Why Your Lab's Autoclaves Are Wasting Water (and Money) and How To Stop It

Summary

Old systems can waste over 10 billion gallons of fresh water each year. For instance, a typical campus or facility will often possess a variety of autoclave makes and models, from 25+ years old to brand new, and it is not uncommon for a university to have over 100 autoclaves on its grounds. Given this, every lab, research institute, and university should perform a facility survey to identify what types of autoclaves are installed and what type of water conservation solution would be appropriate. The potential water savings and cost savings can be tremendous and should not be ignored.

CONSOLIDATED STERILIZER SYSTEMS

GSE International Group Pte Ltd
www.gse-intl.com

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For out of USA and Canada, for further enquiries, contact GSE International Group Pte Ltd | www.gse-intl.com | info@gse-intl.com

Steam autoclaves (also referred to as sterilizers) are common and essential pieces of equipment in today's microbiology and animal labs; however, they traditionally consume a significant amount of water.

Purchasing a steam autoclave that conserves water is a sound investment, ultimately helping to preserve the environment, save money, and ideally achieve LEED points. In example, one small to medium sized traditional autoclave might use upwards of 1 million gallons of water per year. With the conservation of natural resources being increasingly important, this is a societal and financial concern.

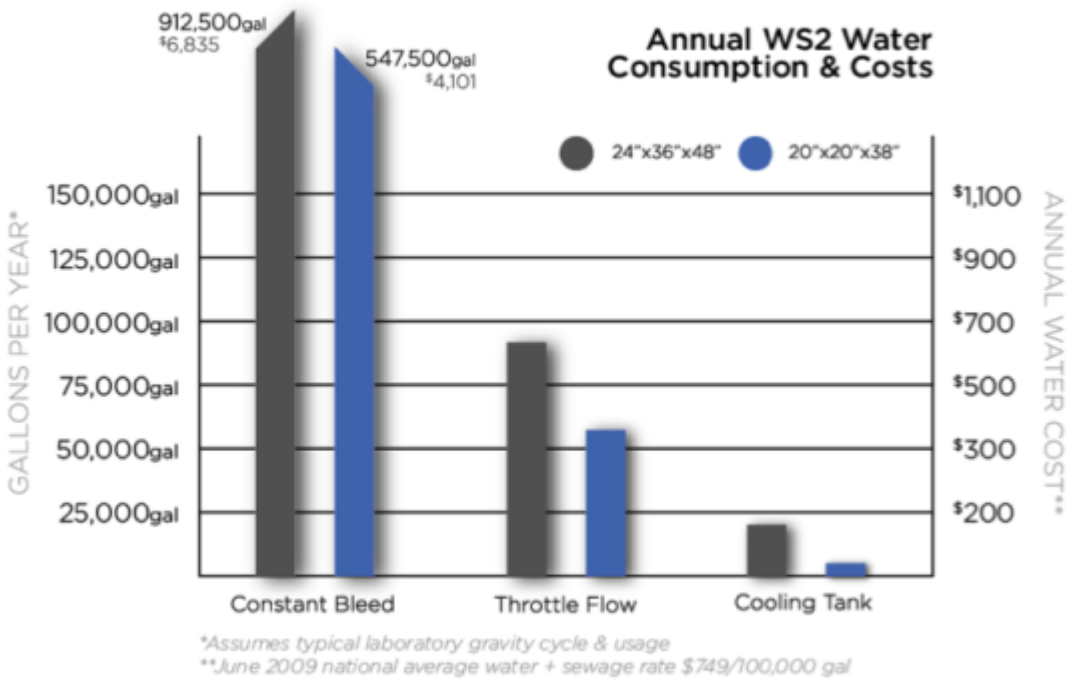
Fortunately, a variety of autoclave water-saving tactics have been developed in recent years to meet the demands of water use conservation. These strategies are also helping labs achieve LEED points and ASHRAE 198.1-2009 compliance for new construction ventures.

