

## Sterilizers and Autoclaves

### What is Steam Quality – Why is it Important to the CS Department?

*A Technical Paper with Test Questions  
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**W**et packs and specks on instruments are often blamed on “poor quality steam”... but what is steam quality? Why does it matter? The purpose of this article is to give the CS Technician and Manager an overview of wet steam and steam quality. The sterilization cycle uses steam to heat instruments, giving us the “time and temperature” needed. Sterilizer manufacturers sometimes specify 97% steam quality (or dryness factor).

"Perhaps the most frustrating and confounding dilemma that we face using steam sterilization is the occurrence of wet packs... "Wet packs represent an economic loss to the institution because goods must be reprocessed. Unrecognized, they are a hazard to the patient. "

- *Preparing instruments, utensils and textiles for sterilization and wet pack solving, STERIS Inc. 2003.*

#### **The beauty of steam.**

Steam is an almost perfect way to heat instruments. Besides being sterile, it condenses and collapses when it gives up heat. More steam automatically flows where it is needed by the collapsing effect. By condensing on cooler surfaces and making a “wet film” it also increases heat flow to that surface. The fact that steam gets wet as it heats the instruments is a good thing. But, if too much water is introduced, it can cause wet packs, and specks, and staining.

#### **Steam fundamentals... by the numbers.**

The 60 psi pressure steam delivered to most CS sterilizers has a specific heat content. Most sterilizers receive steam at 60 psi, and then reduce the pressure in the chamber to 30 psi. To show you how the numbers work, we will look at the heat values of 60 psi steam:



**Figure 1**  
A pint of water makes a pound of steam

To understand how steam behaves, let's “make” a pound of 60 psi steam:

1. We need a pound of water. That's 16 ounces, or a pint. Let's assume the pint of water has just melted from ice and is at 32F.
2. To heat the 32F water to 33F requires a unit of heat called a BTU. (This is where the definition of a BTU originates.)
3. To heat the water up to the 60 psi boiling point of 308F requires a BTU for each degree, or 278 BTU.
4. Making steam requires 905 additional BTU. The temperature stays at 308F. The volume expands from a pint, to about 6 cubic feet.
5. The total heat in the steam is made up of two parts. 278 BTU are stored in water, and 905 BTU in the steam vapor.

**To see what happens in the sterilizer let's now "use" the pound of steam we made:**

1. To heat two 17 pound trays of instruments from 70F to 270F will require about 900 BTU.
2. The pound of steam heats the two trays with the 905 BTU stored in the vapor. (Don't worry about the extra 5 BTU.)
3. The pound of steam vapor condenses and collapses as the 905 BTU are transferred from the steam vapor to the instruments. Remember that the 905 BTU made the pint turn to vapor. When we use this heat, the opposite happens.
4. The 6 cubic of vapor reverts back to a pint of liquid, but spread out all over the instruments as a wet film.

**Condensation and drying.**

In a typical sterilization cycle, with cart and instruments, between 50 to 100 pounds of steam is condensed. That's a lot of pints! The chamber steam trap drains much of the condensate from the chamber. The drying cycle of the sterilizer is designed to evaporate all of the water not already handled by the trap (more about traps later). If the steam system puts more water into the sterilizer than the drying cycle can handle, that can cause wet packs.

Some sterilizer manufacturers specify 97% to 100% steam quality. What exactly is steam quality?

Steam quality measures how much liquid water is traveling with the steam vapor. It is expressed as a weight percentage. For example, if 100 pounds flows through the steam line, and 5 pounds of it is liquid water, then 95 pounds is steam vapor. It is 95% steam quality.

**Chart 1 - Steam Quality is Percent by Weight:**

**Steam Quality Comparison**

Vapor	Liquid	Percent by weight	Percent by volume
100	0	100	100.000
97	3	97	99.997
95	5	95	99.995
90	10	90	99.989
80	20	80	99.975
50	50	50	99.901

This table assumes 100 pounds of steam and water flowing at 60 psi system pressure. The term "steam quality" is shown as the "percent by weight" column. Note the volume column. When steam quality is 50%, it is **still** 99.9% steam by volume.

So, here is the tricky part. In the chart, the last column shows the steam to liquid by volume. The steam vapor occupies about 350 times the volume of the same mass of liquid. Even 50% steam quality is 99.9% steam by volume. So by specifying 97% steam quality, we are actually looking for 99.997% steam by volume. The steam has to be perfect. Many of the other applications in a hospital work just fine with 80% or 90% steam quality. The CS Department is usually the first place where any little steam problem surfaces. You will be the first to call, and the boiler room may not yet realize a problem exists. A steam quality specialist can test your system to determine the steam quality. Getting liquid water out of the steam is critical, as the following answers also illustrate.

