WHITE PAPER

Labware washing techniques and the Sinner's Circle

Manual vs. automated labware washing

Satisfactory cleaning and decontamination of labware directly impacts the outcome of laboratory research results.

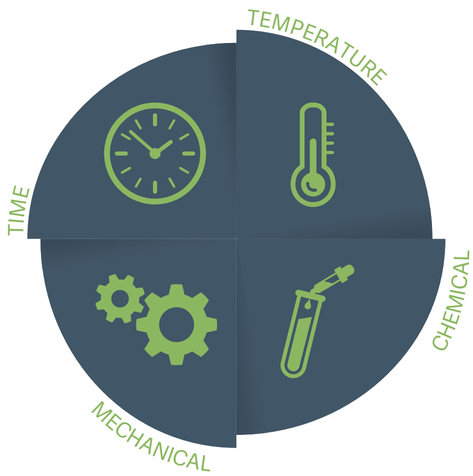
Manual vs. automated labware washing:

Labware washing techniques and the Sinner's Circle

There are several key factors that determine consistency in the labware washing process, whether manual or automatic.

Abstract

Satisfactory cleaning and decontamination of labware directly impacts the outcome of laboratory research results. Effective laboratory processes must include labware free of soil, grease or other residual impurities that can contaminate active processes or samples, and lead to false outcomes. There are several key factors that determine consistency in the labware washing process, whether manual or automatic. Industry professionals refer to these factors as the Sinner's Circle which includes crucial functions of an effective wash process. This report details the challenges and problems associated with manually washed labware versus labware cleaned in automatic washing systems, and illustrates in context the Sinner's Circle as it applies to efficacy and repeatability.



Balancing the Sinner's Circle: manual vs. automatic washing

Effective labware cleaning requires that all four factors of the Sinner's Circle be considered as a balanced equation whereby a trade-off of one factor is compensated by another. The four components of the Sinner's Circle are temperature, time, mechanical impingement and chemical action.

Effective laboratory processes must include labware free of soil, grease or other residual impurities that can contaminate active processes or samples, and lead to false outcomes.

These factors are mutually dependent, each contributing a unique benefit in the cleaning process. Factors are adjusted based on the specific type of cleaning required, the approved facility protocol or physical limitations of the installation. Ideal washing process definitions are ultimately determined by local hands-on laboratory experience with various types of labware, the range and nature of residual soils, availability of labor to set aside for manual chores and throughput demands. Labware cleaning processes are locally documented, codified as approved protocols and entered into the laboratory standard operating procedure.

Temperature

In processes where high temperatures are not desired, due to temperature sensitive labware for example, mechanical, chemical or extended cycle time selections must be adjusted. Other processes may require higher temperature settings to support locally defined pre-decontamination requirements associated with biological byproducts or thermophilic bacteria. Manual processes cannot sustain higher temperatures required for some applications while the automated process can deliver temperatures up to 95°C over an extended length of time.

Time

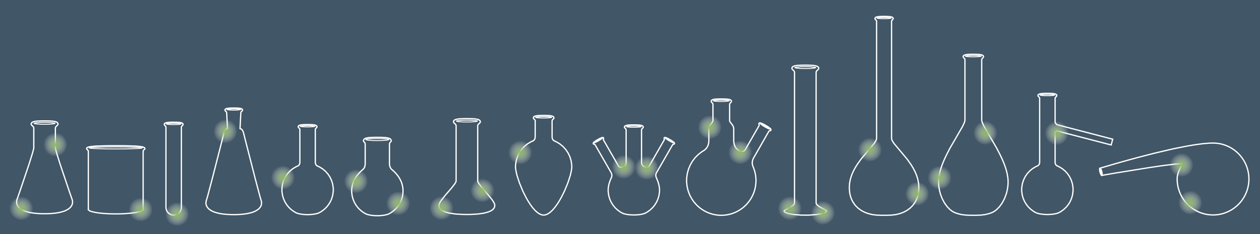
In the context of the Sinner's Circle, the time required for detergent to dissolve and remove soil and the time needed to reach setpoint temperature versus timed performance at the setpoint temperature are important considerations. Wash time should be measured only when setpoint temperature is achieved; this is referred to as "dwell". Longer wash and rinse times are easily programmed in automatic washers to complement temperature, impingement and chemical processes. Automated washing solutions allow precise measurements of required cycle times by ensuring the repeatable balance of circle factors.

