THE MASSACHUSETTS
TOXICS USE REDUCTION INSTITUTE

OCEAN SPRAY CRANBERRIES, INC.
MIDDLEBORO, MASSACHUSETTS

ELIMINATION OF COOLING TOWER CHEMICAL ADDITIVES

TOXICS USE REDUCTION INSTITUTE
CLEANER TECHNOLOGY
DEMONSTRATION SITES & MATCHING GRANTS PROGRAM

Technical Report No. 44 1997

University of Massachusetts Lowell

Ocean Spray Cranberries, Inc.
Middleboro, Massachusetts

Elimination of Cooling Tower Chemical Additives

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The Toxics Use Reduction Institute
Cleaner Technology Demonstration Sites
and Matching Grants Program

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The Toxics 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.

Preface

In its 1997 fiscal year, the Massachusetts Toxics Use Reduction Institute combined the Cleaner Technology Demonstration Sites and Industry Matching Grants programs. The goal of the combined program is to provide companies with the opportunity to test and demonstrate new cleaner technologies as well as to promote the adoption of cleaner technologies by Massachusetts industry. Five companies were selected as demonstration sites to showcase the implementation of technologies that embrace the concepts and principles of toxics use reduction. The program, which included a series of visits to the facilities and related presentations and publications, allowed individuals and firms to observe and assess their value first-hand. Site visits were open to industry, environmental groups, community groups, the media and others.

Associate sponsors of the program included the Massachusetts Office of Technical Assistance for Toxics Use Reduction, the Executive Office of Environmental Affairs, the Department of Environmental Protection, the Environmental Protection Agency of New England, and the Associated Industries of Massachusetts.

This program will continue to provide grants to recognize the many companies across the Commonwealth that have used toxics use reduction and cleaner technologies while enhancing their firm's competitiveness.

The following report is an in-depth analysis of the cleaner technology demonstrated at Ocean Spray Cranberries, Inc., Middleboro, Massachusetts.

Notice

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1.0 Introduction

1.1 Company Description

Ocean Spray Cranberries, Inc., located at Bridge & Wood Streets, Middleboro, Massachusetts, is part of a cranberry growers' cooperative. The Middleboro facility receives, processes, and packages fresh cranberries and juice concentrates into juice products and concentrate mixes. Ocean Spray employs approximately 350 people at its 563,450 square foot manufacturing facility.

The Middleboro facility is comprised of a juice blending & packaging operation, fruit receiving operation, cranberry juice concentrating operation, cooling towers, boilers, waste water treatment facility, and research department. The juice ingredients enter the system through either a juice extractor or from concentrates. These are blended in stainless steel tanks to combine the flavors and other ingredients. The juice is held in storage tanks and processed prior to packaging. The facility packages the juice in either glass or plastic bottles.

1.2 Process Description

The cooling water system cools processes with non-contact water that is continuously recycled. The treatment chemicals are added to adjust pH, prevent scale and slime buildup, and protect against corrosion. A small amount of water is blown-down on a regular basis and fresh water is used to maintain proper water levels.

Ocean Spray currently uses several TURA listed chemicals as corrosion inhibitors, descaling agents, and biocides in its cooling waters used for cooling various operations.

Ocean Spray has installed a newly developed electronic technology that replaces or reduces the use of chemical additives in boilers and cooling processes. The technology has a proven track record in other fields such as heating fluids and pathogen destruction. The function of this technology is based upon continuously changing electronic frequencies, applied to the fluid in proportion to the change in conductivity of that fluid. Conductive media within the fluid become electrically charged and result in destruction of microbes, balance of pH, and inhibition of precipitation (scaling).

1.3 How Does TUR Apply to this Process?

The following management statement on toxics use reduction at Ocean Spray was issued as a general memorandum on March 3rd, 1993.

TURA POLICY STATEMENT

As a grower's marketing cooperative, it is Ocean Spray's mission to ensure our products are grown, processed, and packaged in ways that minimize the use of toxic chemicals. We strive to integrate environmental quality considerations into everyday business decisions. Whenever reasonably possible, we will pro-actively pursue cost-effective process changes to reduce or eliminate the use and/or generation of toxics at the point of production. Where toxics cannot be eliminated at the source, re-use and recycling of materials will be explored and implemented wherever reasonably possible. We measure and continually improve upon our environmental, health, and safety endeavors, and we encourage all employees to forward their suggestions for helping to reduce our reliance upon toxic substances.

Ocean Spray has conducted pollution prevention/toxics use reduction since 1989. Projects completed since that time have involved personnel from all aspects of the company. The opportunity to evaluate a new technology was promoted and supported by the toxics use reduction planning team. The current team consists of the following staff:

MEMBER	POSITION
Mike Pilla	Corporate Resource for EHS Compliance Systems
Brad Carlson	Technical Services Manager
Carl Ferrari	Boiler House Engineer
Jim Colmey	Production Supervisor
Brenda Burr	Quality Assurance Technician
Pat Gallagher	Chief Wastewater Operator

ADVISORS

Bob Mullennix	Corporate Environmental Manager
Herb Hohn	Corporate Regulatory Affairs Manager
Neil Bryson	Director of Regulatory Affairs

The anticipated TUR effects of this project is the elimination of all process cooling water additives containing the TURA listed chemicals sodium hypochlorite (NaOCl) and Sodium Hydroxide (NaOH). -This would be considered either process modification or input substitution, and could result in a reduction of 18,500 pounds of listed chemicals.

1.4 Project Intent

Ocean Spray, like any industry using process steam or cooling water, is faced with continual maintenance of cooling equipment to maintain proper pH levels and to prevent the build-up of scale, bacteria, and algae. The most common method of maintenance is to add a veritable soup of chemicals, each designed to address one of these issues. These chemicals pose risks to worker safety and health during handling, storage and usage, require significant labor, and elevate facility chemical usage levels under TURA. The chemicals are discharged to the facility's wastewater treatment plant and must also be treated. For this project, Ocean Spray chose two cooling towers, one traditionally unmanageable with chemical treatment, and one which represents a more typical cooling tower application.

It is the intent of this project to further the primary goal of eliminating and minimizing the use of toxic chemicals wherever feasible. As a corporate good-neighbor and participant on the Massachusetts OTA Advisory board, Ocean Spray desires to share the successful implementation of new technology which may assist other Massachusetts businesses. Cost driven objectives such as reducing labor required to maintain boilers and process cooling water equipment, and extending the useful life of this equipment, also provide an incentive for the company to use this technology.

1.5 Previous Environmental Achievements

Ocean Spray Cranberries has undertaken a number of projects at Middleboro to reduce its toxics use and save money. Examples of achievements to date are listed below.

- Ocean Spray has an aggressive recycling program at the Middleboro facility. In 1993, the plant recycled 349 tons of corrugated cardboard, 85.7 tons of plastic bottles, and 80 tons of glass bottles.

- Ocean Spray diverts a portion of treated wastewater to clean the rotary screens and sludge presses. This saved Ocean Spray $13,000/year in 1992 and 1993.

- Since 1987, Ocean Spray has sent the cranberry press cake from the juicing operations to a composting facility, resulting in 9,400 tons of organic material being kept from the landfill.

- Since 1992, Ocean Spray has been using magnesium hydroxide instead of sodium hydroxide to reduce the risk to workers in wastewater treatment.

2.0 Description of Technology

2.1 Cooling Towers

Cooling towers are widely used across industrial sectors to provide temperature reductions to process solutions. These processes may include heat treating, bottling, refining, distilling, air conditioning, and other systems where solutions are used to remove heat and maintain critical operating temperatures.

Most cooling towers provide indirect cooling to the process solution through a separate loop of water that circulates through a heat exchanger. This allows the process solutions to transfer their heat load to the water and then exhaust it to the air. In order to transfer the heat from the water to the air a cooling tower is used.

Diagram 1 depicts a typical cooling tower arrangement. Heated water enters at the top and is sprayed down over a fill material . This spreads the water out over a greater surface area and more efficiently extracts the heat. A fan pulls outside air, which is at a lower temperature than the water, up through the fill material and across the water. Evaporation occurs, removing heat in the process. The cooled water collects in a pan or basin beneath the fan and fill material. The water is then returned to the heat exchanger equipment. Fresh water is added to make up for evaporative losses. The system is usually "blown-down" on a regular basis to decrease the total dissolved solids and limit scale and deposit formation.

