Pollution Prevention Technology Profile
Closed Loop Vapor Degreasing

December 28, 2001

Introduction

The purpose of this Technology Profile is to provide general information about closed-loop vapor degreasing technologies in order to raise awareness of their potential to increase cleaning effectiveness and significantly reduce pollution. The Profile provides information about three variations of closed-loop vapor degreasing technologies: closed-loop, closed-loop with vacuum drying, and airless vacuum closed-loop. The Profile contains the following sections:

- Vapor Degreasing Overview
- Regulatory Requirements
- Old Vapor Degreasing Technology
- Newer Vapor Degreasing Technologies
- Appropriate Installations
- Benefits and Challenges
- Costs
- Summary of Case Study Applications
- Summary
- Contacts for More Information

It should be noted that this Technology Profile is not intended to be an “approval” of this technology. The appropriateness of the use of closed-loop vapor degreasing technologies should be determined on a site-by-site basis. Potential users should contact officials in the state in which the facility is located to determine the state-specific regulatory requirements that could apply. A listing of state contacts is located at the end of this profile. Generally, unless otherwise noted, the information presented in this Profile was obtained from the information sources listed in the footnote below. [1]

Vapor Degreasing Overview

During the manufacturing process for numerous products, particularly those made from metal, contaminants including chips, grease, lubricants, oil emulsions, dust and dirt, as well as grinding and polishing pastes, can interfere with production and lower product quality. Therefore, cleaning is needed to remove the contaminants reliably and completely from the work pieces prior to many common processes, such as painting, plating, inspection, repair, assembly, heat treatment and machining. Historically, solvents were used for contaminant removal, but concerns about flammability lead to the

1 Tennessee Department of Environmental Conservation and The University of Tennessee Center for Industrial Services, *Clean Air Act Compliance for Vapor Degreasers*, 1998 Edition; U.S. EPA, *Guide to Cleaner Technologies, Cleaning and Degreasing Process Changes*, EPA/625/R-93/017, February 1994; Center for Emissions Control, *Solvent Cleaning (Degreasing), An Assessment of Emission Control Options*, November 1992; and conversations and correspondence with PERO Corporation, June 2000 through October 2001.

predominant use of what were then considered “safer” alternatives, particularly halogenated solvents such as perchloroethylene and trichloroethylene.[2] Solvent cleaning can be performed on several substrate types, including metal and plastic and is effective at removing a wide variety of contaminates. Therefore, solvent cleaning is used by a wide variety of industries manufacturing a wide array of products.

Vapor degreasing was developed to obtain better cleaning results than a simple immersion system can provide. Vapor degreasing is a process that uses heat to enhance the cleaning process. Vapor degreasers of all types generally operate as a batch process. The part is introduced to the vapor of clean solvent and because the part is at a lower temperature than the solvent vapor, the solvent condenses onto the part. The clean solvent vapor can penetrate the small recesses that a liquid cannot. The solvent removes the contaminants from the part by dissolving/entraining the contaminant particles in the condensed solvent which then falls off the part via gravity. In addition systems can mechanically rotate the parts and/or utilize a vacuum to remove the condensed solvent from recesses. Once the part reaches the temperature of the vapor, condensation ceases. When a traditional open top vapor degreasing (OTVD) process is used, significant air emissions to the area surrounding the tank (known as fugitive emissions) can occur due to the introduction of parts to the tank (displacing vapors); removal of parts (dragging vapors out); and air movement in the shop that drags out vapors as it passes across the open top. Vapor chillers are normally installed along the edges of the OTVD to lower losses, but they are not able to eliminate emissions.

These high fugitive emissions are of concern to many companies for worker health and safety issues inside the plant as well as the environment outside the building. This concern combined with the recent regulation of OTVDs, have created a demand for alternative cleaning processes. The most common pollution prevention alternative, switching to an aqueous cleaning system is not appropriate in all situations and therefore, solvent degreasing is still utilized by firms. In some instances, aqueous cleaning cannot replace solvent cleaning due to one or more of the following reasons:

- Generally, solvents have half the surface tension of water which permits easy penetration of the liquid into parts with small or blind holes and cracks.

- For systems that use heating to enhance cleaning, solvents require approximately a tenth of the energy to heat than water requires.

- The vapor pressure for solvents is much higher than that of water, so less energy is required to dry the parts following cleaning.

