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Pilot of the Pollution Prevention Technology Application Analysis Template

Utilizing

Suparator™ Thin-Film Oil Recovery System

Technical Report No. 47 September 1999

University of Massachusetts Lowell

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Suparator™ Thin-Film Oil Recovery System

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The Toxics Use Reduction Institute
University of Massachusetts Lowell

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The Toxic use reduction Institute is a multi-disciplinary research, education, and policy center established by the Massachusetts Toxics Use Reduction Act of 1989. The Institute sponsors and conducts research, organizes education and training programs, and provides technical support to promote the reduction in the use of toxic chemicals or the generation of toxic chemical byproducts in industry and commerce. Further information can be obtained by writing the Toxics Use Reduction Institute, University of Massachusetts Lowell, One University Avenue, Lowell, Massachusetts 01854.

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The Executive Office of Environmental Affairs' STrategic Envirotechnology Partnership (STEP) and the Toxics Use Reduction Institute (the Institute) located at the University of Massachusetts Lowell entered into an Interagency Service Agreement (ISA) to document the utility of the Environmental Protection Agency – New England's Pollution Prevention Application Analysis Template. The Institute hired the Concord, Massachusetts-based consulting company Alternative Resources, Inc. to complete an analysis of four installations of the Suparator™ Thin-film Oil Recovery System marketed by Aqueous Recovery Resources, Inc. based in Bedford Hills, New York.

This analysis of four installations of the Suparator® Thin-Film Oil Recovery System is one of four analyses completed for this project. The other three reports are on the following technologies: Serec Vacuum Degreasing System; Zero Discharge Systems, Inc.'s Acid Recovery System; and M/A COM Inc.'s Semi-Aqueous Cleaning System. In addition, two narrative summaries discussing the practical utility of adopting the template approach for pollution prevention (P2) technology analysis have been prepared by Karen Thomas (formerly with the Institute) and Tim Greiner of Greiner Environmental.

For additional information about any of these technologies or technology reports, please contact Paul Richard of STEP at 617-727-9800 or for information about the P2 Technology Analysis Template, contact Abby Swaine of the Environmental Protection Agency – New England at 617-918-1841.

The Institute would like to thank the Executive Office of Environmental Affairs and the Environmental Protection Agency – New England for their financial support of this project. The Institute acknowledges the generous cooperation of Jack Scambos and Ted Lenaghan of Aqueous Recovery Resources, Marian Lagosz of Lindberg Heat Treating, Ron Kershner and Ben Pendell of Dana Corporation, Scott Goodsell of Racine Plating Company, Dennis Cain and Jeff Valind of The West Bend Company, and Matt Pliszka of Environmentally Sensitive Solutions, Inc. (ESS).

Christopher Underwood of Alternative Resources, Inc. is the primary author.

DISCLAIMER

This document pilots the Pollution Prevention (P2) Technology Application Analysis Template (P2 Template) on the Suparator® Thin-Film Oil Recovery System. It is designed to assist the user in analyzing the application of P2 technologies. While it provides a template for the general types of questions that should be asked when evaluating a P2 technology, it may not include all of the questions that are relevant to a company or which a company is legally required to ask.

This document is not an official U.S. EPA guidance document and should not be relied upon as a method to identify or comply with local, state or federal laws and regulations. EPA has not examined, nor do they endorse, any technology analyzed using the P2 Template.

Technology Introduction

Two themes evident in this work are worthy of coverage as an introduction to the entire report.

Pollution Prevention AND Process Efficiency
While the Suparator™ Thin-film Oil Recovery System does realize pollution prevention (P2) benefits, it is marketed principally for its ability to improve process efficiency. The most prominent value of the technology is its ability to improve the efficiency of aqueous cleaning and oil recovery processes. The P2 benefits derived from using the technology are in addition to the improvements made to the manufacturing process.

The vendor states that 'the improvement of the manufacturing process while lowering cost is the primary reason Suparator™ has gained the attention of so many manufacturers who have turned to aqueous cleaning.' If sold solely as a P2 technology, companies may not be motivated to consider its implementation unless they were experiencing some pollution problem, thus missing the potential process efficiency (and pollution prevention) gains and related cost savings.

Metrics For Evaluating Process Efficiency Technologies
When evaluating any innovative technology, choosing a metric for measuring the effectiveness of the technology across many applications is a challenge. Given the process efficiency benefits of this technology, evaluation solely of P2 benefits overlooks the wider potential economic and environmental benefits of the technology. These benefits lie in its ability to allow aqueous cleaning to be a viable cleaning option by achieving consistent levels of cleanliness of aqueous-cleaned parts (i.e., maintaining a low level of oil contamination in the aqueous cleaning bath). Without this basic improvement of the steady state process conditions of an aqueous cleaning system, aqueous cleaning, with its corresponding P2 benefits, might never be considered by a potential adopter.

With this in mind, the separation efficiency metric was chosen for two additional reasons: the vendor's literature indicates specific separation efficiencies; and separation testing methods are available.

It should be noted however that separation efficiency measurements may be more appropriate to prove the ability of a technology to achieve certain discharge limits, not necessarily its broader source reduction benefits (e.g., replacement of chlorinated solvent cleaning with aqueous cleaning). An alternative metric would have been to compare the levels of cleanliness achieved in each installation over time for three scenarios: 1) chlorinated solvent cleaning, 2) aqueous cleaning with no Suparator™, and 3) aqueous cleaning with Suparator™. However, this study did not have the advantage of data from scenario 1 or 2, and it was limited by time. In addition, comparing relative levels of cleanliness of different parts in different processes is a challenge in itself. Within this context and realizing the limitations of the study, separation efficiency was evaluated and direct pollution prevention benefits were documented as accurately as possible.

STrategic Envirotechnology Partnership

The STrategic Envirotechnology Partnership (STEP) is an innovative effort begun in 1994 to promote the growth of new environmental and energy efficient technologies in Massachusetts. STEP maximizes the existing resources of its partners -- the Executive Office of Environmental Affairs, the Executive Office of Economic Affairs and the University of Massachusetts system -- to keep Massachusetts a leader in environmental business and to allow Massachusetts citizens to reap the positive benefits associated with the success of these new envirotechnologies.

STEP arose out of a desire to reduce the many uncertainties facing companies with innovative environmental and energy technologies. STEP defines "innovative" technologies as those technologies that offer potentially greater efficiency or environmental protection, or offer comparable results at lower costs in terms of energy, economics or environmental impact. Envirotechnologies encompass all levels of the waste and energy use hierarchy: pollution prevention, resource and energy conservation, renewable energy technologies, recycling/reuse and waste treatment and disposal. STEP offers services in the areas of technology assessment, business support, applied research and development, technology demonstration, regulatory assistance and expedited permitting. For more information on the STEP program, contact Paul Richard at 617-727-9800.

Toxics Use Reduction Institute

Located at the University of Massachusetts Lowell, the Toxics Use Reduction Institute is a multi-disciplinary research, education and policy center. The Institute sponsors and conducts research, organizes education and training programs, and provides technical support to promote reduction in the use of toxic chemicals or the generation of toxic chemical byproducts in industry and commerce.

The Institute's Surface Cleaning Laboratory assists companies in matching specific cleaning needs with appropriate chemistry and process combinations. The Lab outlines cleaning options, tests actual parts or test coupons, evaluates commercially available cleaners, and helps define cleaning specifications.

For additional information about the Institute programs or the Surface Cleaning Laboratory services, contact the main number at 978-934-3275.

1.0 DESCRIPTION OF P2 TECHNOLOGY

1.1 Technology Description

The trend towards aqueous cleaning as an alternative to vapor degreasing for the removal of oily contaminants in manufacturing processes has created new challenges in process water use and subsequent wastewater treatment.

Aqueous cleaning processes often generate effluent streams heavily laden with free and/or emulsified oils. In addition, depending upon the aqueous cleaning application, these effluent streams may also contain the components of the aqueous cleaners (e.g., surfactants, builders, chelating agents, corrosion inhibitors, etc.)[1]. Traditional treatment of water streams contaminated with oils commonly involves end-of-pipe (EOP) mechanical separation by adhesion and/or collection techniques[2]. However, adhesion and collection EOP techniques are poorly adapted for treating the effluent from aqueous cleaning processes. Aqueous Recovery Resources, Inc. (ARR) has recently introduced the Suparator® product package (Suparator®) as an "engineered-for-aqueous cleaning replacement technology" for these traditional EOP techniques.

The design of the Suparator® incorporates an innovative adaptation of Bernoulli's Principle. (Fluid flow across an asymmetric foil causes a pressure differential to be applied along the surface of that foil. This pressure differential is the result of the differing fluid velocities required to maintain laminar flow across the asymmetric structure.) The Suparator® is capable of recovering thin films of floating oil by utilizing the specific gravity differential between oil and water[2]. The thin-film separation technology used by the Suparator® was originally developed for the petroleum refining industry, which required a continuous high-efficiency oil-water separation process[2]. This proven technology was adapted to aqueous cleaning applications to address the need for a reliable and consistent oil-water separation method for modern, high-throughput aqueous cleaning processes. The flow rates and oil loadings associated with such modern, high-throughput aqueous cleaning processes often exceed the processing capability of traditional EOP techniques.

The Suparator® product package includes a stainless steel (304 or 316) process tank, the Suparator® thin-film separation device, and a Suparskim® level-following weir. The Suparator® thin-film separation device is integrated into the stainless steel process tank. The Suparskim® is installed in the "target" tank (i.e., the tank containing the contaminated aqueous cleaning solution). The designs of the thin-film separation device and the level-following weir are patented. The thin-film separation device is currently available in three different general models: the Series 86, 84/85, and 82 (the Series 86 and 84 are intended for aqueous cleaning applications, while the Series 85 and 82 are intended for wastewater applications). The three different models are capable of processing approximately 8, 45, and 500 gpm, respectively. The three different general models are further specified according to the volume of the stainless steel process tank associated with the thin-film separation device. For example, the Model 86/240 unit is a Series 86 thin-film separation device integrated into a 240-liter stainless steel process tank. In addition, the Suparskim®

is available in a variety of sizes. Although Suparator® models are differentiated by flow capacities and footprints, ARR has developed a method of Suparator® product package specification based on the ability of a system to maintain a specified surface area (measured in square feet) free of oil film.

Figure 1-1[3] is a schematic of the Suparator® thin-film separation device and stainless steel process tank. The Suparskim® collects the top layer of liquid from the "target" tank. The Suparskim® automatically adjusts to fluctuations in the liquid level in the "target" tank. This improves the efficiency of the oil-water separation process by ensuring that as oil floats to the surface of the cleaning fluid, it is immediately removed and transported to the Suparator® for recovery. The liquid collected by the Suparskim® is fed to the stainless steel process tank either by gravity or a progressing cavity pump. The oil floats to the top of the stainless steel process tank and enters the Suparator® thin-film separation device. Cleaning fluid not entering the separation device is directed to the outlet of the stainless steel process tank through an adjustable overflow siphon. This overflow siphon is used to maintain the operating liquid level in the stainless steel process tank. The floating oil layer and cleaning fluid entering the Suparator® thin film separation device are separated based on the specific gravity differential of the two substances. The unique inverted wing-shaped separation device continuously collects and concentrates the floating oil, which is discharged to an oil-only trough, while the "oil-free" (or stripped) cleaning fluid is discharged to the outlet of the stainless steel process tank. Collected oil can typically be reused after minimal additional treatment (e.g., filtration or centrifugation for particulate matter removal, heating for water removal, etc.). The cleaning fluid flows back to the aqueous cleaning process for reuse. During operation, the stainless steel process tank is typically covered to minimize heat losses from the cleaning fluid. The cover is vented to maintain atmospheric pressure in the stainless steel process tank. As is the case with the traditional EOP techniques, operating temperatures for the Suparator® product package should be maintained below the boiling point of water to optimize the oil-water separation process.

Figure 1-2[2] illustrates the mechanism by which the Suparator® effects the oil-water separation. The influent to the Suparator® thin-film separation device is split into two regions of laminar flow- an upper flow and a lower flow. The lower flow is directed downward, developing an area of reduced pressure directly behind the deflecting baffle. The upper flow enters the first compartment, which is connected to the area of reduced pressure by a small channel. The reduced pressure draws the water from the first compartment, while the oil (due to its lower specific gravity) remains floating at the surface of the first compartment. The upper, oil-enriched stream from the first compartment subsequently enters the second compartment, where water is again drawn to the area of reduced pressure through a small connecting channel, further "concentrating" the oil-enriched stream. An adjustable water weir sets the thickness of the layer of floating oil collected in the second compartment. Upon reaching a specified thickness, the oil-enriched stream automatically begins to overflow a fixed oil weir into a separate, oil-only trough.