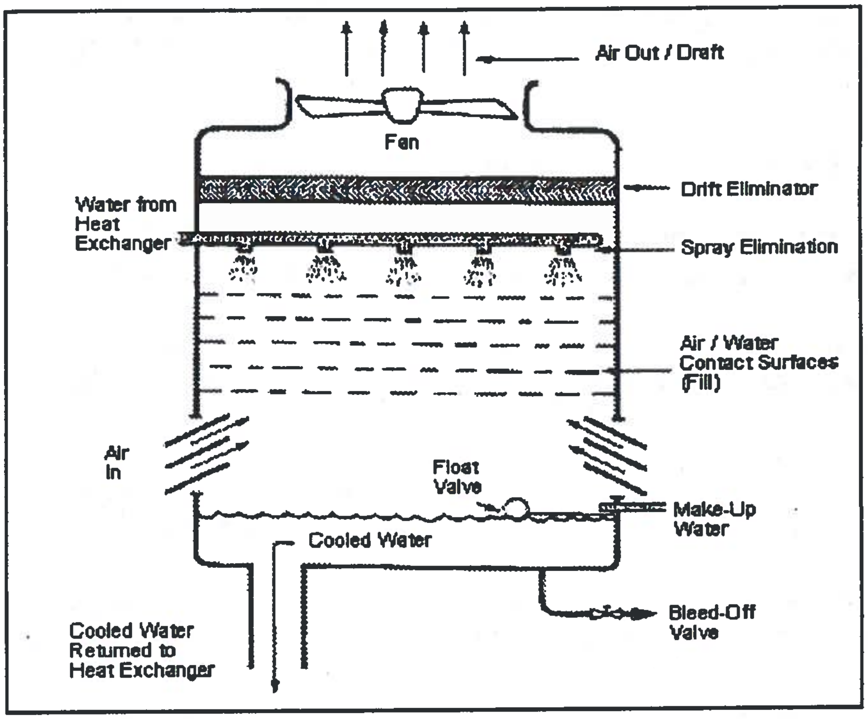

Diagram 1

2.2 Cooling Tower Problems and Use of Chemical Additives

The environment within the cooling tower is extremely wet, containing both hot and cold regions, and many seams, cracks, and other small crevices - a perfect environment for deposition of soluble minerals, corrosion of tower hardware, and growth of bacterial organisms. The development of each of these problems is explained below.

Deposits

As evaporative cooling occurs, water is lost to the atmosphere. This concentrates the chemicals and minerals in the water. Scales and precipitates can form if the water level drops too low, causing a rise in concentration of these chemicals. If the concentrations rise too high, a precipitate will form.

Deposition in cooling water systems may consist of scale or fouling or a combination of both. Scales are hard, dense, crystalline deposits which form due to the insolubilities of minerals at the temperatures and conditions in the cooling tower. As the temperature of water decreases, the solubility of dissolved minerals also decreases and they precipitate out onto the hardware of the cooling tower. Fouling occurs due to the sedimentation or adherence of suspended matter on system surfaces.[1]

Critical factors in deposition of minerals include:

Water Velocity - Low velocities allow suspended materials to settle out, with increased scale formation at high heat conditions.

Heat Flux - Potential scale forming minerals are affected by the quantities of heat being input into the system and the change in temperature across the system. Also called thermal shock.

Temperature - Solubility of minerals and salts in cooling waters are directly affected by the temperature of the water and the temperature of the cooling tower hardware.

Corrosion

Corrosion, or removal of base metals from the cooling tower hardware through oxidation, is a function of pH and the interactions between dissolved metals and base metal. This corrosion can be caused by a galvanic cell formed between two metals such as steel and copper.

Critical Factors that effect corrosion include:

Temperature - The rate of corrosion increases with water temperature. At higher temperatures, the water viscosity is reduced, the rate of oxygen diffusion increases and the electrical conductivity increases, all of which increase corrosivity.

Water Velocity - Flow rates through a system, both fast and slow, can promote corrosion. Low flow rates can cause deposit formation, where corrosion may occur underneath the deposit. High flow rates can lead to erosion or impingement attack.

pH - The lower the pH of the solutions flowing through the tower, the more corrosion will occur. Ideal pH for cooling waters ranges between 6 and 8, with higher pH being more desirable but potentially leading to reduction of other substrate materials.

Biological Organisms

The warm water environment provides a perfect condition for growth of bacteria, algae and fungi. The uncontrolled activities of these organisms can cause corrosion, fouling of mechanisms, odors, poor heat transfers and deposition of biological waste products. There are at least six types of organisms which cause problems within the cooling system.

Slime Formers - create a dense sticky slime that traps suspended particles and fouls heat exchangers. They also create frictional resistance to water flow and promote the growth of other organisms. These are sometimes referred to as biofilms. Biofilms can harbor pockets of extremely acidic organisms and cause micro-corrosion and non-uniform pitting.

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[1] Cooling Tower Institute, Guidelines for Evaluation of Cooling Water Treatment Effectiveness, CTI Bulletin WTP - 130, October 1981.

Spore Formers - such as the genus *Clostridium* and *Bacillus* have the ability to create spores when environmental conditions become unfavorable. These spores can then reinfect the water system when conditions revert. Spores have a dense polysaccharide and lipid coating that resists chemicals and radiation. Dried bacterial materials can have spores that survive years of drought, heat and exposure to sunlight.

Iron Depositing Bacteria - pull soluble iron out of the water stream and bind it to the cooling system hardware. These create nodules and other forms of build-up that reduce flow and harbor additional bacteria, fungus and algae.

Nitrifying Bacteria - convert ammonia to nitric acid and cause corrosion of hardware. Anaerobic corrosive bacteria thrive in oxygen deficient environments (e.g. under deposits) and secrete a highly corrosive waste product which reacts with metal surfaces in a reduction reactions.

Fungi and Algae - can grow in warmer nutrient rich waters where sunlight may hit the tower and provide energy for photosynthesis. Algae can be attached or free-floating colonies.

It is important to make the distinction between incoming chemicals in the water and additives used to maintain the tower. Incoming chemicals include magnesium, calcium, iron, copper and lead which may be present in the water due to minerals in the source aquifer or reservoir. Chemicals added to or leached from the cooling tower system and pipes may include lead, copper, zinc, iron, molybdate, organophosphates, orthophosphates, sodium silicates, aromatic triazoles, non-oxidizing biocides such as isothiazolin, dinitrilopropionamide, quaternary amines, chlorine, bromine chloride, and ozone.

Process Flow and Chemical Inputs/Outputs

Ocean Spray uses a variety of trade name additives containing sodium hydroxide (NaOH) and sodium hypochlorite (NaOCL).

Diagram 2 shows the basic circulation of water through the concentrator cooling tower. Chemicals are added to the water before the water runs through the heat exchanger. Sodium hydroxide and sodium hypochlorite were the only additives to the concentrator tower prior to the installation of the electrical technology.

NaOCL was on a timed injection system where a predetermined amount was injected to the tower regardless of the bacterial contamination level. NaOH feed was based on a pH meter. It was assumed that each chemical was consumed in the tower waters through neutralization or chemical reaction with bacteria.

Chemical Flow Diagram for Concentrator Cooling Tower

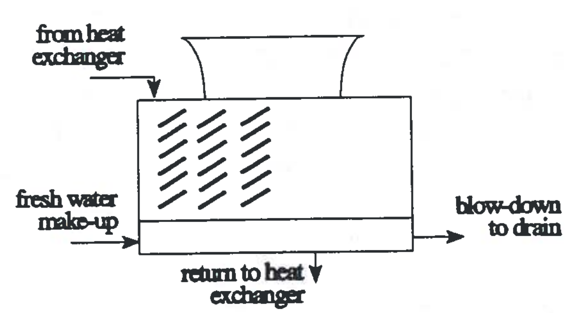


Diagram 2

2.3 The Parrot RSO Transformer

The Parrot technology is unique in two ways;

a) It is used in-process, not at the end of a wastewater treatment plant,

b) It has the ability to conform to continually changing operational parameters without supervision or adjustment.

The basic operating principals behind the technology are the use of a uniquely designed transformer (a Forced Sequential Rephasing Transformer - RSO) that imparts high frequency signals to the fluids passing through the process piping via an electrode and the field coil windings of the transformer. These signals are continuously shifted in frequency (from 60 to 5 million Hertz) according to the temperature, hardness, and flow rate of the fluid. The shifting of the signals has the effect of keeping ionic salts in solution, thus buffering pH changes, halting precipitation of scale, and inhibiting growth of bacteria.

The ionic salts present in the water undergo a change in state as a result of the changing frequencies. For example Calcite (calcium carbonate) will change from a rhombic structure to a trigonal structure and become Aragonite (also calcium carbonate). See Diagram 3. The shape of these new crystals is such that they can not form permanent bonds and are protected from thermal shocks which might otherwise cause them to precipitate out and form a scale or mud-like deposit.

The Parrot technology is currently used in a variety of applications including the cooling towers and boilers of large manufacturers, and for water treatment at a swine farm, a golf course, swimming pools, a restaurant and espresso makers. Ocean Spray is the first juice manufacturer, and the first industry in Massachusetts to use this technology.

