Field Evaluation of Three Models of Water Conservation Kits for Sterilizer Trap Cooling at University of Washington

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Introduction

With ongoing technical and financial support provided by Seattle Public Utilities, the University of Washington has undertaken an aggressive and highly successful water conservation program. Since peaking in the year 2000 at over 2 MGD, water consumption for UW facilities in Seattle has now been reduced by over 20%. This has resulted in savings to UW of over $1.5 million per year at 2004 rates. As additional measures are completed over the next two years, water consumption is projected to drop an additional 10%.

Primary water conservation measures implemented by UW include cooling tower upgrades, conversion of water cooled refrigeration units to air cooled, leak and failed equipment repair, installation of waterless urinals, installation of low flow toilets, replacement of water cooled vacuum pumps with air cooled units, irrigation upgrades, installation of water efficient clothes washers, and upgrades to steam sterilizers and stills. Of all of these measures, excluding repair of failed equipment, the most dramatic and cost effective savings can be attributed to addition or trap cooling water conservation kits to the steam sterilizers.

This paper presents details of the testing process used at University of Washington to evaluate the various models of sterilizer trap cooling water conservation kits currently available. The bulk of the testing and evaluation work was conducted by John Leaden, Energy Management Coordinator at the University of Washington.

Overview of Sterilizer Savings Opportunities

Steam sterilizers use cold water to temper condensate from the steam used to heat the unit, to keep the water entering the drain at or below 140 F. In older sterilizers, the accepted practice was to use a needle valve to set a constant bleed of 1 gpm to mix with the condensate for the entire time the unit is hot. This includes the “idle” time between actual uses of the sterilizer. Most sterilizers at UW are kept at idle between 8 and 24 hours a day, with an estimated average of 16 hours per day. Trap cooling water conservation kits are available which constantly sense the temperature of the condensate entering the drain and regulate the flow of cold water to minimize the amount needed.

Some sterilizers also flow water through a venturi mechanism to pull a vacuum during the dry phase cycle. Kits are also available for replacement of the venturi mechanism

with a vacuum pump, saving an additional 90 gallons per cycle. However, due to the higher installed cost of this kit (estimated at up to $5000 per vacuum pump kit vs. under $2000 per trap cooling kit) and the lower projected water savings, the vacuum pump modification was not pursued by UW at this time.

Approximately 60 sterilizer units have been identified on the University of Washington Seattle campus that could be retrofitted with kits to conserve the amount of idle water consumption. Constant idle water consumption was measured for 16 of the existing sterilizers and fell between 1 gpm and 5 gpm, with an average of 2.6 gpm.

For a 2.6 gpm 16 hour constant flow, using projected 2004 combined water and sewer rates of $8.45 per CCF, this would equate to an average annual cost of $10,291 per sterilizer for trap cooling during idle (or $617,460 per year for 60 units). It was believed that installation of trap cooling kits should result in extremely cost effective savings of the great majority of this expense. Actual savings would be dependant upon model of kit selected, actual total flow of the sterilizer water during idle, and average hours per day the sterilizers are operating or in standby, vs. being completely shut down.

Sterilizer Water Conservation Kit Availability

Three different manufacturers of sterilizer water conservation kits were identified, with expected installed prices falling between $1000 and $1850 each. This study is based on testing conducted to determine the product having the best primary water saving economy with the least amount of maintenance and ease of repair or replacement.

Two units were tested from each of three potential suppliers, with one of each on a vacuum sterilizer and one of each on a gravity sterilizer. The “Water Mizer” manufactured and installed by Continental Equipment Company achieved the best idle water consumption results, (100% idle water reduction), as well as being projected to have the least maintenance and greatest ease of repair or replacement.

Other products tested were from Omega Medical Mechtronics which achieved 93 -97 % idle water reduction, and Steris Corporation which achieved 75 – 87 % idle water reduction.

Overall test results are tabulated in Tables 1.0 and 3.0. Consumption data recorded for each product tested is appended to this document. A narrative describing sterilizer operation and test procedures follows.

