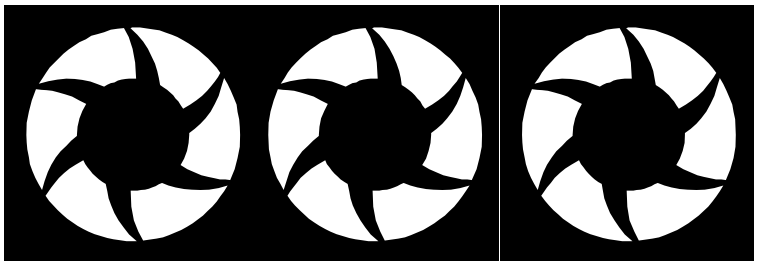
WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Air-Cooled Fluid Coolers

A Case Study on Recycling Cooling Water



Prepared by:
Washington State Department of Ecology
Toxics Reduction Engineer Efficiency (TREE) Team
Publication Number 01-04-028
January, 2002

Disclaimer

The Department of Ecology does not assume any liability for the accuracy or completeness of the information presented in this report. A listing of a company does not constitute a recommendation.

Acknowledgments

The TREE team would like to acknowledge the efforts made by PABCO Roofing Products. In particular, we would like to recognize Dennis Williams, plant manager of PABCO. The team would also like to thank all of PABCO Roofing Product's staff for their cooperation and willingness in sharing their observations of the processes and providing data and other information.

The TREE team also thanks McCormack Manufacturing and Colmac Coil Manufacturing for providing information about their air-cooled fluid coolers.

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Introduction

Many industries use water to cool their manufacturing processes. Generally, the cooling water does not come in contact with the manufactured product and is not reused. Instead, the water is discharged to the environment without any cooling. This is a non-contact, single pass, cooling water process. Using an air-cooled fluid cooler (ACFC) in a closed-loop system is a cost-effective alternative to a single-pass cooling system. These units can have a payback time of less than one year based on savings from reducing water usage, reducing disposal costs, and reducing or possibly eliminating permit fees. In addition, ACFC systems benefit the environment. They reduce the demand for water and they eliminate the discharge of hot water into the environment.

The following sections describe ACFC systems and provide a case study of a company's switch from a single pass system to a closed loop system using an ACFC. This document also describes equipment sizing and the capitol cost and savings associated with air-cooled units.

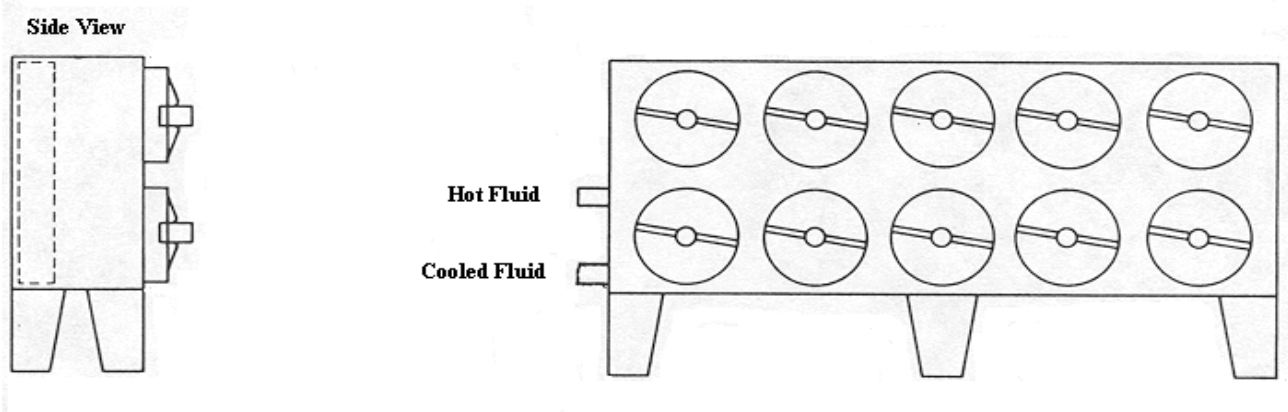


Figure 1: Schematic of Air-Cooled Fluid Cooler

ACFC units are heat exchangers (see Figure 1) that are used to assist cooling of manufacturing processes. Cooling fluid is sent through a series of coils in the ACFC. The coils are connected to fins that help transfer the heat from the fluid. Fans blow ambient air across the fans to remove the heat. Typical units contain 1 to 20 fans but can have as many as 50 fans. ACFC units are designed to cool water, ethylene glycol/water and propylene glycol/water mixtures. Water is the easiest fluid to use for cooling and to dispose of but requires periodic flushing of the ACFC system to prevent microbial growth.