Figure 1-1. Suparator® Thin-Film Separation Device[3]

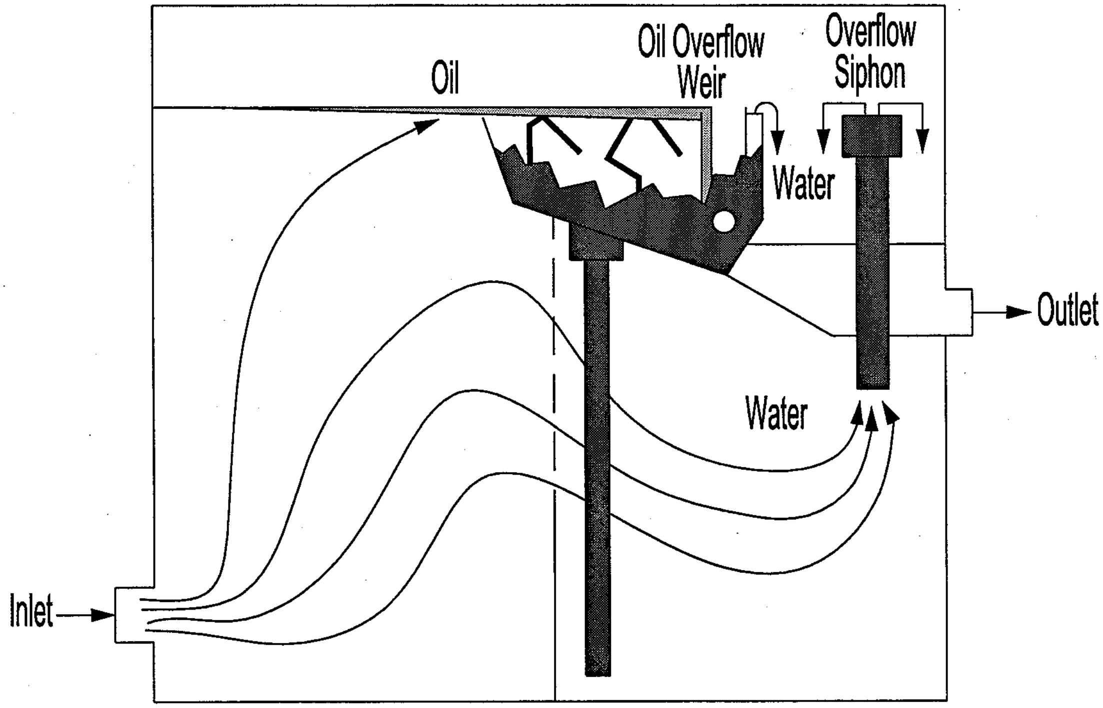
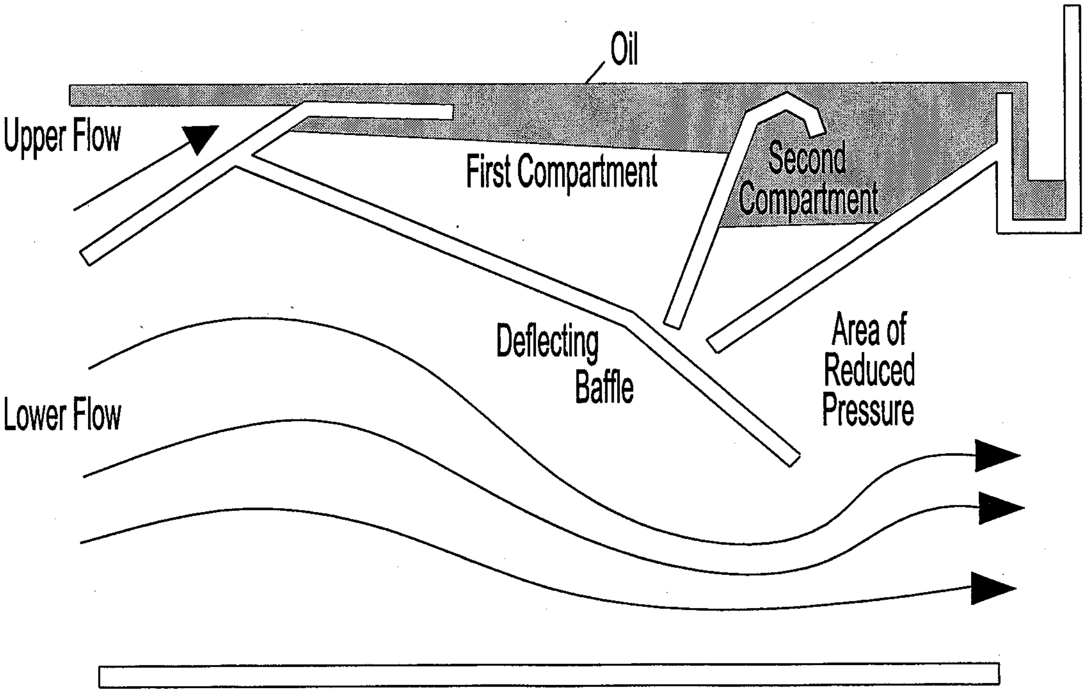


Figure 1-2. Suparator® Separation Method[2]



1.2 Technology Applicability

According to ARR, the Suparator® offers many benefits over traditional EOP techniques. Traditional EOP techniques fall into two general categories: adhesion (i.e., oils wheels/disks and belt skimmers) and collection (i.e., weir skimmers and tank overflow-to-drain)[2]. The primary limitation associated with adhesion techniques is encountered during the treatment of aqueous cleaning system effluent containing surfactants. The surfactant decreases the ability of the oleophilic wheel, disk, and belts to remove oil from the effluent[3]. The potential result of this decrease in oil removal efficiency, especially in high flow cases, is the accumulation of oil in the aqueous cleaning system. In contrast to adhesion techniques, the performance of the Suparator® is unaffected by the presence of surfactants.

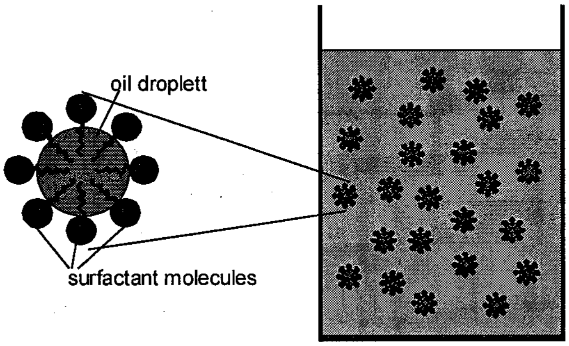
The primary limitations associated with the collection technique stems from the methods used for oil collection. The methods for collection include either underflowing or overflowing a stationary weir. Underflowing results in the accumulation of a thick stagnant layer of floating oil, which compromises the oil recycling process. Overflowing often removes a relatively thick layer of the aqueous cleaning solution with the floating oil (the ratio of cleaning solution to oil in this layer can exceed 4 to1 by volume[4]), which compromises the cleaner recycling process. In comparison to collection techniques, the Suparator® effects a more consistent and efficient oil-water separation.

Other techniques employed by industry to separate oily contaminants from water include coalescers and membrane filtration (microfiltration and ultrafiltration) units[3]. Coalescers are typically used in conjunction with highly emulsifying aqueous cleaners. As the emulsion formed by the aqueous cleaner breaks, the coalescer causes small oil droplets to aggregate into larger oil droplets. Subsequently, these larger oil droplets float to the surface of the aqueous cleaning solution. Although coalescers effectively treat weakly emulsified and mechanically-dispersed oils, an additional step is required to remove the layer of floating oil generated by the coalescer. The traditional EOP techniques are often used for this purpose. Note that coalescing media is available as an option in the Suparator® product package. However, the integration of oleophilic coalescing media with the Suparator® rarely provides any significant increase in oil removal efficiency to justify the additional capital and maintenance costs associated with such media[4]. The incremental increase in oil removal efficiency generated by oleophilic coalescing media is matched by operating the Suparator® at relatively higher flow rates. (Note that to meet the flow rate required to "power" the thin-film separation device, the Suparator® typically operates at four times the flow rate of a standard coalescer/decant tank system of the same footprint.) Alternatively, membrane filtration units have been proven to work in conjunction with oil-rejecting aqueous cleaners. However, the presence of free oils in the feed stream to a filtration unit can contribute to membrane fouling, which reduces the efficiency of the membrane separation process. Depending on the aqueous cleaning application and the purity requirements of the "recycled" cleaning fluid stream, the Suparator® can function as either a substitute or complimentary separation technique for coalescers and membrane filtration units, respectively.

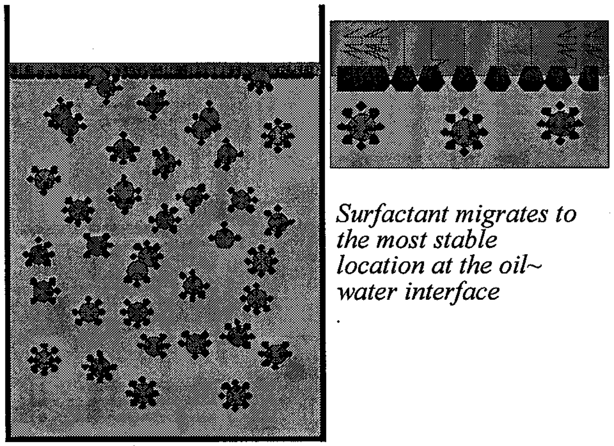
ARR represents the Suparator® as simple "upgrade" that can be quickly and easily retrofitted into an existing aqueous cleaning process. ARR claims that the Suparator® provides the high-efficiency oil and dirt removal required by both small and large volume manufacturers, without affecting the composition of the aqueous cleaning solution. According to ARR, the fundamental difference between the Suparator® and traditional EOP oil-water separation techniques is that the Suparator® continuously separates and collects oil from a minimal oil-water interfacial area[5]. Often times, especially in aqueous cleaning processes with heavy oil loadings, the EOP techniques (as well as the decant tanks associated with coalescers) operate with a relatively thick layer of floating oil covering the entire surface area of the process tank. Typically, three major problems are associated with this situation. First, the effectiveness of the aqueous cleaning process can be reduced. If parts are submersed into and withdrawn from the process tank, oil can be re-entrained into the aqueous cleaning solution and redeposited on the cleaned parts, respectively. Second, the build up of a thick layer of floating oil can promote the growth of bacteria. As time progresses, this bacterial growth will "rot" the oil. Third, the continuous contact of an aqueous cleaning solution with a layer of floating oil can rapidly degrade the performance of the aqueous cleaning solution. The surfactant in the aqueous cleaning solution migrates to the oil-water interface existing below the layer of floating oil. This phenomenon depletes the surfactant concentration within the bulk aqueous cleaning solution, reducing the ability of the aqueous cleaning solution to remove oily contaminants from parts. By design, the Suparator® eliminates these three problems by preventing the accumulation of a thick layer of floating oil.

The potential pollution prevention (P2) benefits most readily derived from the installation of the Suparator® stem directly from the highly efficient oil-water separation process. ARR guarantees that the Suparator® is capable of recovering oil containing less than one percent water by volume[2]. (For comparison, ARR claims that EOP techniques typically recover oil as a fifty percent or higher solution with the cleaning fluid[2].) Further, the oil recovered by the Suparator® has not been degraded by bacterial growth. The net result is a high-purity, high-quality oil stream than can be recycled with minimal, if any, additional treatment. In contrast, oil recovered with EOP techniques is typically of such low quality that it must be disposed of as waste.

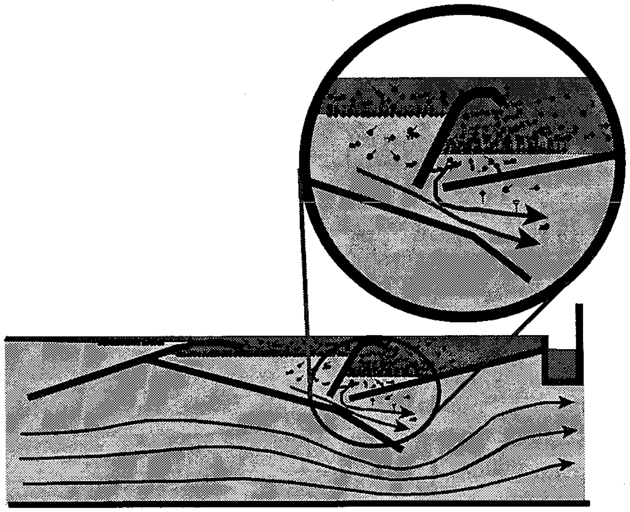
As stated, ARR also claims that oil is recovered by the Suparator® without affecting the composition of the aqueous cleaning solution. The majority of aqueous cleaners use surfactants to effect the formation of oil-in-water emulsions. In forming these emulsions, surfactant molecules "surround" oil droplets, preventing the redeposition of the oil onto cleaned parts. As a floating layer of emulsified oil accumulates and thickens, the surfactant molecules tend to migrate to the oil-water interface. According to ARR, the patented design of the Suparator® facilitates the concentration of surfactant at the oil-water interface and the reintroduction of surfactant into the bulk aqueous cleaning solution flowing beneath the floating oil layer[3]. Figure 1-3[6] illustrates this surfactant migration, concentration, and reintroduction process. With EOP techniques and membrane filtration units, surfactant is typically depleted from the aqueous cleaning solution during oil-water separation. (The reintroduction of surfactant into the aqueous cleaning solution is not encountered with traditional EOP techniques because of the flow patterns and large oil-water interfacial area



Emulsified oil



Surfactant migrates to the most stable location at the oil~ water interface



The patented design of the Suparator® facilitates the concentration of surfactant at the oil-water interface and the reintroduction of surfactant into the aqueous cleaning solution

Figure 1-3[6]. Surfactant Migration, Concentration, and Reintroduction Process

within the process tanks associated with such techniques.) Overall, the installation of the Suparator® will decrease both aqueous cleaner and oil purchase and disposal volumes. Additional P2 benefits, which will be discussed in the industry-specific portion of this report, have been realized on an installation-specific basis.

Aside from the P2 benefits derived from the installation of the Suparator®, ARR highlights the "incremental improvement to production processes" generated by the Suparator®[7]. ARR claims that the installation of the Suparator® imparts consistency to the aqueous cleaning process (and production process) by eliminating the inconsistent and inefficient oil-water separation associated with traditional EOP techniques. According to ARR, the result is an increase in production rates and product quality. For these reasons, ARR believes that the Suparator® represents a solution to a major "stumbling block" (i.e., the need for consistent and efficient oil-water separation) in the implementation of aqueous cleaning within industry.

Other benefits associated with the installation of the Suparator® result from the simplicity of its design and operation. The Suparator® thin-film separation device and the associated stainless steel process tank and Suparskim® have no moving parts. To operate effectively, the Suparator® requires only that the process flow through the unit be maintained at a level sufficiently low to prevent turbulence. (This issue is avoided with a properly matched Suparskim® and Suparator® stainless steel process tank. ARR conducts a pre-sale system evaluation to address this and other issues. Refer to Appendix A for a copy of the Engineering Survey Form used by ARR during the pre-sale system evaluation.) Optimization of the oil-water separation process requires only the manual adjustment of the height settings of the overflow siphon and water overflow weir. A procedure for "fine tuning" Suparator® performance is provided in the complete user's manual supplied with each Suparator®. Further, according to ARR, maintenance required for the Suparator® is minimal, typically consisting of the occasional draining of the stainless steel process tank and subsequent spray cleaning of the thin-film separation device and stainless steel process tank. The progressing cavity pump (provided with optional variable frequency drive), level measurement device, and control panel associated with the Suparator® also require very little maintenance.

Current industrial applications of the Suparator® provided by ARR include the recovery of quench oil (from city water) for reuse and the separation of a variety of oily contaminants from aqueous cleaning solutions created from emulsifying alkaline aqueous cleaners and oil-rejecting neutral aqueous cleaners. Potential applications extend to the separation and recovery of any two fluids with a specific gravity differential comparable to oil and water (e.g., the recovery of automatic transmission fluid from water).