Mechanical

Direct impingement of prewash, wash, rinse and chemical additive is a function of spray arms and injectors configured to match the labware being washed. In a manual cleaning situation, labware cleaned from both the outside and inside requires careful use of utensils, detergent concentrations and duration in the cleaning process. Insufficient cleaning of hard-to-reach interior surfaces and glassware breakage are common in the manual process. When properly loaded and programmed, the automatic washing process mitigates these problems.

Chemical

Heavy soils may require enhanced detergent and additive concentrations. The proper balance of detergents and additives is more difficult to stabilize in the manual process and also exposes the user to harsh chemicals and additives. Detergents and other chemical solvents may also be necessary during prewashing for heavily soiled materials.



Labware types present challenges
While most labware is fabricated from glass, other labware is made with a variety of thermoplastics which tolerate a wide range of chemicals, temperatures and processes. Additionally, labware is available in a variety of shapes and sizes to accommodate the myriad testing procedures that take place in a laboratory. The large array of available shapes can pose difficulties in effective cleaning of all interior surfaces. The line drawing above identifies some key challenges presented in cleaning labware of various sizes and shapes. Green areas demonstrate the most common points of potential contamination found in common labware.

Range of applications

Type of labware is always a primary consideration, including shape, orientation and size. Each vessel requires different cleaning characteristics. From cell culture to physical chemistry, the nature of work performed includes a portfolio of labware that benefits from standardized local washing protocols. The suite of labware in any laboratory is usually based on whether organic or inorganic processes are part of the work product. This distinction provides a baseline reference for the type of soils and residues encountered in the laboratory. These factors include petroleum distillates and heavy greases, cell culture media and substrates associated with life science and biotechnology work. Vessels range from broad-based Erlenmeyer and Fernbach flasks to test tubes, and may include volumetrics, funnels and graduated cylinders. Some labware, such as condensers and fractional distillation vessels, may always require a degree of manual cleaning.

Manual washing

Introduction

Distillation heads, receiving adapters, condensers, burettes, separating funnels and other unique shapes and sizes are most efficiently cleaned manually or through a combination of manual cleaning followed by an automatic washing cycle. Benefits of manual washing are obvious when few items must be cleaned, or when occasional processes require such an effort.

Procedures

Just as labware type depends on the application, so too does the cleaning method. Standard Operating Procedures (SOPs) typically follow the same process for effective manual cleaning.

- Soaks, typically done in a detergent
- Manual scrubbing using a sponge or brush
- Mild acids, acetone or other solvents to dissolve greases or water insoluble contaminates
- Final rinse
- Rack or oven drying
- Disposal of solvents

Regardless of how precisely procedural guidelines are written, human error can create uncertainty in the quality outcome of a manual cleaning process. For many applications, labware should be cleaned immediately following use to minimize staining and promote easier cleaning. Depending on apportionment of labor, however, the assignment of skilled technicians to wash labware can create inefficiencies that delay more important work and restrict throughput.

Balancing the Sinner's Circle

Inconsistency in outcomes and exposure to harsh chemicals are important considerations categorized within the Sinner's Circle. In manual laboratory washing processes, certain factors in the Sinner's Circle are more difficult to regulate in a precise, repeatable way. Cycles often require additional time as mechanical impingement is limited to scrub brushes, sponges and human force. The balancing of the interdependent factors of the circle is far more difficult in the manual process as necessary adjustments must be made by each individual operator during the wash process.

Environmental impact

Measuring chemical, water and energy usage in the manual washing process is nearly impossible from one user to another, and from one washing event to another and results in an unknown environmental impact. Additionally, lower throughput achieved through manual processes often necessitates a reliance on disposable labware which leads to a larger waste footprint.

Labor

Manual washing is costly, labor intensive and usually repetitive. Protective gear worn during potentially chemically hazardous manual washing is a consideration that requires added personnel training in chemical handling and workspace ergonomics. Hand washing exposes operators to potentially harmful chemicals. Additionally, as the percentage of broken glassware is higher in manual processes, operators can face injury from broken glass and risks from exposure to potential contaminations.

Water consumption

Water consumption represents an area of variability in manual processes as water pressure is controlled by individual operators and therefore highly subjective based on the individual.

Consumables

Inconsistencies in manual detergent and additive dispensing can increase costs of consumables and can accelerate the buildup of chemical residues, eventually compromising labware cleanliness.

Automatic washing

Introduction

For automated labware washers, programmable microprocessor controllers enable accurate cycle replication in accordance with approved SOPs.