Typical Sterilizer Operation

Sterilizers, also know as Autoclaves, are basically large ovens, which use steam to neutralize biological contamination on medical instruments and scientific apparatus. Generically the sterilization process incorporates steam heat, at a temperature in excess of

212 ^{o}F, in conjunction with either a vacuum or gravity process to provide the necessary level of decontamination. The effluent of this process is hot condensate water, which must be lowered to 140 ^{o}F, (degrees Fahrenheit), before discharge into local drains.

Tempering of this condensate is accomplished by the infusion of domestic water. A typical sterilizer utilizes a needle valve to apply a constant 1 gpm, (gallon per minute), stream of water into the drain piping to insure that the condensate is equal to or less than 140 ^{o}F. Due to age and wear the 1 gpm flow has been measured to increase to as much as 5 gpm. The flow at adle measured at 16 UW sterilizers averaged 2.6 gpm, substantially higher than the factory specifications.

Although the sterilization process may operate for 60 to 90 minutes the flow of tempering water many older sterilizers may flow continuously 24/7. Sterilizers in standby mode, with the steam jacket hot, but not in a sterilizing cycle continuously consume tempering water. Some newer sterilizers, if properly maintained, will shut off the flow of tempering water when not in use.

During the sterilizing cycle small quantities of water are used to produce vacuum or temper condensate discharge temperature. Water saving kits eliminate the constant flow needle valve by the use of electronic sensors or thermostatic valves to control condensate temperature.

Water Saving Kit Criteria

The water saving kit is a device or group of components that will sense the effluent temperature and only apply tempering water when necessary to reduce the effluent temperature down to 140 ^{o}F.

The device or group of components when installed will not interfere with existing equipment warranties and provide repeatable accuracy in controlling quantity of tempering water and temperature of wastewater delivered to local drains.

Ranking of water saving kits will be based on best ability to control effluent water temperature and quantity during standby and operating modes, ease of installation, compliance with local codes, and local service representation.

Vendors and Products Evaluated

- Continental Equipment Company
  315 North Village Terrace
  Tonganoxie, KS 66086
  800-710-9674

Manufactures the "Water Mizer" a patented commercial water saving device for installation on all makes and models of sterilizers. The device is a self-contained unit for attachment to water and drain connections. Continental has installation and service agreements with certified sterilizer technicians in the Seattle metropolitan area.

- Omega Medical Mechtronics
  P.O. Box 7147
  Bellevue, WA 98008
  425-641-0708

  Installs custom designed water saving kits constructed from generic plumbing fittings and a tempering valve that are incorporated into the existing sterilizer supply and drain water connections. Adaptations are available for all sterilizer makes and models. Omega certified sterilizer technicians serve the Seattle metropolitan area.

- Steris Corporation
  5960 Heisley Road
  Mentor, OH 44060
  800-548-4873

  Provides a propriety kit of electrical and plumbing parts for installation by Steris technicians on all makes and models of sterilizers. Although the parts are generic, the kit contains propriety installation drawings, diagrams, and reference information for various models and replacement parts. Steris certified sterilizer technicians provide service to the Seattle metropolitan area.

Evaluation Process

Water saving kits from each of the three vendors were installed on identical AMSCO model 3021 gravity and AMSCO model 3023 vacuum sterilizers located in laboratory equipment rooms in the MHSC K-wing. Prior to kit installation water meters were installed on each sterilizer to record before and after consumption. Evaluation results are presented in Tables 1.0, 2.0, 3.0, and the attached water consumption data sheets.

The water consumption data clearly indicates the savings achieved by installation of the water saving kits. Originally it was thought that the reduction in total water consumption (table 2.0) would indicate the best choice of product. However the number of sterilizer cycles run with each sterilizer during the test period was difficult to ascertain. Therefore it is difficult to determine best product solely by total water consumption. A more reliable determination is offered by comparing water consumption during idle or standby operation of the sterilizer as shown in table 3.0.