2.0 TECHNOLOGY APPLICATION CASE STUDY #1

Lindberg Heat Treating Company (Lindberg) is a national company involved in the commercial heat treating industry. During the spring of 1998, a Suparator® Model 86/240 unit was installed at the Lindberg facility in Waterbury, CT. The primary function of the Waterbury facility is the heat treating of steel fasteners. The facility receives the steel fasteners, hardens them to a specified level by heat treating, and ships the hardened fasteners to a plating shop for further processing. The Waterbury facility exclusively heat treats the entire product line of a single fastener manufacturer. At the time of the site visit to collect data for this application of the Suparator®, the facility was operating three heat treating lines, with the Suparator® being installed on one of the three lines.

2.1 Application Description

The heat treating line associated with the Suparator® involves six major process steps. Initially, a computerized loading system is used to feed parts onto a conveyor from a manually loaded hopper. Part feed rate is determined by size. Fasteners less than 4" in length (approximately 75% of feed) are typically fed at 2,600 pounds per hour, while fasteners exceeding 4" in length (approximately 25% of feed) are typically fed at 1,200 pounds per hour. During 1998, the facility processed approximately nine million pounds of fasteners, projecting ten million pounds for 1999.

The conveyor transports the parts to a "Dunk and Spray" Prewasher. The Prewasher uses water heated to approximately 180°F to remove any machining fluids from the parts. The Prewasher operates as a closed-loop system, with water being continuously circulated to the spray nozzles from the "dunk" tank. The parts are first immersed in the "dunk" tank and subsequently sprayed with water during removal by an inclined conveyor system.

Prewashed parts are fed into the Meshbelt Hardening Furnace, which imparts the maximum level of hardness to the fasteners achieved during the overall heat treating process. The Furnace burns an air/natural gas mixture to maintain an average operating temperature of 1,650°F. (The minimum operating temperature of the Furnace is 1,400°F.) Ammonia is injected into the Furnace and reacts with the carbon present in the steel fasteners to form a carbonitride surface layer. This carbonitride layer increases the hardness of the parts.

Upon exiting the Furnace, the parts are immediately cooled in the Quench System. The System uses quench oil (Houghto-Quench 3440) maintained at 130°F to rapidly cool the part and "seal in" the carbonitride. Quenching is considered one of the most critical steps in the heat treating process.

Following quenching, excess quench oil is removed from the parts with the "Dunk and Spray" Postwasher. The Postwasher uses water heated to approximately 155°F to remove the quench oil from the parts and operates in a manner similar to the Prewasher. However, the large amount of quench oil entering the Postwasher necessitates the use of an oil-water separation system (i.e., the Suparator®) to maintain the effectiveness of the closed-loop cleaning process. During high throughput production periods, a small amount of polymer

(Houghton Cleaner Additive 3948) is added to the Postwasher water to aid in the oil-water separation process. Figure 2-1 illustrates the current oil-water separation system associated with the Postwasher.

After postwashing, the parts enter the Tempering Furnace. The Tempering Furnace is used to reduce the hardness of the parts to a specified level. It burns a natural gas/air mixture to maintain operating temperatures in the range of 575°F and 700°F. By reheating the parts in the absence of ammonia, the carbonitride surface layer is degraded, reducing the hardness of the part. Finished parts from the Tempering Furnace are shipped to an outside plating shop for further processing.

The Postwasher tank is equipped with the Suparskim® Model 91/275/204RH level-following weir. The Suparator® Model 86/240 unit installed at the Waterbury facility continuously separates the quench oil from the Postwasher water during Postwasher operation. The integrated stainless steel process tank associated with the Suparator® is 240 liters (63.4 gallons) in volume. The maximum flow capacity into the unit is 8.0 to 8.5 gallons per minute. The actual flow rate of Postwasher water into the unit is approximately 8.2 gallons per minute.

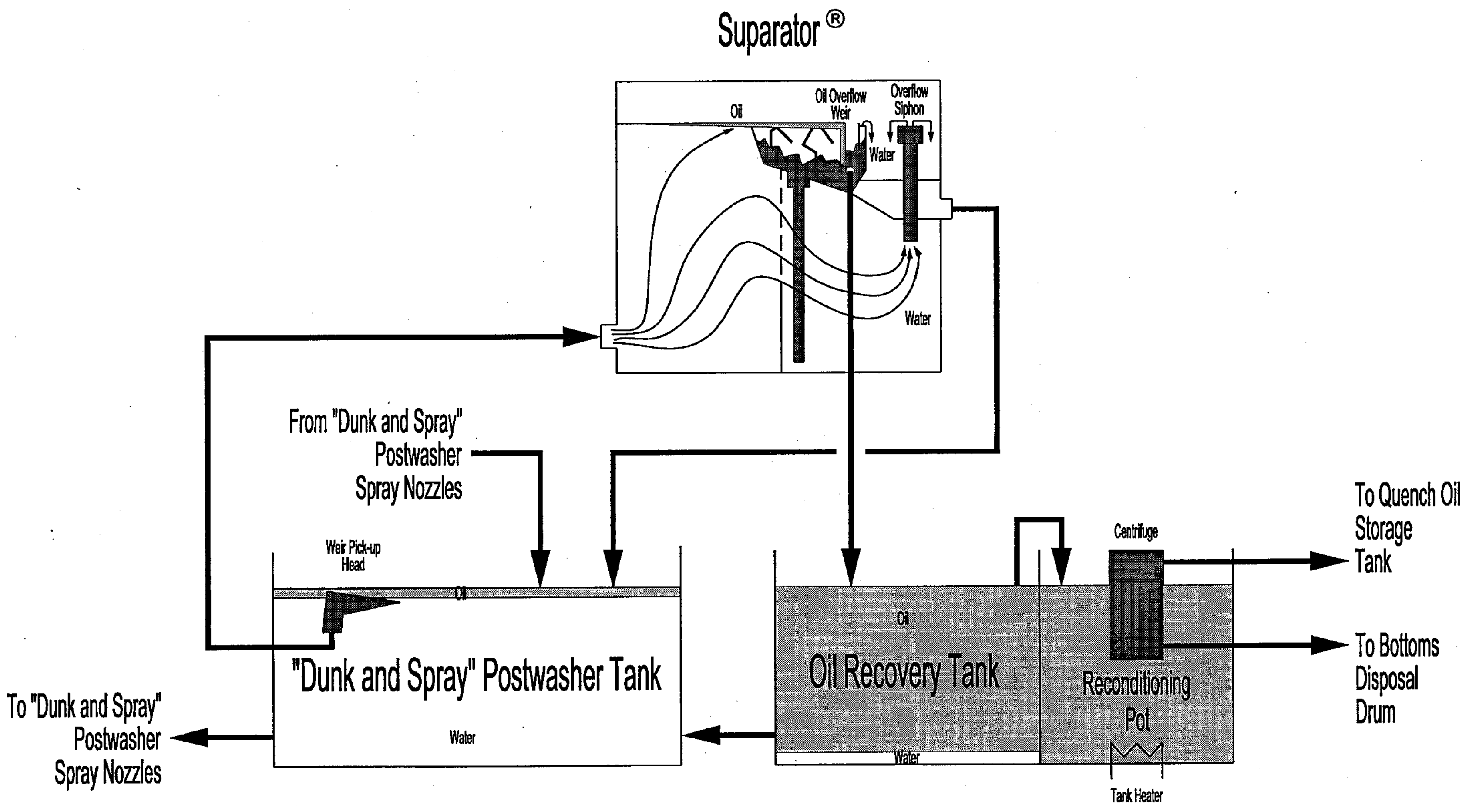
2.2 Application P2 Objectives

As stated, the large amounts of quench oil entering the "Dunk and Spray" Postwasher necessitates the use of an oil-water separation system to maintain an effective closed-loop cleaning process. The separation system initially used in conjunction with the Postwasher was an eight-inch wide oleophilic belt skimmer. The belt skimmer was installed to prevent the accumulation of oil in the Postwasher. Quench oil recovered by the belt skimmer was reused in the Quench System following treatment by an oil reconditioning system (to remove water) and a centrifuge (to remove residual water and particulate matter).

The underlying issue prompting the installation of the Suparator® was the inefficiency of the oil-water separation achieved by the belt skimmer. Because the belt skimmer was incapable of maintaining a sufficiently low concentration of quench oil in the Postwasher, the fasteners entering the Postwasher were not adequately cleaned. As the fasteners entered the Tempering Furnace, the quench oil remaining on the fasteners burned, generating a thick blue smoke (and fastener surface staining). The smoke compromised the air quality both inside and outside the facility. The primary goal of Lindberg was to address this smoke problem in the least capital-intensive method available. (One method considered by Lindberg to eliminate the smoke problem was the installation of an air pollution control system with a capital cost of approximately $800,000[5].)

A secondary concern was the reduction of quench oil purchase and disposal volumes. According to employees at the Waterbury facility, the amount of water remaining in the oil recovered by the belt skimmer exceeded the water removal capacity of the oil reconditioning system and centrifuge installed at the Waterbury facility. (Oil reconditioning system manufacturers prefer less than one percent water in the recovered quench oil feed[5].) Further, the belt skimmer was periodically incapable of recovering all of the quench oil entering the Postwasher for reuse in the Quench System, especially during times of high

Figure 2-1. Lindberg Oil Separation System



processing volume. To account for the disposal of quench oil with excessive water content and the accumulation of the quench oil in the Postwasher, it was necessary to periodically add fresh quench oil to the Quench System. (The quench oil accumulating in the Postwasher that was replaced by fresh quench oil during such periods was disposed of as waste oil.)

2.3 Application Benefits

Immediately after Suparator® installation in the spring of 1998, the smoke problem was eliminated. Further, since the Suparator® installation, the Waterbury facility has significantly reduced quench oil purchase and disposal volumes, as well as Houghton Cleaner Additive 3948 use. These benefits can be attributed to:

- An increase in the quench oil recovery rate from the Postwasher, and
- A decrease in the water content of the quench oil recovered from the Postwasher.

Other benefits stemming from the high efficiency oil-water separation produced by the Suparator® are:

- An improvement in the visual appearance of the hardened steel fasteners (no surface staining, which equates to a higher quality product),
- A reduction in the amount of time required for quench oil reconditioning,
- A decrease in the amount of water disposed of from the quench oil reconditioning system,
- An increase in the total number of fasteners processed (less downtime associated with quench oil recovery and reconditioning), and
- An increase in the quality of quench oil recovered from the Postwasher (less biodegradation).

An indirect P2 benefit that has been realized through the Suparator® installation is the elimination of an abrasive blast cleaning process (to remove surface staining) performed at the plating shop that receives hardened parts from the Waterbury facility. This is the direct result of less oil remaining in the Postwasher water. In addition, the maintenance requirements for the Suparator® are greatly reduced in comparison to the belt skimmer.

2.4 Application Performance

The critical factors in the evaluation of this particular Suparator® application are the "steady-state" concentration of quench oil in the Postwasher and the amount of water remaining in the quench oil recovered from the Postwasher. A sample of quench oil-contaminated Postwasher water was collected for analysis. Laboratory testing revealed the water contained 650 mg/L of oil & grease[†]. The efficiency of the oil-water separation achieved by the Suparator® prevents the formation of blue smoke during the tempering process.

A sample of the quench oil recovered by the Suparator® was also collected for laboratory analysis. Laboratory testing revealed the sample contained 1,080 ppm water[††]. This ppm level equates to a water content of 0.09 percent by volume. The laboratory result confirms the ability of the Suparator® to achieve the ARR guarantee for water content in the recovered oil of "less than one percent by volume". Further, this water content far exceeds the oil reconditioning system manufacturer's preference of less than one percent water in the recovered quench oil feed.

A direct comparison between the Suparator® and the belt skimmer for the Waterbury facility for a variety of operating parameters is presented in Table 2-1. The table illustrates the benefits of the Suparator® over the belt skimmer.

Table 2-1. Separation Technology Performance Comparison – Waterbury, CT

Parameter	Belt Skimmer	Suparator®
Houghto-Quench 3440 purchases (gallons per year)	18,000	1,000
Contaminated Houghto-Quench 3440 disposal (gallons per year)	18,000	0
Houghton Cleaner Additive 3948 purchases (gallons per year)	30	10
Oil-Contaminated Water Disposal from Oil Reconditioning System (gallons per year)	4,950	Negligible
Scheduled Equipment Maintenance (man-hours per year)	64	12
Scheduled Production Downtime Required for Maintenance (production-hours per year)	32	0

2.5 Application Cost Information

The Suparator® system installed at the Waterbury facility includes a stainless steel process tank, the thin-film separation device, and the level-following weir. The system also includes a progressing cavity pump with variable frequency drive, a level measurement device, and a control panel. The total capital cost for the system was $8,200.

[†] The oil & grease testing was performed by Alpha Analytical Laboratories, Inc. of Westborough, MA using EPA Method 1664. This oil & grease test method has an accepted error of +/- 20%.

[††] The water content testing was performed by Saybolt Inc. of Woburn, MA using ASTM Test Method D1744-92. According to Saybolt Inc., this ASTM test method has a reproducibility of +/-10%.

Table 2-2 presents an operating cost comparison between the original belt skimmer and the Suparator®. These operating costs were selected as being the most representative of the cost differential between the two technologies. Based on this cost differential and the initial capital investment for the Suparator®system, the payback period for Suparator® installation (assuming inflationary effects are negligible) was approximately 38 days.

