HOW TO: Guide to Optimal Steam Generation

Introduction

Successful steam sterilization is much more than just achieving verification of sterility with biological indicators. Most users hope to minimize the occurrence of wet packs, instrument staining, chamber scale, rouge and other associated challenges, all of which depend upon the quality of feed water in addition to steam quality and purity being maintained. While steam sterilization is a critical process for every hospital, the importance of the sterilizer's incoming water quality is often overlooked or misunderstood.

Water Quality

Water, though composed of hydrogen and oxygen, is also known as "the universal **solvent**" because more substances dissolve in water than any other chemical. Therefore tap water, otherwise known as **potable water**, may naturally contain minerals and other contaminants derived from the environment or the water delivery system, such as metals, salts, and organic molecules. The following table identifies the potential effects of these factors on instruments being sterilized and suggested water treatment options:

ELEMENTS WHICH CAN AFFECT POTABLE WATER	POTENTIAL IMPACT ON INSTRUMENTATION	WATER TREATMENT OPTIONS
Presence of metals (aluminum, copper, iron, potassium, etc.)	Instrument staining, chamber discoloration	Addition of inline filters and/or **de-ionized (DI)** or **reverse osmosis (RO)** water treatment system
Hardness (presence of calcium and magnesium)	Scale formation from mineral deposits	Addition of softeners in feed water
pH Factors (presence of carbonate, hydroxide and bicarbonate)	Instrument pitting, staining and corrosion	Addition of neutralizing amines in feed water

If not monitored or treated properly, the above conditions may negatively impact the quality of steam production. Instrument decontamination methods used prior to sterilization should also be investigated to ensure that they do not contribute to such issues.

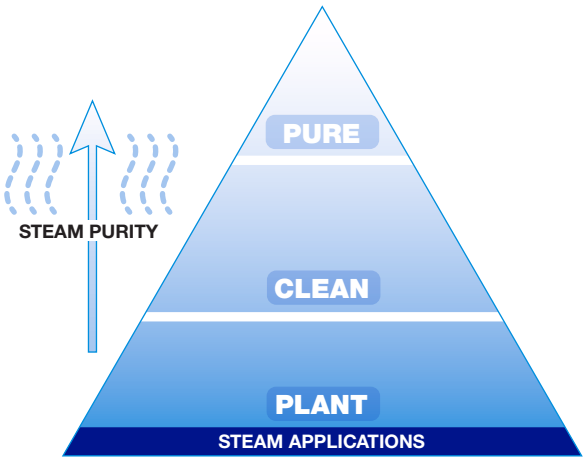
STERIS University Key Learning Objective ➔ The development of a routine water quality testing and analysis program can help minimize such issues. Visit **www.sterisuniversity.com** for more information.

Steam Generation Options

Steam quality can be categorized by the level of purity required by its end-use application;

- **Pure Steam** – Pharmaceuticals and biotechnology; injectable drug production
- **Clean Steam** –Healthcare facilities, laboratories, food & beverage
- **Plant Steam** – Healthcare facilities, laundries, food & beverage, pulp & paper, petro chemical

While all types of steam are capable of providing effective sterilization, all steam is not the same. For the purpose of this guide, our focus will be centered on Plant Steam and Clean Steam, since Pure Steam is not typically used in healthcare facilities.