PABCO Roofing Products - A Case Study

PABCO Roofing Products is located in Tacoma, Washington, in the Commencement Bay area. The facility manufactures asphalt roofing products under SIC code 2952.

Asphalt, fiberglass, roofing granules, felt paper, talc, crushed rock or sand are combined in various quantities to produce roofing products. A fiberglass mat is used as the backbone for roof shingles. Approximately four to five truckloads of asphalt are used a day. Hot asphalt is applied to both sides of the fiberglass mat. Then, a thin layer of rock and sand is applied to the top and the bottom of the shingles, respectively. A mist of water cools the top of the shingles. This is the contact cooling water. The contact cooling water is sent to a sedimentation tank to separate out the suspended solids and the water is reused repeatedly to cool the shingles as contact cooling water.

Cooling water is also used to cool the drums on which the shingles travel. It does not come in contact with the product, so it is non-contact cooling water. Prior to 1997, the facility discharged non-contact cooling water to the Sitcum Waterway via City of Tacoma storm drain #172 under a NPDES permit from the Department of Ecology. The permit allowed the discharge of up to 135,000 gallons of non-contact cooling water per day. The non-contact cooling water was used only once in a single pass during the manufacturing process and then discharged. In 1996, the facility installed an air-cooled fluid cooler system to cool the non-contact water, which allowed reuse of the water. As a result, Pabco attained zero discharge of cooling water. In 1997, following a request by the facility, the Department of Ecology terminated the NPDES permit.

The facility also has boiler blowdown and forklift washwater. This is discharged to the City of Tacoma sanitary sewer under a separate discharge permit from the City.

Currently, two air-cooled fluid coolers (from McCormick, Oregon) are used to cool the non-contact cooling water (see Figures 2 and 3). Makeup water for the cooling system is obtained from City of Tacoma (City) via a storage tank (see Figure 4). Part of the stored cooling water is also used as makeup water for the contact cooling water system described earlier. The City makeup water averages about 2000-5000 gallons every two days.

No antifreeze solution is used in the ACFC system. Instead, the system has in-line heaters to keep water from freezing during the winter. The ACFC's also have swamp coolers that are used in the summer to enhance cooling of the water. At Pabco, the larger ACFC (Figure 3) is used in summer while the smaller one (Figures 2 and 3) is used in winter season.

The temperature coming into the ACFC is 100° F. The exit temperature is either at ambient or 10° F above ambient.

Figure 2. Photo of Small Radiator at PABCO

Figure 3. Housing for the two air-cooled units.

PABCO Cooling System

Figure 4: Flowchart of Cooling System for PABCO

Equipment Sizing

Facilities interested in determining how much benefit could be gained from installing an ACFC system to cool their manufacturing process would first need to size the cooler. ACFC units cooled fluid coolers are sized based on their gross heat rejection or ability to transfer heat. System capacities are typically measured in British thermal units per hour (BTUH) or a thousand BTU's per hour (MBH). Typical sizes of prefabricated air-cooled units are between 2,000 to 230,000 BTUH. The capacity is also a factor of air temperature so it is common to see the gross heat rejection in terms of BTUH per degree of temperature difference (TD). The formula below is used to calculate the gross heat rejection rate for water.

$$\frac{MBH}{TD} \Longrightarrow \frac{BTUH}{TD} \times 1{,}000 \Longrightarrow \frac{GPM \times (EFT - LFT) \times 0.49}{TD}$$

Definitions:

MBH/TD = Gross Heat Rejection (BTUH / degrees F)
EFT = Entering Fluid Temperature (degrees F)
LFT = Leaving Fluid Temperature (degrees F)
GPM = Flow rate of Fluid (Gallons per minute)
TD = Temperature Difference (degrees F) = Entering Fluid Temp. – Entering Air Temp.[1]

[1]Entering Air Temperature is the ambient air temperature for the geographical area.