Table 2-2. Operating Cost Comparison and Payback Period – Waterbury, CT

Belt Skimmer Operating Costs		**Suparator® Operating Costs**	
Houghto-Quench 3440 Purchases	$63,000[a]	Houghto-Quench 3440 Purchases	$3,500[a]
Houghto-Quench 3440 Disposal	$6,480[b]	Houghto-Quench 3440 Disposal	$0[b]
Houghton Cleaner Additive 3948 Purchases	$1,600[c]	Houghton Cleaner Additive 3948 Purchases	$530[c]
Oil-Contaminated Water Disposal	$1,780[b]	Oil-Contaminated Water Disposal	$0[b]
Scheduled Maintenance	$1,150[d]	Scheduled Maintenance	$220[d]
Production Downtime for Scheduled Maintenance	$8,000[e]	Production Downtime for Scheduled Maintenance	$0[e]
Total Annual Cost	**$82,010**	**Total Annual Cost**	**$4,250**
		Payback Period for Suparator®	**38 days**

[a] Based on Table 2-1 and Houghto-Quench purchase cost of $3.50 per gallon
[b] Based on Table 2-1 and waste disposal cost of $0.36 per gallon
[c] Based on Table 2-1 and Houghton Cleaner Additive 3948 purchase cost of $1,600 per 30 gallons
[d] Based on Table 2-1 and labor cost of $18 per man-hour
[e] Based on Table 2-1 and loss of revenue of $250 per production-hour

Currently non-quantifiable cost benefits resulting from Suparator® installation can be derived from the higher quality of the hardened fasteners produced by the facility and the elimination of the smoke problem. In addition, the installation of the Suparator® has provided the Waterbury facility with the capability to increase fastener processing rates, potentially resulting in a significant increase in annual production revenues. Finally, the Waterbury facility is perceived as being both quality-minded and environmentally-friendly. These two perceptions are often an integral part of retaining current and future customers.

2.6 Application Regulatory/Safety Requirements

According to employees at the Waterbury facility, no significant regulatory or health and safety issues were encountered either during or after Suparator® installation. In fact, the installation of this technology alleviated potential environmental and worker health problem by eliminating the smoke. Complete Suparator® operator training is provided as part of the installation package.

2.7 Application Implementation Considerations

The installation, operation, and maintenance of the Suparator® were reported to be uncomplicated and non-labor intensive by employees at the Waterbury facility, especially in comparison to prior experiences with the belt skimmer.

The single major consideration arising from this application is the need to institute a scheduled maintenance (cleaning) program. The Suparator® was initially operated for six months without cleaning (despite recommendations presented in the Suparator® user's manual), resulting in the accumulation of a layer of settled metal fines on the bottom of the process tank. These metal fines result from the washing of the steel fasteners.

To prevent future equipment fouling, the Suparator® is currently cleaned on a monthly basis. Cleaning requires approximately one hour, and involves taking the Suparator® off-line, draining the process tank, and spray washing the thin-film separation device and process tank with water. Because the cleaning procedure is simple and short, scheduled production downtime is not required.

3.0 TECHNOLOGY APPLICATION CASE STUDY #2

Dana Corporation (Dana) is an international automotive parts supplier. In September 1998, a Suparator® Model 86/240/002T unit was installed at a high-volume Dana manufacturing facility. (For purposes of this Technology Application Case Study, the Dana facility at which the Suparator® was installed will be referred to as the test facility.) The test facility fabricates automotive parts using iron castings received from a corporation-owned foundry.

3.1 Application Description

The part fabrication process at the test facility consists of a series of machining, cleaning, surface treatment, and visual inspection steps. A medium distillate oil (oil) is used as the lubricant during certain machining steps. During the first cleaning step, oil is removed from the castings using an aqueous cleaning system to prepare the castings for further machining and surface treatment steps. The Suparator® is being used in conjunction with the aqueous cleaning system to maintain low oil concentrations within the cleaner bath. The subsequent cleaning steps required during the part fabrication process are performed using vapor degreasing. The finished parts are inspected and shipped to the customers.

The aqueous cleaning system installed at the test facility uses an oil-rejecting alkaline cleaner in combination with agitation to effect oil removal from the castings. The aqueous cleaning system consists of an agitation tank (containing the aqueous cleaning solution), a city water rinse tank, a rust inhibitor solution tank, and a drying oven. Oil-contaminated cleaning solution continuously overflows the agitation tank into a separate process tank. This process tank is equipped with the Suparskim® Model 91/100/204LH level-following weir and an underflow/overflow weir. The integrated stainless steel process tank associated with the Suparator® is 240 liters (63.4 gallons) in volume. The maximum flow capacity into the unit is 8.0 to 8.5 gallons per minute. The actual flow rate into the unit is approximately 6.1 gallons per minute. Figure 3-1 illustrates the oil separation system installed at the test facility.

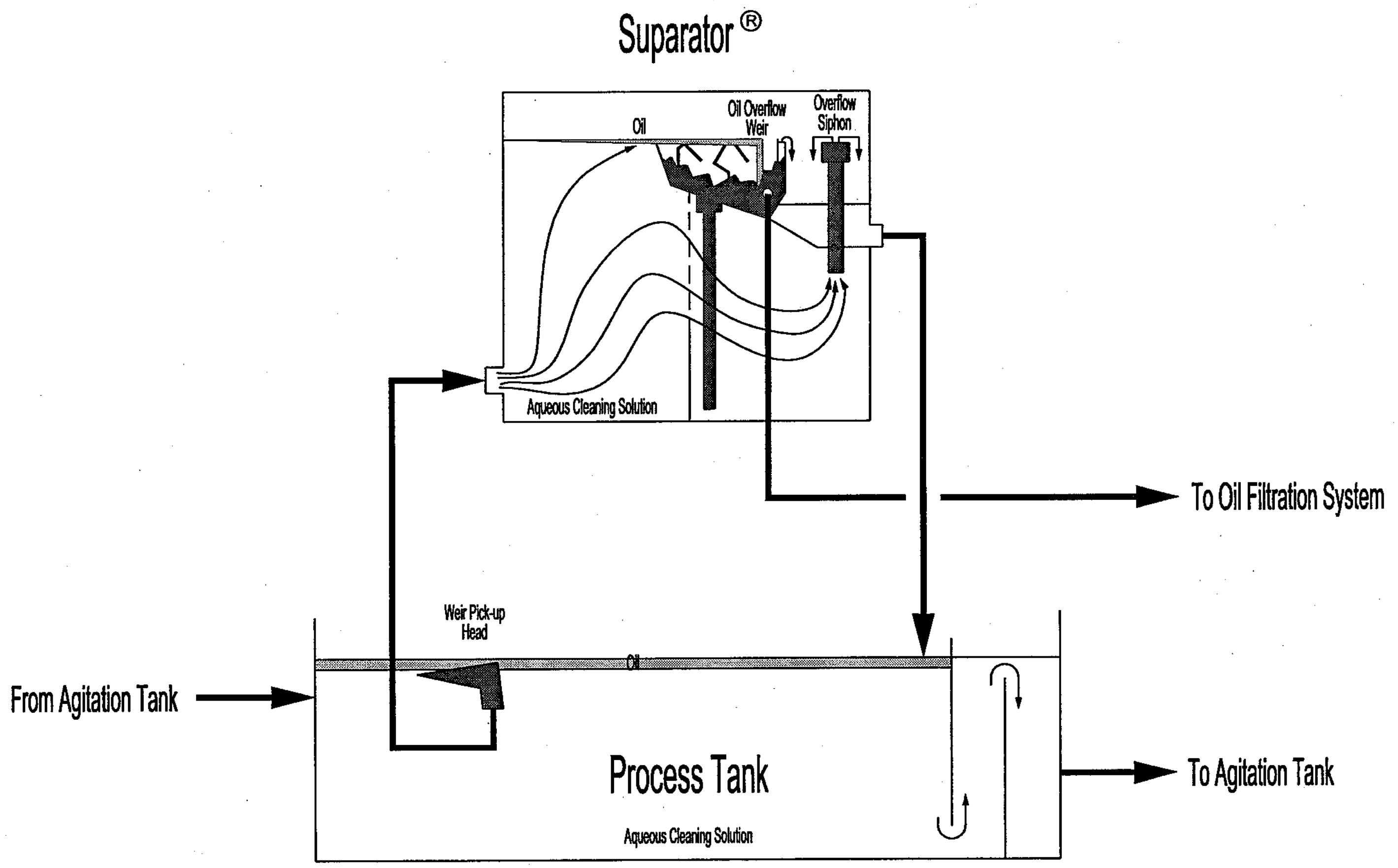
3.2 Application P2 Objectives

Elimination of vapor degreasing was the driving force behind the installation of the aqueous cleaning system at the test facility. However, an aqueous cleaning system must incorporate an effective, reliable oil removal method to optimize the quality, consistency, and cost-effectiveness of the cleaning process. The two methods considered for oil removal from the contaminated aqueous cleaning solution at the test facility were ultrafiltration and the Suparator®. The methods were compared based on the following parameters:

- Initial capital cost,
- Annual operation and maintenance costs,
- Rate of oil recovery, and
- Production downtime resulting from maintenance of the oil removal equipment.

Based on this comparison, the Suparator® was selected over ultrafiltration.

Figure 3-1. Dana Oil Separation System



3.3 Application Benefits

The Suparator® is one of the major factors contributing to the effectiveness of the aqueous cleaning system installed at the test facility. And it is the effectiveness of the aqueous cleaning system that has allowed for the partial elimination of vapor degreasing at the test facility. By partially eliminating vapor degreasing, the test facility has decreased the environmental and worker health hazards associated with the handling and use of trichloroethylene, as well as trichloroethylene purchase and disposal volumes (and costs).

Further, the success encountered by Dana with aqueous cleaning at the test facility is prompting the installation of two Suparator®-equipped aqueous-based drum washers at the test facility. Dana stated that the installation of these drum washers will further eliminate vapor degreasing at the test facility.

Another major benefit realized through the installation of the Suparator® is the ability of the test facility to rapidly recover the medium distillate oil from the aqueous cleaning solution for reuse. This significantly reduces periodic oil purchase and disposal volumes. The oil recovered by the Suparator® must only be passed through a fabric filter to remove particulate matter prior to reuse within the test facility as a machining lubricant. Currently, 60 to 80 gallons of oil are recovered by the Suparator® each week.

Finally, Dana indicated that the test facility was being used as the "corporate trial case" for aqueous cleaning. Dana operates manufacturing facilities throughout the world. The success encountered at the test facility is prompting the future installation of aqueous cleaning systems at other Dana facilities. In addition to the corporate cost savings and environmental and worker health benefits, Dana expects the reporting and permitting requirements associated with trichloroethylene use to be decreased or eliminated for certain Dana facilities.

3.4 Application Performance

For this particular application, the ability of the Suparator® to rapidly recover large volumes of oil from the oil-contaminated aqueous cleaning solution without adversely affecting the composition of the recycled aqueous cleaning solution (i.e., depleting the solution of surfactant) is critical. Samples of the oil-contaminated aqueous cleaning solution flowing into the Suparator® (i.e., influent) and samples of the recycled aqueous cleaning solution flowing from the Suparator® (i.e., effluent) were collected by ARI for laboratory analysis. Table 3-1 summarizes the laboratory results.

Table 3-1. Laboratory Testing Results – Dana Test Facility

Source	Oil & Grease (mg/l)[a]	Surfactant (% by volume)[b]
Influent	2,501	3.33
Effluent	901	4.18

[a] The oil & grease testing was performed by Alpha Analytical Laboratories, Inc. of Westborough, MA using EPA Method 1664. This oil & grease test method has an accepted error of +/- 20%.

[b] The surfactant testing was performed by the Toxics Use Reduction Institute Surface Cleaning Laboratory at the University of Massachusetts Lowell using the Bama Chem Nonionic Surfactant Kit. At the writing of this report, the accepted error for this surfactant test method had not yet been determined by Bama Chem.

The results indicate that the Suparator® recovered approximately 64% of the oily contaminants contained in the influent, which confirms the effectiveness of the oil-water separation achieved by the Suparator®. The results also indicate that the Suparator® does not deplete the aqueous cleaning solution of surfactant. In fact, the testing suggests that the Suparator® increases the concentration of surfactant in the aqueous cleaning solution. Although the higher percentage of surfactant in the effluent may be attributable to the errors inherent in the surfactant testing procedure, ARR confirms (based on field experience) that the testing results match performance levels consistently observed for other Suparator® installations. As stated in Section 1.2, ARR describes this phenomenon as the surfactant in the aqueous cleaner migrating out of the layer of floating oil collected in the Suparator® to be reintroduced to (and concentrated in) the aqueous cleaning solution flowing beneath the collected oil layer (refer to Figure 1-3).

A sample of the medium distillate oil recovered by the Suparator® was also collected by ARI for analysis. Laboratory testing revealed the sample contained 137 ppm water[†]. This ppm level of water content, which is comparable to the manufacturer specification of <100 ppm for "virgin" medium distillate oil, equates to a water content of 0.01 percent by volume, which far exceeds the guarantee from ARR of "less than one percent by volume".

Overall, the results indicate that the Suparator® performs very well in this particular application. The data gathered at the test facility confirms the ability of the Suparator® to rapidly and continuously collect large volumes of concentrated (i.e., low water content) oil from the influent, while simultaneously preserving high surfactant concentrations in the effluent.

3.5 Application Cost Information

The Suparator® system installed at the test facility includes a stainless steel process tank with a stainless steel cover, the thin-film separation device, and the level-following weir. The system also includes a level measurement device and a control panel. As purchased, the original system included a progressing cavity pump with variable frequency drive. The total capital cost for the original system was $9,075.

[†] The water content testing was performed by Saybolt Inc. of Woburn, MA using ASTM Test Method D1744-92. According to Saybolt Inc., this ASTM test method has a reproducibility of +/-10%.

At the writing of this case study, Dana had not developed any projected annual savings in operating costs directly attributable to the use of the Suparator® at the test facility (i.e., the actual operating costs associated with the existing Suparator®-equipped aqueous cleaning system versus the estimated operating costs associated with the existing aqueous cleaning system equipped with no oil-water separation technology). As stated, the Suparator® is one of the major factors contributing to the effectiveness of the aqueous cleaning system installed at the test facility. The high-efficiency oil-water separation, cleaner bath life extension, and oil recycling attributed to the Suparator® increase the performance and cost-effectiveness of the aqueous cleaning system at the test facility. Without the Suparator®, the cost-effectiveness of switching to aqueous cleaning from vapor degreasing at the test facility would very likely be significantly reduced.

With respect to non-quantifiable cost benefits resulting from the installation of the aqueous cleaning system, it should be noted that the switch to aqueous cleaning from vapor degreasing has not reduced the quality of the parts at the test facility. It should also be noted that the installation of the aqueous cleaning system at the test facility has not increased the production downtime required for cleaning system maintenance or decreased the overall facility production rate. The test facility is high-volume, and losses in revenue resulting from decreases in production are of major concern. In addition, as stated in Section 3.3, by partially eliminating vapor degreasing, the test facility has decreased the environmental and worker health hazards associated with the handling and use of trichloroethylene.

