WaterSense at Work

Laboratory and Medical Equipment

7.6 Vivarium Washing and Watering Systems

Best Management Practices for Commercial and Institutional Facilities

EPA WaterSense

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WaterSense® is a voluntary partnership program sponsored by the U.S. Environmental Protection Agency (EPA) that seeks to protect the nation's water supply by transforming the market for water-efficient products, services, and practices.

WaterSense at Work is a compilation of water efficiency best management practices intended to help commercial and institutional facility owners and managers from multiple sectors understand and better manage their water use. It provides guidance to help establish an effective facility water management program and identify projects and practices that can reduce facility water use.

An overview of the sections in *WaterSense at Work* is below. This document, covering water efficiency for vivarium washing and watering systems, is part of **Section 7: Laboratory and Medical Equipment**. The complete list of best management practices is available at www.epa.gov/watersense/best-management-practices. WaterSense has also developed worksheets to assist with water management planning and case studies that highlight successful water efficiency efforts of building owners and facility managers throughout the country, available at www.epa.gov/watersense/commercial-buildings.

- **Section 1. Getting Started With Water Management**
- **Section 2. Water Use Monitoring**
- **Section 3. Sanitary Fixtures and Equipment**
- **Section 4. Commercial Kitchen Equipment**
- **Section 5. Outdoor Water Use**
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This document is one section from *WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities* (EPA-832-F-23-003). Other sections can be downloaded from www.epa.gov/watersense/best-management-practices. Sections will be reviewed and periodically updated to reflect new information. The work was supported under contract 68HERC20D0026 with Eastern Research Group, Inc. (ERG).

Photo Credit

On the cover page, the bottom left photograph of the technician loading a cage and bottle washer was provided courtesy of LabRepCo (www.labrepco.com).

Overview

Vivaria, or animal research laboratories, utilize water-using equipment for the care and feeding of animals. This equipment includes cage, rack, bottle, and tunnel washers and automatic animal watering systems. Washers can use large volumes of water based on the number of rinse cycles and water used during each cycle. Animal watering systems can use large volumes of water if constant flows or frequent flushing is required.

Cage, Rack, Bottle, and Tunnel Washers

Batch-type cage, rack, and bottle washers operate similarly to a residential dishwasher in that equipment and/or bottles are loaded into the front-loaded washer, usually onto washer racks, and the washer completes a wash cycle. Traditional cage-and-rack washers include multiple cycles (e.g., pre-rinse, wash, final rinse). During each cycle, traditional units can use between 40 and 60 gallons of hot water. Accounting for water use in all cycles, traditional cage-and-rack washers can use as much as 320 to 480 gallons of water per load. More recent models of cage-and-rack washers use less water per cycle and allow users to choose the number of rinse cycles to minimize total water use per load. Some units also allow water from the final rinse cycle to be reused in the next cycle. More recent units can use less than 50 gallons of water per load, and some use as little as 12 gallons per load.[1]

Cage and bottle washer
Photo courtesy of LabRepCo (www.labrepco.com)

Tunnel washers are conveyor-type washers that are capable of cleaning a number of cages, racks, and other laboratory accessories at once. Tunnel washers are typically found only in high throughput vivarium operations. There are four main cycles in the tunnel washer: pre-rinse, wash, first rinse, and final rinse. Tunnel washers operate using a counter-current washing process, recycling the water from each cycle in the previous cycle (i.e., the final rinse uses fresh water, which is then recycled and used for first rinse,

[1] Beckinghausen, David. September 2006. "Energy-Efficient Washing Systems." *ALN Magazine*. https://web.archive.org/web/20170101175230/https://www.alnmag.com/article/2006/09/energy-efficient-washing-systems.

the first rinse can be recycled in the wash cycle, and so on). Water is disposed of after the pre-rinse cycle.

Facilities may use treated water (e.g., softened, reverse osmosis permeate) for wash and rinse cycles depending on their needs. High-quality water should only be used if necessary. See *WaterSense at Work Section 7.1 Water Purification* at www.epa.gov/watersense/best-management-practices for more information on water purification. Water purification typically produces a reject water stream in addition to the useful permeate stream, which increases the total water used by these systems. In addition, many washers have optional cold-water tempering systems that cool the washer's discharge water to ensure that it does not exceed sanitary sewer requirements, which can also impact a washer's total water use.

Because tunnel washers are designed for high throughput, they are not necessarily more efficient than batch-type washers for smaller operations. A 2015 study found that batch-type cage and rack washers use 21 percent less water and 69 percent less steam than tunnel washers, likely due to lower-than-expected equipment throughput and high tunnel washer idle time.[2] Vivarium operations should take care to choose cage, rack, and bottle washing equipment that is the right size for the facility's washing needs.

Animal Watering Systems

Automatic animal watering systems provide drinking water to laboratory animals in place of manually-filled bottles. There are two types of animal watering equipment, flushing animal watering systems and recirculating animal watering systems—which differ in their method of bacterial buildup prevention.

