United States
Environmental Protection
Agency

Risk Reduction
Engineering Laboratory
Cincinnati, OH 45268

Research and Development

EPA/600/SR-93/223 February 1994

EPA

# Project Summary

# Ultrasonic Cleaning as a Replacement for a Chlorofluorocarbon-Based System

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**The study summarized here evaluated, on a technical and economic basis, the replacement of a solvent vapor degreasing system using chlorofluorocarbons (CFC-113) with an ultrasonic cleaning system using a heated water-based cleaning fluid for cleaning stainless steel parts.**

**The intent of the substitution was to reduce fugitive volatile emissions while eliminating the use and handling of hazardous materials at the facility. The ultrasonic cleaning system was custom fabricated to meet the dimensions requirements of the parts fabricated on site. Cleaning standards for the new system were to remain consistent with the criteria used for vapor degreasing.**

**Through the utilization of an ultrasonic cleaning system, fugitive emissions have been significantly curtailed. Volatile emissions are estimated to be reduced 68% (3,450 vs. 10,876 lb/yr) over the period 1990 to 1992. This reduction was in addition to the elimination of bench top freon cleaning units at the facility, which reduced emissions from 25,215 to 10,876 lb/yr from 1987 to 1990. The elimination of 26 drums/yr of stillbottoms generated through solvent reclamation was also realized.**

**To complete the economic evaluation, the costs of raw material (cleaners), utilities, and labor was considered along with waste disposal. An annual savings, utilizing the ultrasonic cleaning system, was projected to be $27,875 with the most significant savings realized with the cost differential in raw materials because of the high cost of chlorofluorocarbon cleaning solvents. A payback period of 1.6 yr was calculated for the project.**

**Additional benefits from the emission reduction include improved working environment, reduced indoor air pollutants, and better community relations.**

***This Project Summary was developed by EPA's Risk Reduction Engineering 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 use of CFCs in vapor degreasing cleaning systems has been the accepted standard in various industries for many years. This process has been universally accepted because of the efficiency and ease with which parts are cleaned and the subsequent compliance with quality control standards for cleanliness of the parts or materials cleaned. In recent years, however, the disadvantages of this technology have become increasingly apparent — the process' generation of fugitive emissions resulting in reporting requirements under SARA Title III, concerns about employee health and safety, and increased cost and taxation of CFCs. Furthermore, CFCs are targeted for eventual elimination because of their ozone depleting characteristics.

The project objectives were to evaluate the technical feasibility, performance, economic impact, and reduction of fugitive volatile emissions resulting from the substitution of vapor degreasing with aqueous ultrasonic cleaning.

This is a study of the effectiveness and applicability of ultrasonic cleaning using a heated water-based cleaner as a means to clean stainless steel components. An evaluation was completed under the Erie County/EPA WRITE Program as a joint effort by Conax Buffalo Corp., Cheektowaga, NY; Erie County Environmental Compliance Services, Buffalo, NY; Recra Environmental, Inc., Amherst, NY; and the U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, OH.

## Procedure

The industrial participant for this program was Conax Buffalo Corporation (Conax). Conax has been engaged in the design and manufacture of highly engineered, precision products for industrial, aerospace, nuclear, fiber optic, and military applications. At Conax, stainless steel, aluminum and copper parts coated with standard screw oils, water-based coolants, inhouse shop dirt, and metal shavings are cleaned in a series of cleaning and rinsing tanks of modular design using a heated alkaline solution. Previously, cleaning activities involved the use of two types of freon-based solvents that generated more than 10,000 lb of fugitive emissions annually from two vapor degreasers and two work bench stations.

Since 1990, chlorinated solvents and chlorofluorocarbons (CFC-113) including trichloroethylene, 1,1,1-trichloroethane, trichlorotrifluoroethane (freon), and a freon/acetone mixture have been used at Conax. The CFCs are used for both degreasing parts after machining, and cleaning parts prior to assembly, shipment, or stock. Until recently, four operations within Conax utilized chlorinated solvents and CFCs. These include machining centers parts cleaning, machine shop vapor degreasing, assembly vapor degreasing, and final assembly cleaning.