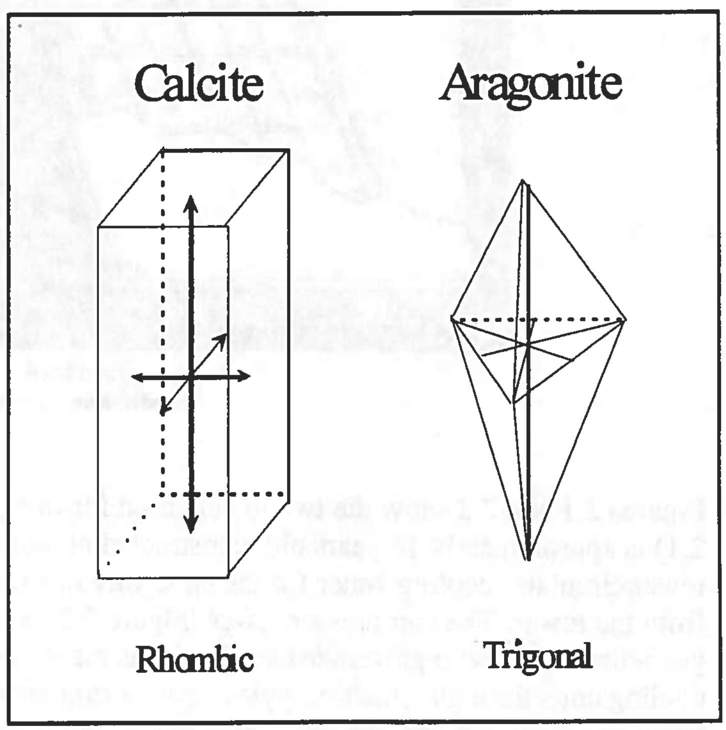


Diagram 3

2.4 Application to Cooling Towers

Diagram 4 shows the typical installation of Parrot technology on a crossflow tower. Crossflow cooling towers pull air from the outside, through slats on the side of the tower, and across fill material over which process water is distributed. Heat is removed from the process water through evaporation. The warmed air is then pulled up through the center of the tower and out the top by means of a large fan.

A larger diameter Parrot (6 or 8" unit) is placed on the recirculating water line running to the top of the tower. A smaller Parrot (1 or 2" unit) is placed on the fresh water make-up line feeding the cold water basin. Both of these units have control panels that plug into a 110 or 220 volt AC electrical source. The key to proper installation is in maintaining hydraulic conductivity in the circulation of the waters and locations of the Parrot. This way all regions of the system receive the Parrot signals and minerals stay in solution, even through areas of thermal shock.

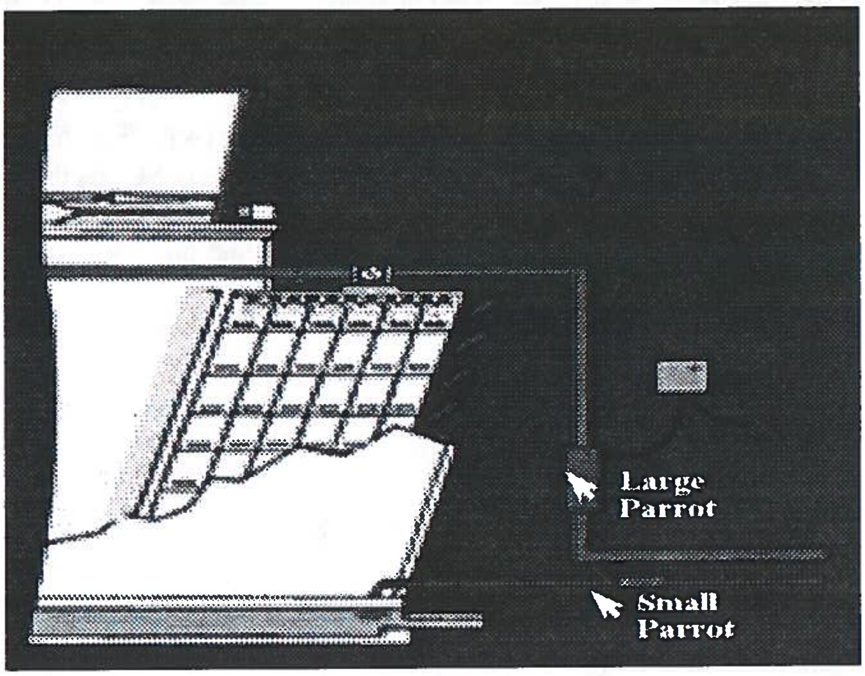


Diagram 4
Credit: Marley Corp.

Figures 2.1 and 2.2 show the two towers used for this project. The concentrator tower (Figure 2.1) is approximately 14 years old, constructed of wood and steel with plastic fill material. This tower circulates cooling water for the concentrator tower, and also receives steam condensate from the tower. The compressor tower (Figure 2.2) is six years old and constructed of galvanized steel with galvanized steel coils as the heat exchange medium. This tower has cooling coils through which propylene glycol runs from the facility's air compressors to the tower and back. Compressed air is required to run many processes at the facility. Figure 2.3 shows a photograph of a Parrot RSO Transformer.

Figure 2.1: Concentrator Tower

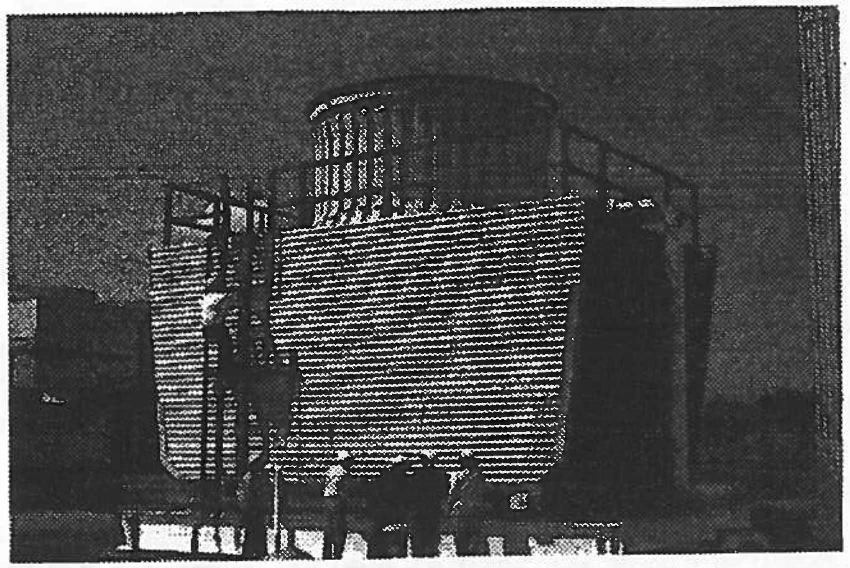


Figure 2.2: Compressor Tower

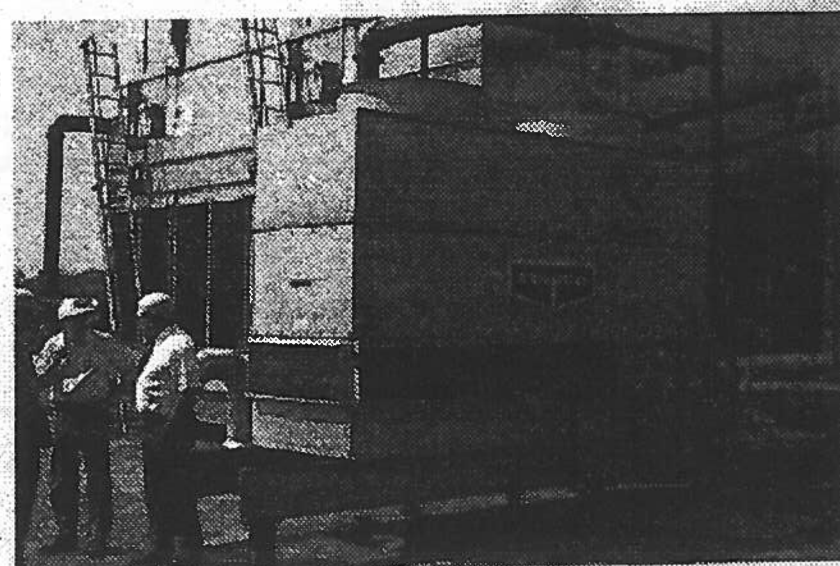
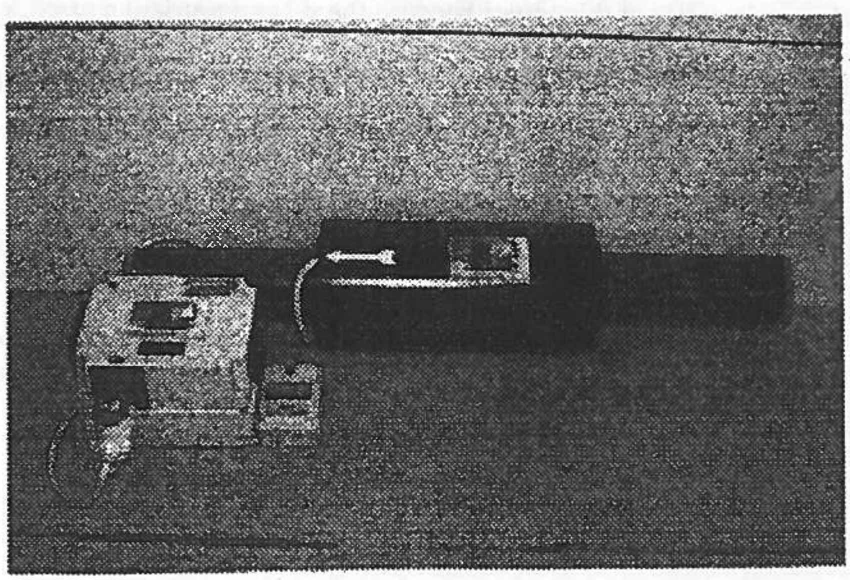


Figure 2.3: Parrot RSO Transformer



3.0 Environmental & Occupational Health Assessment

3.1 TURA Chemical Use Before and After Technology Implementation

The concentrator and compressor cooling towers use three chemicals to inhibit bacterial growth and prevent corrosion. These are:

- **Sodium hypochlorite** (TURA chemical) for bacteria control
- **Sodium hydroxide** (TURA chemical) for pH adjustment of water
- **Pyrophosphate/phosphonate/azole polymers** for corrosion prevention (compressor tower only)

Cooling towers represent one of the largest chemical users at the facility. The numbers below represent total chemical use at the two towers used in this project.