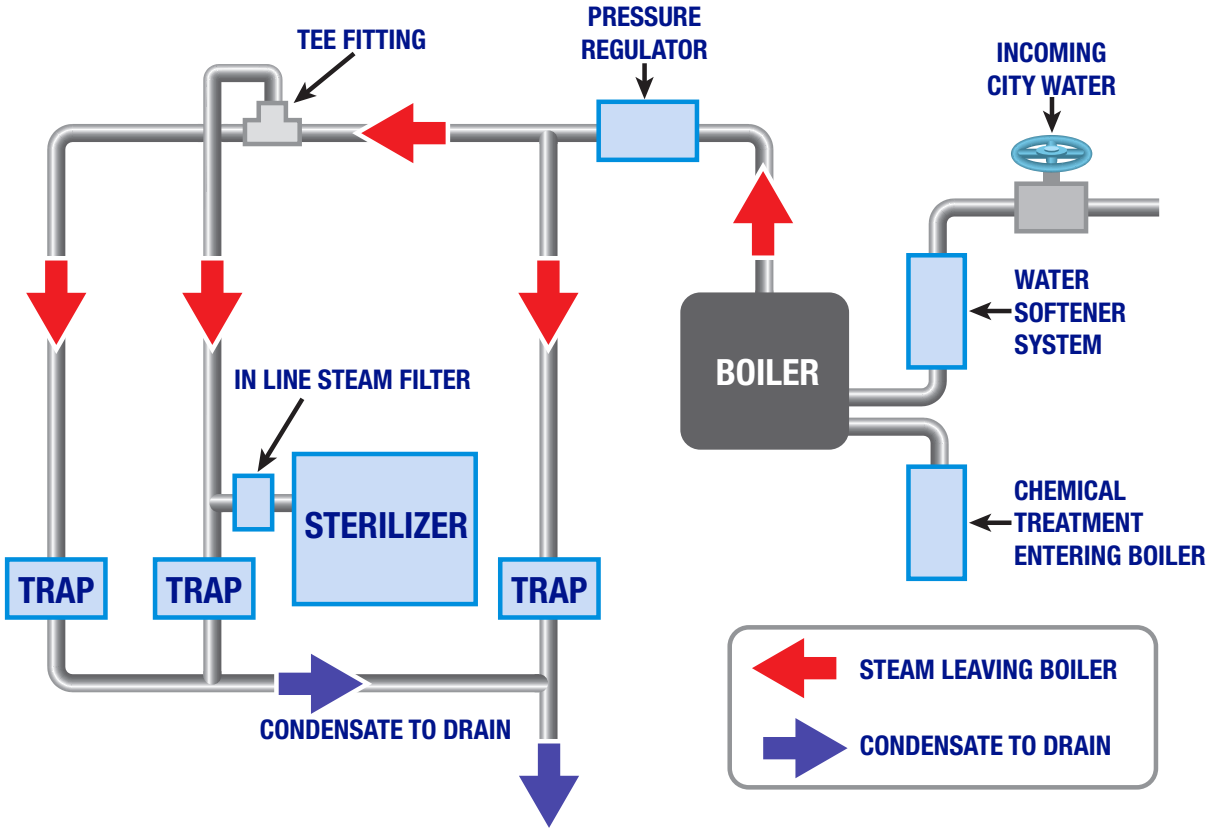


Plant Steam

Plant steam is the most common type of steam generated in U.S. healthcare and is sometimes referred to as house steam. Plant or house steam comes from a large, centrally located boiler and can be used for multiple applications including sterilization, laundry, food service and heating. Steam supplied to the sterile processing department is typically 3-5% of total steam production for the average facility. It is important to know that steam quality may vary seasonally due to the need for heat during winter months, or even at different times of each day during peak demand for kitchen, laundry, showers, etc.

Plant steam is the most economical to produce. The boiler water can be heated with electricity or may use natural gas as the most cost effective method for heating. Softened feed water may be used to decrease water hardness and reduce mineral deposits in the generator vessel. See **Figure1** for an example of a typical plant steam system.

Figure 1: Typical Plant Steam System within a Healthcare Facility



How Plant Steam is Made

Incoming municipal water is treated with the use of a water softener. Chemical additives are also added to the boiler to aid in controlling foaming, hardness and the pH level of the softened water. Steam leaving the boiler travels through a pressure regulator and plumbing lines that typically consist of black iron piping. If needed, in-line filters can be added close to the sterilizer to control any particulates that may be transferred in the steam.

How Plant Steam is Maintained

Boiler water is chemically treated to control pH levels, deposits and foaming. It is important that excessive amounts of boiler additives are not transported with the steam to the sterilizer as this may result in undesirable deposits on the chamber and instruments.

STERIS University Key Learning Objective ➔ For optimal steam penetration and processing results, steam should be "dry" and consist of 97% vapor and 3% liquid.

"Wet" steam (less than 97% vapor) can result in poor heat transfer and potential process control issues such as wet packs. Over a prolonged period, this may affect plant performance and increase maintenance and operational costs. Boiler operating pressure and loading, water treatment management and efficient distribution can all influence the quality of steam within the process.

A well-designed and maintained steam system minimizes or prevents boiler carryover and is properly trapped to prevent excessive steam condensate or water droplets from reaching the sterilizer load. For the vast majority of U.S. hospitals, plant steam is the type of choice.