Water Consumption Technology in Traditional Steam Autoclaves

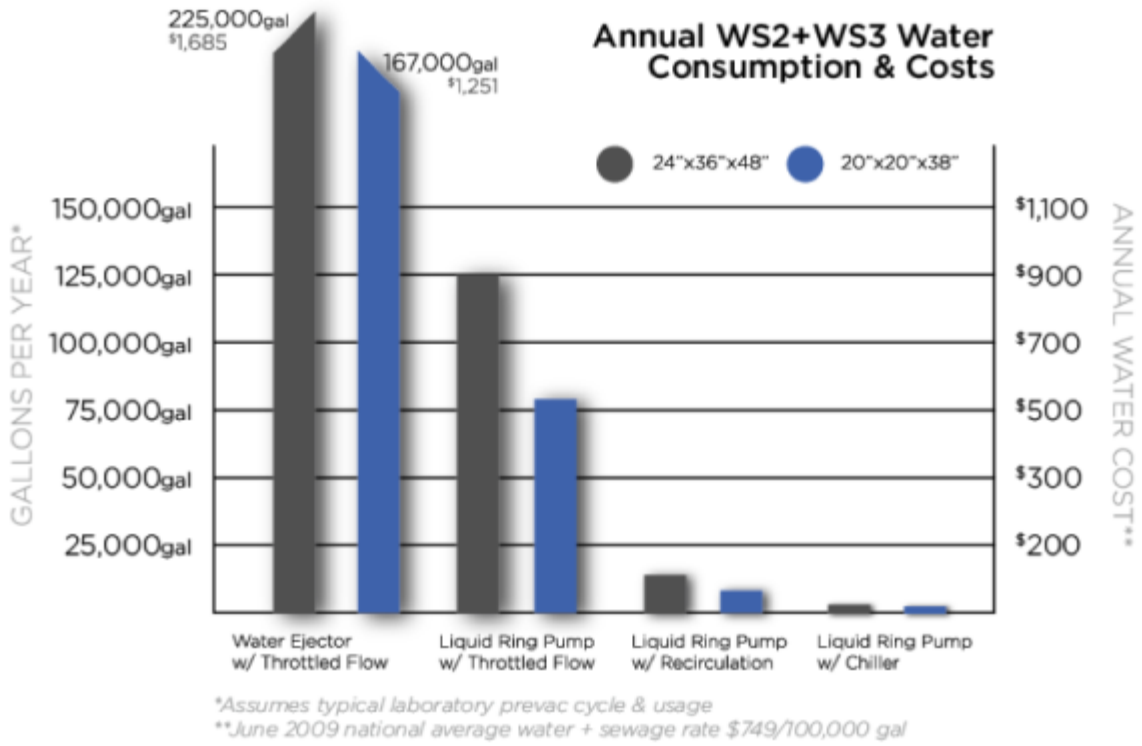
There are three reasons a steam autoclave consumes water – steam generation, effluent cooling, and vacuum generation. Let's take a look at each.

#1. Steam Generation: At its core, an autoclave is designed to use pressurized, high temperature steam to kill viruses, bacteria, and/or other microorganisms that can exist in any load in the chamber of a sterilizer. These chambers are usually double-walled containers with a space known as the "jacket" between the walls. As an autoclave is turned on and in the idle state, this jacket is filled with steam to pre-heat the unit in preparation for operation. Tap water or purified water is the source of this steam. This water consumption source will be called water source number one, or WS1.

#2. Effluent Cooling: Autoclaves also use water to cool the waste they produce. During both an idle state and mid-sterilization, steam is always condensing within the sterilizer and then being discharged to a floor drain. Due to building codes, all waste (or effluent) must be cooled to below 140°F before discharge and this is achieved, for the most part, by introducing raw, cold water to a sterilizer's waste stream, immediately discharging the entire mixture to the drain. This cooling water will be referred to as water source number two, or WS2. Unfortunately, many older model autoclaves engage a "constant-bleed" of cold water to cool waste; this means cold water passes through the sterilizer toward the drain 24/7, even when the sterilizer is off. The result is 1,500-2,500 gallons of raw, cooling water (WS2) being used per day, and this is equal to nearly 1 million gallons per year.