- 1995 = 18,779 lbs of additives
- 1996 = 15,359 lbs of additives
- 1997 = 1,123 lbs of additives as of April

The performance of these chemicals is questionable at best. According to Ocean Spray, the concentrator tower has always presented challenges and became the focus of the project due to its reputation. Despite the use of 11,105 pounds of NaOCl and 3,757 pounds of NaOH in 1996, the tower remained problematic.

These problems are directly related to the failure of biocides (mostly NaOCl in this case) to penetrate biofilm exo-polymers. Laboratory experiments and computer modeling have described the observed behaviors of free chlorine in penetrating layers of bacterial produced slimes.[2] The effectiveness of the chlorine drops off dramatically due to a diffusion gradient within the biofilm and bacterial production of counter-enzymes that degrade the biocide.[3] The chemicals may penetrate to the first layer and cause it to slough off, but are used up and expose fresh bacteria under the first layer that then reinoculates the flowing water.

In the compressor tower, chemical treatment has prevented corrosion but not the formation of mineral scale, which can decrease heat transfer efficiencies in the cooling coils. Bacterial control is easier at this tower because there is no nutrient source, wood basin, or stagnant areas.

The Parrot technology may allow Ocean Spray to cease using sodium hypochlorite and corrosion inhibitors in the compressor tower, and reduce or possibly eliminate sodium hypochlorite in the

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2 Martin Hamilton, Brian Goldstein, Modeling Biocide Action Against Biofilms, Biotechnology and Bioengineering, John Wiley & Sons, Inc., Vol 49, Pp. 445-455, 1996.

3 Xiao Chen and Phillip Stewart, Chlorine Penetration into Artificial Biofilm is Limited by a Reaction-Diffusion Interaction, Environmental Science & Technology, American Chemical Society, Vol 30, No.6, 1996., page 2078.

concentrator tower. As of the date of this report, both towers were gradually being cleaned of accumulated biofilms and scale, which will further reduce the need for chemicals. Sodium hydroxide will still be needed to adjust pH in the concentrator due to the lack of minerals in the steam condensate used as make-up water.

If the continuing evaluation proves satisfactory to Ocean Spray and other cooling towers in the facility are brought under Parrot control there could be a significant impact to chemical usage. If fully implemented, Parrot control of these towers would represent a reduction in use of 62,665 pounds of chemicals to maintain the all seven cooling towers, with 28,900 pounds being regulated chemicals under TURA.

3.2 Worker Exposure to Toxic Substances

The use of electrical transformers raises the issue of electromagnetic (EM) fields and the highly controversial issues of their health impacts. As part of the technical assessment, Ocean Spray reviewed the Parrot technology's operational specifications and conferred with other users of the system. Since the electrical usage is so low (200 Watts) the corresponding field strength is also low. Due to the facility's piping layout, the Parrots were mounted near ceiling level (20 feet above workers).

3.3 Reductions in Waste

The cooling towers are strictly a water process, and generate no solid or hazardous waste. Blow-down waters from the cooling towers are piped to the facility wastewater pre-treatment plant. Use of the Parrot may decrease the amount of residual chlorine in these wastewater which may cause harm to the pre-treatment plant's digestive organisms.

Some municipal wastewater treatment authorities are considering banning the use of certain cooling tower chemicals. If municipalities ban the discharge of these chemicals, users will have to find substitutes or ship their blow-down waters off-site as hazardous waste. In these situations the Parrot may offer a chemical-free solution that would prevent a large amount of hazardous waste.

4.0 Economic Implications

4.1 Raw Material Costs

The most recent cost data available (1996) shows Ocean Spray used four chemical additives to treat the cooling waters of the two towers studied in this project. These include:

- Sodium Hydroxide
- Sodium Hypochlorite
- CW 4325 (compressor tower only)
- IS 11278 (compressor tower only)

Tables 1 and 2 in Appendix A list operating costs connected with the compressor tower and the concentrator tower respectively. Table 1 represents a more typical cooling tower application cost profile.

4.2 Capital Equipment Costs

> **The Parrot saves Ocean Spray over $4,500/year in chemicals and maintenance per tower.**

The financial assessment of the Parrot technologies was done without including any of the financial assistance resulting from the TURI grant program. In the case of the compressor tower, reliable control of microbial growth was obtained through the use of two Parrot units. The capital costs of this installation was $4,100. This included one 1-1/2" Parrot on the recirculating line and one 3/4" Parrot on the fresh water make up line.

The capital costs for the concentrator were significantly larger. This application required an 8" Parrot on the recirculating line, a 1" unit on the make-up line, a 2" unit on a by-pass line holding stagnant water, (2) Parrot electrodes in the hot-well tank, and (2) electrodes in the cold water basin of the tower. The capital cost for this installation was $23,200. As the project continues into the Fall of 1997, and the tower can be properly cleaned, it may be possible to reduce the number of Parrot units.

4.3 Regulatory Compliance Costs

The total regulatory burden on the Middleboro facility is estimated to range from $70,000 - $120,000 per year. This includes salaries for environmental personnel, contractor and consultant labor, and fees paid to the State of Massachusetts under the Toxics Use Reduction Act (TURA). All of these costs can be allocated to processes within the plant that contribute to the need for these services. The compressor and concentrator cooling towers use TURA listed chemicals, and are therefore responsible for a portion of these costs. The Total Cost Assessment (Tables 3 and 4 in Appendix A) shows the allocated compliance costs for each tower and the cost savings achieved through the Parrot. Only the costs of training and fees were included. These totaled $93 for the compressor tower and $1,929 for the concentrator tower.

4.4 Waste Disposal Costs

The cooling tower waters flow to the facility's wastewater pre-treatment plant and are adjusted for pH and removal of BOD, TDS, and TSS. Wastewater from the two towers are no more than 1,000 gallons per day out of an average flow of 250,000 gallons. There are no other waste disposal costs associated with tower operation.

Ocean Spray conducts effluent testing on cooling tower waters to ensure that standards for water treatment are met. This activity was considered a part of waste management although it could also be grouped with quality control or maintenance costs. The cost for in-house laboratory analysis and labor for relating the test result to an appropriate corrective action range from $2,600 for the compressor tower to $3,100 for the concentrator tower.

Figures 4.1 and 4.2 represent testing during normal operating practice. The project period involved more frequent tests, sometimes verified with outside laboratory analysis. The costs mentioned above include labor for pulling samples from the tower basins once per week, analyzing them using a presumptive test method with most probable number of bacterial colonies. No allocation was made for counter-measures that would be required if the sample values exceeded the criteria.

Once the new technology has been in-place long enough to remove the accumulated bio-films, optimum conditions are expected to develop which could significantly reduce the need to test the tower. Experiences at other installations have shown a reduction of 50% in the amount of monitoring performed.