Because of their ozone depleting characteristics, CFCs are targeted for eventual elimination per the 1987 Montreal Protocol and Clean Air Act. The costs of CFCs are increasing and the use of CFCs is going to be taxed. Reclamation of CFCs generates stillbottoms that are F002 hazardous waste. The ultrasonic parts cleaning system was installed to avoid and eliminate the problems associated with further CFC use.

For 2 wk in January 1992, the ultrasonic cleaning system was evaluated for 131 batches of parts ranging from large tubes to pins and from 1 to several thousand parts/batch. Because this was considered typical production, the results would be extrapolated to an annual basis. Average cleaning times and chemical addition requirements were documented, and subjective quality control inspections were done on each batch. Project forms developed for the project tracked the time in minutes for each batch at each station in the cleaning process. Clean and rinse tank pH was monitored along with the clean and heated rinse tank temperatures. The number and description of parts in each batch were also listed on another project form. Averages for processing times, pH, and temperatures were calculated along with totals for a breakout of batch part quantities from 1 to 15, 15 to 100, 100 to 1000 and 1000+ parts/batch.

The batches of tubes cleaned during the monitoring period were totaled. The 8-ft-long tubes were of particular interest due to the part configuration. To limit fugitive emissions, the surface area and working area of the vapor degreasers were limited. This required a "double dip" procedure for cleaning the 8-ft-long tubes. Because of the length of the tubes, this procedure required an extended period of CFC use resulting in greater emission generation. The ultrasonic cleaner was designed to accommodate long tubes in a "single dip" cleaning operation eliminating the emissions and facilitating smoother parts cleaning operation.

The Miraclean* system used by Conax is designed and manufactured by Chautauqua Metal Finishing Supply of Jamestown, NY. It is a modular design of cleaning and rinsing tanks, employing an aqueous cleaning agent within the ultrasonic tank to accelerate and facilitate the cleaning action (i.e., cavitation). Miraclean systems have a variety of available options such as additional rinse tanks and dryer station to meet individual customer needs.

The ultrasonic cleaning system purchased by Conax entails six cleaning stations (see Figure 1). At Station 1, small parts were placed in metal baskets for cleaning. Baskets were required to have minimal mass, be made of metal, and be of open construction to limit interference with the free passage of both sound waves and cleaning fluids. An overhead crane was used for larger, more cumbersome parts.

Station 2, the cleaning tank, contained six ultrasonic transducers mounted on the side of the tank. The tank also was designed with an interior grease trap/overflow weir and sparger system to remove insoluble oils and extend bath life.

Stations 3 and 4 are counterflow rinse tanks. A counterflow rinse was incorporated to minimize fresh water use. The rinse tanks diluted the concentration of cleaner that remained on the part after cleaning. The first rinse tank, Station 3, has an overflow weir that collects insoluble solution that remains on the part.

Station 5 incorporates a final hot rinse into the system. Heat was added to facilitate part drying subsequent to cleaning.

Station 6 provided an area for unloading parts from baskets. An air gun was provided to facilitate drying of parts with configurations that tended to retain water (i.e., dead end tap holes).

Overall dimensions of the Miraclean system are 10' x 6.5' x 3' high. Fiberglass covers were installed to retain heat, conserve energy, and reduce evaporation and humidity in the work area.

Samples of the wash tank (Station 2), rinse tank (Station 4), and final hot dip tank (Station 5) were taken to be analyzed for oil and grease and total organic carbon. Samples were taken just before changeout of the wash tank, of the wash solution after neutralization, and early in the use of fresh solution to track the concentration of organic contaminants in the system.

## Results and Discussion

### *Historical Background*

For comparison purposes, historical information on fugitive emissions reporting and hazardous waste generation was acquired from Conax. Fugitive emission data was collected from Form "R" reports. Totals for each are shown in Table 1.

A significant reduction in fugitive emissions is noted from 1987 to 1990 resulting from the elimination of bench top freon cleaning units at the machining areas. Fugitive volatile emission reductions from the 1990 efforts also resulted in the elimination of the Blakslee freon vapor degreasing unit. The Miraclean system was installed in August 1991.

