal finishing wastewater at Gull Industries in Houston, Texas. The verification test evaluated the ability of the combined treatment system to remove regulated contaminants from the wastewater and recover the wastewater for reuse.

Testing was performed during treatment of three batches of wastewater, with each batch approximately equaling the average volume of wastewater generated daily at Gull Industries. Samples were collected of the raw wastewater, intermediate streams, final treated wastewater, and process residuals, including sludge. Chemical usage, electricity usage, and labor data were collected to perform the cost analysis.

## TECHNOLOGY DESCRIPTION

The Kaselco system is a series of tanks and associated equipment used to process industrial wastewater containing dissolved metals and organics such as oil. Wastewater is initially processed by electrocoagulation and subsequently passes through de-foam, thickener, and clarification tanks. The unique aspect of the Kaselco system is the electrocoagulation step. Electrocoagulation is a process that uses electricity (direct current) and metal plates to cause metal contaminants in wastewater to become destabilized and precipitate. The current flow causes the steel anode plates to dissolve slowly, thereby releasing ferrous ions into the wastewater. The ferrous iron that is dissolved in the wastewater chemically reacts with the hexavalent chromium and reduces it to the trivalent state. During this reduction process, the iron is converted to trivalent iron hydroxide and other compounds. A co-precipitation effect occurs in which the iron hydroxide adsorbs heavy metal cations (e.g., nickel) onto its surface. Electrolysis gases are separated from the wastewater in the de-foam tank, which is agitated by a mechanical mixer. A polymer is added to improve floc formation as the wastewater exits the de-foam tank. The wastewater is then transferred through a sludge thickener to a conventional clarifier where solids separation takes place. The overflow from the clarifier is discharged to a storage tank. The underflow from the clarifier and thickener are dewatered on a filter press and sent off-site for recovery or disposal.

At Gull Industries, an ion exchange polishing system is used after electrocoagulation to further process the wastewater. The ion exchange polishing system consists of three skid-mounted, ion exchange pressure vessels, with interconnecting piping and control valves. It is also equipped with a PC-based control system. Wastewater exiting the ion exchange system is reused by Gull Industries for rinsing on their electroplating line.

## VERIFICATION OF PERFORMANCE

Verification testing was performed November 26-30, 2001. The performance of the Kaselco in combination with an ion exchange system was evaluated with respect to key operating and performance criteria. The results of these analyses are summarized below.

**Pollutant Removal Efficiency.** Average pollutant concentrations and removal percentages measured during a three-batch operation of the Kaselco and ion exchange systems are shown in **Table i**. Note that the clarifier discharge is not the same as the ion exchange influent due to the fact that a holding tank between the two systems could not be completely discharged. The parameters listed in this table are regulated under current metal finishing effluent standards [Ref. 1] and/or are found in the proposed Metal Products and Machinery (MP&M) rule [Ref. 2]. The Kaselco system effectively removed 98.8 percent or greater of each pollutant found in the influent above detection limits except for total organic carbon (TOC) and manganese. These two parameters are not regulated by metal finishing standards, but are proposed parameters in the MP&M rule. The ion exchange system removed 98.3 percent or greater of each pollutant parameter found in the influent above detection limits.

| Parameter | Kaselco System Avg. Results | | | Ion Exchange System Avg. Results | | |
|---|---|---|---|---|---|---|
| | Avg. Raw Wastewater mg/L | Avg. Clarifier Discharge mg/L | % Removal* | Avg. IX Influent mg/L | Avg. IX Effluent mg/L | % Removal* |
| **Sulfide** | ND | ND | - | ND | ND | - |
| **O&G (HEM)** | ND | ND | - | ND | ND | - |
| **TOC** | 32.7 | 21.6 | 33.9% | 19.6 | 0.3 | 98.3% |
| **Cadmium** | 0.002 | ND | 100% | ND | ND | - |
| **Chromium (T)** | 69.9 | 0.2 | 99.6% | 0.28 | ND | 100% |
| **Chromium +6**[1] | 30.1 | ND | 100% | 0.09 | ND | 100% |
| **Copper** | 2.15 | 0.02 | 99.0% | 0.05 | ND | 100% |
| **Lead** | 1.26 | ND | 100% | 0.02 | ND | 100% |
| **Manganese** | 0.29 | 0.39 | NR | 0.74 | ND | 100% |
| **Molybdenum** | ND | ND | - | ND | ND | - |
| **Nickel** | 114.0 | 1.4 | 98.8% | 5.2 | ND | 100% |
| **Silver** | ND | ND | - | ND | ND | - |
| **Tin** | 0.150 | ND | 100% | ND | ND | - |
| **Zinc** | 2.85 | ND | 100% | 0.12 | ND | 100% |

ND = not detected
*Batches 1&2 Only because of a potential analytical error in batch 3
NR=not reported due to increase in effluent.
*Percent removals are calculated only for pollutants found above detection limits in the raw or influent wastewater. Nondetects in discharges were considered to be zero.