Figure 4.1: Compressor Tower

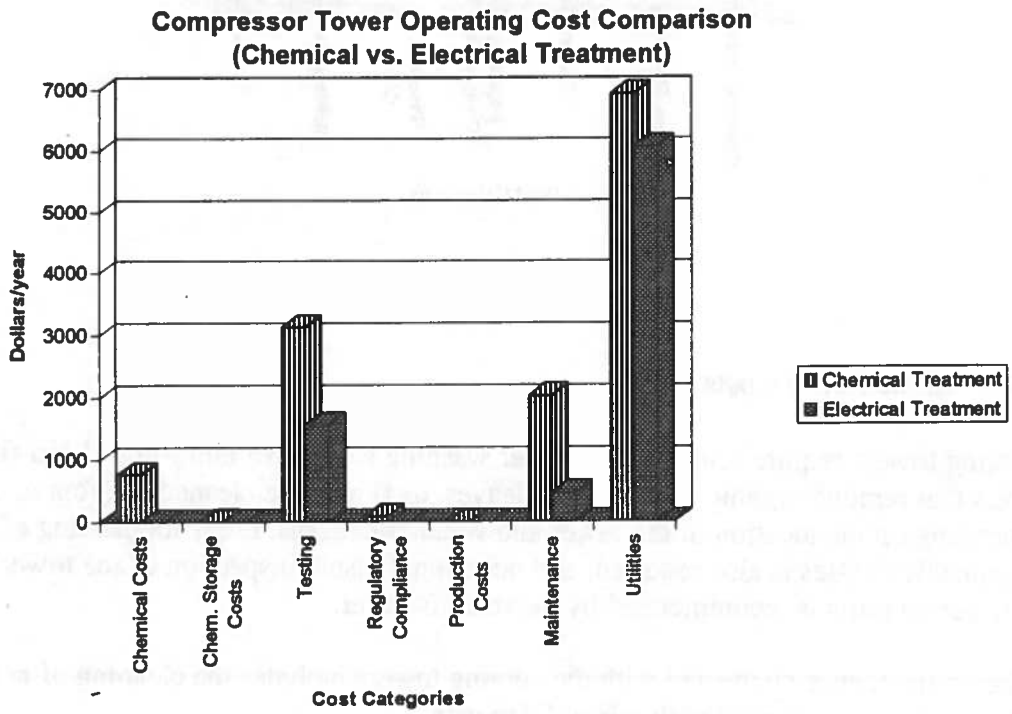
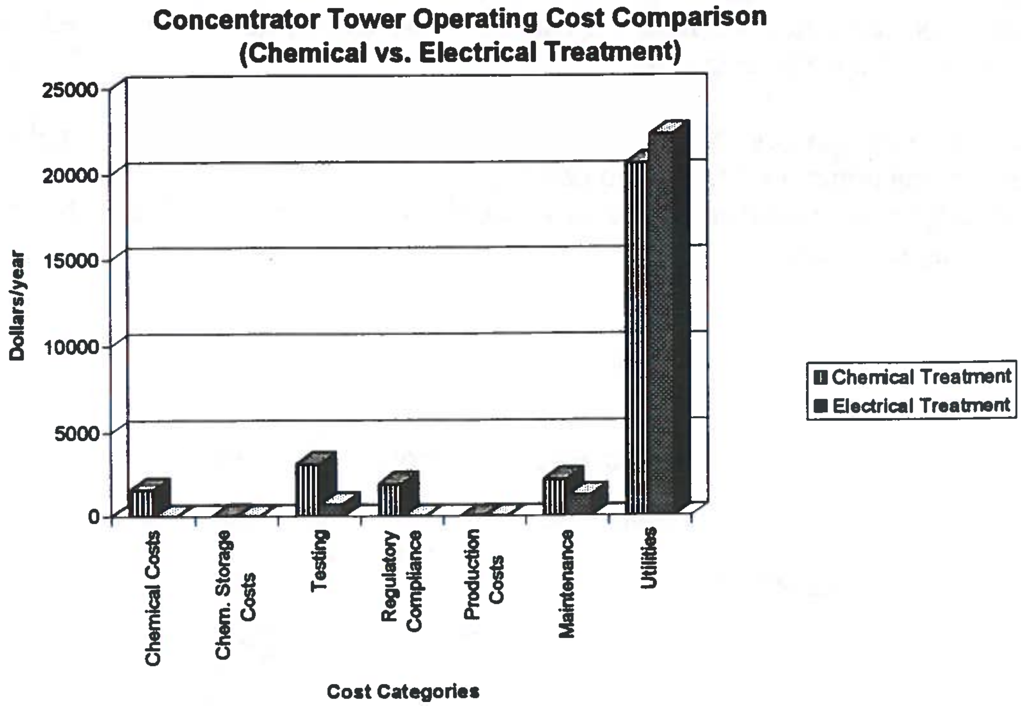


Figure 4.2: Concentrator Tower



4.5 Maintenance Costs

Cooling towers require semi-annual power washing to remove build-ups of bio-film. In-line filters that remove organic debris (bugs, leaves, dirt) must be cleaned as often as once per day depending on the location of the tower and weather patterns. Daily monitoring of flow and chemical feed rates is also required, and occasional visual inspection of the tower basin, fill, and distribution ports is recommended by the manufacturer.

Other maintenance connected with the cooling towers includes the cleaning of heat exchangers that may become clogged with mineral deposits.

Once the initial clean-out of accumulated bio-film is completed, the Parrot is expected to maintain the towers with a minimum of maintenance. The tower and the Parrot will still require monitoring, but the Parrot has no moving parts, and only a fuse that may need replacing if a sudden electrical surge causes it to fail. Clean-outs of the tower basins would be performed on a bi-annual or quarterly basis but require less labor and time because of the greatly decreased amount of biofilm and algae growing on the tower.

4.6 Total Cost Assessment

A preliminary Total Cost Assessment was performed for each of the Parrot applications. Tables 3 and 4 (Appendix A) show details of costs associated with the compressor tower and the concentrator cooling tower respectively.

Compressor Tower
In the case of the compressor application, the annual operating costs before the Parrot installation were $12,940, and after the Parrot these costs should drop to $8,086. The Parrot is expected to save $4,800 per year over traditional chemical treatments. Table 4.1 summarizes a variety of financial indicators such as payback, ROI, and Net Present Value. The compressor application has a payback period of slightly more than 10 months, without including the impact of more process reliability (production impacts).

Table 4.1: Cost Summary for Compressor Tower

Capital Cost	($4,100)
Annual Savings	$4,854
Payback	10 months
ROI	greater than 30%
Net Present Value	$14,803

Concentrator Tower
Even though this tower required more than the typical number of Parrots to achieve control, it still has a positive cashflow when compared to traditional chemical treatment. This Total Cost Assessment was performed with the assumption that all seven units would remain on the tower indefinitely. It is more likely that some units would be removed once the system has thoroughly cleaned itself out and stabilized. Total capital costs for this system were $23,200. Operating costs under traditional treatment were $29,414 and would be expected to drop to $24,224 under Parrot control. This is a $5,190 annual operating cost savings. Table 4.2 summarizes the financial feasibility of the concentrator application. The payback in this case is nearly four and one half years.

Table 4.2: Cost Summary for Concentrator Tower

Capital Cost	($23,200)
Annual Savings	$5,190
Payback	4 years 5 months
ROI	approximately 11.5%
Net Present Value	$1,636

5.0 Installation and Validation

5.1 Installation Issues

The RSO transformers were delivered to Ocean Spray on January 20, 1997. The cooling tower was drained prior to installation of the device. Contractors were hired to weld flanges on the RSO pipe section, cut the cooling tower pipes and install the RSO transformer. The first two units became operational on January 25, 1997. All chemical additions were suspended at that time.

On January 30, 1997, the pH readings of the cooling waters had dropped to 3.0 and it was decided that sodium hydroxide should be introduced to raise the pH and prevent corrosion of heat exchanger and concentrator hardware. Normally, freshwater introduced after a blow down provides enough mineral content to stabilize pH at 9 or 10. However, since the concentrator cooling tower has only steam condensate as make up water (entering with a pH of 3), there was insufficient mineral content to stabilize pH.

5.2 Testing Protocol

Piat, the manufacturer of the Parrot technology, and Ocean Spray staff met and discussed appropriate test criteria for evaluating the concentrator tower installation. The test parameters are shown in Table 5.1. These parameters are very stringent, in keeping with Ocean Spray's high level of in-house quality control. Applications at other manufacturers have typically had Total Plate Count (TPC) limits of under 10,000 colony forming units, while most chemical treatments try to keep TPC below 50,000 colony forming units. Due to the short timeline for evaluation (less than six months) a thrice weekly sampling protocol was established. These samples would be collected by Ocean Spray staff and processed by the in-house laboratory.

Table 5.1
Test Parameters for Ocean Spray Concentrator Application

Test Criteria	Total Plate Count	E. Coli Count	pH	Total Dissolved Solids	Conduct-ivity	Total Chlorine	Free Chlorine
Expected Value	< 1,000	neg.	6 - 8	value	< 100 umho	value	value

Criteria such as total dissolved solids (TDS), total chlorine and free chlorine were simply measured to determine their value but did not have to fall below or above a pre-determined limit. Even though it has a completely different application, the same criteria were applied to the compressor tower because it facilitated direct comparison of test results.

In addition to tests for total dissolved chlorine, free chlorine, total dissolved solids, E coli, and total plate counts, Ocean Spray also installed corrosion coupons to examine possible metal loss as a result of the Parrot. Due to overlapping schedules between coupons installed by the chemical supplier and those to be installed by an unbiased third party laboratory, no corrosion test results were available as of the writing of this report. Although no corrosion has ever been found at other sites using the Parrot, this topic will be fully explored as part of the ongoing partnership between Piat and Ocean Spray.

5.3 Test Results

Cooling tower waters were tested three times per week (Monday, Wednesday, and Friday), using the tube incubation and presumptive test method for estimating bacterial colonies. This method provides a relatively quick average number of colonies present in water or other liquid media samples. See Appendix B for the full spreadsheet of all test results for both towers. Figures 5.1 and 5.2 show the pH and TPC for the concentrator tower, and Figures 5.3 and 5.4 show the same criteria for the compressor tower.