- Detergent and water hydrolyzes the grease to form a soap and glycerol, whereas solvent dissolves grease so it is more easily removed.

2 As discussed later, the use of halogenated solvents for vapor degreasing has become increasingly regulated. This regulation, combined with concerns about the toxicity of, and the potential for groundwater contamination by, these halogenated solvents has lead some facilities to consider returning to the flammable solvents, and to a movement by manufacturers to create yet another round of “new and improved” solvents.

- Generally, solvents can be filtered, distilled and recycled whereas, aqueous systems require treatment and typically generate a greater volume of waste that requires disposal.

In addition, aqueous cleaning systems can require a larger physical space than a solvent system due to the increased cleaning, drying and handling equipment. In some plant situations, the larger equipment footprint might be impractical. However, aqueous cleaning can be appropriate for many cleaning situations, particularly when combined with ultrasonic technology. With aqueous cleaning, the main environmental concern is with wastewater, rather than the air emissions concerns associated with solvent cleaning. Most solvents are inherently a hazardous waste; however aqueous systems can also produce hazardous waste depending upon the characteristics of the cleaning additives and the material removed from the parts.

Regulatory Requirements[3,4]

Due to prevalence of OTVDs throughout manufacturing operations and their high fugitive emissions, on December 2, 1994, U.S. EPA published the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Halogenated Solvent Cleaning (59 CFR 61801). The Halogenated Solvent NESHAP applies to all open top vapor degreasers that use one of the six halogenated solvents listed in Table 1.

Table 1 - Common Solvents Used for Degreasing

	CAS Number
Methylene chloride (aka: dichloromethane)	75-09-2
Perchloroethylene (aka: tetrachloroethylene)	127-18-4
Trichloroethylene	79-01-6
1,1,1 Trichloroethane	71-55-6
Carbon tetrachloride	56-23-5
Chloroform (aka: trichloromethane)	67-66-3

There are three primary methods for compliance with the NESHAP:

- Control Combinations - requires three items to meet compliance: minimum equipment design, mandated operating practices, and one of a specified set of control technology combinations. This compliance method does not have emission limits. The allowable control combinations are contained in the table on the next page.

- Idling Emissions: requires a combination of minimum equipment design and operating practices with emission limits. The specified maximum allowable idling emission rate for batch machines is 0.045 lbs. per hour per ft^2 of the opening's surface area. Idling emissions are the emissions from the machine when it is turned on but is not in use to clean parts.

3 Tennessee Department of Environmental Conservation and The University of Tennessee Center for Industrial Services, *Clean Air Act Compliance for Vapor Degreasers*, 1998 Edition.
4 U.S. EPA, *Guidance Document for the Halogenated Solvent Cleaner NESHAP*, EPA-453/R-94-081.

- Alternative Standard: meet halogenated solvent emission limit from each machine as calculated on a three-month rolling average basis, using any method. The emission limit for batch vapor solvent cleaning machines is 30.67 lbs per month per ft^2 of the opening's surface area. There are no specified equipment design or operating practices with this compliance method.

Control Combinations for Batch Vapor Cleaning Machines

Batch Vapor Cleaning Machine Size	Option or Control Combination Number	Controls: Working Mode Cover	1.0 Freeboard Ratio	Super Heated Vapor	Freeboard Refrigeration	Reduced Room Draft	Carbon Adsorber	Dwell
Solvent-air Interface Area Less than or equal to 1.21 square meters (13 square feet)	1	✓	✓	✓				
	2			✓	✓			
	3	✓			✓			
	4		✓	✓		✓		
	5				✓	✓		
	6		✓		✓			
	7				✓			✓
	8		✓			✓		✓
	9				✓		✓	
	10		✓	✓			✓	
Solvent-air Interface Area Greater than 1.21 square meters (13 square feet)	1		✓	✓	✓			
	2				✓	✓		✓
	3	✓		✓	✓			
	4		✓	✓		✓		
	5			✓	✓	✓		
	6		✓		✓	✓		
	7			✓	✓		✓	

(Source: U.S. E.P.A., *Guidance Document for the Halogenated Solvent NESHAP*, EPA-453/R-94-081)

All solvent degreasing systems generate some quantity of hazardous waste due to the nature of the process. The purpose of degreasing is to remove contaminants from the part. The applicable hazardous waste requirements depend on the quantity of hazardous waste generated, which in turn is related to the condition of the parts before cleaning and the degreasing process used.