A log of cleaning activity was kept for 2 wk during January 1992 (1/13-24/92). Engineers at Conax described this 2-wk period as typical of production for the facility. Information was gathered on 131 batches of parts cleaned during the 2-wk period. Average time/batch spent in the Miraclean unit is approximately 8 min. This compared well with the 7 min/cycle for the vapor degreasers.

Wastes associated with the vapor degreasing units included emissions and stillbottoms estimated at 26 drums/yr and

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

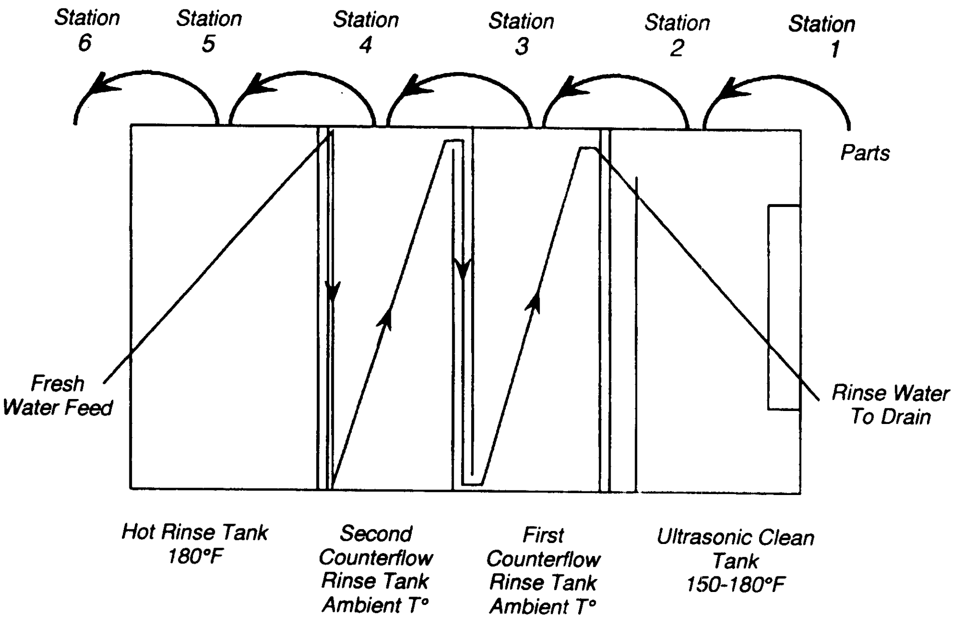


***Figure 1.*** *Conax's Miraclean System Schematic.*

***Table 1.*** *Historical and Projected Emissions and Waste Generation*

| Year | Fugitive Emissions (lb) | Hazardous Waste (lb) |
|---|---|---|
| 1987 | 25,215 | 2,670 |
| 1988 | 32,990 | 1,290 |
| 1989 | 12,819 | 4,400 |
| 1990 | 10,876 | 1,595 |
| 1991* | 6,900 | 1,890 |
| 1992† | 3,450 | 1,380 |

* *Estimated for remainder of 1991.*
† *Projected for 1992.*

1,134,000 million gal/yr of non-contact cooling water. The water-based cleaning medium used in the Miraclean system generated an estimated 1050 lb/yr of waste that, subsequent to neutralization, could be sewered along with the 567,000 gal/yr of rinsewater. Approximately 55 gal/yr (450 lb) of oil collected by the ultrasonic cleaning process was sent for fuel blending.

## Fugitive Emission Reduction

Emissions generated at Conax originated from cleaning operation at the machining centers, the assembly tables, and the Blakslee vapor degreaser. The elimination of CFC use at the machining centers by substituting aqueous cleaners into the bench top ultrasonic cleaning units reduced emissions by 14,500 lb/yr over a period from 1987 to 1990.

The elimination of the Blakslee vapor degreaser further reduced emissions to a projected total of 3,450 lb/yr for 1992, a reduction of 68% from 1990. Total volatile emission reduction projections, from 1987 to 1992, are 86% from 25,215 to 3,450 lb/yr resulting from the two operational changes.