Figure 5.1
pH in Concentrator Tower

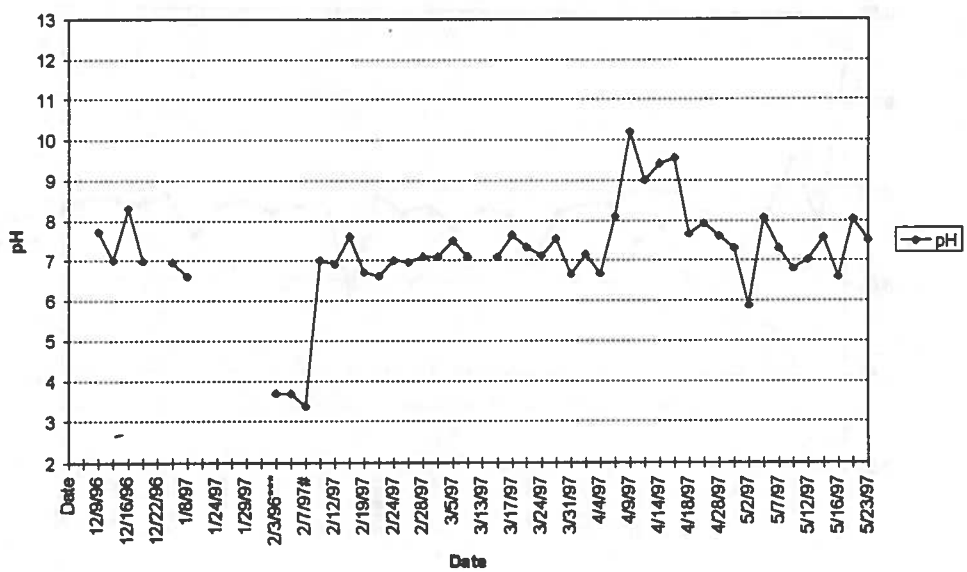


Figure 5.2
Concentrator Plate Counts

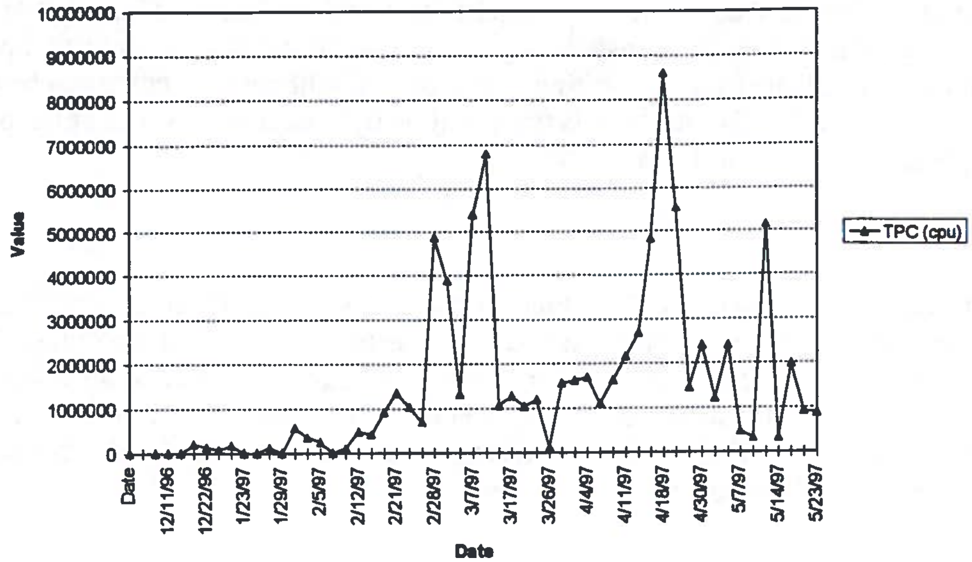


Figure 5.3
pH in Compressor Tower

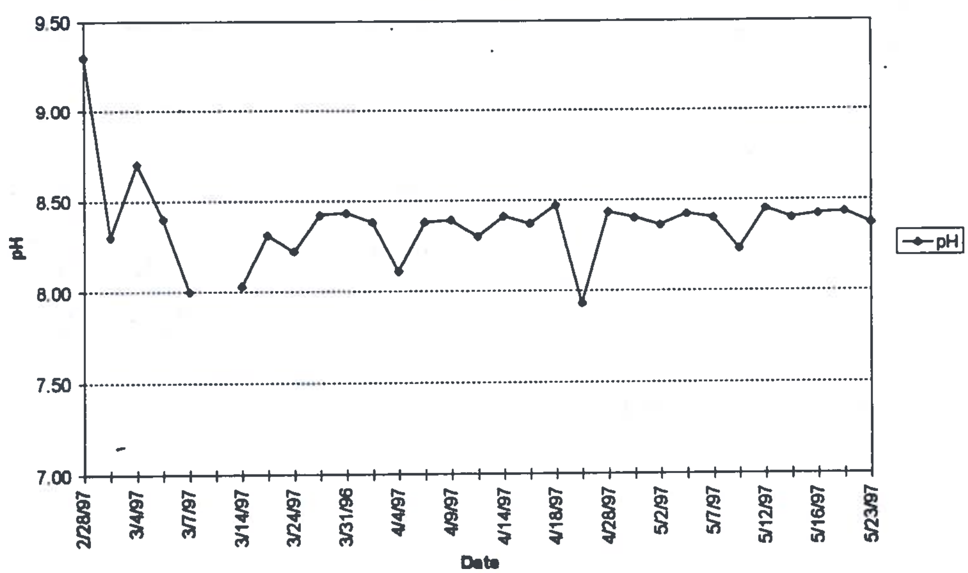
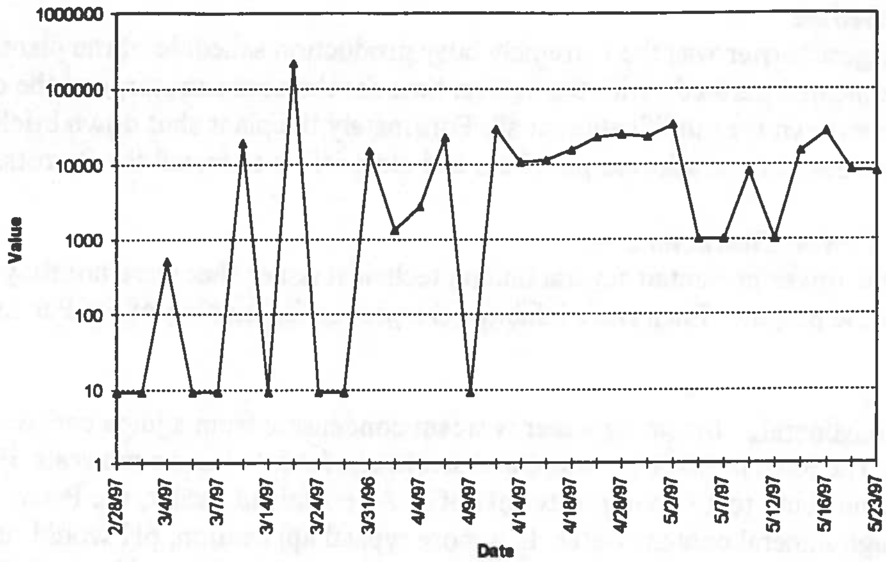


Figure 5.4
Compressor Plate Counts



6.0 Barriers & Resources Encountered

6.1 History of Other Successes

Ocean Spray had not had positive experiences with alternative cooling tower water treatment systems. Prior to project start-up much concern was voiced over similarities between this device and a magnetic system which failed during a 1990 trial run. The helpful, cooperative attitude of the Piat staff helped to dispel these concerns.

6.2 Cooling Tower Selection

The manufacturers of the Parrot technology visited the Ocean Spray facility and spent a full afternoon explaining the development and workings of the Parrot, its current application in other fields such as boilers, fountains, swimming pools and coffee makers. The project staff agreed upon a specific cooling tower (the concentrator tower) that could be used as an experiment. While not representative of other cooling towers at the facility, the concentrator tower had a reputation of being the "bad boy" among the towers, and all previous attempts to control algal growth, odor, and bacteria levels had failed. It was thought that if the Parrot could solve the problems of this tower, it would work on any tower.

Later in the project, the second tower was added to compare results being seen in the concentrator with a more typical application. The second application was on the air compressor cooling tower. Both of these towers had sampling ports, corrosion coupon racks and a history of chemical treatment.

6.3 Technical Barriers

Production Schedule

The first and largest barrier was the extremely busy production schedule of the plant. Installation of the device coincided perfectly with the busiest time for the concentrator, and the cooling tower could not be shut down for modification at all. Fortunately the plant shut down briefly over Presidents Day weekend and allowed plumbers and electricians to install the Parrots.

Concentrator Tower Characteristics

The concentrator tower presented several unique technical issues that were not fully understood at the outset of the project. Each issue inhibited the proper functioning of the Parrot in some manner.

Low pH/No Minerals. Incoming water is steam condensate from a juice concentrating process. The juice is acidic in nature and steam condensate has no minerals. Both of these factors contribute to a cooling water pH of 3. As explained earlier, the Parrot functions best in high mineral content water. In a more typical application, pH would rise due to the action of the Parrot on the dissolved minerals. These minerals would remain in solution and drive the pH up.

High Nutrient Loading. The incoming water also contained a large supply of sugar. It had been noted that water from the hot well tank leaves a sticky residue upon drying. No analysis was performed to measure the sugar content of the water. Sugars are an excellent food source for bacteria, and thus the bacteria in the cooling tower basin were fed with an unlimited supply of food.