3.6 Application Regulatory/Safety Requirements

According to employees at the test facility, no significant regulatory or health and safety issues were encountered either during or after Suparator® installation. Complete Suparator® operator training is provided as part of the installation package.

3.7 Application Implementation Considerations

The installation, operation, and maintenance of the Suparator® were reported to be "straightforward and easy" by employees at the test facility. Dana employees working from diagrams provided by ARR performed the initial installation during one eight-hour shift. The time required for Suparator® maintenance activities are minimal (Dana estimates two man-hours per month). Since installation, the performance of the Suparator® has fulfilled all expectations. As stated in Section 3.3, at the time of the site visit to collect data for this application of the Suparator®, Dana intended to order two more Suparator® units for use in the test facility.

The single problem encountered during this application was the failure of the progressing cavity pump originally installed with the Suparator®. The swarf washed from the castings during the aqueous cleaning process slowly wore down the impeller of the pump, gradually reducing pump efficiency. Dana replaced the original pump with a second progressing cavity pump, which eventually failed in the same manner. In February 1999, Dana replaced the second progressing cavity pump with a diaphragm pump. This pump has performed well and Dana believes it has solved the "pump problem".

4.0 TECHNOLOGY APPLICATION CASE STUDY #3

The West Bend Company (West Bend) facility in West Bend, WI specializes in the manufacturing of cookware. During February 1998, a Suparator® Model 86/240/001T unit was installed in the Premier Cookware division at the West Bend facility. Based on the performance of this initial unit, four additional Suparator® Model 86/240/003T units were installed at the facility during June 1999. The high-volume production lines associated with the five Suparator® units manufacture various pieces of stainless steel cookware. The finish quality of this stainless steel cookware is critical to the point-of-sale value perceived by consumers. (West Bend refers to the finish quality of this cookware as “Jewel Finish”.)

4.1 Application Description

The production lines associated with the five Suparator® units involve a series of machining and finishing processes. Although these production lines vary based on the type of cookware being manufactured, employees at the West Bend facility indicated that the operating conditions of the aqueous cleaning systems associated with these production lines are similar. The Suparator® units are being used to remove excess oil and maintain low oil concentrations within aqueous cleaning solutions. (A total of eighteen aqueous cleaning systems are in operation at the West Bend facility. The Suparator® units are installed on the five aqueous cleaning systems that experience the highest loadings of oily contaminants.) For this reason, the performance of a single Suparator®-equipped production line was documented in this case study.

For the production line detailed in this case study, the initial step is the drawing of stainless steel disks into the desired cookware shape. A water-soluble drawing oil is used as a lubricant during the drawing process. Following the drawing process, a stamping process is used to remove excess stainless steel from the cookware. After the stamping process, a rolling process is used to eliminate the sharp edges from the cookware that result from the stamping process. A petroleum-based oil is used as the lubricant during the rolling process. The final processes involved with the manufacture of the cookware are surface finishing operations. A belt sanding operation is used to impart a “shiny” finish on the outside surface of the cookware, removing all surface defects from the stainless steel in the process. The petroleum-based oil used during the rolling process is used in conjunction with a natural (i.e., animal-based) grease to provide lubrication during the belt sanding operation. Following this operation, a second sanding operation is used to impart a “shiny” finish on the inside surface of the cookware. A petroleum-based sanding oil is used as a lubricant during this operation. After these two sanding operations, the oils remaining on the cookware are removed by aqueous cleaning in a belt conveyor spray washer. Following aqueous cleaning, a buffing process and a dry bottom finishing process complete the overall cookware manufacturing process. The final step prior to the packaging and shipping of the cookware is a second aqueous cleaning process to remove residual contaminants resulting from the buffing and bottom finishing processes. (No Suparator® units are installed on the “second” aqueous cleaning systems. These aqueous cleaning systems experience relatively low loadings of oil contaminants.)

Each of the belt conveyor spray washers installed at the West Bend facility use the same oil-rejecting surfactant-based neutral pH (i.e., the pH of the aqueous cleaning solution ranges from 7.0 to 8.0 at use dilution) cleaner. This neutral cleaner is purchased from Environmentally Sensitive Solutions, Inc. (ESS) of Milwaukee, WI. The aqueous cleaner is used at a ten percent solution in "soft" water (i.e., water treated to remove hardness ions). The aqueous cleaning solution is held at approximately 150°F. The aqueous cleaning solution is pumped through spray nozzles to effect oil removal from the cookware. During production, the cookware is continuously fed through the spray washers on conveyor belts. The initial spray cleaning step is followed by a city water rinse, a "soft" water recirculatory rinse, and a final deionized water rinse. Similar to most common spray washer designs, each of these rinses also uses spray nozzles. (The cookware is not immersed at any time during the aqueous cleaning or rinsing processes. All cleaning and rinsing is performed with spray nozzles.) After the final rinsing step, the cookware is passed under an air knife to remove residual water prior to entering a drying oven to eliminate any remaining water.

For every aqueous cleaning system at the West Bend facility, oil-contaminated aqueous cleaning solution is continuously collected in a tank located beneath the aqueous cleaning solution spray nozzles (the cleaner reservoir tank). This tank is equipped with the Suparskim® Model 91/100/204LH level-following weir. The Suparator® units installed at the West Bend facility continuously separate the oil from the aqueous cleaning solution during aqueous cleaning system operation. The integrated stainless steel process tank associated with each Suparator® is 240 liters (63.4 gallons) in volume. The maximum flow capacity into each unit is 8.0 to 8.5 gallons per minute. The actual flow rate into each unit is approximately 6.0 gallons per minute. Figure 4-1 illustrates the oil separation system installed at the West Bend facility.

4.2 Application P2 Objectives

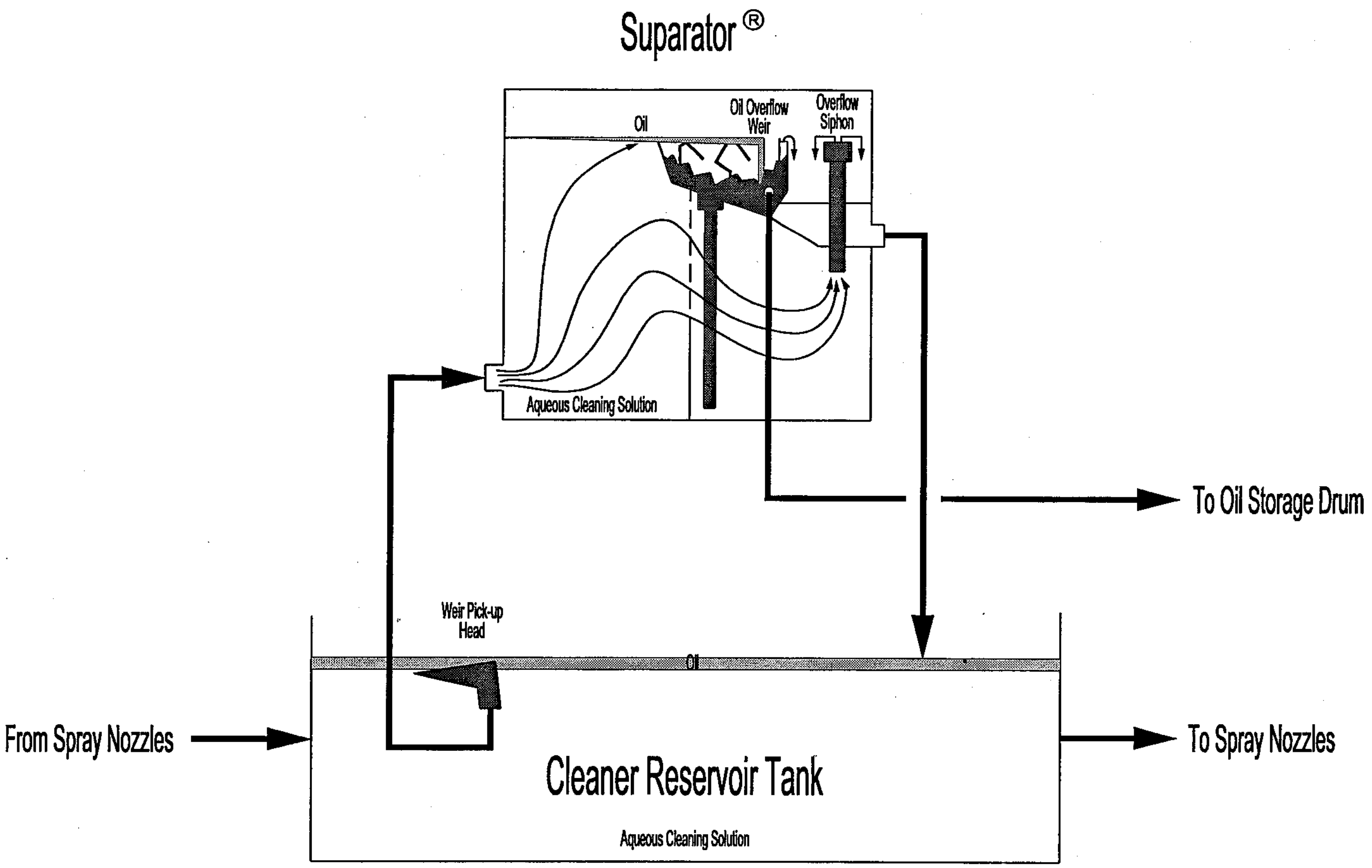
The installation of the first Suparator® at the West Bend facility was prompted by both regulatory and economic concerns. During recent years, the local regulations governing the discharge of wastewater from the West Bend facility were becoming increasingly restrictive on the permissible concentrations of oil and grease. This trend prompted the West Bend facility to investigate the use of various oil-water separation technologies.

In addition, the facility was purchasing large quantities of sanding oil for use in the cookware sanding operations. (Note that the petroleum-based sanding oil used during the sanding of the inside surface of the cookware represents the vast majority of the oily contaminants being removed by the aqueous cleaning systems.) The West Bend facility recognized that significant cost savings could be achieved by recovering the sanding oil from the aqueous cleaning solution for reuse within the cookware manufacturing process.

4.3 Application Benefits

The West Bend facility currently uses both a cyclonic oil-water separation system and the Suparator® for the removal of oily contaminants from aqueous cleaning solutions. The aqueous cleaning system manufacturer included the cyclonic system as original equipment on each of the aqueous cleaning systems installed at the West Bend facility. Although it

Figure 4-1. West Bend Oil Separation System



has been partially replaced at the West Bend facility by the Suparator®, the cyclonic system continues to be used with the aqueous cleaning systems that experience relatively low loadings of oily contaminants.

Certain drawbacks are associated with the use of the cyclonic system. The first drawback is the inefficiency of the system (i.e., the system removes significant quantities of aqueous cleaning solution during the oil-water separation process). The second drawback is the labor-intensive collection method for the oil recovered by the system. The effluent (i.e., the "oil" stream) from the cyclonic system is continuously transferred to a "quiet" tank located adjacent to the cleaner reservoir tank during aqueous cleaning system operation. The aqueous cleaning systems at the West Bend facility typically operate over two eight-hour shifts per day. During the eight hours of aqueous cleaning system downtime, the effluent from the cyclonic system contained in the "quiet" tank splits into two phases (i.e., oily contaminants and aqueous cleaning solution). At the beginning of each new workday, employees at the West Bend facility must collect the floating oil from the surface of the "quiet" tank using a wet-dry vacuum. The amount of water (and aqueous cleaner) mixed with the oil recovered by the vacuum precludes the reuse of any oil collected with the cyclonic system within the West Bend facility.

In comparison, the Suparator® is a highly efficient, non-labor-intensive oil-water separation method. The oil collected by the Suparator® has an extremely low water content and is suitable for reuse within the West Bend facility. In addition, oil collected by the Suparator® continuously flows into a 55-gallon storage drum, requiring no "quiet" tank or operator labor. The installation of the first Suparator® unit at the West Bend facility in February 1998 yielded significant increases in aqueous cleaner bath life (resulting in significant decreases in aqueous cleaner purchases). It is expected that the four new Suparator® units will produce similar results.

Although sanding oil recovered by the five Suparator® units is not currently reused at the West Bend facility, there are intentions to do so in the future. The sanding oil contains chlorine and disposal costs associated with the sanding oil are significant. (All of the other types of oil used at the West Bend facility do not contain chlorine. These "other" oils are disposed of at no cost to the West Bend facility.) By reusing the sanding oil, the West Bend facility will eliminate disposal costs and reduce the liability associated with the disposal of waste oils. (Because of a prior negative experience associated with the use of recycled sanding oil at the West Bend facility, the sanding oil recovered by the Suparator® units is not currently reused at the facility. Extensive testing of the recovered sanding oil must be performed to ensure that use of the recovered oil will not have any detrimental effects on the finished cookware.)

Additional benefits stemming from the installation of the Suparator® (relative to the use of the cyclonic system) include an improvement in the quality of the finished cookware and a decrease in the concentration of oil in the wastewater being discharged from the West Bend facility to the local publicly-owned treatment works (POTW). The increase in quality is the result of less oil remaining on the cookware after aqueous cleaning, which decreases the potential for staining during the drying process. The decrease in oil concentration in the wastewater discharged to the local POTW is also the result of less oil remaining on the cookware after aqueous cleaning. In this case, less oil remains to be washed from the cookware during the city water rinse step. (The effluent from the city water rinse step is discharged directly to drain.) Both of these benefits can be attributed to the high-efficiency, continuous oil-water separation effected by the Suparator®.

Prior to installation of the Suparator®, the West Bend facility experimented with the use of an oleophilic disk separator (i.e., a disk skimmer) as a replacement for the cyclonic system. However, this method did not produce acceptable results at the West Bend facility during the evaluation period.

4.4 Application Performance

For the aqueous cleaning application at the West Bend facility, the ability of the Suparator® to rapidly recover large volumes of oil from the oil-contaminated aqueous cleaning solution without adversely affecting the composition of the recycled aqueous cleaning solution (i.e., depleting the solution of surfactant) is critical. Samples of the oil-contaminated aqueous cleaning solution flowing into a Suparator® (i.e., influent) and samples of the recycled aqueous cleaning solution flowing from a Suparator® (i.e., effluent) were collected from a representative aqueous cleaning system installed at the West Bend facility by ARI for laboratory analysis. The aqueous cleaning solution tested was heavily loaded with sanding oil. Table 4-1 summarizes the laboratory results.