**Table i. Averaged Pollutant Concentrations and Removal Percentages**

**Ability to Meet Metal Finishing and Proposed Target Effluent Levels.** The results from each set of analytical data were compared to the applicable metal finishing (40 CFR 433) and proposed MP&M limitations (66 FR 423) to determine if the Kaselco and ion exchange systems achieved these standards. For the Kaselco system, the metal finishing limitations were met for all parameters for each batch of wastewater treated. The Kaselco system also met the proposed MP&M limitations for all parameters with the exception of manganese during treatment of batch 1. The proposed MP&M limit for manganese is 0.25 mg/L; and the Kaselco clarifier discharge for batch 1 contained 0.509 mg/L Mn. For the ion exchange system, the metal finishing limitations and proposed MP&M limitations were met for all parameters for each batch of wastewater treated.

**Reusability of Treated Wastewater.** The reusability of the treated wastewater as process water was determined by comparing the results of the specific conductance and total dissolved solids (TDS) analytical tests of the ion exchange system effluent to standards used by Gull Industries for water reuse. Treated water meeting these standards was deemed reusable. The Gull Industries standards are:

- Specific conductance: maximum of 500 µS
- TDS: maximum of 250 mg/L

For wastewater batches 1, 2 and 3, the combined Kaselco/ion exchange polishing system met the Gull Industries water reuse criteria. The highest conductance found after treatment was 19.6 µS; the highest TDS level was 56 mg/L. During the period of testing, it was observed that Gull Industries reused the water produced by the combined Kaselco/IX system as rinse water on their electroplating line.

**Sludge Generation.** Thickener and clarifier underflow from the Kaselco system are dewatered using a filter press. The volume of sludge generated from the filter press after the treatment of 3 batches of wastewater (10,333 L) was 65.4 L (2.31 $ft^3$). On a flow-normalized basis, the quantity of sludge generated was 6.2 L/1,000 L (0.85 $ft^3$/1,000 gal). Analytical results show that the sludge had a specific gravity (bulk density) of 1.20. The calculated weight of the sludge was 78.5 kg (172.6 lbs.). On a weight percentage basis, the sludge contained the following percentages of metals: 10.5 percent Fe, 1.5 percent Ni, and 0.5 percent Cr. Other metals were found in lower concentrations.

**Additional Pollutant Removal.** The additional pollutant removal of the combined Kaselco/ion exchange polishing system installed at Gull Industries was measured by determining the quantity of regulated pollutants removed beyond the level required by the current metal finishing regulations (40 CFR 433). The overall additional pollutant removal from use of the combined Kaselco/ion exchange polishing system was a reduction of 126.5 g of regulated metals for the three batches of wastewater treated during the test. On an annual basis (260 days/year), assuming 3,400 L of wastewater treated per day, the reduction in regulated (current and proposed) metals in wastewater discharged is projected to be 10,822 g/yr.

**Energy Use.** The power consumption of the Kaselco system is 17.9 kWh/1,000 L (67.9 kWh/1,000 gal.) of wastewater processed. The power consumption of the ion exchange system is 0.67 kWh/1,000 L (2.54 kWh/1,000 gal.) of wastewater processed.

**Cost of Operation.** The following parameters were considered in the cost analysis: chemical reagents, steel plates, other materials (e.g., filters), electricity, labor, and sludge management. The cost of treatment for the Kaselco system, excluding labor, was $6.06/1,000 L ($22.91/1,000 gal.) and $18.18/1,000 L ($66.85/1,000 gal.), including labor. Labor costs were affected by design of the system tested. The installed system at Gull Industries is a batch system. Kaselco also manufactures automatic, continuous flow systems that would be less labor intensive. The cost of treatment for the ion exchange system, excluding labor, was $2.77/1,000 L ($10.47/1,000 gal.) and $3.91/1,000 L ($14.79/1,000 gal.), including labor.

## SUMMARY

The Kaselco system effectively treated electroplating wastewaters containing hexavalent chromium, nickel, and other regulated parameters during the test. Hexavalent chromium reduction was achieved over a wide pH range (2.9 to 6.0), without adjusting the pH or adding reducing reagents, other than the iron contributed by dissolving steel anodes. Further, the electrocoagulation process caused the pH to increase as hexavalent chromium reduction took place, to within a suitable range for metals precipitation. A polymer was added following the electrocoagulation step to congeal precipitated metals.

The discharge from the Kaselco system met the 40 CFR 433 metal finishing standards for all parameters. Because of the Kaselco system's design, iron and manganese are added to the wastewater and subsequently precipitated and removed as sludge along with other parameters. The manganese concentration in the clarifier effluent was above the proposed MP&M limitation for one of the three batches of wastewater treated during the test. With this one exception, the discharge from the Kaselco system met the proposed MP&M standards for all parameters. Thickener and clarifier underflow from the Kaselco system are dewatered using a filter press. The volume of sludge generated from the filter press after the treatment of 3 batches of wastewater (10,333 L) was 65.4 L (2.16 $ft^3$).

The ion exchange polishing system effectively removed regulated pollutant parameters down to below detection limits. The effluent from the ion exchange system meets the water use criteria at Gull Industries, and it is recycled to the electroplating line.

The combined Kaselco/ion exchange polishing system provides a significant environmental benefit by removing regulated metal parameters well below required limits. On an annual basis, at Gull Industries the benefit would be a reduction of 10,822 g (23.8 lbs) of regulated metals discharged.

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