Wood Basin. The concentrator tower was also unique in its construction. The cold water basin was fabricated from 2" x 8" pressure treated wood beams and ⅞" thick plywood for a floor. Wood can not be kept free of bacteria because of its porous nature. The cellulose fibers provide excellent support and anchors for bacteria. Some species of bacteria degrade cellulose and create a middle layer between undamaged wood and the biofilm exo-polymer. This damaged area was witnessed on the concentrator cooling tower basin. Large sheets of biofilm clung to the sides and floor of the basin. Only after several months of continuous treatment by the Parrot did these sheets begin to degrade and eventually lift up to reveal the slightly damaged wood surface beneath and a sponging cellulose mush in between.

Dead Leg. The cooling tower was outfitted with a winter bypass pipe. This pipe came from the hot-well tank inside the building, through the roof and into the cold water basin. This 110 degree water would prevent the basin from freezing up during the winter. Operation of this section of pipe was controlled by a thermostatically controlled solenoid valve. When not in use, approximately 100 feet of 2" pipe lay full of warm, sugary, stagnant water, a perfect breeding ground for bacteria and reinoculation site for the tower. Ocean Spray staff addressed this problem by adding a 2" Parrot to this line.

No Blow Down. Initial discussion about the tower's operation revealed that the tower did have blow down, or a way for the recirculated water to exit from the cooling loop. However, it turned out to be only a ½" line with a valve barely open. This was really more of a continuous bleed-off than a full discharge of the contents of the tower basin. As the tower operated and water was evaporated, the sugars and other debris were left behind. Ocean Spray staff changed this by installing two 2" valves and opening them for four minutes every day.

No Fresh Water. The city water line into the basin had a Total Dissolved Solids meter set for 1200. When the mineral content reached this level the valve would open and allow fresh city-water to enter. Since steam condensate was returned to the tower and contained no minerals, the TDS rarely rose above 200. Because of this, no city water ever entered the tower. Ocean Spray fixed this by manually opening the valve after the four minute blow-down to refill the basin. This had the additional bonus of introducing minerals to the mineral poor cooling waters.

"Die-Off" Period

This describes the period (approximately four months) where the Parrot continuously killed the bacteria in the water and the surface layer of the biofilm. As this layer died and peeled off, as witnessed by the large increase in slime build-up in the in-line filters, fresh bacteria were exposed to the water, or liberated as free floating colonies. The die-off period for the concentrator tower was longer than in most other towers partly due to the following reasons:

Wood Basin. As mentioned above, the wood basin provides excellent breeding grounds for bacteria and an anchor point for biofilm exo-polymers.

Silicon Sealant. Analysis of the biofilm mass revealed a large percentage of silicon. This element is present to some degree in corrosion inhibitors in the form of silicates, however none have been used on the concentrator tower. Closer inspection of the tower construction revealed silicon sealant had been used to repair the leaks in the basin where boards met, pipes came in, or diffusion ports were fastened to the distribution basin. Conversations with Dow Chemical and Dupont Corporation (the two largest manufacturers of silicon sealants) revealed that silicon does degrade in low pH environments and is not recommended as an underwater sealer. Furthermore, silicon is readily incorporated into bio-film polymers when dissolved at the base layer of the biofilm that is in contact with the substrate. Once incorporated, the silicon can act as a barrier to outside chemical penetration (i.e. use of chlorine as a biocide).

6.4 Financial Barriers

There were no real financial barriers. The grant paid for one unit, while Piat and Ocean Spray signed a six month trial agreement for the rest. In this agreement Ocean Spray paid a portion up-front, and the balance when satisfied that the equipment functioned to their expectations. The relatively short payback of this technology lends itself to outright purchases.

7.0 Application & Transferability

7.1 Transfer to Other Food Processing Industries

The Parrot has a wide transferability within the food and beverage industry. It is already in use in Europe at a Heineken bottling plant in Holland, has been recently installed in a Hood Ice Cream plant in Connecticut and at a hog farm in North Carolina. The simplicity of its installation and minimal maintenance requirements further reduce work load for facilities personnel. The ability to kill or disable such organisms as cryptosporidium make it a prime technology for municipal water treatment. It is already used by a restaurant in Connecticut to prevent spotting of the glasses in the dishwasher.

7.2 Transfer to Other Industries

Most companies have at least one cooling tower providing cooled process water for a chiller loop, compressor system or manufacturing process. The compressor tower at Ocean Spray is one such typical application. The Parrots's success in this application bodes well for other potential users.

Some companies use additives having trace quantities of metals such as molybdenum and chromium. In certain areas of the country, such as metropolitan Boston, the number of users / dischargers of metals containing additives have contributed to the banning of municipal sewage sludge from agricultural land application due to high metals levels. The Parrot technology could provide a metals-free alternative for companies in those geographic areas.

The concentrator cooling tower represents the most difficult application to date. Successful removal of the accumulated biofilms in this tower demonstrate the unique strengths of the Parrot system. In the words of Ocean Spray's staff, "If it can handle the concentrator tower, it can handle any tower."

Appendix A
Financial Analysis
Tables 1-4

Table 1

Operating Cost for Chemical Water Treatment
Compressor Tower

Cost Item	Description		Cost Factor	Unit Price	Total Units	Total Cost
Purchase Costs	NaOH		100%	$0.18	none	$ -
(1996 figures)	NaOCl		100%	$0.08	184	$ 15
	CW4325		100%	$2.70	202	$ 545
	IS-11278		100%	$1.52	133	$ 202
Storage/Floor Space	Chemicals	(1)	100%	$1.00	10	$ 10
Waste Management	Treatment Chemicals		0%	$0.00	none	$ -
	Testing Equip.	(2)	100%	$10.00	52	$ 520
	Testing Labor	(3)	100%	$25.00	104	$ 2,600
Regulatory Compliance	Safety/Training Equipment		1%	$1.00	11181	$ 78
	Fees & Taxes					
	- Base Fee	(4)	0%	$1.00	4625	$ 7
	- Chemical		1%	$1.00	1100	$ 8
	Manifests, Test Reports		0%	$0.00	none	$ -
Insurance			0%	$0.00	none	$ -
Production Costs	$/Unit of Product	(5)	Refer to notes for reliability concerns			$ -
	Labor/Unit Product					$ -
	Other					$ -
Maintenance	Time	(6)	100%	$25.00	77	$ 1,925
	Materials		100%	$100.00	1	$ 100
Utilities	Water	(7)	100%	$2.76	370	$ 1,021
	Electricity	(8)	100%	$0.08	73860	$ 5,909
	Gas/Steam				none	$ -
Total Annual Operating Cost:						$ 12,941

Table 2

Operating Cost for Chemical Water Treatment
Concentrator Tower

Cost Item	Description	Cost Factor	Unit Price	Total Units	Total Cost
Purchase Costs	NaOH	100%	$0.18	3735	$ 669
(1996 figures)	NaOCl	100%	$0.08	11105	$ 900
	CW4325	0%	$2.70	202	$ -
	IS-11278	0%	$1.52	133	$ -
Storage/Floor Space	Chemicals (1)	100%	$1.00	20	$ 20
Waste Management	Treatment Chemicals	0%	$0.00	none	$ -
	Testing Equip. (2)	100%	$10.00	52	$ 520
	Testing Labor (3)	100%	$25.00	104	$ 2,600
Regulatory Compliance	Safety/Training Equipment	11%	$1.00	11181	$ 1,230
	Fees & Taxes				
	- Base Fee (4)	8%	$1.00	4625	$ 347
	- Chemical	16%	$1.00	2200	$ 352
	Manifests, Test Reports	0%	$0.00	none	$ -
Insurance		0%	$0.00	none	$ -
Production Costs	$/Unit of Product (5)	Refer to notes for reliability concerns			$ -
	Labor/Unit Product				$ -
	Other				$ -
Maintenance	Time	100%	$25.00	77	$ 1,925
	Materials	100%	$250.00	1	$ 250
Utilities	Water (6)	100%	$2.76	1	$ 3
	Electricity (7)	100%	$0.08	257472	$ 20,598
	Gas/Steam			none	$ -
Total Annual Operating Cost:					$ 29,412

Table 3

Financial Analysis of Electrical Water Treatment
Compressor Tower

Capital Costs	Description	Chemical Treatment	Electrical Treatment	New
Equipment Purchase		$ -	$ 3,500	
Disposal of Old Process			none	
Research & Design			none	
Initial Permits			none	
Building/Process Changes			$ 600	
Total Capital Costs:			$ 4,100	

Operating Costs	Description	Chemical Treatment	Electrical Treatment	Difference
Purchase Costs	NaOCl	$ 15	$ -	$ 15
Chemicals	CW4325	$ 545	$ -	$ 545
	IS-11278	$ 202	$ -	$ 202
Storage Costs	Floor Space (Chemicals)	$ 10	$ -	$ 10
Waste Management	Treatment Chemicals	$ -	$ -	$ -
	Testing	$ 3,120	$ 1,560	$ 1,560
	Disposal	$ -	$ -	$ -
Regulatory Compliance	Safety/Training Equipment	$ 78	$ -	$ 78
	Fees or Taxes	$ 15	$ -	$ 15
	Manifests, Test Reports	$ -	$ -	$ -
Insurance		NA	NA	$ -
Production Costs	$/Unit of Product	Refer to notes for reliability concerns		
	Labor/Unit Product	Refer to notes for reliability concerns		
Maintenance	Time	$ 1,925	$ 460	$ 1,465
	Materials	$ 100	$ -	$ 100
Utilities	Water	$ 1,021	$ 21	$ 1,000
	Electricity	$ 5,909	$ 6,045	$ (136)
	Gas/Steam	$ -	$ -	
Annual Operating Costs:		12,940	$ 8,086	$ 4,854