Flushing animal watering systems use a periodic, high-pressure flow to "flush" and remove bacteria from piping. Residual chlorination is typically used to further control bacterial growth. Recirculating animal watering systems use a constant flow of water treated with ultraviolet disinfection or other methods before distribution for animal watering. Flushing systems use more water than recirculating systems, because water is discharged to the drain after the flushing cycle is complete.[3]

Automatic watering systems require regular observation of the systems and the animals. Because automatic watering systems do not allow for monitoring of animal water intake, if not maintained properly, they pose the risk of flooding cages or clogging valves.[4]

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[2] Zynda, Jeffrey R. April 2015. "A Shift in Designing Cage-Washing Operations." *Lab Animal*, Volume 44, No. 4.
[3] Schultz, Carl C. March 1, 2006. "Re-circulating vs. Flushing: Animal Watering System Alternatives." *ALN Magazine*. https://web.archive.org/web/20170101175502/https://www.alnmag.com/article/2006/02/re-circulating-vs-flushing-animal-watering-system-alternatives.
[4] Cosgrove, Chris, et al. July 1, 2003. "Vivarium Automation Part 1." *ALN Magazine*. https://web.archive.org/web/20120531120854/http://www.alnmag.com/article/vivarium-automation-part-1?page=0,3.

Operation, Maintenance, and User Education

To ensure that cage, rack, bottle, and tunnel washers and animal watering systems are using water most efficiently, consider the following operation, maintenance, and user education tips for each.[5]

Cage, Rack, Bottle, and Tunnel Washers

- Only run cage, rack, and bottle washers when they are full. For tunnel washers, schedule wash runs to maximize the equipment washed during each run, thereby reducing the amount of tunnel wash runs required per day.
- Use high-quality, treated water only for the final rinse cycle.
- Operate the cage, rack, bottle, and tunnel washers near or at the minimum flow rate recommended by the manufacturer.
- If the number of rinse cycles can be chosen, use the fewest number of rinse cycles necessary to effectively clean equipment. Use cleaner rinsing detergents so fewer rinse cycles are needed.

Cage and rack washer running a full load
Photo courtesy of LabRepCo.
(www.labrepco.com)

- Fix and repair any leaks. Inspect valves and rinse nozzles for proper operation and repair worn nozzles.

Animal Watering Systems

- For animal watering systems that use flushing, minimize the number of flushing cycles while ensuring sufficient control of bacterial growth.
- Consider collecting and reusing wastewater from animal watering systems for other purposes within the facility, matching the end use with the level of water quality that exists or that can be achieved through water treatment. For more information, see *WaterSense at Work Section 8: Onsite Alternative Water Sources* at www.epa.gov/watersense/best-management-practices.

[5] International Institute for Sustainable Laboratories (I2SL) and U.S. Environmental Protection Agency (EPA). May 2022. *Best Practices Guide Water Efficiency in Laboratories*. Page 14. www.epa.gov/system/files/documents/2022-06/ws-I2SL-Laboratory-Water-Efficiency-Guide.pdf.

- Identify and repair any leaks and ensure proper operation of the system, especially for systems that employ automated flushing.

Retrofit Options

In washers with cold-water tempering systems, install a solenoid valve to only apply tempering water when necessary; otherwise, consider replacing the tempering systems with a heat exchanger to cool effluent prior to discharge.

For animal watering systems, consider adding a water treatment and recirculation system.[6]

Replacement Options

When replacing or purchasing new vivarium washing and water systems, consider the following options.

Cage washer with robotic handling
Photo courtesy of LabRepCo.
(www.labrepco.com)

Cage, Rack, Bottle, and Tunnel Washers

When purchasing a new washer or replacing existing equipment, consider choosing a batch-type washer or otherwise ensuring equipment is the right size for the operation. If discharge water needs to be cooled to meet sanitary sewer requirements, use a heat exchanger for cooling as opposed to tempering water. In addition, look for models that use less water per load with the following features:[7]

- Cycle selection that allows users to choose fewer rinse cycles.
- Reuse of final rinse water as wash water for the next load.
- Water intake monitoring to adjust the amount of water used based on load size.
- Use of high-quality water only during the final rinse cycle.

Animal Watering Systems

As an alternative to automatic animal watering systems, manual bottle fillers use only as much water as the animals need for drinking purposes. Where automatic animal watering

[6] *Ibid.*
[7] *Ibid.*

systems are used, consider systems that recirculate treated water when purchasing new equipment.[8]

Savings Potential

Cage, rack, bottle, or tunnel washers can be replaced with more efficient equipment to save water. Retrofitting or replacing existing animal watering equipment will also achieve water savings.

To estimate facility-specific water savings and payback, use the following information.

Cage, Rack, Bottle, and Tunnel Washers

Washers can be replaced with new, more water-efficient technologies that reduce the amount of water used during rinse and wash cycles and reuse rinse water in the next wash cycle.