Plant Steam Advantages and Disadvantages to CSSD

ADVANTAGES	DISADVANTAGES
Lowest Cost Option	Non-dedicated steam supply may result in variability in steam quality if not properly maintained
Requires no additional equipment or floor space in CSSD	
Requires no additional maintenance by CSSD	

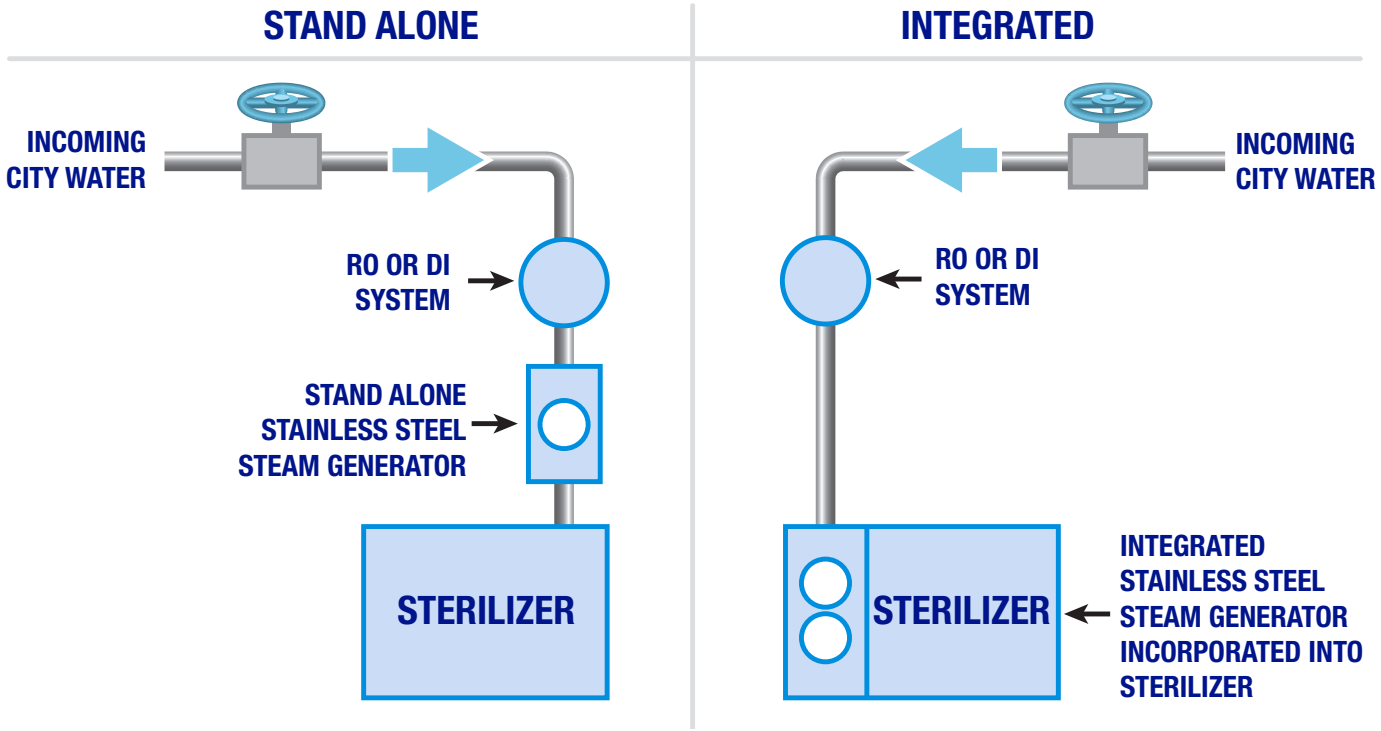
Clean Steam

Clean steam is generated from RO or DI water, which contains no dissolved minerals. In some cases, the clean steam generator is a smaller stainless steel electric type, (typically less than 180 kilowatts). Indirect steam generators may also be used to generate clean steam. Since they are dedicated to sterilizer and/or washer operations, if properly sized for the equipment, a well maintained steam generator can help to eliminate the fluctuation in steam quality that may occur with the use of plant steam.

How Clean Steam is Made

Electric steam generators contain heating coils which heat the water in a pressure vessel much like an electric home water heater does. With this option, the electric heating elements come into direct contact with the feed water to heat it and produce steam. Electric steam generators can be integrated within the sterilizer framework to minimize footprint requirements, or they can be stand-alone generators. **Figure 2** shows a typical clean steam setup with stand alone or integrated steam generator.