Table 4-1. Laboratory Testing Results – West Bend, WI

Source	Oil & Grease (mg/l)[a]	Surfactant (% by volume)[b]
Influent	26,730	1.59
Effluent	390	2.06

[a] The oil & grease testing was performed by Alpha Analytical Laboratories, Inc. of Westborough, MA using EPA Method 1664. This oil & grease test method has an accepted error of +/- 20%.

[b] The surfactant testing was performed by the Toxics Use Reduction Institute Surface Cleaning Laboratory at the University of Massachusetts Lowell using the Bama Chem Nonionic Surfactant Kit. At the writing of this report, the accepted error for this surfactant test method had not yet been determined by Bama Chem.

The oil & grease testing indicates that the Suparator® tested by ARI recovered approximately 99% of the oily contaminants contained in the influent, which confirms the effectiveness of the oil-water separation achieved by the Suparator®. According to ESS, the performance of the Suparator® is optimized by using an oil-rejecting cleaner. Independent laboratory testing performed by ESS for Suparator®-equipped aqueous cleaning systems using oil-rejecting cleaners documented similar Suparator® oil recovery rates (as well as reductions in the metals content in spent aqueous cleaning solutions)[8].

The surfactant testing indicates that the Suparator® does not deplete the aqueous cleaning solution of surfactant. In fact, the testing suggests that the Suparator® increases the concentration of surfactant in the aqueous cleaning solution. As stated in Section 3, although the higher percentage of surfactant in the effluent may be attributable to the errors inherent in the surfactant testing procedure, ARR confirms (based on field experience) that the testing results match performance levels consistently observed for other Suparator® installations. As stated in Section 1.2, ARR describes this phenomenon as the surfactant in the aqueous cleaner migrating out of the layer of floating oil collected in the Suparator® to be reintroduced to (and concentrated in) the aqueous cleaning solution flowing beneath the collected oil layer (refer to Figure 1-3).

A sample of the sanding oil recovered by the Suparator® was also collected by ARI for analysis from the same representative aqueous cleaning system. Laboratory testing revealed the sample contained 13,700 ppm water[†]. This ppm level equates to a water content of 1.2 percent by volume. Although this slightly exceeds the water content guarantee from ARR of "less than one percent by volume", the Suparator® unit from which the oil sample was collected had been recently installed and no laboratory testing had been performed to determine the water content in the oil. With some minor "fine tuning", the unit can be expected to meet the ARR guarantee. Regardless, this water content is much lower than the water content of oil collected by the cyclonic system and the oleophilic disk separator.

Overall, the results indicate that the Suparator® performs very well in this particular application. The data gathered at the West Bend facility confirms the ability of the Suparator® to rapidly and continuously collect large volumes of concentrated (i.e., low water content) oil from the influent, while simultaneously preserving high surfactant concentrations in the effluent.

4.5 Application Cost Information

Each of the five Suparator® systems installed at the West Bend facility includes a stainless steel process tank, the thin-film separation device, and the level-following weir. Each system also includes a progressing cavity pump with variable frequency drive, a level measurement device, and a control panel. The total capital cost for each system was $7,485, which reflected the quantity discount offered for multiple one-time installations.

Operating data associated with the first Suparator® unit (installed in February 1998) was used as a basis to estimate savings in operating costs resulting from the replacement of a cyclonic system with a Suparator® system. (At the writing of this case study, operating data was not available for the four Suparator® units installed in June 1999.) The savings in operating costs for the West Bend facility are presented in Table 4-2. The operating costs presented in Table 4-2 were selected as being the most representative of the cost differential between the two oil-water separation technologies. Based on these cost savings and the initial capital investment for a Suparator®system, the payback period for the replacement of a cyclonic system with a Suparator® system (assuming inflationary effects are negligible) is approximately 15 months. As the savings in operating costs are more accurately quantified by the West Bend facility over time, ARR expects this payback period to decrease.

[†] The water content testing was performed by Saybolt Inc. of Woburn, MA using ASTM Test Method D1744-92. According to Saybolt Inc., this ASTM test method has a reproducibility of +/-10%.

Table 4-2. Operating Cost Savings – West Bend, WI[a]

Benefit of Suparator® Installation	Annual Operating Cost Savings
Extension of aqueous cleaner bath life • Decrease in aqueous cleaner purchases by 50% • Decrease in labor for tank cleaning by 50%	$3,640
Increase in oil-water separation efficiency • Decrease in aqueous cleaner losses with oil	$540
Increase in oil-water separation efficiency • Decrease in labor involved with oil collection	$840
Decrease in electric power consumption[b]	$1,000
Total Savings	**$6,020**

[a] Developed by Dennis Cain of the West Bend Company

[b] Based on the substitution of a 5 hp motor (associated with the cyclonic system influent feed pump) with a 1 hp motor (associated with the Suparator® influent feed pump)

The savings in operating costs associated with the installation of the Suparator® also support the use of a surfactant-based neutral aqueous cleaner at the West Bend facility. Based on environmental considerations (i.e., the elimination of worker safety and wastewater treatment issues), the West Bend facility switched to a surfactant-based neutral cleaner from an alkaline cleaner approximately six years ago, despite the fact that the neutral cleaner was slightly more expensive on a per gallon basis than the alkaline cleaner. This slightly higher per gallon cost of the surfactant-based neutral cleaner is offset by the decrease in annual aqueous cleaner purchase costs.

Currently non-quantifiable cost benefits resulting from Suparator® installation at the West Bend facility can be derived from:

- the reduction in scheduled oil-water separation equipment maintenance,
- the opportunity to potentially reuse sanding oil within the facility,
- the higher quality of the cookware manufactured at the facility,
- the elimination of cookware rework resulting from quality issues, and
- the ability to consistently meet permitted limits for oil and grease concentration in wastewater discharges from the facility.

4.6 Application Regulatory/Safety Requirements

According to employees at the West Bend facility, no significant regulatory or health and safety issues were encountered either during or after Suparator® installation. Complete Suparator® operator training is provided as part of the installation package.

4.7 Application Implementation Considerations

In general, the employees at the West Bend facility are very satisfied with the performance of the Suparator®. The employees responsible for the operation and maintenance of the five Suparator® units have requested that Suparator® units be installed on the remaining aqueous cleaning systems at the West Bend facility that experience high loadings of oily contaminants.

However, a few minor issues were encountered following the initial installation of the Suparator® unit at the West Bend facility in February 1998. First, a regularly scheduled cleaning program had to be instituted to prevent the accumulation of settled particulate matter on the bottom of the Suparator® process tank. This cleaning program requires little time and manpower. In addition, the influent piping to the Suparator® occasionally became clogged with fibrous material (the fibrous material was introduced to the aqueous cleaning system from the cookware manufacturing process), requiring the Suparator® to be taken off-line for maintenance. This problem was addressed by placing a fine mesh screen on the intake of the Suparator® influent line. An alternative method of addressing both of these issues presently being considered at the West Bend facility is the installation of a bag filter on the influent line of the Suparator® (prior to the progressing cavity pump intake).

A final issue encountered with the five Suparator® units installed at the West Bend facility has arisen from the method of mounting the level-following weirs in the cleaner reservoir tanks. The Suparator® units at the West Bend facility were retrofitted into existing cleaner reservoir tanks. Aqueous cleaning system process conditions and facility floorspace constraints required that the level-following weirs be mounted at a "fixed" level within the cleaner reservoir tanks (i.e., the level-following weirs are capable of adjusting to a maximum 4" liquid level change in the cleaner reservoir tanks). Automatic water make-up systems (which were present prior to the installation of the Suparator® units) are used to maintain the liquid levels in the cleaner reservoir tanks within the operating range reported by West Bend to ARR during the initial pre-sale system evaluation. It is critical that liquid levels be maintained within this range to prevent the progressing cavity pumps associated with the Suparator® units from "running dry" and to ensure that the level-following weirs collect the upper layer of liquid from the cleaner reservoir tanks. Employees at the West Bend facility expressed concerns regarding the dependability of these automatic water make-up systems (e.g., potential system malfunctions, introduction of the opportunity for operator error, etc.), stating in retrospect that installing the level-following weirs in a "free floating" (rather than "fixed") configuration may have been preferable.

5.0 TECHNOLOGY APPLICATION CASE STUDY #4

The Racine Plating Company (Racine) facility in Racine, WI specializes in the surface finishing of metal parts (primarily electroplating). Two Suparator® Model 86/240/001 units were installed at the Racine facility during May 1999. The Racine facility functions as a "job shop", processing many different types of metal parts contaminated with different types of oils.

5.1 Application Description

The surface finishing processes offered by the Racine facility include:

- Zinc, copper, nickel, bright chrome, and hard chrome plating;
- Pickling, passivating, phosphating, irriditing, and black oxide coating; and
- Tumbling & deburring, polishing & buffing, and vapor degreasing.

Prior to undergoing any of the surface finishing processes (with the exception of tumbling & deburring and vapor degreasing), the metal parts must be cleaned of oily contaminants. In sequential order, the overall process used for the removal of oily contaminants consists of an aqueous cleaning step (using an alkaline cleaner), an electrocleaning step, and a pickling step (using sulfuric acid). Immediately following each of these steps is a city water rinse. Two such cleaning lines are in operation at the Racine facility.

The Suparator® units are being used to maintain low oil concentrations within the aqueous cleaning solutions used at the Racine facility. The facility currently uses two different types of alkaline aqueous cleaners. One type is an emulsifying chemistry (described by employees at the facility as intermediate between fully emulsifying and fully oil-rejecting), while the other type is an oil-rejecting chemistry. At the time of the site visit to collect data for this application of the Suparator®, the emulsifying chemistry was being phased out in favor of the oil-rejecting chemistry. (The remaining stock of emulsifying cleaner was still being used on one of the cleaning lines at the Racine facility during the site visit, while the cleaning line using the oil-rejecting cleaner had been "started" only two days prior to the visit.)

The data gathered during the site visit to the Racine facility focuses on the performance of the cleaning lines while using emulsifying cleaners in the aqueous cleaning step. The emulsifying cleaner in use during the site visit (which is delivered in flake form) is used at a ratio of ten ounces per gallon in city water, with the cleaning solution being held at approximately 160°F. The cleaning line currently using the emulsifying cleaner operates as a "rack system", with the parts being sequentially immersed in each of various cleaning and rinsing tanks. (The cleaning line currently using the oil-rejecting cleaner operates as a "barrel system".) For the "rack system", air is used to agitate the aqueous cleaning solution to aid in the removal of oily contaminants from the metal parts. Employees at the Racine facility estimate that for both cleaning lines the initial aqueous cleaning step removes in excess of 99% of the oily contaminants from the metal parts.

For each cleaning line, the tank containing the oil-contaminated aqueous cleaning solution (i.e., the soak cleaner tank) is equipped with the Suparskim Model 91/100/204 level-following weir. The Suparator® Model 86/240/001 units installed at the Racine facility continuously separate the oil from the aqueous cleaning solution during aqueous cleaning system operation. The integrated stainless steel process tank associated with each Suparator® is 240 liters (63.4 gallons) in volume. The maximum flow capacity into each unit is 8.0 to 8.5 gallons per minute. The actual flow rate into each unit is approximately 5.9 gallons per minute. Figure 5-1 illustrates the oil separation systems installed at the Racine facility.

5.2 Application P2 Objectives

The installation of the Suparator® units at the Racine facility was intended to:

- Extend aqueous cleaner bath life,
- Reduce the number of "finished" parts that require rework due to quality issues, and
- Reduce rinse water consumption.

Employees indicated that the reworking of parts represents a significant portion of annual revenue losses for the Racine facility. Reworking is typically required after oil-contaminated parts are plated. By maintaining low concentrations of oil in the cleaning and rinse tanks, the number of parts requiring reworking is significantly reduced.

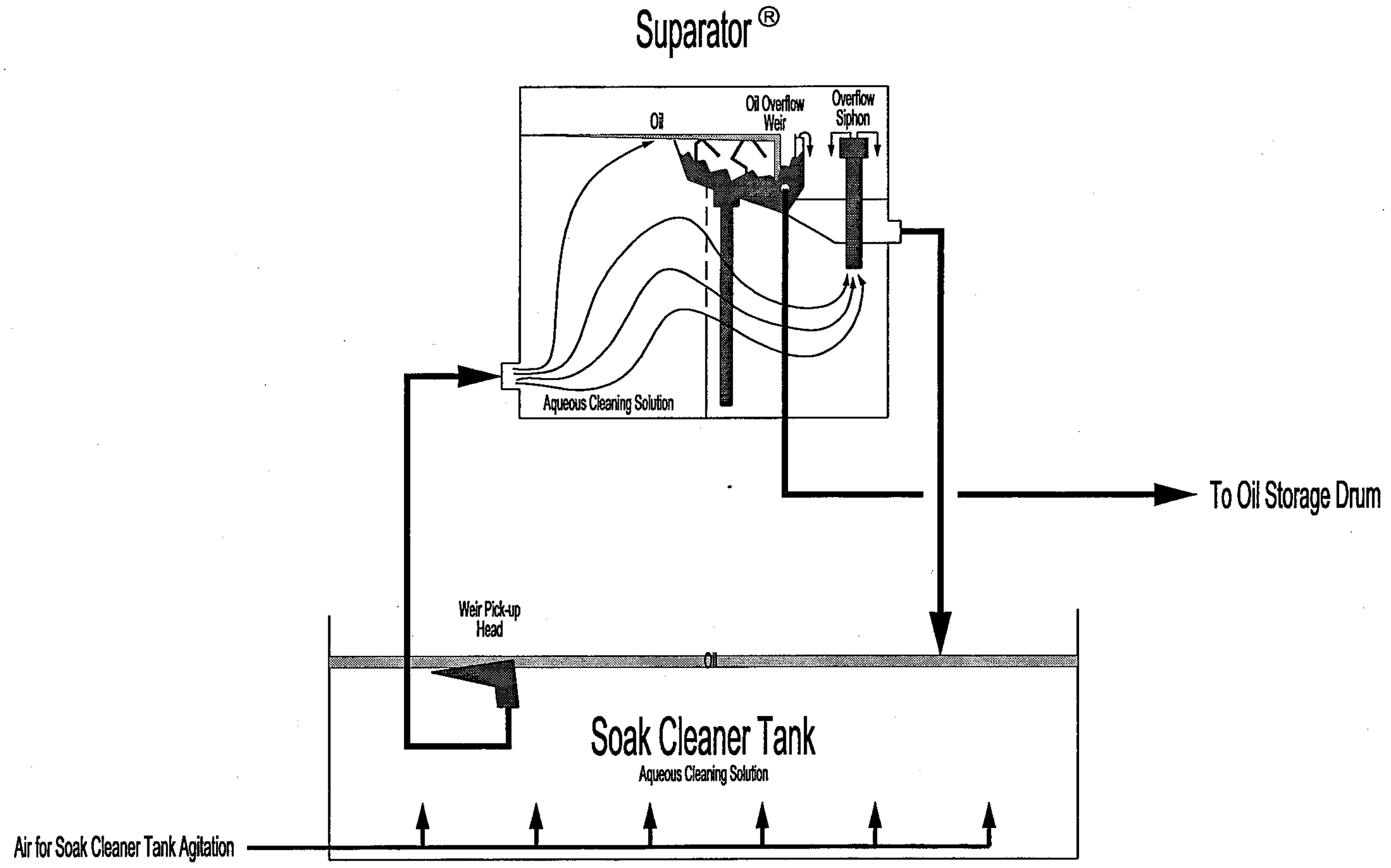
The Racine facility has no intention of recycling the oil recovered by the Suparator®. No potential uses for the oil exist at the Racine facility. Further, the recovered oil represents a mixture of many different types of oils and cannot be sold to an outside user for a particular purpose (i.e., lubricant, coolant, etc.).