Old Solvent Degreasing Technology

Generally, an open top vapor degreaser (OTVD) is a tank with a heating system at the bottom that boils the liquid solvent. The solvent vapor is denser than air and therefore, displaces the air in the tank. There are condenser coils around the periphery of the interior of the tank at the upper extreme of the cleaning zone that keep most of the vapors from rising beyond that level. One configuration of an open top vapor degreaser (OTVD) is shown in Figure 1.0.

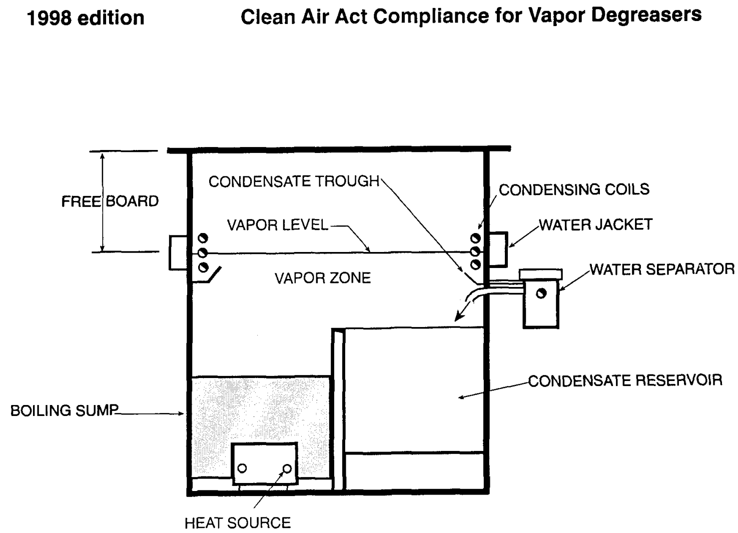

Figure 1 - Open Top Vapor Degreaser

(Source: Clean Air Act Compliance for Vapor Degreasers, UT Center for Industrial Services, 1998 edition.)

Fugitive air emissions from OTVDs can be significant, creating safety concerns within the plant. Therefore, OTVDs are typically segregated from the production process, and workers wear personal protective equipment, such as a respirator, when using the OTVD. Due to air emission losses, OTVDs require frequent addition of fresh solvent to replenish the reservoir. In addition, the entire apparatus requires periodic cleaning to remove the contaminants that build up on the bottom of the OTVD. Cleaning generates a hazardous waste that must be properly handled, stored, transported, and treated and/or disposed. Most OTVD equipment is designed for a 20 year lifespan; however, OTVDs that are in operation after 30 years have been observed.

Newer Vapor Degreasing Technologies

Because the air regulations permit the use of compliant OTVDs, they are still widely utilized in the United States.[5] Quality requirements are constantly increasing in manufacturing processes and cleaning, degreasing, rust prevention and drying are becoming more important because these processes are critical to the quality and subsequent correct functioning of the work pieces. In response to the increased demands for cleanliness, combined with increased demands for worker and environmental protection, new vapor degreasing systems have been developed. Three such vapor degreasing system designs are covered in this profile: closed-loop, vacuum, and airless vacuum. Each of these systems significantly reduces fugitive emissions and can meet the alternative standard of compliance. These newer solvent degreasing systems that can provide numerous benefits when compared to OTVDs, such as improved cleaning and product quality, reduced air emissions, and reduced solvent purchase, hazardous waste disposal, and labor costs. Generally, closed-loop, vacuum, and airless vacuum systems are built for a 20 to 25 year lifespan, similar to an OTVD.

Closed-Loop Vapor Degreaser

5 Open top vapor degreasers are no longer legal for operation in many European countries

The parts to be cleaned are placed in a basket and introduced into an airtight work chamber. After the door is closed, the solvent vapors are introduced. The condensate and removed contaminates collect through an opening in the floor of the chamber. When cleaning is complete, the vapors are exhausted from the chamber and circulated over a cooling coil to condense the solvent. The condensed solvent is separated from contaminants, such as water and grease, and reused in the system.[6] Air is circulated through the chamber and residual solvent vapors are captured by carbon adsorption. When the solvent concentration in the chamber is reduced to a specified level, the door is then opened and the parts removed. Air emissions can be reduced 98 percent or more when compared with an OTVD. A schematic of one configuration of a closed-loop system is provided in Figure 2.