Figure 2: Clean Steam Setup (Electric)

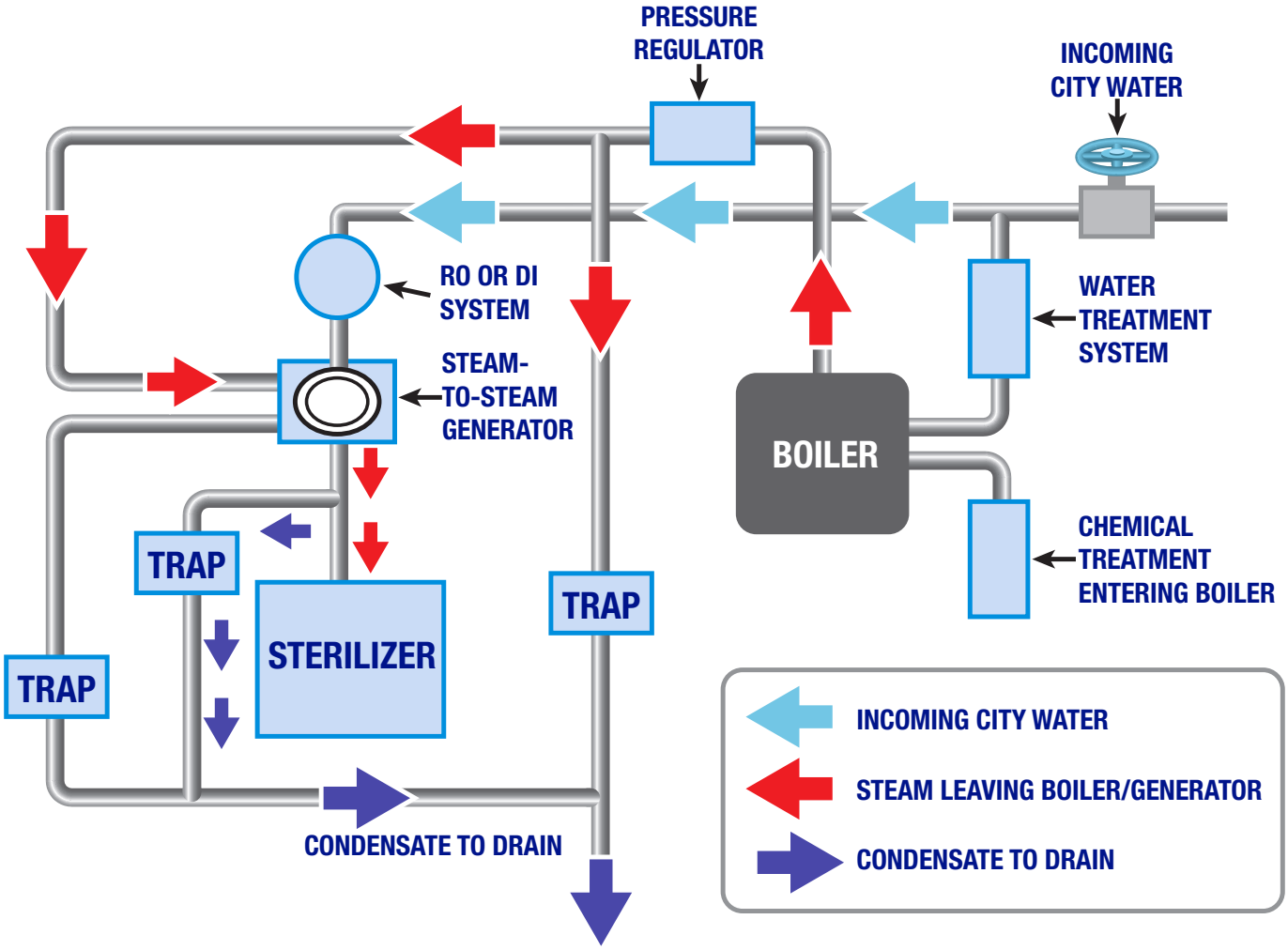


It is important to know that RO or DI water can be used in clean steam applications, but piping and components must be stainless steel due to the aggressive nature of this type of water. Stainless steel is a relatively hard, inactive metal that resists corrosion. In contrast, copper and brass are softer, more active metals. Since there are few ions present in DI or RO water, ions from copper and brass piping tend to leach into the water and cause corrosion.

Clean steam generators can also be of the steam-to-steam or "indirect" type. With this type of generator, house steam is used to heat water within a system of heat exchangers, with the house steam never coming into direct contact with the water. While this option is the most economical to operate, it is less efficient than an electric steam generator and has a much higher acquisition cost. With indirect steam generators, it is sometimes necessary to install a steam reservoir, also known as a "header", to collect and store steam for processing and to increase the efficiency of the generator.