5.3 Application Benefits

As stated, the data gathered during the site visit to the Racine facility focuses on the performance of the cleaning lines while using emulsifying cleaners in the aqueous cleaning step. The installation of the Suparator® units has benefited each of the steps associated with the cleaning lines while using emulsifying cleaners. The life of the aqueous cleaner and electrocleaner baths have been extended, resulting in decreased emulsifying cleaner and electrocleaner use and purchases, respectively. The life of the pickling baths have been extended, resulting in decreased sulfuric acid use and purchases. (Because of the overall chemical use in the plating processes, environmental reporting responsibilities will not be reduced at the Racine facility.)

These benefits are the direct result of the continuous, highly efficient oil-water separation achieved by the Suparator®. In the case of the aqueous cleaning step, the increase in bath life is the result of oil removal and cleaner component (i.e., surfactants, builders, etc.) recycling. In the case of the electrocleaning and pickling steps, the increase in bath life is the result of less oil being "dragged down" the cleaning line to interfere with electrocleaner

Figure 5-1. Racine Plating Oil Separation System



and sulfuric acid, respectively. (Employees at the Racine facility estimate that oil drag-out from the aqueous cleaning bath has been reduced by 70 to 80 percent.) In general, the visual appearances of all of the cleaning process tanks have also improved. The aqueous cleaning tank remains clear (as opposed to gradually becoming cloudy), while the quantity of floating oil on the electrocleaning and pickling tanks has been significantly reduced. (The cause of the majority of the rework at the Racine facility is the redeposition of oil from this floating layer on the metal parts during removal from the pickling tanks.)

In addition, for each cleaning line, the three city water rinsing steps have been combined into single, three-stage counterflow cascade processes. Before the installation of the Suparator®, the three city water rinsing steps associated with each cleaning line were operated independently of one another. By combining the three rinses into a cascade configuration, the flow rate of make-up city water (the rinse tanks continuously overflow to drain) has been reduced by approximately 50%. This decrease in water use can be attributed to less oil remaining on the parts after the cleaning (i.e., aqueous cleaning, electrocleaning, and pickling) steps, which can in turn be attributed to the performance of the Suparator®.

Although operating data is currently unavailable for the cleaning lines while using the oil-rejecting cleaner, employees at the Racine facility expect the performance of the cleaning lines while using the oil-rejecting cleaner to be comparable (if not superior) to the performance while using the emulsifying cleaners. Regardless of aqueous cleaner type, employees at the Racine facility expect aqueous cleaner bath lives to at least triple.

Prior to installation of the Suparator®, the Racine facility experimented with the use of oleophilic disk separators (i.e., disk skimmers) and overflow/underflow tanks. However, these methods did not produce acceptable results at the Racine facility during the respective evaluation periods.

5.4 Application Performance

For the aqueous cleaning application at the Racine facility, the ability of the Suparator® to prevent the accumulation of oil in the cleaning line without adversely affecting the composition of the recycled aqueous cleaning solution (i.e., depleting the solution of surfactant) is critical. Samples of the oil-contaminated aqueous cleaning solution flowing into the Suparator® (i.e., influent) and samples of the recycled aqueous cleaning solution flowing from the Suparator® (i.e., effluent) were collected from the aqueous cleaning system using the emulsifying cleaner by ARI for laboratory analysis. The aqueous cleaning solution tested was contaminated with a variety of unknown oils. Table 5-1 summarizes the laboratory results

Table 5-1. Laboratory Testing Results – Racine, WI

Source	Oil & Grease (mg/l)[a]	Surfactant (% by volume)[b]
Influent	1,040	15.40
Effluent	1,440	20.39

[a] The oil & grease testing was performed by Alpha Analytical Laboratories, Inc. of Westborough, MA using EPA Method 1664. This oil & grease test method has an accepted error of +/- 20%.

[b] The surfactant testing was performed by the Toxics Use Reduction Institute Surface Cleaning Laboratory at the University of Massachusetts Lowell using the Bama Chem Cationic Surfactant Kit. At the writing of this report, the accepted error for this surfactant test method had not yet been determined by Bama Chem.

The oil & grease testing indicates that the Suparator® does not effectively recover large volumes of oily contaminants from emulsifying alkaline aqueous cleaning solutions. (Considering the accepted error of +/- 20% associated with the oil & grease testing method, the influent and effluent oil & grease concentrations may be considered approximately equal.) However, this result is not unexpected, as ARR does not represent the Suparator® as being capable of directly recovering strongly emulsified oils (the emulsion must be "broken" using separate means before the oil can be effectively recovered by the Suparator®). ARR suggests a more accurate indicator of Suparator® performance in this application would be the collection of long-term cleaning line operating data with and without the Suparator® to compare the respective rate of change of the "steady-state" concentration of oil in the aqueous cleaning solution for these two scenarios.

The surfactant testing indicates that the Suparator® does not deplete the aqueous cleaning solution of surfactant. In fact, the testing suggests that the Suparator® increases the concentration of surfactant in the aqueous cleaning solution. As stated in Section 3, although the higher percentage of surfactant in the effluent may be attributable to the errors inherent in the surfactant testing procedure, ARR confirms (based on field experience) that the testing results match performance levels consistently observed for other Suparator® installations. As stated in Section 1.2, ARR describes this phenomenon as the surfactant in the aqueous cleaner migrating out of the layer of floating oil collected in the Suparator® to be reintroduced to (and concentrated in) the aqueous cleaning solution flowing beneath the collected oil layer (refer to Figure 1-3).

A sample of the oil recovered by the Suparator® was also collected by ARI for analysis from the aqueous cleaning system using the emulsifying cleaner. Laboratory testing revealed the sample contained 4,885 ppm water[†]. This ppm level equates to a water content of 0.4 percent by volume. The laboratory result confirms the ability of the Suparator® to meet the ARR guarantee for water content in the recovered oil of "less than one percent by volume".

Overall, the results indicate that the Suparator® performs well in this particular application. The laboratory data gathered at the Racine facility confirms the ability of the Suparator® to preserve high surfactant concentrations in the effluent and recover oil with extremely low

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[†] The water content testing was performed by Saybolt Inc. of Woburn, MA using ASTM Test Method D1744-92. According to Saybolt Inc., this ASTM test method has a reproducibility of +/-10%.

water content. Although the Suparator® alone is not capable of effectively recovering large volumes of oily contaminants from emulsifying alkaline aqueous cleaning solutions, the benefits presented in Section 5.3 document the improvements to cleaning line performance directly attributable to the Suparator®. In comparison to the EOP techniques previously tested at the Racine facility (i.e., disk skimmers and overflow/underflow tanks), the Suparator® appears to effect a superior oil-water separation.

5.5 Application Cost Information

Each of the two Suparator® systems at the Racine facility includes a stainless steel process tank, the thin-film separation device, and the level-following weir. Each system also includes a progressing cavity pump with variable frequency drive, a level measurement device, and a control panel. However, the two Suparator® systems at the Racine facility are installed in different configurations ("pump-feed" versus "gravity-feed"). (The "pump-feed" configuration is associated with the "rack system", while the "gravity-feed" configuration is associated with the "barrel system".) The total capital cost for the "pump-feed" system, which includes the standard float-type level measurement device, was $6,110. The total capital cost for the "gravity-feed" system, which includes a conductivity-type level measurement device, as well as an additional check valve and air-operated automatic shut-off valve, was $8,650.

Operating data associated with the cleaning lines while using the emulsifying cleaner was used as a basis to estimate savings in operating costs resulting from the installation of a Suparator® system. The savings in operating costs for the Racine facility are presented in Table 5-2. (Although it is stated in Section 5.3 that employees expect aqueous cleaner bath lives to at least triple, the savings in operating costs presented in Table 5-2 were developed from conservative estimates of the benefits of Suparator® installation.) Based on these cost savings and the initial capital investment for the Suparator® system, the payback period for the installation of a "pump-feed" Suparator® system (assuming inflationary effects are negligible) is 6 to 7 months. Using the same procedure, the payback period for the installation of a "gravity-feed" Suparator® system is approximately 9 months.

Table 5-2. Operating Cost Savings – Racine, WI[a]

Benefit of Suparator® Installation	Annual Operating Cost Savings
Extension of aqueous cleaner bath life • Decrease in aqueous cleaner purchases by 50%	$6,500
Extension of electrocleaner bath life • Decrease in electrocleaner purchases by 25%	$2,500
Extension of pickling bath life • Decrease in sulfuric acid use for cleaning[b]	$200
Decrease in water consumption for rinsing by 50%	$2,400
Total Savings	**$11,600**

[a] Developed by Scott Goodsell of the Racine Plating Company

[b] Sulfuric acid is used primarily for other purposes at the Racine facility (i.e., plating and wastewater treatment)

A currently non-quantifiable cost benefit resulting from Suparator® installation at the Racine facility can be derived the reduction in the number of “finished” parts that require rework due to quality issues. (At the time of preparation of this case study, insufficient data was available to estimate the actual annual reduction in rework that will directly result from the installation of the Suparator®.)

5.6 Application Regulatory/Safety Requirements

According to employees at the Racine facility, no significant regulatory or health and safety issues were encountered either during or after Suparator® installation. Complete Suparator® operator training is provided as part of the installation package.

5.7 Application Implementation Considerations

Overall, the employees at the Racine facility are very satisfied with the performance of the Suparator®. The employees are particularly impressed by the simple design (i.e., no moving parts), the ease of installation, and the minimal maintenance requirements of the Suparator®. One minor issue was encountered following the installation of the Suparator® units at the Racine facility. The effluent from the Suparator® was initially returned to the soak cleaner tank via a sparging bar. Based on prior cleaning line operating experience, employees at the Racine facility decided to eliminate the sparging bar in an effort to improve the effectiveness of the aqueous cleaning step. Effluent is currently returned to the soak cleaner tank from a single discharge point.

A second consideration mentioned by employees at the Racine facility concerns the relative advantages of a “pump-feed” Suparator® system versus a “gravity-feed” Suparator® system. The supposed advantage of the “gravity-feed” system over the “pump-feed” system is that oil is not re-emulsified by the progressing cavity pump prior to entering the Suparator® process tank. Re-emulsification of the oil by the pump could potentially hinder the performance of the Suparator®. However, employees at the Racine facility pointed out that the possibility of accidental overflow of the Suparator® process tank is greater with the “gravity-feed” system than with “pump-feed” system. In addition, the “gravity-feed” system is more expensive to purchase and maintain than the “pump-feed” system due to the need for an upgraded level sensor, check valves, and automatic shut-off valves (i.e., an “overflow protection package”). Employees at the Racine facility preferred the “pump-feed” system, citing that the re-emulsification of the oil by the progressing cavity pump is much less a concern than the potential for accidental overflow and increased capital and maintenance costs associated with the “gravity-feed” system.

6.0 CONCLUSIONS

The four Technology Application Case Studies (case studies) presented in this technology evaluation report (report) demonstrate the viability of the Suparator® as an alternative to traditional EOP oil-water separation techniques. The following sections summarize the Suparator® benefits, performance, costs, regulatory/safety requirements, and implementation considerations documented in the case studies.

6.1 Technology Benefits

The case studies presented in this report revealed a variety of benefits resulting from the installation of the Suparator®. These benefits were realized through:

- The direct replacement of alternative oil-water separation techniques,
- The elimination of an alternative cleaning method with a Suparator®-equipped aqueous cleaning system, and
- The installation of the Suparator® on an aqueous cleaning system not previously using any oil-water separation technique.

The benefits pertained to environmental, worker health, and economic factors. A compilation of all of the benefits documented during the preparation of the case studies is presented in Table 6-1.

While the actual benefits derived from the installation of the Suparator® will vary according to the application, the case studies demonstrate the advantages of replacing traditional EOP oil-water separation techniques and cleaning methods with a Suparator®-equipped aqueous cleaning system.

Table 6-1. Benefits of Suparator® Installation

Potential Impacts	Environmental Benefits	Worker Health Benefits	Economic Benefits
Decreased waste oil disposal volumes	X	X	X
Decreased waste oil disposal costs (per gallon)			X
Decreased virgin oil purchase costs			X
Decreased oil concentration in wastewater discharges to the local POTW	X		X
Decreased spent aqueous cleaning solution disposal volumes	X	X	X
Decreased aqueous cleaner purchase costs			X
Decreased use of trichloroethylene for vapor degreasing	X	X	X
Decreased use of surface treatment chemicals for metal parts	X	X	X
Decreased environmental reporting requirements			X
Decreased worker health risks associated with chemical exposure		X	
Decreased use of rinse water	X		X
Decreased electric power consumption			X
Decreased reworking of finished parts due to oil contamination			X
Increased production rates			X
Increased quality of finished parts			X

6.2 Technology Performance

The case studies presented in this report verified the ability of the Suparator® to achieve a continuous, high-efficiency oil-water separation for a variety of aqueous cleaning applications. The aqueous cleaning applications included:

- Separation of a quench oil from city water,
- Separation of a medium distillate oil from an oil-rejecting alkaline aqueous cleaning solution,
- Separation of a sanding oil from an oil-rejecting neutral aqueous cleaning solution, and
- Separation of miscellaneous oils from an emulsifying alkaline aqueous cleaning solution.

