



## Project Summary

# Evaluation of Alternatives to Chlorinated Solvents for Metal Cleaning

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The Massachusetts Toxics Use Reduction Institute (TURI) was funded by the Environmental Protection Agency to perform research to support the EPA's 33/50 Program, a voluntary pollution prevention program to reduce national releases and offsite transfers of 17 toxic chemicals. The research project investigated alternatives to chlorinated solvents used for metal degreasing at three companies. The results reported for one company document a situation where the conversion to an aqueous cleaning system had already been implemented. Those for a second company provide real-time information about the conversion from an intermediate solvent to an aqueous system. Results for the third company contribute information about alternatives that must be applicable to a variety of substrates and configurations. Testing of the alternatives was conducted both at the companies and at the TURI's Surface Cleaning Laboratory located at the University of Massachusetts Lowell, Lowell, MA. In addition to the technical evaluations, the project evaluated financial and environmental impacts of the alternative systems. For the financial analyses, the Total Cost Assessment methodology includes many important environmental costs not typically included in a financial analysis. A substitution analysis methodology that provides qualitative results was developed and used to evaluate the environmental, occupational, and public health effects of the alternative cleaning processes.

*This Project Summary was developed by the 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

Cleaning and degreasing of metal parts in the metal finishing and metal working industries have traditionally been accomplished by the use of chlorinated solvents in vapor degreasers or immersion systems. In this context, cleaning and degreasing is, simply, the removal of contamination from the metal surface. This function is necessary for successful part performance in subsequent operations (e.g., plating or welding) or is desirable aesthetically. The chlorinated solvents most commonly used for metal cleaning include: 1,1,1-trichloroethane (1,1,1-TCA), trichloroethylene (TCE), perchloroethylene (PERC), dichloromethane (methylene chloride or METH), and chlorofluorocarbons. Chlorinated solvents are effective cleaners and, in the past, have been considered "safe" to workers because they are nonflammable.

Due to concern over the ozone layer, photochemical smog, and worker health, increasingly strict environmental regulations have been promulgated on the use of chlorinated solvents. The result has been higher costs associated with the purchase and disposal of chlorinated solvents. Traditional chlorinated solvent cleaning is becoming a process of the past. For many companies, however, changing from a proven process to a new technology is a difficult task. Many alternatives presented as "perfect" solutions are found to be ineffective cleaners, too expensive, or to present safety hazards. A careful evaluation of the options can help in selecting the most cost effective and technically feasible solution without compromising worker health and safety or environmental protection.



the new process and necessitate further evaluation following installation. An economic evaluation of a technically proven chemical or process provides valuable information affecting the decision to implement or not. The results of the financial assessment further inform the decision to adopt or not. However, technical and financial information combined is not the final word in decision making. Further evaluation is required to assess the environmental, health, and safety issues involved with the chemicals and processes. While the technical and cost assessments

are not simple, the environmental, health, and safety assessment, called substitution analysis, is perhaps the most difficult because there is no generally agreed-on and reliable method for evaluating the environmental and worker health and safety risk of alternatives.

In using the three evaluative steps described above, it is important to remember that each project and facility may have different priorities for making decisions about whether to implement a particular technology. This was clearly demonstrated in this project as the participating compa-

nies had different motives for seeking substitute technologies. This in turn, dictated which evaluative step was most important to them and indicates that the results of any one of the three can be the driving factor in a decision. Despite the emphasis placed on one evaluative step on a given project, all three aspects must be evaluated so that valuable pieces of information are not ignored.

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## Approach

### Technical Analysis

During the technical analysis phase, alternatives to the chlorinated solvents were identified, demonstrated, and evaluated. The three companies that participated in this project were Parker Hannifin Corporation, Market Forge, and Company A, an electroplating facility. At its Waltham, MA facility, Parker Hannifin manufactures pumps for aircraft engines under primary SIC code 3724. In 1992, the company began to investigate the replacement of its two vapor degreasers with an aqueous cleaning system. The original idea was to replace both vapor degreasers with one immersion cleaning system that could satisfy the highest cleanliness needs. After careful consideration of cleaning needs and logistics, the company decided to replace the vapor degreasers with three pressure spray washers for frequent remote cleaning following machining, one ultrasonic unit for the highest cleanliness needs and one immersion tank for cleaning following heat treatment. Parker Hannifin was chosen to document a situation where the conversion to aqueous cleaning had already been made and to evaluate the new system for its health and safety, environmental, and financial performance. A technical evaluation was performed at TURI's Surface Cleaning Laboratory in order to make improvements to Parker Hannifin's current aqueous cleaning process.