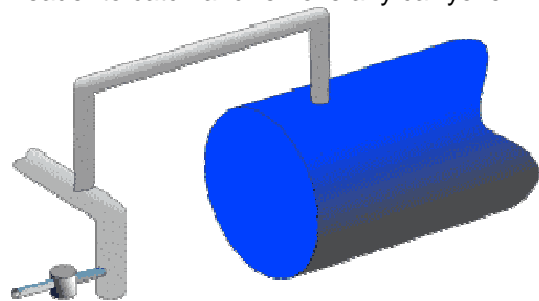
**What causes poor quality steam?**

The first source of poor steam quality can be the boiler. Water that is carried out with the steam is called carryover. "Carryover can never be eliminated completely. Even the best boiler designs operating with well-controlled water chemistry produce trace amounts of carryover." 1

Think about boiling water on a stove... Making more steam on really high heat creates "messy" boiling. The same thing happens in the boiler on a larger scale. The steam load increases in the winter to heat the facility. The steam boilers keep up with higher loads in winter. As the boilers make more steam, they may "throw" more carryover out with the steam vapor.

Most hospitals experience a sudden surge in steam load even throughout the day. At 7 AM, the doors are opening, the kitchen is cooking, showers start, the laundry starts... AND the sterilizers start. It's not unusual to see steam quality change hourly.

The boiler is piped up with special piping called a boiler header to catch and remove any carryover.

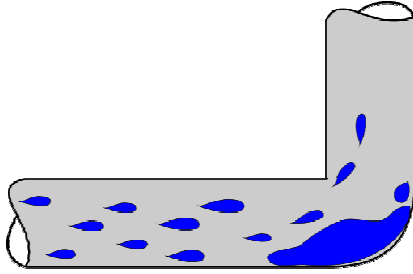


**Figure 2 - Boiler and Boiler Header**

**Is the boiler the only cause of poor steam quality?**

Water also forms in the piping between the boiler and the sterilizer. Condensation of hot steam against the cooler pipe wall forms this liquid water. Pipe insulation has a big impact on steam quality. An un-insulated steam pipe can

flood with liquid water in a matter of hours. It can flood in minutes if the insulation is wet.



**Figure 3 - Pipe Droplets Forming a Slug**

That's why the steam system must have drain legs (drip legs) to remove the liquid water at various points along the piping. If your system is old, expanded, or even brand new, the drain legs might be forgotten, missing, clogged, have failed valves, or be installed incorrectly.

A steam quality specialist can also help you check insulation, the location and function of the drains, all the way back to the steam supply.

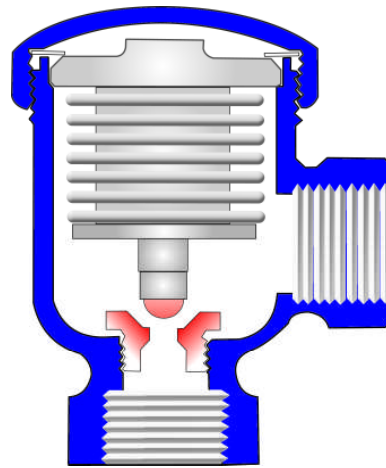
#### **How does Poor Steam Quality contribute to specks on instruments?**

Water in the system is a major cause of specks on instruments. Corroded metal can dissolve into the water. High velocity water scrubs the steel or copper oxidation off the pipe wall, and then specks occur. This dissolved material is smaller than particles that filters are designed to stop. They can pass through filters. Green specks can be caused by copper piping corrosion. Black specks come from steel or iron piping.

#### **How do Steam Traps impact Steam Quality?**

A steam trap is an automatic valve that drains liquid water and vents air, but keeps (traps) steam in the system. The internal mechanism senses condensate and air, and opens the valve to drain the system. Steam pressure pushes the undesired fluid out.

There are several different kinds of steam traps. The ones most commonly found on sterilizers are thermostatic bellows types. See figure 4.



**Figure 4 - Thermostatic Steam Trap**

The bellows moves to open and close the valve. The bellows has a fluid inside that responds to the temperature outside the bellows. Like a musical accordion, the bellows compresses or expands to open and close the valve. The bellows is made from metal and typically breaks every few years.

Steam traps are located at system drain legs and on steam filters. Traps are tested with a special ultrasonic stethoscope and temperature sensor to ensure they are working correctly.

#### **Test Questions**

1. T/F Steam Quality measures steam velocity. The slower the steam, the higher the quality.
2. T/F Steam Quality is based on volume flow, not mass flow.
3. T/F There is more heat stored in liquid than steam vapor, especially at 60 psi
4. T/F During the steam sterilization cycle the instruments should never get wet.
5. T/F Green specks are caused by corrosion of iron piping
6. T/F Steam Traps take water and extract corrosion products.
7. T/F Pipe insulation is designed to be wet to prevent excessive heat loss.
8. T/F Drain legs or drip legs are harmful to maintaining good steam quality.
9. T/F Boilers only make pure steam and normally don't discharge water.

Questions or comments? Please contact us:



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