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Project Summary

Evaluation of New and Emerging Technologies in the Metal Finishing Industry

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A research program was completed to identify new and emerging waste management technologies in the metal finishing industry. A limited field sampling and analytical program was pursued to define performance at full scale operating facilities for the following technologies:

1. **Buoyant media filtration – 3M***
2. **Zerpol® zero liquid discharge**
3. **Zerpa distillation solvent recovery**

Information was developed regarding cost, performance, safety, and applicability of these technologies. A preliminary evaluation of the processes based on the limited testing indicated potential applications for all three processes in segments of the metal finishing industry.

This Project Summary was developed by EPA's Water Engineering 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

Enactment of federal legislation over the preceding decade has resulted in the implementation of extensive pollution management programs in the electroplating and metal finishing industry. Effluent limitations and pretreatment standards have been established for a number of toxic metals (Cd, Cr, Cu, Pb, Ni, Ag, Zn), cyanide, total toxic organics (TTO), oil and grease, total suspended solids (TSS), and pH.

Although the effluent standards are based on application of a specific technology, the individual discharger has the option to select an alternative method of treatment. New processes for treatment of metal finishing wastes and/or recovery of valuable wastewater components have been developed in response to the environmental legislation and regulations of the preceding decade. The U.S. Environmental Protection Agency (EPA) and The American Electroplaters' Society, Inc., (AES) have been involved in many studies to define the performance of promising techniques and to distribute the information to the affected segments of the metal finishing industry. These technologies offer great environmental benefits by improving existing processes and by enhancing industry's ability to meet applicable standards while minimizing adverse economics impacts. This project represents a continuation of this cooperative effort between EPA and AES.

The principal objectives of the research program were to identify and evaluate in a preliminary manner new technologies which could be considered as alternatives to existing waste management practices in the metal finishing industry. Attention was directed toward methodologies with the potential for treating industrial liquid effluent and residual solvent and solids streams. The objective was to evaluate the effectiveness and potential of these emerging technologies for applicability on an industry-wide scale. In some cases, the technologies incorporated a novel mod-

*Mention of trade names or commercial products does not constitute endorsement or recommendation for use

ification to a component of a conventional precipitation process; thus it was not mandatory that the candidate technologies be entirely free of the chemical precipitation treatment method.

Procedure

The research program was initiated in May 1983 with an aggressive effort to solicit the metal finishing industry for information regarding new technologies. A limited number of the latter were selected to be characterized by means of field sampling and analysis. The candidate technologies were evaluated on the basis of the following criteria:

1. Technical merit
   - Energy requirements
   - Cost of technology
   - Degree of applicability
   - Anticipated performance
   - Safety considerations
2. Technical probability of success
   - Current level of demonstration
   - Technical barriers
   - Legal constraints
3. Cost of sampling and analysis program

Determination of eligibility for participation in the field characterization phase of the research centered on the criteria used to define "new" and "emerging" technologies. Well-established technologies were, therefore, precluded from this analysis. The requirement for completion of field sampling and analysis at an operating metal finishing facility eliminated additional technologies that were not sufficiently developed to locate full- or pilot-scale treatment systems. The decision to restrict consideration to new and emerging technologies at a specific stage of development was consistent with the objectives and requirements of this research program. Elimination of a technology from consideration did not reflect or imply any adverse judgment regarding the merit of the technology.

Three technologies were evaluated in the field by means of a limited sampling and analysis program:

1. Buoyant media filtration – 3M
2. Zero liquid discharge – Zerpol®
3. Distillation solvent recovery – Zerpa

Results and Discussion

Buoyant Media Filtration

Buoyant media filtration refers to a granular bed filtration process in which liquid passes in an upflow mode through a media which has a density less than the density of the filtrate. The media is held in place below the liquid surface by a retaining screen. Backwash of the media is achieved by reversal of the flow and subsequent fluidization of the media. This flow reversal is accomplished by gravity withdrawal of fluid from the bottom of the filter unit.