Located in Everett, MA, Market Forge manufactures cooking steamers. Prior to August 1993, Market Forge used a 1,1,1-TCA vapor degreasing system to degrease carbon steel and aluminum boiler parts before welding. The performance of TCA was satisfactory, but its use was discontinued because of the labeling requirements of the Montreal Protocol. On the advice of their supplier, Market Forge switched from TCA to an aliphatic petroleum distillate solvent (CAS 64742-88-7). As soon as the switch was made, the welders of both the carbon steel and aluminum parts began to experience problems. Market Forge was chosen as a company in the difficult transition stage. A technical evaluation was performed at TURI's Surface Cleaning Laboratory to find a suitable cleaning process and chemistry to replace the petroleum distillate. Based on the information obtained from this project, Market Forge purchased an American Metal Wash pressure spray washer. The unit was recently installed and is operating effectively.

Company A is a job-shop electroplating company located in Massachusetts. By the nature of the job-shop business, Company A cannot always predict what types of metals it will have to clean and thus requires a flexible cleaning system, capable of cleaning many different substrates. Currently the company cleans all parts in a vapor degreaser using TCE. Company A was chosen because its situation is one shared by many job-shop platers in the northeast, namely, a wide variety of substrates and contaminants. A technical assessment identified the following alternatives for further study: media blasting using sodium bicarbonate, plastic or carbon dioxide, ultrasonic aqueous, "closed" vapor degreasing, upgrading of the existing vapor degreaser, Advanced Vapor Degreasing (AVD™) system, and supercritical carbon dioxide.

### Financial Analysis

For the financial analysis, a total cost assessment methodology was used to perform financial analyses of the alternative cleaning processes. Traditional financial analysis often includes only the costs directly associated with production, such as labor and capital and does not include the costs (and savings) that make pollution prevention projects profitable. The Total Cost Assessment methodology used in this project is an innovative evaluative tool that examines many other important costs associated with an investment including staff time for environmental reporting, waste management costs, and permitting fees.

### Substitution Analysis

A substitution analysis methodology was developed and used to evaluate the environmental, occupational, and public health effects of the alternative cleaning processes. The substitution analysis described is qualitative in nature. It allows the comparison of alternatives using many criteria, but a final decision as to the best alternative must be made by the investigator. Described in worksheet format, this approach highlights both the areas of concern for alternative processes and areas where those substitutes clearly are superior to the current process. The worksheet will aid the decision maker in making informed decisions without overlooking important issues.

### Conclusions

Some general conclusions were drawn from the technical evaluation phase in regard to chemical compatibility/process specification and "drop-in" replacements.

For chemical compatibility/process specification, it was concluded that rinsing of a non-silicated cleaner is not always necessary even when a painting operation follows, and aqueous immersion cleaning can be a viable option for steel and aluminum substrates prior to nitriding or following heat treat operations. With regard to "drop-in" replacements, it was concluded that a thorough technical evaluation of so-called "drop-in" replacements is necessary to avoid unforeseen costs and that job shops present an unmet challenge to the vendors of "drop-in" replacements.

Some general conclusions were made following the financial analysis phase: 1) if the aqueous systems are replacing older solvent-based equipment, a savings in electricity costs may be realized, especially if air drying is not required; 2) depending on the cooling capacity of the vapor degreaser, the aqueous systems may actually use less water; 3) the profitability of an investment in aqueous cleaning equipment can be improved by purchasing based on cleaning needs at different stages in the production process; 4) the aggressive taxes on CFCs and TCA have made aqueous alternatives feasible economically; and 5) the Total Cost Assessment methodology (P2/Finance Software) can be used in an iterative process to determine costs for unknowns by requiring a certain net present value. These costs can then be assessed to determine if, for example, a regulatory requirement could be met for a certain cost rather than actually attempting to place a value on meeting the regulatory requirement.

This project studied three principal evaluation steps that inform the decision-making process for chemical or process substitution: technical evaluation, economic evaluation, and environmental, health and safety evaluation. Each evaluation step is important in determining the viability of a substitute technology, in comparison to the existing technology as well as to other competing substitute technologies. The steps can be performed in any order and their relative importance can vary from project to project. The technical evaluation of a replacement process for an existing technically successful process is often the most important evaluative step. The success or failure of the technical evaluation determines whether or not the process will be evaluated further. Complete technical evaluation at the lab- and pilot-scale levels can lead to a smooth transition into the new process. An incomplete technical evaluation can lead to unforeseen problems with the incorporation of

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*The complete report, entitled "Evaluation of Alternatives to Chlorinated Solvents for Metal Cleaning," (Order No. PB97-147946, Cost: \$28.00, subject to change) will be available only from:*

*National Technical Information Service*

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*Springfield, VA 22161*

*Telephone: 703-487-4650*

*The EPA Project Officer can be contacted at:*

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