#3. Vacuum Generation: Autoclaves also use water to create a vacuum because in certain types of loads within the unit it is necessary to remove air and ensure proper sterilization. This is achieved by drawing a vacuum. Autoclaves either use either a venturi based water-ejector or a liquid ring pump (LRP) to create the vacuum. In both systems, the water used to create the vacuum is immediately directed to the drain. This water source will be referred to as water source number three, or WS3. Note, most autoclaves are provided with a water-ejector because of the lower upfront costs, unless a liquid ring pump is specified. While an autoclave equipped with a liquid ring pump does save water, a substantial opportunity for further water savings remains because the water used by the vacuum system is typically sent directly to drain, which is not the most efficient process.



Today's Available Water Saving Solutions for Traditional Steam Autoclaves

It is important to note that **the greatest volume of water consumed in an autoclave does not take place during the steam generation process**, as this only requires 30-50 gallons per day. In fact, this figure pales in comparison to the other two autoclave processes, each of which can use between 10 and 50 times more water per day. So, to combat effluent cooling and vacuum generation inefficiencies, some autoclave manufacturers now offer optional systems and solutions that substantially reduce water usage. Let's take a look each.

Effluent Cooling Improvements: Newer autoclaves do not enlist the same constant-bleed design as older models. To improve the cooling process, newer systems regulate the cold water (on and off) only when hot effluent, greater than 140°F, is present. The result is an average reduction[1] of 90% of the cooling water (WS2) consumed compared to that of a traditional, constant-bleed unit. As well, some manufacturers now offer an optional system that can be installed on an existing constant-bleed system. This system incorporates a combination condensate cooling and mixing tank. In specific, this tank condenses and cools hot waste primarily by using previously cooled effluent, and only as needed is a small amount of cold water injected into the system. An installation like this can reduce water consumption by up to 900,000 gallons per year, reducing the average water bill by more than $6,500 per year (this calculation based on national average commercial water + sewage rates)[2]. Typical return on investment (ROI) is 3-6 months, as equipment and installation costs range from $1,500-3,000.

Note: In recent years, the use of a facility-chilled water loop to cool the waste steam and condensate has become an increasingly popular option. These systems incorporate a heat exchanger to transfer the heat load from the effluent into the chiller loop. These systems rely on the chilled water loop for the cooling; however, it is good practice to have a safety backup cooling system that uses cold, raw water. Also, while in theory this configuration reduces the raw water consumption down to zero, in practice, a small amount of water is still used for makeup and cooling.

Vacuum Generation Improvements: Installing a recirculation system – which pumps the water back to the vacuum system – radically reduces the overall water that is consumed. A recirculation system will also work to cool condensate in the same manner as the previously discussed cooling tank does for effluent cooling; this is an added benefit. Combining both factors, a recirculation system can create a net water savings of approximately 85%, or $1,000-1,600 per year, in reduced water costs. Costs for this configuration vary greatly between manufacturers; therefore the ROI ranges from 2-5 years.

Considering Design When It Comes to Water Saving Solutions

Each water consumption solution noted above does require some design consideration, however. Let's take a look at each.

Effluent Cooling Improvements & Design Considerations: Incorporating a chilled water type system as a solution to effluent cooling inefficiencies is highly dependent on the accessibility of chilled water and the existing capacity of the house chiller. Due to some design specifics, some autoclaves place an extraordinary burden on the chiller. As a result, it is vital to understand the following: The necessary flow rate, the allowable line pressure, the maximum temperature rise, and the maximum pressure drop of the chilled water, as well as the total heat input into the chilled water loop.