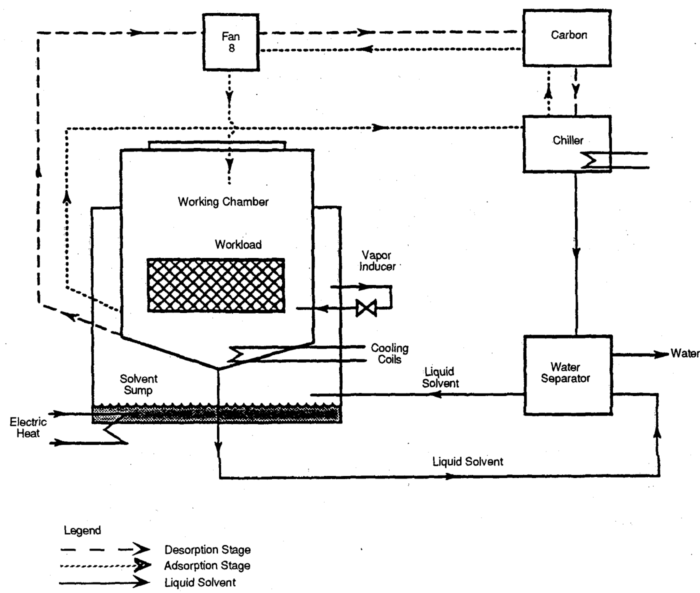

Figure 2 - Closed-Loop Vapor Degreaser (Source: U.S. EPA, *Guide to Cleaner Technologies, Cleaning and Degreasing Process Changes*, EPA/625/R-93/017, February 1994)

Different vendors incorporate additional features to enhance the cleaning action. For example, one vendor designs machines that can clean in a multi-stage process such as using an immersion bath and or flushing action first, with a subsequent vapor degreasing phase. Another vendor performs vapor degreasing first followed by a spray rinse.

Vacuum Vapor Degreaser

A vacuum vapor degreaser operates much like the closed-loop system described above. The primary difference is that the final stage of the process is vacuum drying. A vacuum system reduces the pressure to below 5 torr in the work chamber, and the parts dry using the heat energy that was gained from the solvent vapor. The vapors are evacuated by the vacuum pump and are captured in the vapor recovery

6 Generally, the solvents used are filtered before they are used each time and vaporizing the solvent also serves to distill it. In addition, a vacuum distiller can be used to distill the contents of the vapor sump to produce separate streams of solvent, cutting oil, and sludge.

system. The use of the vacuum drying cycle increases the quantity of solvent recovered for reuse and speeds the drying process, reducing the time required to clean a given number of parts.

Airless Vacuum Vapor Degreaser

In an airless vacuum vapor degreaser the work chamber is under vacuum during the entire process. After the parts are loaded and the chamber door is sealed, air is evacuated and the pressure reduced to below 5 torr. The solvent vapors are introduced to the chamber and condense on the part. Vapors are evacuated by a vacuum pump, again reducing pressure, which increases volatilization of the solvent from the part. The chamber is returned to atmospheric pressure and any residual solvent vapor is exhausted through a carbon filter. There are two primary advantages of an airless system over a vacuum drying system. First, it requires less energy to vaporize the solvent in a vacuum environment. Second, the vapor is quickly and evenly distributed throughout the chamber, creating a more uniform cleaning action on all areas of the parts.

Appropriate Installations

The degreasing principles used by closed-loop, vacuum, and airless vacuum degreasers are identical to those used by an OTVD. In addition, overall space and energy needs are similar. Therefore, the alternative systems are appropriate for use in any application that uses an OTVD. Vacuum systems are particularly well-suited for applications where the cleaning performance of OTVDs is problematic: small parts, blind hole cleaning, removal of tiny metal chips, and for ultrasonic cleaning. However, custom closed-loop and vacuum equipment can be designed to meet virtually any technical criteria. The main potential limitation on the appropriateness of a closed-loop system for a particular situation is cost.

Benefits and Challenges

All three of the newer vapor degreasing technologies offer a similar set of benefits and challenges to potential users when compared to the old OTVD technology.