## Economic Analysis

An economic analysis of the changeover from CFC vapor degreasing using the Blakslee unit to the Miraclean ultrasonic system utilizing an aqueous-based cleaning solution is included as part of the project.

Fixed and variable costs have been considered as part of the evaluation. Fixed costs include the cost for equipment and installation of the Miraclean system. These costs include the ultrasonic equipment, NEMA enclosure, three tank system, pumps, filter, sparger pump, tank covers, overhead crane, supplies, and labor.

Variable costs included in the economic assessment were raw materials, power costs, sewer fees, off-site disposal, water costs, and labor. Raw material cost was determined using 1990 cost data and material use supplied by Conax. Labor cost was estimated using $15/hr as a basis. Sewer fees and water cost information was supplied by Conax. Total operating costs were determined as a summation of variable costs.

A total operating cost/batch of parts cleaned was also determined for comparison.

Based on these costs, annual savings and a payback period for the new Miraclean system were calculated for the project.

The total fixed costs for the Miraclean system according to information provided by Conax was $44,411. Variables costs calculated for the two systems are listed in Table 2.

Annual savings projected using the aqueous ultrasonic system was calculated to be $27,178. This resulted in a per batch savings of $7.94 ($7.26/batch vs. $15.20/batch for vapor degreasing). A payback period for the system using the savings calculated and reported total costs was determined to be 1.6 yr.

As the cost for the use of CFCs continue to increase as anticipated, the impact to the economics associated with the substitution of ultrasonic aqueous cleaning would be even more favorable.

## Conclusions

With the installation of an ultrasonic parts cleaning unit utilizing water-based cleaners, the elimination of vapor degreasing using solvent-based cleaners is possible without impacting cleaning quality. A reduction in the generation of fugitive emissions and hazardous waste associated with a vapor degreaser is realized along with cost savings.

The quality of the cleaning realized by Conax as a result of the changeover is as good, or in some cases, better than with vapor degreasing. Freon-cleaned products would, at times, have a slight powder residue deposition after drying. This is because of the inability of solvents to dissolve inorganic salts that accumulate on the parts. No such problem was encountered with the Miraclean system. At no time during the evaluation were parts returned for recleaning by Conax's inhouse quality assurance or assembly departments.

Freon use was reduced by approximately 77% (1990 to 1992). Annual waste reduction realized was over 12,000 lb when fugitive emissions are included. Transport


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and fate of wastes changed from predominantly uncontrolled air emissions of freon to predominantly cutting and cleaning rinsewaters that can be sewered and treated by the local public wastewater treatment facility.

An annual cost savings of $27,178 was calculated and results primarily from a reduction in raw material costs, a savings that is anticipated to become more significant over time. This savings provides a 1.6 yr payback period for the project.

***Table 2.*** *Variable Costs*

| | *Freon Vapor Degreaser ($)* | *Aqueous Ultrasonic Cleaning System ($)* |
|---|---|---|
| *Utility Costs* | *1,559* | *8,087* |
| *Labor Costs* | *8,205* | *8,295* |
| *Raw Material Costs* | *33,939* | *1,203* |
| *Water Costs* | *1,780* | *890* |
| *Sewer Costs* | *6,200* | *6,200* |
| *Off-Site Disposal* | *370* | *200* |
| *Total Operating Costs* | *52,053* | *24,875* |

The benefits realized by Conax as a result of the replacement of the solvent vapor degreaser with an ultrasonic water-based cleaning system include reduced fugitive emissions; reduced hazardous material handling and waste generation; and improved cleaning efficiency, working environment, and community relations. The results of this evaluation conclude that ultrasonic cleaning using water-based cleaners provides a viable and economically advantageous alternative to the problems associated with solvent vapor degreasing.

The full report was submitted in fulfillment of CR-816762-02-0 by Erie County Department of Environment and Planning under the sponsorship of the U.S. Environmental Protection Agency.

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*The complete report, entitled "Ultrasonic Cleaning as a Replacement for a Chlorofluorocarbon-Based System," (Order No. PB94-121 696/AS; Cost: $27.00, subject to change) will be available only from:*

*National Technical Information Service*
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*The EPA Project Officer can be contacted at:*

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