PIX 12662

The U.S. Environmental Protection Agency tests innovative projects to verify the applicability of new water efficiency methods before implementation at other facilities that may receive similar results, including the Research Triangle Park laboratory campus.

The U.S. Department of Energy's (DOE) Federal Energy Management Program (FEMP) facilitates the Federal Government's implementation of sound, cost-effective energy management and investment practices to enhance the nation's energy security and environmental stewardship.

WATER EFFICIENCY IMPROVEMENTS AT VARIOUS ENVIRONMENTAL PROTECTION AGENCY SITES

Best Management Practice Case Study #12 — Laboratory/Medical Equipment

The U.S. Environmental Protection Agency (EPA) built a successful water conservation program and reduced potable water use through a series of initiatives at EPA laboratories. EPA completed projects in all of the U.S. Department of Energy (DOE) Federal Energy Management Program's (FEMP) 14 Best Management Practice (BMP) categories. The projects highlighted below demonstrate EPA's ability to reduce water use in the laboratory/medical equipment BMP category by implementing vacuum pump and steam sterilizer replacements and retrofits. Due to the success of the initial vacuum pump and steam sterilizer projects described in this case study, EPA is implementing similar projects at several laboratories throughout the nation.

Reducing Vacuum Pump System Water Use

Many EPA laboratories are equipped with a central vacuum system in which a vacuum pump located in a mechanical room provides vacuum service to laboratory spaces throughout the building. Laboratory processes, such as filtration, distillation, and extraction, are commonly operated under vacuum conditions. The central laboratory vacuum is often provided by a liquid ring vacuum pump. Liquid ring vacuum pumps use water to form a moving cylindrical ring inside the pump casing. A vacuum is created by the changing geometry inside the pump casing when the impeller and liquid ring rotate. As the water rotates within the pump, it gains heat and gathers impurities from gases collected by the vacuum system.

In simple liquid ring vacuum pump systems (as shown in Figure 1), water is continuously discharged and replaced with fresh water to dissipate heat and remove impurities. Even if flowing at only one gallon per minute (gpm), the discharge from this type of vacuum pump system sends roughly 525,000 gallons to the sanitary sewer annually.

Kansas City Science and Technology Center

The Kansas City Science and Technology Center (KCSTC) began operations in May 2003, occupying approximately 72,000 square feet. Built on a former brownfield site, KCSTC received an honorable mention in 2004 in the Sustainable Design/Green Buildings category of the Federal Closing the Circle Awards, which are given by the Office of Federal Environmental Executive. The facility received a Gold rating in the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) 2.0 Rating System.

While KCSTC was designed and constructed with many sustainable aspects, an opportunity to further reduce water use in KCSTC's vacuum pump was identified in 2008. The original liquid ring vacuum pumps at KCSTC

PIX 17617

Figure 1. Example of a continuously discharging-type pump system

PIX 17616

Figure 2: Example of Recovering and Recycling-Type Pump Systems

were continuously discharging water to the drain, requiring approximately 1 million gallons per year in make-up water. In 2008, EPA decided to replace the original liquid ring vacuum pumps with a recovery and recirculation system, as shown in Figure 2. The new recovery and recirculation system recycles nearly all of the discharge water back into the vacuum pump as make-up water. The recovery water loop is passed through a heat exchanger to remove the heat before it re-enters the system. The new system must purge a limited amount of water, known as blow-down, to remove the buildup of impurities from the system. Fresh water is added to the system to make up for the loss of blow-down water, but the amount of make-up water added under the new system configuration is much less than the amount used in the initial design.

EPA estimates that by recovering and recycling the discharge water in the new liquid ring vacuum pumps, KCSTC reduced water use in the vacuum pump systems by approximately 80 percent or 800,000 gallons per year—approximately 25 percent of the facility's total water use. The project cost EPA $57,000 and saves the facility $5,400 annually in water and sewer costs.

Research Triangle Park, Research Triangle Park, North Carolina

Located near Raleigh and Durham, North Carolina, the Research Triangle Park (RTP) laboratory campus is the EPA's largest operation outside of Washington, D.C. The Main Building of the RTP campus has 1.1 million square feet of office, laboratory, computer, and conference space. The building was fully occupied in 2003 after nearly a decade of planning and incorporating sustainable design practices. It is one of the largest "green buildings" in the world and provides numerous practical examples of sustainable principles. The RTP Main Building houses the Office of Research and Development, the Office of Air Quality Planning and Standards, and the Office of Administration and Resources Management. The building won the 2007 Energy Partner of the Year Award from the EPA Sustainability Group.