Benefits

There are numerous benefits to using a closed-loop system, including improved cleaning, and reductions in: air emissions, worker exposure, solvent purchases, hazardous material handling, hazardous waste generation, operator labor requirements, and regulatory requirements.

Improved Cleaning: OTVDs have difficulty cleaning some parts, particularly those with small holes or that have small diameter tubes. Closed-loop, and especially vacuum systems can produce a cleaner part than an OTVD in many situations. Improved cleaning can result in improved product quality and reduced rework, and can also improve customer satisfaction.

Air Emissions: The newer technologies have dramatically lower air emissions than an OTVD. Using the idling emissions compliance option, a compliant OTVD can emit up to 0.045 lbs. per hour per square foot of opening. For a machine with a 10 foot square opening that operates 20 hours per day, 6 days per week, that equates to 2,808 pounds per year of emissions. A closed-loop system that can meet the same production rate would emit less than 30 pounds per year.

Worker Exposure: The emissions from compliant OTVDs are generally fugitive emissions and therefore, the air within the facility can smell of solvents, and workers inside and outside the building are exposed. A closed-loop system can dramatically improve the workplace environment, possibly increasing employee productivity and loyalty to the company. In addition, in most circumstances, a closed-loop system eliminates the need for the operation of a dedicated exhaust system and the use of personal protective equipment (PPE) by workers, both of which translate into a cost savings for the facility.

Solvent Purchases: The newer technologies require significantly less solvent to operate. In an OTVD, there are fugitive emissions from the OTVD itself, and also from the parts as they are removed from the tank. The closed-loop systems capture and reuse more of the solvents, significantly reducing fugitive emissions and the subsequent need to replenish the solvent reservoir. Facilities generally report solvent purchase reductions from 83 to 98 percent, with several experiencing 97 percent or more. This can represent a significant annual cost savings.

Hazardous Materials Handling: The reduced purchase of solvents also reduces the quantity of solvent that needs to be stored and handled at the facility. Because there is much less need to transfer virgin solvent to the unit and hazardous waste from the unit, the opportunity for spills and worker injury is reduced. These reduced risks could reduce insurance rates.

Hazardous Waste Generation: The newer technologies produce significantly less hazardous waste than from cleaning the same parts in an OTVD. The solvent and contaminants are removed from the cleaning chamber after each load. The equipment includes a process to remove the contaminants and reuse the solvents. In an OTVD, the contaminants fall to the bottom of the tank and require periodic cleaning. Cleaning frequency depends on the nature of the contamination of the incoming parts. The sump cleanout process for an OTVD can expose workers to high concentrations of solvent vapors and can require conformance with OSHA confined space requirements. The configuration of closed-loop systems is significantly different and does not create worker safety issues of the same magnitude. Facilities where closed-loop technology is installed are generally able to cut hazardous waste by 75 percent or more, enabling many facilities to move from large quantity (LQG) to small quantity generator (SQG) status. The reduction of hazardous waste generation could reduce insurance costs.

Operator Labor Requirements: The newer technologies require less operator time and attention than an OTVD. In an OTVD cycle times are relatively short, meaning that the operator must attend to the equipment throughout the work shift. The alternative technologies are all fully enclosed automated systems. Typical cycle times are on the order of 6-12 minutes. An automated conveyor can be used to cue-up 10 or more baskets that can run consecutively without operator attention. Therefore, the operator(s) can have enough time available to perform other tasks at the facility. Most closed-loop systems incorporate programmable cycles that are coded onto the parts route sheets, so the operator can line up batches of different part sizes and configurations in the cue.

Regulatory Compliance: The significant reduction in air emissions realized from replacing OTVDs with closed-loop systems can move a facility below the threshold for major source of hazardous air pollutants, significantly reducing permitting and compliance monitoring and reporting requirements. In addition, there are fewer regulatory requirements associated with SQG status when compared to LQG. Therefore, less staff time is required to perform the required training, monitoring, recordkeeping, and reporting when an alternative system is used.

Challenges

Generally, there are three main challenges, other than capital cost, associated with closed-loop vapor degreasers: production rate reduction, solvent degradation, and the fact that solvents are toxic and create a hazardous waste.