Procedures

Using intuitive touchscreen controls, operators can use preprogrammed or customized cycles to meet the parameters needed for specific applications. Standard cycle parameter programs may include:

- Prewash
- Wash
- Running Water Rinses
- Rinse, Demineralized Water
- Final Rinse, Demineralized Water
- Drying
- Cooling

In addition to greater parameter control and proper balance of the Sinner's Circle, microprocessors capture data for documentation of cycle performance. Pump pressure, temperature monitoring and process reports can all be easily documented with the use of automated washers. Though washing machines may appear to complicate a process, this is not true for all brands. Those designed with ease of use in mind allow operators to start the machine and run the necessary cycle with one button. Throughout the evolution of analytical and life science laboratories, the same factors in weighing manual cleaning against the investment in automatic washing have remained the same. These include use of labor, repeatability of results, efficacy of the washing process and protection of desired throughput.

Balancing the Sinner's Circle

In automated laboratory washers, the factors of the Sinner's Circle are adjusted to increase or reduce temperature, extend or shorten cycle time, apportion detergents and additives for maximum efficiency and savings, and optimize loading configurations to match the mechanical impingement required to wash, rinse, deionize and, where required, dry the labware. Automation of this balancing process guarantees the most effective labware decontamination with the highest possible throughput. Automated washing provides precise control of factors in the circle. This level of precision reduces the risk of contamination and delivers unparalleled safety of research and experiments.

Environmental impact

Availability of dependable glassware cleaning reduces the need for petroleum-based consumable labware that ends up in landfills. Effective cleaning is achieved through a combination of optimized water pressure and flow, accurate chemical dosing and lower effluent water temperatures. This process minimizes environmental impact while lowering water consumption and saving energy.

Labor

Automatic labware washers save labor and free skilled technicians to perform other work. Operators are required to complete the entire wash cycle in manual processes which often pulls them from other research tasks and lowers laboratory throughput. Using an automatic labware washer provides a measurable return on investment that can be calculated using internal labor rates and rates of return established by facility management and financial accounting.

Water consumption

In the automatic washer, water consumption offers greater precision and control, and more opportunity to minimize waste. An accurate calculation of water consumption in the automatic labware washing system is based on a number of factors that can lead to misrepresentation among comparative systems. Regardless of manufacturer, water consumption is always based on water volume per fill and number of fill cycles programmed. Therefore, it is the nature of the required cycle that always determines water consumption. Some applications require few cycle sequences, others require more. A more accurate expression of water economy suggests that minimal use of required cycles is the best measure of environmental impact. Cycle consistency found in automated solutions allows for acquisition of data, more informed establishment of necessary cycles and more accurate budgeting of utility expenses.

Consumables

Chemicals used during labware washing are often the greatest expense. Automated detergent dispensing distributes the correct measurement of detergent needed for the wash cycle every time the process is run. Automated washers produce a repeatable ratio between detergent and water for each wash cycle. This eliminates the over-dispensing commonly found in manual washing processes and leads to substantial cost savings over the washer lifecycle.

Conclusion

Regardless of cleaning method, successful processes are dependent on the factors of the Sinner's Circle. While labware washers balance these factors automatically, manual management of these parameters presents significant challenges. Therefore, manual labware washing is not an effective method to assure balance of circle factors. The main problem with manual washing is the high risk of contamination. The inability to regularize manual washing processes causes the cleaning and drying of labware to be compromised with research chemicals or cleaning chemicals, grease and residual microbial soil that leads to false research results and expensive retesting.

The most reliable, economical and consistent labware cleaning is achieved through the use of an automatic washer. It is only through comparison of manual and automated processes that the balancing of the *Sinner's Circle* and its importance in effective, repeatable results can be fully appreciated. Because repeatability in cleaning, elimination of cross contamination, standardization of processes and continuity of outcomes are critical to performance in any laboratory, efforts to remove human error through laboratory automation are valid investments. This is particularly true when these efforts permit skilled technical labor to focus on higher value work. Only automated washing solutions can provide efficiency, efficacy, repeatability and consistency in the labware washing process to precisely balance the Sinner's Circle and assure consistent outcomes.

How to select an automatic washer

While the initial investment of a labware washer represents a larger upfront cost, total life cycle costs and payback are measurable based on calculations using internally generated data from facility management. Automatic washing systems deliver a "quality of clean" from the precise management of all tenants of the Sinner's Circle. Labware washers offer drying cycles that increase turn-around time and minimize labor. Integral drying cycles eliminate additional loading and unloading required to move labware from rack or oven drying, thereby accelerating throughput and reducing risk of breakage. Drying cycles can also provide high heat exposure to more effectively decontaminate labware or prepare for follow-up sterilization.