Information gathered for the case studies through direct observations and discussions with employees confirmed that:

- For applications where the recycling of oil is a consideration, the Suparator® is capable of recovering a high-quality (i.e., no bacterial degradation), high-purity (i.e., low concentrations of water and other impurities) oil stream that can be recycled with minimal, if any, additional treatment,
- For applications where the recycling of oil is not a consideration, the Suparator® is capable of significantly reducing waste oil disposal volumes and costs by recovering an oil stream with low water content (i.e., <1 percent water by volume versus >10 percent water by volume),
- The Suparator® is capable of significantly extending the life of aqueous cleaning solutions by consistently and efficiently recovering cleaner components (i.e., surfactants),
- The Suparator® is "simple" to install and operate,
- The Suparator® introduces no additional regulatory or safety issues, and
- The Suparator® requires minimal maintenance.

Further, the results of the laboratory testing performed as part of the case studies substantiated that:

- The Suparator® is capable of recovering oil containing less than one percent water by volume, as guaranteed by ARR, and
- The Suparator® does not deplete the aqueous cleaning solution of surfactant during the oil-water separation process. In fact, the testing results suggest that the Suparator® increases the concentration of surfactant in aqueous cleaning solutions, supporting the claim by ARR that the Suparator® facilitates the reintroduction of surfactant into aqueous cleaning solutions (refer to Section 1.2).

Finally, the information gathered for the case studies through discussions with employees also substantiated the claims of ARR that the installation of the Suparator® generates an "incremental improvement to production processes". In each of the case studies, the installation of the Suparator® resulted in an increase in production rates and/or product quality.

6.3 Technology Cost Information

To further quantify the economic benefits, payback periods for the purchase and installation of the Suparator® were calculated for three of the four case studies prepared for this report. The payback periods, which ranged from 38 days to about 15 months, confirm the cost-effectiveness of the Suparator®. Table 6-2 summarizes the capital costs and payback periods documented in the case studies. Note that the payback period calculated for the West Bend facility is based on preliminary estimates of savings in operating costs. As the savings in operating costs are more accurately quantified by the West Bend facility over time, ARR expects this payback period to decrease.

Table 6-2. Suparator® Capital Costs and Associated Payback Periods

Installation Site	Suparator® System Capital Cost	Payback Period
Lindberg Heat Treating Company-Waterbury, CT	$8,200	38 days
The West Bend Company-West Bend, WI	$7,485	15 months
Racine Plating Company-Racine, WI	$6,110	6 to 7 months

6.4 Technology Regulatory/Safety Requirements

In general, systems integral to a manufacturing process that do not generate air emissions or provide EOP treatment are not subject to additional regulatory oversight. In many cases, the oily waste recovered by the Suparator® that is not recycled on-site can be disposed of as non-hazardous waste. Potential users of this technology should contact local and state authorities to determine if any specific regulatory requirements exist. ARR assists potential users in addressing Suparator®-related health and safety requirements by providing complete Suparator® operator training as part of the installation package.

For each of the Suparator® applications documented in the case studies, no significant regulatory or health and safety issues were encountered either during or after Suparator® system installation.

6.5 Technology Implementation Considerations

Although the Suparator® is relatively simple to install, operate, and maintain, certain aspects pertaining to the implementation of this technology that potential users should consider were identified during the preparation of this report. The general implementation considerations identified were:

- *The need to compare the relative advantages of a "pump-feed" Suparator® system versus a "gravity-feed" Suparator® system.* The supposed advantage of the "gravity-feed" system over the "pump-feed" system is that oil is not re-emulsified by the progressing cavity pump prior to entering the Suparator® process tank. Re-emulsification of the oil by the pump could potentially hinder the performance of the Suparator®. However, when the "gravity-feed" system is not equipped with an "overflow protection package" (i.e., an upgraded level sensor, check valves, and automatic shut-off valves), the possibility of accidental overflow of the Suparator® process tank is significantly greater with the "gravity-feed" system than with "pump-feed" system. The optimal feed system will vary depending on aqueous cleaning system type and configuration. Note that according to ARR, the payback delay resulting from the additional costs associated with a "gravity-feed" system equipped with an "overflow protection package" (in comparison to a "pump-feed" system) is not a significant determining factor for the purchase of a Suparator®.

- *The need to institute a scheduled maintenance (cleaning) program.* The particulate matter in the cleaning solutions treated by the Suparator® tends to accumulate in the stainless steel process tank associated with the Suparator®. The case studies suggest that such cleaning programs typically require minimal time and manpower. The user's manual provided with each Suparator® includes a section on equipment maintenance and cleaning.
- *The need to prevent the intake of contaminants into the progressing cavity pump associated with the Suparator®.* The contaminants entering the progressing cavity pump may clog the pump or damage the pump impellers. Potential solutions documented while preparing the case studies include the installation of screens, bag filtration equipment, and/or magnetic metal recovery systems on the pump intake line, and/or replacing the progressing cavity pump with a diaphragm pump. Note that ARR does not recommend the replacement of the progressing cavity pump with a diaphragm pump.

In addition to these general implementation considerations, the retrofitting of existing aqueous cleaning systems with the Suparator® may create application-specific implementation considerations. For example, the Suparator® units at the West Bend facility were retrofitted into existing cleaner reservoir tanks. Aqueous cleaning system process conditions and facility floorspace constraints required that the level-following weirs be mounted at a "fixed" level within the cleaner reservoir tanks (i.e., the level-following weirs are capable of adjusting to a maximum 4" liquid level change in the cleaner reservoir tanks). Automatic water make-up systems (which were present prior to the installation of the Suparator® units) are used to maintain the liquid levels in the cleaner reservoir tanks within the operating range reported by West Bend to ARR during the initial pre-sale system evaluation. It is critical that liquid levels be maintained within this range to prevent the progressing cavity pumps associated with the Suparator® units from "running dry" and to ensure that the level-following weirs collect the upper layer of liquid from the cleaner reservoir tanks. Employees at the West Bend facility expressed concerns regarding the dependability of these automatic water make-up systems (e.g., potential system malfunctions, introduction of the opportunity for operator error, etc.), stating in retrospect that installing the level-following weirs in a "free floating" (rather than "fixed") configuration may have been preferable.

To the extent possible, potential implementation considerations resulting from the retrofitting of existing aqueous cleaning systems with the Suparator® should be identified prior to Suparator® installation. Further, operational and maintenance procedures should be established to address these application-specific implementation issues. As stated in Section 1.2, prior to the installation of any Suparator®, ARR comprehensively reviews the potential Suparator® application (i.e., aqueous cleaning system configuration and operating conditions, floorspace availability, etc.). Based on this review, ARR provides potential users with the Suparator® product package best suited to that particular application. ARR also provides potential users with application-specific design and operation recommendations to facilitate the operation of the Suparator® in the most efficient and least labor-intensive manner possible.

A final implementation consideration not detailed in the case studies (but related to the Suparator®) is the selection of the aqueous cleaning chemistry used in conjunction with the Suparator®. The case studies document Suparator® performance with a variety of aqueous cleaning solutions (i.e., an oil-rejecting alkaline aqueous cleaning solution, an oil-rejecting neutral aqueous cleaning solution, and an emulsifying alkaline aqueous cleaning solution). Laboratory testing suggested that the oil-water separation achieved by the Suparator® is most efficient when the Suparator® is used in conjunction with an oil-rejecting neutral aqueous cleaning solution. Laboratory testing also suggested that the oil-water separation achieved by the Suparator® is least efficient when the Suparator® is used in conjunction with an emulsifying alkaline aqueous cleaning solution. Despite the variations in oil-water separation efficiencies associated with different aqueous cleaning chemistries, all of the Suparator® applications detailed in the case studies were considered successful.

However, because of application-specific variations in production and aqueous cleaning processes, a potential user of the Suparator® should evaluate the exact goals to be achieved from the installation of the Suparator® at the facility of the potential user. During this evaluation, potential users should consider that the use of an oil-rejecting aqueous cleaner may increase the P2 and production process benefits derived from the installation of the Suparator® by optimizing oil-water separation efficiencies. Potential users should also consider that the use of neutral aqueous cleaners may increase the P2 benefits derived from the installation of the Suparator® by eliminating the worker safety and wastewater treatment issues associated with alkaline aqueous cleaners.

In closing, it should be noted that ARR does not represent that a potential user of the Suparator® is required to change aqueous cleaning chemistry for oil separation and recovery to be effective with the Suparator®. However, ARR has observed that current users of the Suparator® have improved the performance of the Suparator® by changing various aqueous cleaning process parameters (e.g., temperature, agitation, chemistry, and time).

ENDNOTES

1 McLaughlin, M.C., Zisman, A.S., et al, The Aqueous Cleaning Handbook, Morris-Lee Publishing Group, 1998

2 Scambos, John P., “A Mechanical Innovation for Oil Separation,” Precision Cleaning, August 1997, pp.9-11

3 Scambos, John P., “Cleanliness and Quality vs. Cost: A Trade-Off,” Products Finishing, February 1999, pp.42-56

4 Telephone interview, John. P. Scambos of Aqueous Recovery Resources, Inc. (ARR), June 2, 1999

5 Personal interview, John P. Scambos of Aqueous Recovery Resources, Inc. (ARR), April 1,1999

6 Ken Hold, b.v., Heteren, Netherlands, 1999

7 Telephone interview, John. P. Scambos of Aqueous Recovery Resources, Inc. (ARR), August 26, 1999

8 Telephone interview, Matt Pliszka of Environmentally Sensitive Solutions, Inc. (ESS), August 31, 1999

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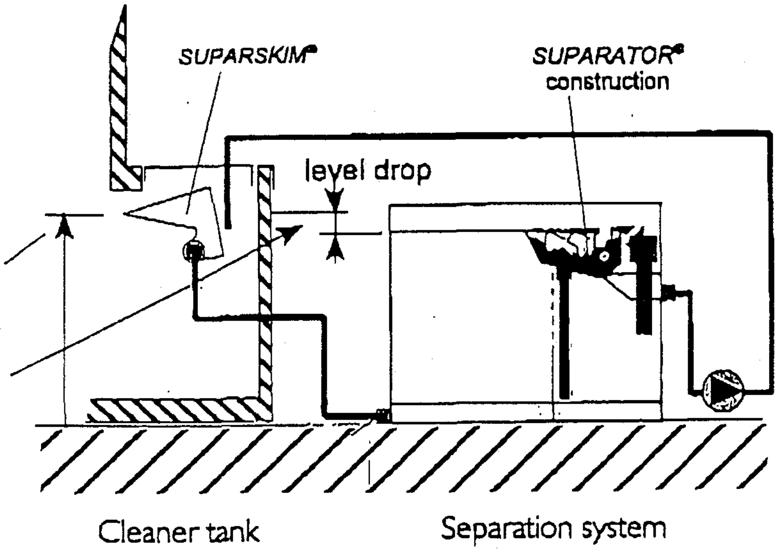
APPENDIX A

AQUEOUS CLEANING SKIM & TREAT QUESTIONNAIRE



Installation parameters

Information required:

1. Measure height of the fluid level in the existing cleaner tank ***above the floor level.***

 ___________ inches

2. Measure the rise / drop change **in the fluid level** (i.e., **during the "parts in - parts out" process or in filling the spray headers** - typically 1½" - 3")

 ____________ inches

3. The length and width dimensions of the cleaner tank will give the surface area that needs to be cleared of oil film.

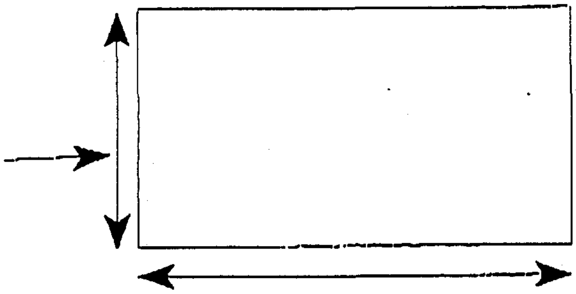
 _________ **L x** ________ **W**

4. Shade location (within tank across →) occupied by parts / racks during washing (give clearance from sides to determine Suparskim™ placement).

In the top view and side tank view across, mark the size and position in the cleaner tank of any sub-surface obstructions, particularly along the walls of the tank.

Top View of Cleaner tank

Length & Width dimensions needed



Side View of tank

5. Cleaner characteristics:

Operating temperature _____

Operating pH _____

Lifetime (1 day, 1 week, etc.) _____

(MSDS Data Sheets of the aqueous cleaner and the lubricants being used, if available)

Refer to Series 86 Cut Sheet for overall dimensions

Return to ARR, Inc. @ Fax: (914) 242-7346

PROSPECT DATA SHEET

Referral Information

Date: ______________________

Name: ______________________ Where? __________

Title: ______________________ Date? __________

Firm: ______________________ Advert? YES ____ NO ____

Address: ______________________ Editorial? YES ____ NO ____

____

City: ______________________ Tel: (____) __________

State/Zip: __________ __________ Fax: (____) __________

APPLICATION INFORMATION

Type of Use: ______________________

____

Existing System: ______________________

____

Spray/Immersion?: ______________________

Existing Problems: ______________________

____

Type of Cleaner? ______________________

'Dump & Replace' Frequency ______________________

Other Notes: ______________________

____

____

____

Follow-up action: ☎ ______________________

✉ ______________________

By whom? JPS ____ TL ____ Front Desk ____

SEND FOLLOWING INFO'

Principle: ______

Brochure: ______

AQ Skim & Treat ______

Q'naire: ______

86 Cut: ______

86 App: ______

91 Cut: ______

91 App: ______

84/85 Cut: ______

87 App: ______

B&W Advt: ______

Spotlight: ______

Trial terms: ______

Eng'g Sols: ______

Trade Press: ______

Other Info': ______

References: ______

PClean article: ______

PF article: ______

SJ article: ______

Philips: ______