Production Rate: The alternative technologies require a longer processing time per load. Typical cycle times are on the order of 6-12 minutes. Therefore, alternative systems need a larger cleaning chamber capacity that can process more parts per batch in order to maintain the production rate of an OTVD. In an OTVD solvent vapor is always in the tank and parts are heated quickly. However, in the alternative systems, solvent vapor needs to be generated and introduced anew with each load. The alternative systems also need time to remove the condensed solvent-contaminant mixture, and exhaust the vapor from the chamber - a process that is not performed with an OTVD. Therefore, the amount of time the parts are in the cleaning chamber is longer in an alternative system than in an OTVD. However, as mentioned above, there is an associated benefit with longer cleaning cycle times, particularly when an automated conveyor is used and 10 or more baskets can be cued: the operator(s) have adequate time to perform other tasks at the facility.

Solvent Degradation: Solvents contain stabilizers to prevent its breakdown and ensure performance. In an OTVD, solvent loss and replenishment occurs regularly so breakdown of the solvent is not apparent. However, in a closed-loop system, the solvent is constantly reused and only small volumes of make-up are required after relatively long intervals. Therefore, the stabilizers can become exhausted allowing the solvent to breakdown and form an acid. Monitoring of solvent condition is required and periodic addition of new stabilizer to the solvent is necessary. The solvent testing does not require sophisticated laboratory equipment and an operator with average aptitude can be trained in approximately two hours to perform the tests.

Hazardous Solvents: All the technologies discussed in this profile utilize solvents, primarily those listed earlier in Table 1. Each of the most commonly used solvents is considered toxic and presents a potential hazard to human health. Therefore, the handling of solvents presents worker health and safety concerns in addition to the potential liability associated with an accidental spill. In addition, when solvents are used, the waste generated is considered hazardous.

Costs

Capital: The following rough costs are for a unit with a basket weighting of 50 to 60 pounds with approximately 1 cubic foot of capacity. The capital cost of a compliant OTVD that can process 600 pounds per hour would be approximately $65,000. The cost of a closed-loop system that can process 575 pounds per hour would be approximately $145,000 and a comparable vacuum system would cost approximately $165,000. An airless vacuum system that can process approximately 520 pounds per hour would cost approximately $230,000.

Operation and Maintenance: The use of an alternative system significantly lowers virgin solvent purchase costs when compared to operation of an OTVD. In addition, hazardous waste generation and the associated disposal cost is also significantly lower. The significantly reduced hazardous waste generation and air emission rates combine to lower the labor costs associated with monitoring, recordkeeping, and reporting to maintain regulatory compliance. The newer systems are more complex than an OTVD and have different maintenance requirements. Overall, most installations report lower maintenance costs for the alternative machines.

Generally, the operation of an alternative system requires less labor than an OTVD because the process is more highly automated and cycle times are longer. Operators can perform other tasks while the machines are running. Finally, energy costs associated with the alternative systems can be higher than for an OTVD. Alternative systems must move the solvent vapor into and out of the chamber for each load - an energy requirement that OTVDs do not have. However, an OTVD is constantly boiling and condensing the solvent - processes that occur for short periods with the alternative systems.

Summary of Case Study Applications[7]

Available case study information from installations of alternative vapor degreasing technology is summarized below. Case studies were found on closed-loop vapor degreasing and airless vacuum vapor degreasing.

Closed-Loop Vapor Degreaser

7 Mention of any company, process, or product name should not be considered an endorsement by NEWMOA, NEWMOA member states, or U.S. EPA

Connecticut Spring and Stamping Corporation makes a variety of spring products from both wire and sheet metal. After the winding, bending, stamping and grinding operations, some products must be cleaned before a final finish is applied. Beginning in the 1960's the company used two open top vapor degreasers, each with a 10 square foot opening, to clean the products with perchloroethylene. In response to the new federal Clean Air Act requirements for solvent degreasers, the company installed two PERO Model 2501A batch closed-loop[8] degreasers with an in-line still to recover the perchloroethylene and a closed-loop cooling system that eliminated wastewater generation.