EXAMPLE:

For the following process numbers:

Entering Fluid Temperature (EFT) = 100 degrees F
Leaving Fluid Temperature (LFT) = 80 degrees F
Flow rate of Fluid (GPM) = 150 gallons per minute
Entering Air Temperature = 65 degrees F

$$\frac{MBH}{TD} \Longrightarrow \frac{GPM \times (EFT - LFT) \times 0.49}{TD} \Longrightarrow \frac{150 \times (100-80) \times 0.49}{(80-65)} \approx 42$$

Once the gross heat rejection number is calculated, the best size for the process can be determined by calling a vendor or by using vendor sizing graphs. The actual size of the equipment will vary somewhat depending on the vendor. In the next section the gross heat rejection numbers are used to find capitol cost estimates of fluid coolers for the process.

Capitol Costs and Savings

An air-cooled fluid cooler's capitol costs can be approximated with the chart below. Us the gross heat rejection number to find the corresponding equipment costs.

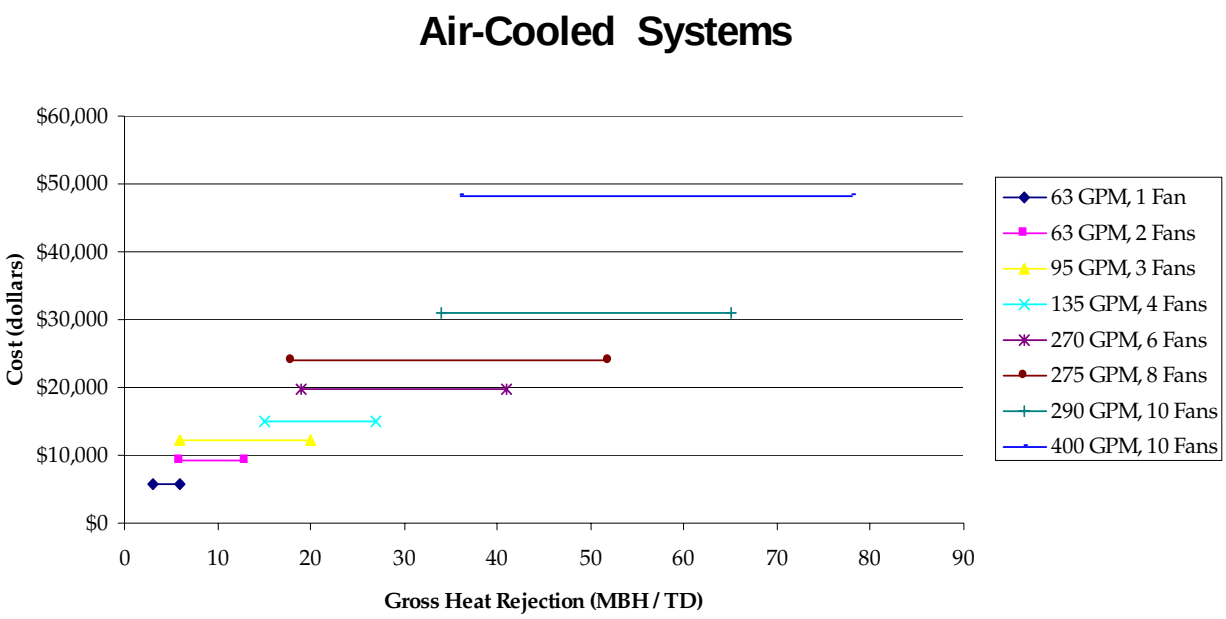


Figure 5: Capitol Costs for Air-Cooled Systems

There are several potential savings with use of a fluid cooler. The largest savings is the reduction of water usage. The switch to a closed loop system from a single pass system can reduce water usage by approximately 80% as was realized by PABCO. With this reduction in water usage, wastewater discharge and corresponding permit fees will also be reduced.

The chart on page 10 (Figure 6) was developed to project cost savings based on capital costs for fluid coolers, annual NPDES permit fees, water costs and sewer fees for Washington State. Use the chart to estimate annual projected savings when a single pass cooling system with a given flow volume is replaced with an air-cooled closed-loop system. Any necessary installation costs are not included.