Evaluation Comments

Continental Equipment:
Installation involved mounting the reservoir, which contains all of the operating parts, and attachment to water source and drain connections. Calibration is accomplished by inserting a thermocouple into the water reservoir and adjusting the thermostatic valve to maintain 140 ^{o}F discharge water temperature. "Water Mizer" construction allows condensate to pre-cool in a reservoir prior to dispensing to a local drain.

There was no thermal related noise associated with operation of the "Water Mizer."

The tempering valve and capillary element is the only normal maintenance part. It has a long service life and is easily replaceable.

The vacuum and gravity sterilizers in standby mode consumed no tempering water during a one hour observation period.

Overall product ranking: Continental Equipment - Outstanding

Omega Medical Mechtronics:
Installation involved custom assembly and incorporation of standard plumbing copper fittings to interface with the existing sterilizer piping, water source, and drain connections. Calibration is accomplished by measuring discharge water temperature with a thermometer and adjusting the thermostatic valve to maintain 140 ^{o}F discharge water temperature. Fabrication from standard fittings reduces original component cost and necessitates custom tailoring to each sterilizer. The piping assembly allows condensate to dispense directly to a local drain.

Low thermal related noise is present prior to the flow of tempering water to cool the condensate.

The tempering valve and capillary element is the only normal maintenance part. It has a long service life and is easily replaceable.

In standby mode the vacuum sterilizer consumed 0.06 gallons of tempering water at 90 second intervals. The gravity sterilizer consumed 0.20 gallons of tempering water at 60 second intervals. During a one hour observation period with sterilizers in standby mode the vacuum sterilizer consumed 4.48 gallons and the gravity sterilizer 8.97 gallons.

Overall product ranking: Omega Medical Mechtronics – Excellent

Steris Corporation:
Installation involved the attachment of an electronic sensor to the existing drain piping, installation of an electric control module, and incorporation of an electrically operated solenoid valve in the source water supply. No calibration is provided. The electronic

sensor has a fixed set point and adjustment range, that cause the tempering valve to open when the discharge pipe temperature reaches 137.8 ^{o}F, and close when the pipe temperature reduces to 63.0 ^{o}F. Existing piping allows condensate to dispense directly to a local drain.

Low thermal related noise is present prior to the flow of tempering water to cool the condensate.

There are several electric components as well as the solenoid tempering valve that may require maintenance. Of particular concern is the electronic sensor, which is rated at a maximum of 5000 – 100,000 cycles of operation. Due to the low voltages and current involved this quantity could reasonably be exceeded however, operating cycles have been recorded ranging from 1490 – 4000 cycles per week which could necessitate a shorter maintenance interval.

In standby mode the vacuum sterilizer consumed 0.32 gallons of tempering water at 30 second intervals. The gravity sterilizer consumed 0.37 gallons of tempering water at 60 second intervals. During a one hour observation period with sterilizers in standby mode the vacuum sterilizer consumed 38.64 gallons and the gravity sterilizer 22.4 gallons.

Two specific concerns are noted about the Steris installation. First, the type of line voltage electrical wiring extending from the wall mounted electric control module to the solenoid valve may not comply with local electrical codes for the attachment of electrical wiring to the building structure. Second, after a month of operation the tempering valve on the gravity sterilizer was observed staying open for extended lengths of time. The discharge pipe was cold but the valve remained open until the electronic sensor was touched. During a separate one hour observation period with the sterilizer turned off and the discharge pipe cold the valve remained open until the electronic sensor was touched. 71.21 gallons or water was dispensed during the one hour period. Consultation with the Steris installing technician has determined that the sensor is defective. The technician will install a replacement when it arrives.

The water saving kit installed on the vacuum sterilizer has operated in a reliable and repetitive manner since installation.

Overall product ranking: Steris Corp. - Marginal

Conclusions

Retrofitting existing sterilizers with water conserving kits was determined to be a very cost effective water conservation measure for UW. Payback is expected to be less than 3 months, dependant upon model of kit selected, initial constant water flow of the sterilizers being retrofitted, hours of operation (including standby), and the level of incentives provided by the utility.