The RTP Main Building originally housed efficient recirculating-style vacuum pumps; however, EPA observed that the three installed pumps appeared to be discharging more water than needed to operate the equipment. RTP staff determined the system could run more efficiently, and by adjusting the blow-down rate, they could reduce the volume of discharge water without impacting the vacuum system performance.

The original blow-down cycle was set to purge the system every five minutes for 45 seconds, discharging around 500,000 gallons per year to remove impurities from the vacuum pump. Without impacting system performance, the blow-down cycle was optimized to occur every 10 minutes for 30 seconds, reducing water consumption in the system by 340,000 gallons of water per year. Without having to buy any replacement or retrofit equipment, RTP now uses 67 percent less water and saves approximately $4,000 of annual water and sewer costs from this operational change.

Andrew W. Breidenbach Environmental Research Center, Cincinnati, Ohio

The Andrew W. Breidenbach Environmental Research Center (Cincinnati AWBERC) is the EPA's second largest research and development facility. Cincinnati AWBERC encompasses 429,780 square feet of facility space on 22 acres located five miles north of downtown Cincinnati, Ohio.

Cincinnati AWBERC's original vacuum pump reached the end of its useful life after 35 years of service. The original vacuum pump used approximately 200,000 gallons of water per year. When it came time to replace the original vacuum pump, EPA selected several pump options to research as replacement pumps. The pumps selected as replacement candidates were a new liquid ring pump, a rotary vane oil-less pump, an oil lubricated rotary vane pump, a dry "oil-less" rotary screw pump, a flooded oil lubricated rotary screw pump, and a claw-style pump. Based on mission needs and vacuum demands, EPA chose a pump that was water efficient, energy efficient and low maintenance for Cincinnati AWBERC..

EPA chose to replace the vacuum pump with one that uses claw technology to create its vacuum without using any liquid. Claw technology captures air from the inlet pipe in two non-contacting claws rotating in opposite directions. As the air in the claw hook is compressed by the rotation of the claw, it is transformed into a high-pressure air pocket. As the air pocket approaches the exhaust line opening, the air pocket exits the vacuum chamber at a high rate of velocity, creating a vacuum behind it, as illustrated in Figure 3. EPA

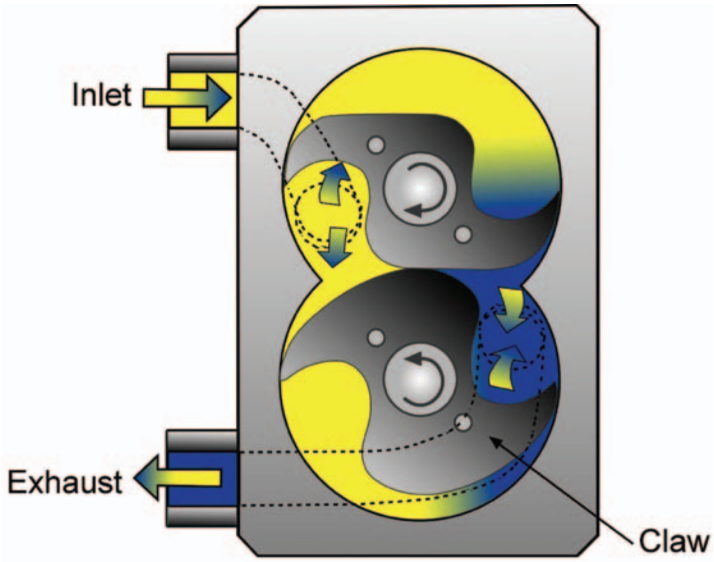

Figure 3. Typical claw technology

Annual Water and Cost Summary

Location	Thousand Gallons	Annual Savings
Kansas City Science and Technology Center	800	$5,400
Research Triangle Park Main Building	340	$4,000
Andrew W. Breidenbach Environmental Research Center	200	$2,000

selected a claw vacuum pump that was also energy efficient, saving Cincinnati AWBERC nearly $2,000 in utility cost and approximately 11 million British thermal units (Btu) — or 3,224 kilowatt-watt hours (kWh) — annually, which is enough energy to power the average U.S. single family home for 3.5 months.[1] The pump cost $84,000 and saves Cincinnati AWBERC 200,000 gallons of water per year.