The particular media examined in this study was manufactured by the 3M Company. The media, known as macrospheres, is available in diameters ranging from 0.3 mm to 6 mm. Potential applications of the technology include:

1. Effluent polishing following conventional clarification.
2. Replacement of conventional clarification.
3. Modification of conventional clarification to include a buoyant media filter at the surface of an existing clarifier.

A production facility was surveyed which included parallel installation of a buoyant media filter and a conventional slant-tube clarifier. Comparative evaluation of the conventional and emerging technology was pursued on the basis of this side-by-side experimentation. Although both units achieved compliance with applicable effluent standards, it was determined that the buoyant media filter achieved lower effluent concentrations and reduced variation in effluent concentration in comparison to the clarifier. A summary of the data is provided in Table 1.

Table 1. Buoyant Media Filter Performance

Parameter	Clarifier	Filter
Zn		
mean, mg/L	1.69	0.79
standard deviation, mg/L	1.37	0.32
P		
mean, mg/L	2.12	0.87
standard deviation, mg/L	2.71	1.04
Cu		
mean, mg/L	0.51	0.55
standard deviation, mg/L	0.62	0.42
Fe		
mean, mg/L	0.27	0.13
standard deviation, mg/L	0.34	0.11
Cr		
mean, mg/L	0.20	0.03
standard deviation, mg/L	0.25	0.04

Zerpol®-Zero Liquid Discharge

The Zerpol® process achieves zero discharge of liquid effluent by recycle and reuse of treated effluents as rinsewater. Chemical treatment of the rinsewaters is conducted in a batch mode, with sequential treatment in a single reactor for cyanide oxidation, chromium reduction, metal hydroxide precipitation, and gravity sedimentation. A high purity rinsewater is produced by condensation of steam generated by a boiler receiving a portion of these treated rinsewaters as feed. The condensate is used for critical rinsing operations, and the remaining treated effluent is used for other rinsing operations. Residual salts and solids are removed from the system as boiler blowdown and metal hydroxide sludge, respectively.

Three installations were surveyed which have successfully operated in a zero liquid discharge mode for more than 3 years. Data are reported in Table 2 for the two reuse streams -- the treated effluent and the condensate.

Several restrictions were noted when selecting process chemicals to maintain satisfactory product quality and boiler operation:

1. Make-up water should be softened to avoid boiler scaling problems.
2. Sodium salts should be used instead of lime for chemical precipitation to avoid boiler scaling problems.
3. Peroxide should be used instead of chlorine for cyanide oxidation to avoid spotting associated with high chloride levels in recycled rinsewater.
4. Cleaners (e.g., gluconates, soaps) that upset boiler operation should be avoided.

Zerpa Distillation Solvent Recovery

Zerpa Industries, Inc., introduced a small-scale batch distillation unit in 1981. The apparatus contains a heating element, condenser, and storage reservoir for recovered solvent. The units are available in capacities ranging from 14 to 35 gal per batch. This reduced capacity provides smaller generators with an economical alternative for solvent recovery. Applications have been reported for recovery of many solvents of interest to the metal finishing community, including freon, trichloroethylene, 1,1,1-trichloroethane, VM&P naphtha, methyl ethyl ketone, toluene, and lacquer thinner.

One facility surveyed practiced recovery of a solvent blend consisting of

Table 2. *Zerpol®-Zero Liquid Discharge*

Parameter	Treated Effluent	Condensate
Plant A		
Ca, mg/L	*2.39*	*0.16*
Mg, mg/L	*1.11*	*0.02*
Cu, mg/L	*102**	*47**
Ni, mg/L	*79*	*1.3*
Cr, mg/L	*0.83*	*0.01*
CN, mg/L	*216**	*20**
TDS, mg/L	*9553*	*703*
TSS, mg/L	*131*	*3*
pH	*9.12*	*9.46*
Plant B		
Ca, mg/L	*8.1*	*3.29*
Mg, mg/L	*5.4*	*1.34*
Cd, mg/L	*12.9*	*2.74*
Cr, mg/L	*1.2*	*1.71*
Cu, mg/L	*18.3*	*2.79*
Zn, mg/L	*13.4*	*3.25*
CN, mg/L	*3.2*	*0.5*
TDS, mg/L	*16200*	*11800*
TSS, mg/L	*21*	*14*
pH	*8.21*	*9.14*
Plant C		
Ca, mg/L	*9.09*	*0.13*
Mg, mg/L	*3.16*	*0.07*
Cd, mg/L	*17.3*	*0.16*
Cr, mg/L	*73.2*	*0.34*
Zn, mg/L	*15.0*	*0.17*
CN, mg/L	*11*	*0.3*
TDS, mg/L	*9833*	*85*
TSS, mg/L	*315*	*3*
pH	*6.85*	*9.17*