Results:

- Reduced purchases of perchloroethylene by over 98 percent
- Reduced hazardous waste generation by over 95 percent
- Reduced perchloroethylene air emissions by over 99 percent
- Changed its hazardous waste generator status from a Large Quantity Generator to a Small Quantity Generator
- Reduced environmental management and regulatory burdens
- Increased employee morale due to the dramatically reduced odors and the elimination of the need to wear personal protective equipment

Implementation Issues:

- In the first month, the pH went out of spec and the system had to be drained. The vendor worked with the company to change procedures to prevent its recurrence.
- Three month employee adjustment period due to the increased maintenance requirements

Costs:

	1995	**1998**	**Savings/Year**
Perchloroethylene Purchases	89,760 lbs. at $0.43/lb. (6,600 gallons)	2,992 lbs. at $0.52/lb. (220 gallons)	$37,040
Perchloroethylene Hazardous Waste Generated	43 drums at $190/drum (32,164 lbs. = 2,365 gallons)	4 drums at $190/drum (30% perc and 70% oils and dirt)	$7,410
Perchloroethylene Air Emissions	57,596 lbs.	30 lbs.	not calculated
Wastewater Processed by Evaporator	300,000 gallons (est.)	none	not calculated
Total Calculated Savings per Year			$44,450
Capital Costs (est.)			$300,000 (includes

8 State of Connecticut Department of Environmental Protection, *Parts Degreasing, Connecticut Spring and Stamping Corporation, A Pollution Prevention Case Study*, December 1998. Please note that, according to the manufacturer, the systems purchased were not vacuum systems and the language in the case study stating that the systems are "batch vacuum degreasers" is incorrect

			installation)
Payback Period			6.75 years*

* There are numerous benefits to the use of the closed loop system that were not quantified in this case study: the significant reduction in the volume of wastewater processed by the evaporator; reduced labor costs for degreaser operation and also for regulatory compliance monitoring, recordkeeping, and reporting; and improved employee moral and productivity. If these costs could be quantified, the payback period would be substantially shortened.

The full Connecticut Spring and Stamping Corporation case study can be obtained by contacting the Connecticut Department of Environmental Protection Office of Pollution Prevention at (860) 424-3297.

Airless Vacuum Vapor Degreaser[9]

Sono-tek Corporation[10] completed a Technology Application Analysis of its airless vacuum vapor degreasing system using the EPA P2 Template format. The analysis contains information from four facilities, two of which are summarized below. The complete Technology Application Analysis is available by contacting: Abby Swaine, U.S. EPA Region 1 at (617) 918-1841 or swaine.abby@epa.gov.

A.T. Wall manufactures a variety of products including wave guide tubes, some up to 20 feet long, that are used to carry or transmit microwave radiation. The company had used open top vapor degreasers to clean the tubes with 1,1,1 trichloroethane. In response to the new air regulations, A.T. Wall sought an alternative. Aqueous systems were too large due to the additional cleaning, drying and handling equipment and also could not adequately clean the longer tube lengths. The company purchased an airless vacuum vapor degreasing system from Serac Corporation that uses perchloroethlyene.

Texas Instruments manufactures electronic devices and electronic components. The plant has two degreasing operations that service all the various departments. The company purchased two airless vacuum vapor degreasing systems from Serac, one that uses tricholorethylene and one that uses perchloroethylene.

Results:

- At A.T. Wall, solvent purchases were reduced by over 97 percent, from more than 37,000 pounds per year to less than 300, and hazardous waste was reduced by approximately 75 percent.

- At Texas Instruments, solvent purchases for one unit were reduced by almost 97 percent, from 63,775 pounds per year to 2,155. The other unit saw purchases reduced by over 83 percent, from 23,915 pounds per year to 3,984. The differences between the units can be attributed to

9 U.S. EPA and Greiner Environmental, *Pilot of the Pollution Prevention Technology Application Analysis Template* [P2 Template]*Utilizing Airless Vacuum Vapor Degreasing*, October 1999.

10 Sono-tek was known as Serac Corporation at the time the case studies were compiled.

different contaminant levels on the incoming parts. More solvent is lost to hazardous waste generation when the parts are more contaminated.

- At Texas Instruments, spills, leaks and other upsets that require emergency response were virtually eliminated. Such incidents were frequent with the OTVDs, with equipment downtime estimated at 30 to 40 hours each year.

Implementation Issues:

- Sono-tek systems are custom designed, and therefore, can have issues that arise with implementation. These include, a bolt on a rotation device broke and had to be redesigned, a problem with obtaining a vacuum seal on the chamber door, and difficulty obtaining satisfactory throughput (solved by purchasing a second unit).