Cash Flow Summary	Description	Chemical Treatment	Electrical Treatment	
Total Operating Costs		$ (12,940)	$ (8,086)	
Incremental Cash Flow	**(Annual Savings) =**		**$ 4,854**	
- Depreciation			$ (410)	
Taxable Income			$ 4,444	
Income Tax (40%)			$ (1,778)	
Net Income			$ 2,666	
+ Depreciation			$ 410	
After Tax Cash Flow			$ 3,076	
Present Value	10 years		$ 18,903	
Total Capital Cost			$ (4,100)	
Net Present Value	**(Project Net Worth) =**		**$ 14,803**	

Table 4

Financial Analysis of Electrical Water Treatment Concentrator Tower

Capital Costs	Description	Chemical Treatment	Electrical Treatment	
Equipment Purchase		$ -	$ 22,000	
Disposal of Old Process			none	
Research & Design			none	
Initial Permits			none	
Building/Process Changes			$ 1,200	
Total Capital Costs:			$ 23,200	

Operating Costs	Description	Chemical Treatment	Electrical Treatment	Difference
Purchase Costs Chemicals	NaOCl	$ 900	$ -	$ 900
	NaOH	$ 669	$ -	$ 669
	IS-11278	$ -	$ -	$ -
Storage Costs	Floor Space (Chemicals)	$ 20	$ -	$ 20
Waste Management	Treatment Chemicals	$ -	$ -	$ -
	Testing	$ 3,120	$ 720	$ 2,400
	Disposal	$ -	$ -	$ -
Regulatory Compliance	Safety/Training Equipment	$ 1,230	$ -	$ 1,230
	Fees or Taxes	$ 699	$ -	$ 699
	Manifests, Test Reports	$ -	$ -	$ -
Insurance		NA	NA	$ -
Production Costs	$/Unit of Product	Refer to notes for reliability concerns		
	Labor/Unit Product	Refer to notes for reliability concerns		
Maintenance	Time	$ 1,925	$ 1,150	$ 775
	Materials	$ 250	$ 100	$ 150
Utilities	Water	$ 3	$ 690	$ (687)
	Electricity	$ 20,598	$ 21,564	$ (966)
	Gas/Steam	$ -	$ -	
Annual Operating Costs:		29,414	$ 24,224	$ 5,190

Cash Flow Summary	Description	Chemical Treatment	Electrical Treatment	
Total Operating Costs		$ (29,414)	$ (24,224)	
Incremental Cash Flow	**(Annual Savings) =**		**$ 5,190**	
- Depreciation			$ (2,320)	
Taxable Income			$ 2,870	
Income Tax (40%)			$ (1,148)	
Net Income			$ 1,722	
+ Depreciation			$ 2,320	
After Tax Cash Flow			$ 4,042	
Present Value	10 years		$ 24,836	
Total Capital Cost			$ (23,200)	
Net Present Value	**(Project Net Worth) =**		**$ 1,636**	

Appendix B
Test Data

Grab Sample Analysis

Concentrator Tower

Target Date	conductivity <100 umho	pH 6.5 to 8.0	TDS (mg/L)	TPC (cpu) <1000	Chlorine Total	Chlorine Free	Coli neg.
12/9/96		7.72	420	<10est	0.66	0.04	<10
12/11/96		7.00	540	2,010	>3.5	>3.5	<10
12/16/96		8.31	364	<10est	0.21	0.01	<10
12/18/96		6.99	748	206,000			<10
12/22/96	440			132,000	<.01	<.01	neg
1/7/97	340	6.95	348	72,000	<.01	<.01	neg
1/8/97	380	6.59	336	168,000	<.01	<.01	neg
1/23/97	450			1,000	0.03	0.02	neg
1/24/97	410			3,000	0.41	0.34	neg
1/27/97	530			124,000	0.04	0.02	<10
1/29/97	380			<10	0	0	neg
1/31/97	270			560,000	0	0	<10
2/3/96***	210	3.7	124	354,000	0	0	<10
2/5/97	220	3.7	136	248,400	0	0	<10
2/7/97#	230	3.38	136	<10	0	0	<10
2/10/97	340	7	152	106,200	0	0	<10
2/12/97	240	6.9	164	486,000	0	0	<10
2/14/97	260	7.6	272	410,000	0	0	<10
2/19/97	250	6.7	208	915,000	0.01	0.02	<10
2/21/97	310	6.6	284	1,346,000	0.01	0.01	<10
2/24/97	290	7	208	1,017,000	0	0	5.1
2/26/97	330	6.96	312	695,000	0	0	<10
2/28/97	360	7.1	320	4,860,000	0	0	9.2
3/3/97	360	7.1	376	3,880,000	0	0	6.9
3/5/97	300	7.5	2968	1,310,000	0	0	2.2
3/7/97	260	7.1	280	5,400,000	0	0	12
3/13/97	270		N/A	6,790,000	0	0	12
3/14/97	290	7.09	140	1,060,000	0	0	6.9
3/17/97	250	7.64	192	1,270,000	0	0	6.9
3/20/97		7.34	208	1,026,000	0	0	N/A
3/24/97	260	7.12	188	1,180,000	0	0	<10
3/26/97	290	7.55	236	110,000	0	0	<10
3/31/97	380	6.65	372	1,560,000	0	0	<10
4/3/97	350	7.16	228	1,610,000	0	0	<10
4/4/97	330	6.66	324	1,690,000	0	0	6.9
4/7/97	560	8.10	776	1,090,000	0	0	6.9
4/9/97	640	10.20	628	1,620,000	0	0	12.0
4/11/97	590	9.00	568	2,150,000	0	0	6.9
4/14/97	670	9.41	692	2,680,000	0	0	>23
4/16/97	700	9.56	776	4,820,000	0	0	>23
4/18/97	290	7.66	264	8,600,000	0	0	>23
4/25/97	290	7.93	292	5,540,000	0	0	>23
4/28/97	280	7.61	232	1450000	0.01	0	NEG
4/30/97	360	7.31	412	2400000	0.01	0.01	NEG
5/2/97	390	5.87	400	1200000	0.01	0.02	NEG
5/5/97	870	8.07	1028	2400000	0	0	NEG
5/7/97	780	7.3	984	470000	0.05	0.01	NEG
5/9/97	1220	6.79	1424	315000	0.02	0.01	NEG
5/12/97	490	7.02	596	5140000	0.01	0.01	6.9
5/14/97	680	7.57	688	320000	0	0	NEG
5/16/97	660	6.58	996	1980000			6.9
5/19/97	590	8.04	632	900000			<10
5/23/97	450	7.51	400	870000			<10

Grab Sample Analysis							
Compressor Tower							
Target Date	pH 6.5 to 8.0	TDS (mg/L)	TPC (cpu) <1000	conductivity <100 umho	Chlorine Total	Chlorine Free	Coli neg.
2/26/97	9.02	416	9	1040	0.02	0.01	9
2/28/97	9.30	388	9	1020	0.02	0.01	9
3/3/97	8.30	384	9	1030	0.02	0.01	9
3/4/97	8.70	472	500	1030	0.02	0.01	9
3/5/97	8.40	432	9	1050	0.02	0.01	9
3/7/97	8.00	272	9	900	0.02	0.01	9
3/13/97		N/A	19200	930	0	0	9
3/14/97	8.03	344	9	710	0	0	9
3/20/97	8.31	492	216000		0	0	
3/24/97	8.22	512	9	1010	0	0	9
3/26/97	8.42	524	9	1060	0	0	9
3/31/96	8.43	484	14900	1070	0	0	24
4/3/97	8.38	480	1320	1030	0	0	9
4/4/97	8.11	484	2700	1050	0	0	9
4/7/97	8.38	496	22500	1030	0	0	9
4/9/97	8.39	500	9	1060	0	0	9
4/11/97	8.3	492	29000	990	0	0	9
4/14/97	8.41	532	10500	1150	0	0	9
4/16/97	8.37	568	11400	1160	0	0	24
4/18/97	8.47	548	15400	1120	0	0	9
4/25/97	7.93	544	22500	1150	0	0	9
4/28/97	8.43	556	24500	1200	0	0	0
4/30/97	8.4	520	22600	1150	0	0	0
5/2/97	8.36	588	33000	1170	0.01	0.01	0
5/5/97	8.42	608	1000	1130	0.01	0.02	0
5/7/97	8.4	568	1000	1090	0.03	0.03	0
5/9/97	8.23	564	8000	1110	0.02	0.01	0
5/12/97	8.45	568	1000	1080	0.02	0.01	0
5/14/97	8.4	576	15000	1120	0.01	0	0
5/16/97	8.42	504	27000	1130			0
5/19/97	8.43	536	8400	1110			0
5/23/97	8.37	600	7900	1130			9