Figure 6: Projected Savings in Washington State

Conclusion

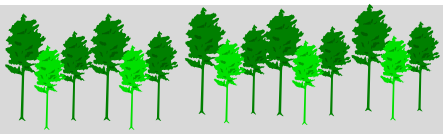
Air-cooled fluid systems are an inexpensive and environmentally friendly alternative to single-pass cooling systems. Companies that make the switch usually have a payback of less than one year! Air-cooled systems reduce the usage of fresh water and may even eliminate the need for your company to have a wastewater discharge permit.

Appendix

About The TREE Project

What is TREE and how can it benefit your business?

The Toxic Reduction Engineer Efficiency (TREE) team is a group of Ecology engineers with expertise in industrial processes and pollution prevention. The team can find ways to reduce your waste, increase your efficiency and save you money. TREE is a free technical assistance service (i.e., non-regulatory) for businesses. After a review and analysis of your business's operation the TREE team will provide suggestions in a report for your use.



Generate less waste, improve your company's efficiency, and save money! Ecology's TREE team can help!

In 1999, TREE worked with three companies in Washington State. The team made suggestions that reduced water use by 22 million gallons and could reduce hazardous waste generation by 32,000 pounds. By using the information supplied by Ecology's TREE team, these companies could save a total of $94,000 each year.

The successful TREE team earned the Governor's Award for Service & Quality Improvement in 1998. The team was also commended by Governor Gary Locke in his recent "Governing for Results" report.

What has TREE done for Washington businesses?

Recent TREE projects include:

Industrial Plating

Implemented TREE recommendations have:

- Reduced water and wastewater use by 75 percent;
- Reduced hazardous waste production by 100,000 pounds each year;
- Saved the company $57,000 in 1999.

"It's a win-win approach! With our limited resources, we were able to achieve remarkable success with TREE. Working with the TREE team is a real education, you can see where opportunities are and how simple techniques can reduce waste and save money." — Bob James, General Manager

Basin Frozen Foods

Implemented TREE findings have:

- Reduced daily water consumption by 100,000 gallons;
- Improved wastewater quality dramatically; and
- Saved approximately $10,000 annually.

"I give the TREE team as high a recommendation as I can. I'm glad they came down and gave us a hand." — Rich Tolman, Plant Manager

Prototron Circuits

Suggested improvements to Prototron's plating, rinsing and waste treatment operations should:

- Save Prototron more than $50,000 per year after an eight-month payback; and
- Eliminate 11,000 pounds of hazardous-waste sludge each year.

The TREE team is "helpful and pleasant to work with … they did their homework before they came." — Kevin Richardson, Plating Manager

Rainier Ballistics

Implementing TREE findings can:

- Reduce water use by about 200,000 gallons a year;
- Save $30,000 annually; and
- Reduce hazardous waste by more than 20,000 pounds each year.

"I found the entire TREE team to be very courteous, professional and of incredible value to my firm. They helped show us ways to possibly save money, while at the same time reducing the amount of hazardous waste we create." — Eric Hampton, General Manager

Is my business a potential TREE candidate?

The ideal candidates for TREE projects are small- to medium-sized, private companies that are willing to work with Ecology to optimize resource use. Applications are welcome! Anyone may complete and submit a project application form which is sent directly to the TREE team members. You can obtain an application from the Ecology web site or contact a team member noted below. Even if you are not certain you fit the profile, do not hesitate to apply.

How are businesses selected as TREE projects and what are the initial steps in the process?

TREE applications are reviewed and ranked each time the TREE team is ready to begin a new project. The top-ranked facilities are contacted to determine their interest in and need for TREE assistance.
The TREE team uses the following criteria to select a facility:

- There is a potential to reduce the affect the facility has on the environment.
- There is potential to improve process efficiency and reduce waste.
- The facility is willing to work in good faith with the TREE team.
- The facility would be willing to implement system changes where economically feasible.
- The facility's management needs TREE assistance, due to the lack of in-house engineering staff or minimal experience with pollution-prevention implementation.

Once your facility is selected for TREE assistance, the team will make several visits to gather information about your processes. A report is developed with specific recommendations on how you can reduce waste generation, reduce resource consumption and increase savings. It is up to you to decide whether or not to implement these pollution-prevention opportunities. Many TREE-suggested opportunities have been implemented by past project facilities, to their benefit.

Where do I go to get more information?

Visit our website at *www.ecy.wa.gov/programs/hwtr/tree* or contact one of the TREE team members listed below.

The TREE Team

James DeMay	(360) 407-6338	jade461@ecy.wa.gov
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