Figure 3 shows a clean steam system with a steam-to-steam generator. This type of generator is located near the sterilizer and requires additional floor space in the sterile processing area.

Figure 3: Clean Steam Layout within a hospital
Steam-to-Steam (Indirect)



It is more costly to use RO treated water vs. plant steam produced with softened water, due to the fact that for every gallon of treated water produced, an equal amount of water is wasted in the process.

All pipe and process components, such as control valves, safety valves and sensors associated with clean steam generators and which feed the steam to the sterilizer are of stainless steel materials.

STERIS University Key Learning Objective ➔ Stainless steel is actually stain resistant, not stain proof. Implementing a clean steam system does not guarantee corrosion-free operation of sterilizer chamber or piping.

How Clean Steam is Maintained

In addition to routine maintenance on water treatment equipment, proper cleaning and maintenance of all stainless steel piping and components is critical to ensure successful sterilization. Stainless steel corrosion, known as rouge, describes a variety of discolorations on stainless steel surfaces. The color is dependent on the amount of oxygen in the system; in steam lines it is usually black. See STERIS document M4093EN "A CSSD Manager's Guide to Rouge Removal" for more information.

Clean Steam Advantages and Disadvantages to CSSD

ADVANTAGES	DISADVANTAGES
Consistent, dedicated CSSD steam supply	Higher production cost to generate steam (additional capital, utility and maintenance requirements)
	May require additional CSSD floor space for steam generator
	Aggressive to piping and components (Requires stainless steel)

Industry Requirements

In the US, ANSI/AAMI ST79 provides guidance on steam quality for healthcare applications. According to the standard, "there are two common sources for steam used for sterile processing: hospital steam boiler systems and self-contained, electric boilers. In both cases, a treated water supply is necessary to remove total dissolved solids (TDS). Each system should be designed, monitored, and maintained to ensure that the quality, purity, and quantity of the steam provided are appropriate for effective sterile processing." Therefore, steam quality depends heavily on water quality prior to steam production.

In summary, both plant steam and clean steam are viable options for hospital steam generation. Proper design and maintenance of each system is required to achieve consistent and successful steam sterilization outcomes, while minimizing wet packs, instrument staining, chamber scale and rouge. The following checklist can be a useful tool for CSSD Managers who wish to take a proactive approach to steam generation in their facilities:

Steam Generation Maintenance Checklist

- ☐ Routine steam quality testing
- ☐ Routine feed water quality testing
- ☐ Preventive maintenance of steam traps
- ☐ Preventive maintenance of piping shut-off valves
- ☐ Preventive maintenance of inline steam filters
- ☐ Preventive sterilizer maintenance
- ☐ Routine chamber cleaning / de-rouging program

Glossary of Terms

Solvent - liquid in which a solute is dissolved to form a solution.

Potable water - Drinking water or potable water is water safe enough to be consumed by humans or used with low risk of immediate or long term harm.

Carryover – solids in the form of metals or residues which are transferred from plumbing lines to the steam sterilizer chamber and/or surgical instruments.

Scale formation - a deposit of minerals left after the evaporation of water.

Neutralizing amines - used to neutralize the acid generated by the dissolution of carbon dioxide in boiler water.

Water softener - a device or substance that softens hard water by removing certain minerals.

De-ionized (DI) Water System - utilizes a chemical process whereby an ion exchange resin is used to trap specifically charged ions such as Sodium, Calcium, Iron, Copper, Chloride and Bromide.

Reverse Osmosis (RO) Water System - a liquid filtration method whereby water is forced through a membrane at high pressure. Small pores in the membrane permit the passage of water molecules but prevent the larger ions mentioned previously from passing through, resulting in water that is free of most dissolved minerals.

Expert Advice from A Line of One.

A highly qualified, industry-recognized team of chemists, engineers and service professionals is available to offer product and process consultation for your steam generation requirements. Only STERIS can provide solutions designed to work in concert to help you get the results you need, time and time again.

Visit sterisuniversity.com for professional guidance on any of the following related topics:

- Water quality analysis
- Instrument staining troubleshooting
- Wet pack troubleshooting
- Chamber cleaning / De-rouging services
- Instrument cleaning / Repair services

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STERIS Corporation
5960 Heisley Road
Mentor, OH 44060-1834 · USA
440-354-2600 · 800-548-4873
www.steris.com

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