Retrofitting Steam Sterilizers to Reduce Water Use

Sterilization is commonly required in laboratory and medical settings to disinfect containers, trays, and other instruments and apparatuses. Steam sterilization is often the preferred approach because it is non-toxic, relatively inexpensive, and able to sterilize a wide range of materials, such as stainless steel or plastic.

The construction of steam sterilizers includes a chamber surrounded by a steam jacket that insulates and helps regulate the temperature of the chamber. Steam is applied under pressure to destroy bacteria and other impurities. The steam supply line delivers steam to the sterilizer by passing the steam through the jacket into the inner chamber. A discharge line for steam and a discharge line for condensed water are connected from the chamber through the steam jacket to the drain system. Most steam sterilizers operate in two modes of operation – standby mode and active mode. Sterilization is initiated during the active mode. During the standby mode, the sterilizer passes a small amount of low-pressure steam into the chamber through the steam jacket to keep the equipment ready to use.

National plumbing codes prohibit water over 140°F from being discharged to the sewer. A cold water supply to the discharge stream acts as a tempering agent, reducing the condensate temperature below 140°F, which allows the water to be discharged to the drain. Many steam sterilizers are kept in standby mode 24 hours a day to avoid the time-consuming startup process. Older models of steam sterilizers were designed to allow tempering water to flow constantly during standby mode, resulting in large amounts of water use. Depending on the size of the sterilizer, standby tempering water usage may range from 0.5 gpm to 3 gpm in inefficient models. Most new steam sterilizer models are equipped with a thermocouple in the condensate drain that opens a valve, allowing tempering water to flow only when the condensate flow reaches a preset temperature.

Older models can be retrofitted to help reduce the system's water use using several methods. These methods include 1) installing a small expansion tank to allow steam to condense and cool before discharging, and 2) installing conservation kits that only allow tempering water to flow when condensate is being discharged to the drain. Conservation kits have a temperature sensor on the drain

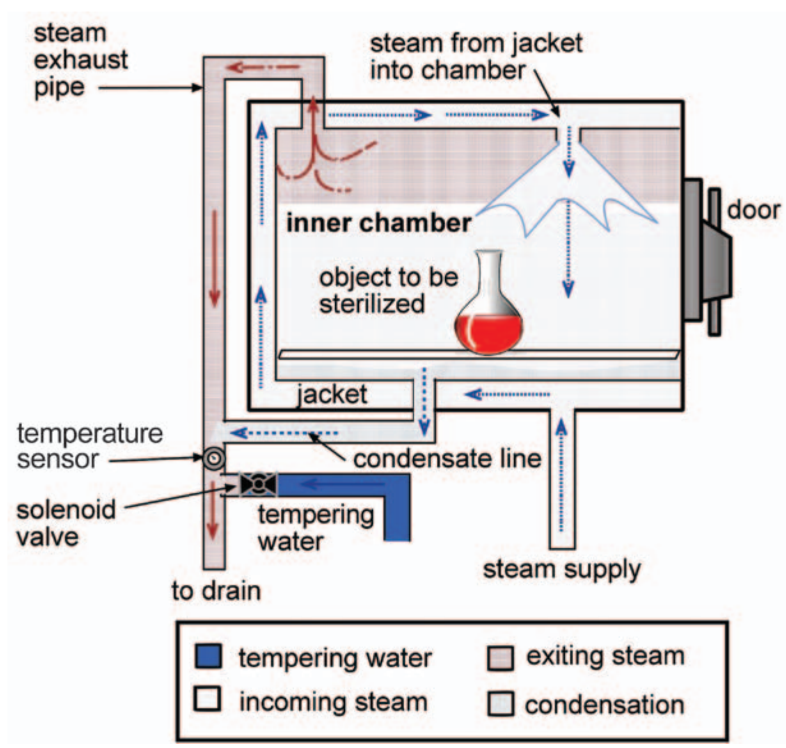

Figure 4. Typical steam sterilizer

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[1] According to U.S. Energy Information Administration Independent Statistics and Analysis 2008 data, the average U.S. residential utility consumer used an average of 920 kWh per month.