Given the evaluation comments and data displayed in the tables and the attached water consumption data sheets the Continental Equipment Company product appeared to provide maximum water savings.

The custom designed installation by Omega Medical Mechtronics, although not a standard commercial product, also provided substantial water savings. The thermal noise associated with the tempering process is detectable but not necessarily objectionable.

The Steris installation provided a lesser amount of water savings and incorporates a number of parts that can require frequent maintenance. The lesser amount of water savings, multiple operating parts, and failure within a few weeks of operation cause concern for the long term reliability of this product.

Table 1.0 Comparison of Evaluation Criteria

	Product Installation	Commercial Off the shelf product	Temperature Control Range	Temperature Calibration Method	Frequency Of Tempering Water flow	Noise Level	Complies with Codes	Local service available	Installed Cost	Ability to conserve water	Overall Rating
Continental Equipment Company	One piece self contained reservoir and valve	Yes	Maintains 140 ^{o}F (30)	Inserted Thermocouple	Seldom (30)	None	Mech – yes Elect – n/a (5)	yes	higher (3)	Outstanding (30)	♦♦♦♦♦ (93)
Omega Medical Medtronics	Fabricated from locally available plumbing valve and fittings	No	Maintains 140 ^{0}F (30)	Surface Thermometer	Repetitive cycle (20)	Low	Mech – yes Elect – n/a (5)	yes	lower (5)	Excellent (20)	♦♦♦♦ (80)
Steris Corporation	Propriety kit of electrical and plumbing parts and fittings	Yes	Valve open @ 137.8 ^{o}F Valve closed @ 63.0 ^{o}F (0)	Fixed range No adjustment	Frequent flow (5)	Low	Mech – yes Elect – no (2)	yes	higher (3)	Low (5)	♦ (15)
Maximum Points Value			30		30		5		5	30	(100)

Table 2.0 Comparison of total water consumption

	Average water consumption over one week period before retrofit (gallons per day)	Average water consumption over one week period after retrofit (gallons per day)	Percent reduction of water consumption (%)
Steris Corporation AMSCO 3021 Gravity sterilizer	4326	1354	68 %
Steris Corporation AMSCO 3023 Vacuum sterilizer	3187	525	84 %
Omega Medical AMSCO 3021 Gravity sterilizer	3870	305	92 %
Omega Medical AMSCO 3023 Vacuum sterilizer	3419	64	98 %
Continental Equipment AMSCO 3021 Gravity sterilizer	1519	117	92 %
Continental Equipment AMSCO 3023 Vacuum sterilizer	2510	267	89 %

Note:
Table 2.0 displays total water consumption compiled from water consumption recording data but does not compare sterilizer activity cycles, i.e. the respective amounts of time a sterilizer was in an active mode, standby mode, or turned off. Also, the amount of original tempering water flow was not considered in the calculation of percentage reduction.

Table 3.0 Comparison of tempering water consumption with sterilizer in standby mode. Sterilizer idle, not in use, steam jacket hot.

	Measured idle flow rate before retrofit in gallons per minute	Measured idle flow **BEFORE** retrofit (*Gallons during one hour interval*)	Measured idle flow **AFTER** retrofit (*Gallons during one hour interval*)	Percent reduction during one hour interval
Steris Corporation AMSCO 3021 Gravity sterilizer	2.77 gpm	166.2	22.44	87 %
Steris Corporation AMSCO 3023 Vacuum sterilizer	2.62 gpm	157.2	38.64	75 %
Omega Medical AMSCO 3021 Gravity sterilizer	2.0 gpm	120.0	8.97	93 %
Omega Medical AMSCO 3023 Vacuum sterilizer	2.7 gpm	162.0	4.48	97 %
Continental Equipment AMSCO 3021 Gravity sterilizer	1.87 gpm	112.2	0.00	100 %
Continental Equipment AMSCO 3023 Vacuum sterilizer	2.47 gpm	148.2	0.00	100 %