An example of this occurs in many buildings that have chiller loops operating between 100-300 psig (this is typical) with allowable pressure drops between 5-10 psig. These chillers will often have a primary loop temperature of 42°F, with an allowable temperature rise of +15°F on the return line. If the steam sterilizer cannot house those requirements then support equipment may be needed, such as pressure reducing valves, expansion/bladder tanks, and pumps on the chiller loop. Remember, though, that installing supplementary equipment can be quite burdensome to package into the available space and can have high associated costs, such as purchase, install, and maintenance price tags.

Vacuum Generation Improvements & Design Considerations: When considering a recirculation system install, remember to keep in mind how much space is available. Some recirculation systems and some heat exchanger systems can enlarge the footprint of the autoclave, or require a separate equipment skid. As a result, space requirements must be accounted for.

An Alternative Approach – No Additional Equipment or Systems

Turn It Off: Aside from modifications to traditional, existing systems, there is a very simple, zero cost, and minimal effort approach to also noticeably reduce the water consumption of an autoclave: Turn it off. With the exception of a constant-bleed autoclave, the act of simply turning off an autoclave at night and over the weekends can produce significant water savings. Many autoclaves are left on constantly, 24/7. This does the mean the system is always ready to be used, but the steam necessary to maintain the right warm temperature means continuously creating condensate. To put this in perspective, if an autoclave is only on during the workday, it can save up to 70% of the cooling water (WS2) consumed. For this reason, some manufacturers include an automatic on-off feature on their sterilizers. This feature allows the control system to pre-heat the sterilizer prior to the start of the workday and to shut off the steam supply at the end of the day and over weekends. The more advanced systems can even be configured so that each facility can set up a different start time and stop time for each day of the week. Some autoclaves also are equipped with a feature much like a computer's sleep mode, in which the steam supply will shut off if the unit hasn't been used for a specified period of time.

Grey Water: As of late, there has been some discussion and interest in the autoclave industry as to the use of grey water (rain water, non-potable water from a lake or well, or waste water from other processes) for once-through and tank-based cooling. Unsurprisingly, using grey water could complicate a project due to filtration and biological growth concerns, so it is generally advisable not to incorporate its use into a water conservation strategy.

LEED Points and ASHRAE Compliancy

The U.S. Green Building Council's LEED Rating System is designed to help facility designers and owners receive recognition for prioritizing the conservation of natural resources. Projects are graded and rated from LEED Certified up to LEED Platinum. The right sterilizer, appropriately configured, can contribute to multiple categories. An example of what is graded includes Water Efficiency and Innovation in Design. Specifics regarding the amount of contribution toward LEED credits depend in large part on the project and sterilizer configuration. However, the contribution can be significant and should not be overlooked.

LEED focuses on the results and accomplishments of a specific design, it is not to be mistaken for a building code or a specification. This is why ASHRAE 187.1-2009 is important. ASHRAE 187.1, titled "Standard for the Design of High-Performance, Green Buildings," is a standard written in an effort to be easily incorporated into building specifications and codes. Prior to the last few years, the use of this code has been steadily gaining approval within the construction industry. Section 6, "Water Use Efficiency," is exceptionally central to autoclaves, as it prohibits constant-bleed style cooling for autoclaves and requires the use of mechanical vacuum systems in lieu of water-jet (venturi) vacuum systems. This section also prohibits the use of potable water for once-through cooling. Though this last requirement is limited in scope to HVAC systems, it is conceivable that this requirement will broaden to include other processes or capital equipment within buildings.

The Key Takeaway

Steam autoclaves, are a major source of water consumption in labs. While this consumption is being addressed by more modern systems and installation options, there are, unfortunately, still tens of thousands of older sterilizers with the constant-bleed cooling system in use today. These systems waste over 10 billion gallons of fresh water each year. For instance, a typical campus or facility will often possess a variety of autoclave makes and models, from 25+ years old to brand new, and it is not uncommon for a university to have over 100 autoclaves on its grounds. Given this, every lab, research institute, and university should perform a facility survey to identify what types of autoclaves are installed and what type of water conservation solution would be appropriate. The potential water savings and cost savings can be tremendous and should not be ignored.