line and a solenoid valve that can be installed on the cold water supply line, as illustrated in Figure 4. When the temperature sensor detects condensate water above the maximum temperature, the solenoid valve activates, allowing the cool water to temper the hot water flow. If hot condensate is not detected in the drain line, the cold water line valve remains closed. Instead of allowing water to flow as much as 3 gpm during standby, this modification provides cooling water only when necessary. EPA installed this type of system at several facilities and saves an estimated 90 percent of potable, tempering water flow.

Andrew W. Breidenbach Environmental Research Center, Cincinnati, Ohio

In Fiscal Year 2009, the facility manager at Cincinnati AWBERC noticed the constant sound of running water directly above his office. Upon further investigation, he discovered that the five steam sterilizers located in the room above had continuously flowing tempering water. He determined that the best option for reducing the potable water use was to install conservation kits on the sterilizers, reducing unnecessary tempering water flow. Cincinnati AWBERC installed five water conservation kits on the steam sterilizers to only allow tempering water to flow when the temperature in the drain line is above 140°F.

The five conservation kits, which cost $15,000, save Cincinnati AWBERC 1.2 million gallons of water per year. The project saves Cincinnati AWBERC approximately $9,200 in water and sewer costs annually, with a payback period of less than two years.

Environmental Science Center, Fort Meade, Maryland

The EPA Environmental Science Center (ESC), consisting of approximately 162,000 square feet, was completed in 1999 and houses the Office of Analytical Services and Quality Assurance (OASQA) for EPA Region 3 and the Analytical Chemistry and Microbiology Laboratories of the Office of Prevention, Pesticides, and Toxic Substances (OPPTS).

One steam sterilizer at the ESC was operating with a continuous flow of tempering water to the drain, estimated by EPA employees to be 0.5 gpm. In July 2009, ESC installed a retrofit kit that significantly reduced the use of tempering water by only allowing tempering water to flow when condensate is being discharged to the drain at temperatures above 140°F. This modification cost approximately $3,000 and saves ESC approximately 240,000 gallons of water and $2,700 annually in water and sewer costs, generating a payback period of 14 months.

Nationwide Applicability

EPA intends to replace or retrofit all old steam sterilizer models to save potable water. Water conservation kits were installed on steam sterilizers at EPA's Region 2 Laboratory in Edison, New Jersey, saving approximately 450,000 gallons of water per year. The National Exposure Research Laboratory in Athens, Georgia; Gulf Ecology Division Laboratory in Gulf Breeze, Florida; and Atlantic Ecology Division Laboratory in Narragansett, Rhode Island; installed new steam sterilizers that regulate the flow of tempering water to drain to only when it is required.

Annual Water and Cost Summary

Location	Thousand Gallons	Annual Savings
Andrew W. Breidenbach Environmental Research Center	1,200	$9,200
Environmental Science Center	240	$2,700

Opportunities for retrofits or new equipment installations have been identified at two other laboratories in Cincinnati, Ohio, and Chapel Hill, North Carolina, offering an additional potential savings of 350,000 gallons of water per year.

Acknowledgements

FEMP acknowledges the following individuals for supporting this program and case study:

- EPA Sustainable Facilities Practices Branch: Dexter Johnson and Bucky Green
- EPA KCSTC: John Begley and Chris Taylor
- EPA RTP Campus: Greg Eades, Pete Schubert, Bill Gaines, Alex Montilla, and Sam Pagan
- EPA Cincinnati AWBERC: John Kappa, Andy Franke, and Rick Koch
- EPA ESC at Fort Meade: Rick Dreisch
- ERG: Holly Cannon and Roy Sieber

For More Information

- FEMP Water Efficiency program: www.femp.energy.gov/program/waterefficiency.html
- FEMP Water Efficiency Best Management Practices: www.femp.energy.gov/program/waterefficiency_bmp.html
- Additional information on the facilities in this case study and all EPA facilities: www.epa.gov/oaintrnt/facilities/

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DOE/GO-102011-3121 • March 2011

FEMP Federal Energy Management Program