Costs:

	A.T. Wall	**Texas Instruments**
Solvent Use Reduction	$75,660 (97 percent)	$61,500
Hazardous Waste Reduction	$3,500	$8,000
Energy Savings*	($1,500)	$12,000
Avoided Regulatory Costs	$9,000	$16,000
Other Costs/Savings	$9,000 Labor $2,000 Oil Waste Elimination $2,500 Misc.	$14,000 one time avoided permit costs (subtracted from capital cost - not included in annual savings)
Total Calculated Savings per Year	$100,160	$97,500
Capital Costs (est.)	$300,000	$317,241 for both
Payback Period	36 months	37 months

* The two firms collected and analyzed information differently.

Summary

For cleaning situations where the continued use of solvents is necessary, closed-loop vapor degreasing systems can be an excellent alternative to an OTVD. Solvent purchases, hazardous air emissions and hazardous waste generation are all significantly reduced with a closed-loop system, providing direct operating cost savings. Potential challenges are generally outweighed by the associated benefits, and implementation problems can be overcome by working with the vendor.

Although capital cost payback is not immediate, there are numerous other benefits to closed-loop systems when compared to an OTVD that are not easy to quantify and should be considered. These not easily quantifiable benefits are outlined in the Benefits and Challenges section and include: improved cleaning and product quality; reduced worker exposure to toxics and improved working conditions and employee morale; reduced risk of accidents and spills associated with virgin material and hazardous waste handling and storage; and reductions in regulatory requirements for training, monitoring, recordkeeping, and reporting.

Contacts for More Information

Vendors in the Northeast

Mention of any company, process, or product name should not be considered an endorsement by NEWMOA, NEWMOA member states, or U.S. EPA.

PERO Corporation
900(G) River Street
Windsor, CT 06095
(860) 298-0317

PERO manufactures closed-loop, vacuum, and airless vacuum solvent vapor degreasers, as well as aqueous cleaning systems

Sono-tek Cleaning Systems (formerly Serac)
P.O. Box 28129
Providence, RI 02908
(401) 421-6080

Sono-tek custom manufactures airless vacuum solvent vapor degreasing systems

Branson Ultrasonics Corporation
41 Eagle Road
Danbury, CT 06813
(203) 796-2298

Branson manufactures ultrasonic precision cleaning machines including aqueous cleaning systems and a vacuum solvent vapor degreaser

State Technical Assistance Programs

In Connecticut: Kim Trella Department of Environmental Protection 79 Elm Street Hartford, CT 06106 (860) 424-3242	**In Maine:** Peter Cooke Department of Environmental Protection 17 State House Station Augusta, ME 04333 (207) 287-6188
In Massachusetts: John Raschko Office of Technical Assistance 251 Causeway Street, Suite 900 Boston, MA 02114 (617) 292-1093	**In Massachusetts**: Linda Benevides, STEP Program Executive Office of Environmental Affairs 251 Causeway Street Boston, MA 02108 (617) 626-1197
In New Hampshire: Paul Lockwood Department of Environmental Services 6 Hazen Drive Concord, NH 03301 (603) 271-2956	**In New Jersey:** Ruth Foster Department of Environmental Protection 401 East State Street, PO Box 423 Trenton, NJ 08625 (609) 292-3600
In New York: Dennis Lucia Department of Environmental Conservation 50 Wolf Road Albany, NY 12233 (518) 457-2553	**In Rhode Island:** Rich Girasole Department of Environmental Management 235 Promenade Street Providence, RI 02908 (401) 222-4700, ext. 4414
In Vermont: Greg Lutchko Department of Environmental Conservation 103 South Main Street Waterbury, VT 05671 (802) 241-3627	**At NEWMOA:** Jennifer Griffith NEWMOA 129 Portland Street, 6th Floor Boston, MA 02114 (617) 367-8558, ext. 303

The Northeast Waste Management Officials' Association (NEWMOA) is a nonprofit, nonpartisan interstates organization that addresses regional waste and pollution prevention issues. The membership is composed of state environmental agency directors of the hazardous waste, solid waste, waste site cleanup, pollution prevention and underground storage tank programs in Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. NEWMOA provides a forum for increased communication and cooperation among the member states, a vehicle for the development of unified position on various issues and programs, and a source for research and training.