**Unrepresentative conditions resulting from heating coil leak.*

toluol, butanol, ethylene glycol mono ethyl ether acetate (cellosolve acetate), and VM&P naphtha. The solvent consumption did not exceed 100 gal per month. The recovered solvent was satisfactory for reuse in this application. Comparative data for virgin and recovered solvent are provided in Table 3.

Table 3. *Zerpa Solvent Recovery Characterization of Recovered Solvent*

Solvent Compound	As % of Total: Virgin Solvent	As % of Total: Recovered Solvent
Toluol, %	*20.2*	*25.9*
Butanol, %	*17.6*	*13.3*
Cellosolve Acetate, %	*18.1*	*21.6*
Naphtha, %	*44.0*	*38.3*

Conclusions and Recommendations

Three new technologies for management of wastes in the metal finishing industry were characterized through a limited field sampling and analysis program. The study objectives were confined to a preliminary evaluation of the technologies because of the constraints on field sampling activities. Evaluation of the processes in the specific applications selected for study may not provide sufficient information to assess applicability in all segments of the industry, but the information developed through this type of program provides a starting point for general evaluation of any new or emerging technology.

A buoyant media filtration system developed by 3M was demonstrated to achieve compliance with federal effluent guidelines when applied instead of a clarifier. The test system was subjected to significant hydraulic and solids loading fluctuations, and the buoyant media filter evidenced improved stability of operation when compared to a slant-tube clarifier. Alteration of conventional clarification systems to provide a buoyant media filter appears to be generally feasible, in which case the applicability of the process would be very significant.

Three facilities surveyed have successfully achieved zero liquid discharge for a period in excess of 3 years using the Zerpol® process. Reuse of treated effluent and condensate as rinsewater make-up did not produce problems with product quality for the chemical conditions and plating operations identified in this report. Prior operational difficulties with the boiler were reported if certain cleaners were used. Consequently, adoption of the Zerpol® process may limit flexibility in selection of chemicals in various plating and cleaning solutions. The rinsewater quality was characterized for the three facilities surveyed. The suitability of these streams for rinsewater make-up must be evaluated on a case-by-case basis for each rinsing operation.

Successful operation of a solvent recovery system for a blend containing toluol, butanol, cellosolve acetate, and VM&P naphtha was documented using a Zerpa batch distillation unit. The reclaimed solvent was acceptable as a substitute for the virgin solvent blend.

The criteria for selecting technologies restricted consideration to those processes that were recently developed. This time factor precluded examination of long-term operating data for evaluation of life cycle costs and specific long-term operating problems. This general limitation applies to all three of the technologies reported here.

With respect to the buoyant media filtration system, extended studies to evaluate media durability, alternative media, particle size distribution, and alternative backwash operation practices (frequency, duration, and hydraulic loading) would enhance system development.

Development of a complete material and energy balance for the Zerpol® process would require an extended presence. A detailed examination would be beneficial to identify energy requirements for boiler operation throughout summer and winter periods. Full characterization of boiler function and associated condensate water quality cannot be established on the basis of the limited sampling effort involved in this study. Completion of a material balance would also require data on sludge and salt production over a compositing period that corresponds with the duration of characterization of the influent and reuse stream.

Long-term operating data would be required to assess maintenance and repair costs for the Zerpa distillation unit. Such data were not readily available because of the short history of operation.

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The complete report, entitled "Evaluation of New and Emerging Technologies in the Metal Finishing Industry," (Order No. PB 85-216 562/AS; Cost: $11.50, subject to change) will be available only from:
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