Automatic washers can be programmed for specific, timed wash cycles to ensure the most efficient use of resources while cleaning labware to predetermined standards. Certain applications, such as forensic testing and some types of microbiological testing, require high levels of sanitation to achieve accurate results. Such applications must meet American Society for Testing and Materials (ASTM) International Standards, designed to prevent time and supply losses caused by chemically unclean equipment, for cleaning laboratory glassware and polymeric labware used in microbiological analysis. Automatic labware washers can include preset wash cycles and enable the development of customized process solutions to ensure compliance. For applications that require advanced cleanliness to neutralize pathogens, higher temperatures (up to 95°C for select brands), longer dwell times and HEPA filtered drying air help meet appropriate decontamination levels.

Creating load configurations

Laboratory washing best practices start with load configurations. Loads should be built to maximize space inside the interior wash chamber while optimizing rinse and detergent effectiveness. Various rack systems and spray arm configurations allow many types of labware to be cleaned in an automatic washer. Many washers have multiple loading levels and interchangeable rack systems that provide the greatest level of flexibility as labware of any size and shape can be configured for appropriate, automatic cleaning.

Injectors for inside-out cleaning

Some labware and equipment can be oddly shaped or difficult to clean manually without specialized equipment. A variety of injectors, rotating spray arms and other devices provide precision cleaning for any type of labware and easily reach difficult angles or tight spaces for better decontamination. Leading brands can provide application specific customizations to accommodate any type of labware.

Programming cycles

Automatic washers include preprogrammed wash cycles that can be modified and adapted at Performance Qualification to meet specific load needs. Phases that are applicable in the program group which can be modified and altered include: water to be used, temperature,phase time, dosing amount and more.

Parameters to consider:

- Number of phases for the program (prewash, wash, acid rinse, cold rinse and hot rinse/final rinse, neutralizing rinse)
- Duration on each phase
- Water inlet selection for each phase
- Temperature for each phase
- Selection of additive intake
- Drying and cooling

The control panel should be mounted at eye level to improve ergonomic interface.

Getinge produces technologies that provide a high level of repeatability and throughput for maximized return on investment. Getinge systems used in whole or in part can help laboratories gain ongoing savings and enhance operations across the organization.

Getinge’s range of lab washers includes the Lancer ULTIMA series which was developed for a broad range of laboratory and research applications worldwide. Washing solutions from Getinge offer the widest range of flexibility on the market through racks, baskets and application specific configurations. To learn more about the Getinge Lancer ULTIMA series of washers, visit our Undercounter and Freestanding product pages.

Balancing the Sinner's Circle	Manual Method	Automatic Washer
Temperature	Temperatures are restricted to safe and comfortable hand washing	Higher temperatures not suitable for hand washing are easily programmable
Time	Consumes labor, difficult to approximate	Precise timing once cycle starts; no labor involved
Mechanical	Depends on available utensils; frequent breakage is expected	Exterior and interior cleaning through spray arms and injectors, if needed, assure thorough cleaning, minimize breakage
Chemical	Manual measuring	Automatic dosing of detergents and additives according to cycle programming

Restrictions and Advantages	Manual Method	Automatic Washer
Detergent and Additive Consumption	Too much or too little, depending on operator; concentrations uncertain	Precise, predictable and cost effective; concentrations are accurate
Control Over Parameters	Analog, human performance	Digital, precise
Cross Contamination	Difficult to prevent	Risk reduced through smart rack loading, cycle selection and cleaning performance
Environmental Impact, Water Consumption	Depends on user technique; faucets often left running too long	Water consumption is precise, repeatable
Ergonomic Comfort	Tedious	Limited to loading and unloading labware racks

Operator Safety	Manual Method	Automatic Washer
Process Documentation	Analog; depends on user adherence to protocol	Digital; cycle performance records can be maintained automatically
Programmability	None	Flexible
Repeatability of Results	Difficult	Accurate

Getinge is a global provider of innovative solutions for operating rooms, intensive care units, sterilization departments and for life science companies and institutions. Based on our firsthand experience and close partnerships with clinical experts, healthcare professionals and medtech specialists, we are improving the everyday life for people - today and tomorrow.

Ekebergsvägen 26 · Box 69 · SE-305 05 Getinge · Sweden

www.getinge.com

LS2871-labwarewashing-white-paper-170323-en