Current Water Use

To estimate the current water use of an existing cage, rack, bottle, or tunnel washer, identify the following information and use Equation 1 below:

- The washer's water use in gallons or liters per load. This is typically provided by the manufacturer through product literature or a website. The water use will be dependent upon the flow rate of each rinse or wash cycle, duration of each cycle, and number of cycles.
- Average number of wash loads per day.
- Days of operation per year.

Equation 1. Water Use of Cage, Rack, Bottle, or Tunnel Washer (gallons or liters per year)

= Washer Water Use x Wash Processes per Day x Days of Operation

Where:

- Washer Water Use: Gallons (or liters) per load
- Wash Loads per Day: Washes per day
- Days of Operation: Days of cage, rack, bottle, or tunnel washer operation per year

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[8] *Ibid.*

Water Use After Replacement

To estimate the water use after replacing an existing cage, rack, bottle, or tunnel washer, use Equation 1 on page 5, substituting the water use of the replacement washer. The water use of the replacement washer should be provided by the product manufacturer. If the number of rinse cycles can be selected, base the water use on the fewest number of rinse cycles needed for effective washing operations.

Water Savings

To calculate the water savings that can be achieved from replacing an existing cage, rack, bottle, or tunnel washer, identify the following information and use Equation 2 below:

- Current water use as calculated using Equation 1.
- Water use after replacement as calculated using Equation 1.

Equation 2. Water Savings From Cage, Rack, Bottle, or Tunnel Washer Replacement (gallons or liters per year)

= Current Washer Water Use – Water Use After Washer Replacement

Where:

- Current Washer Water Use: Gallons (or liters) per year
- Water Use After Washer Replacement: Gallons (or liters) per year

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Energy Savings

Because cage, rack, bottle, and tunnel washers use hot water, a reduction in water use will also result in energy savings. The energy required to heat water can be dependent on the proportion of water used in washers that is hot; fuel used for water heating (e.g., electricity, natural gas); the efficiency of the water heater; and water heater temperature set points. Since this information is not always readily available, energy savings that can be achieved from replacing existing equipment can be estimated using the water savings calculated using Equation 2 and the assumptions presented in Equation 3 on the next page:

Equation 3. Energy Savings From Cage, Rack, Bottle, or Tunnel Washer Retrofit or Replacement (kWh of electricity or Mcf of natural gas per year)

= Water Savings x Average Percent of Water That Is Hot x (Energy per Gallon or Liter Heated x Temperature Increase for Water Heater ÷ Water Heater Efficiency)

Where:

- Water Savings: Gallons (or liters) per year
- Average Percent of Washer Water That Is Hot: Facility-specific
- Energy per °F per Gallon Heated or per °C per Liter Heated:
  - 0.00244 kWh of electricity per °F per gallon (0.00117 kWh per °C per liter); or
  - 0.000008 Mcf of natural gas per °F per gallon (0.0000038 Mcf per °C per liter)
- Temperature Increase for Water Heater: °F or °C based on incoming water temperature and water temperature of washer required for sanitization
- Water Heater Efficiency (unless otherwise known by the facility):
  - 1.0 for an electric hot water heater; or
  - 0.75 for a natural gas hot water heater

More detailed information to assist in calculating energy savings that result from saving water can be found on WaterSense's data and information web page at www.epa.gov/watersense/data-and-information-used-watersense.

Payback

To calculate the simple payback from the water and energy savings associated with cage, rack, bottle, or tunnel washer replacement, consider the equipment and installation cost of the replacement washer, water and energy savings as calculated using Equation 2 on page 6 and Equation 3, respectively, and the facility-specific cost of water, wastewater, and energy.

Animal Watering Systems

Water savings from retrofitting or replacing a flushing automatic animal watering system with a recirculating automatic animal watering system will vary based on how much water can be recirculated. Facility owners and managers should use their judgment when deciding whether potential water savings merit the equipment and installation cost of the retrofit or replacement.

Additional Resources

Beckinghausen, David. September 2006. "Energy-Efficient Washing Systems." *ALN Magazine*. https://web.archive.org/web/20170101175230/https:/www.alnmag.com/article/2006/09/energy-efficient-washing-systems

International Institute for Sustainable Laboratories (I2SL) and U.S. Environmental Protection Agency (EPA). May 2022. *Best Practices Guide: Water Efficiency in Laboratories*. www.epa.gov/system/files/documents/2022-06/ws-I2SL-Laboratory-Water-Efficiency-Guide.pdf.

Schultz, Carl C. March 1, 2006. "Re-circulating vs. Flushing: Animal Watering System Alternatives." *ALN Magazine*. https://web.archive.org/web/20170101175502/https://www.alnmag.com/article/2006/02/re-circulating-vs-flushing-animal-watering-system-alternatives

Zynda, Jeffrey R. April 2015. "A Shift in Designing Cage-Washing Operations." *Lab Animal*, Volume 44, No. 4.

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