The Reduction in Water Consumption of Sterilizer Equipment Resulting From the Installation of Water-Mizer™ Systems

A Technical Evaluation Prepared by:

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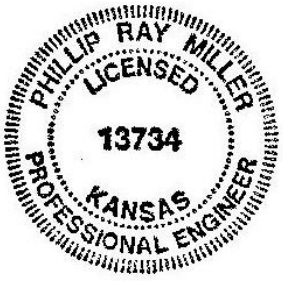


I certify that the information herein has been prepared under my direct supervision and the contents are true and correct.

1
Executive Summary

TDK Consulting Services was contracted by Continental Equipment Company Inc. to evaluate the reduction in water consumption of sterilizer equipment resulting from the installation of Water-Mizer™ systems. The Water-Mizer is a tempering device that mixes cold water with hot water discharged from sterilization equipment to reduce the discharged water temperature. There is an additional system available that can be added to the original Water-Mizer that captures and re-uses water that is necessary to produce the vacuum for this equipment. Both of these systems were evaluated.

The testing consisted of installing Water-Mizer equipment on two of three sterilizers of the same make and model, leaving the third sterilizer as a control, and observing the operation of all three units during comparable operation. The testing configurations are shown in Table 1-1. Four Sterilization Cycles were observed for each unit during a one-day period. Water consumption and other observations were recorded.

Table 1-1 Testing Configurations

	Installations
Unit 1	Water-Mizer with Recirculation System Installed
Unit 2	Water-Mizer Installed
Unit 3	No Water-Mizer Equipment Installed

The testing was successfully completed with no operational problems. Results are summarized in Table 1-2. Calculations with report data are contained in Appendix G and are referenced in report text with the use of footnotes.

Table 1-2 Test Results, gallons/cycle

	Unit 1	*Unit 2*	*Unit 3*
Test 1	62	253	356
Test 2	74	281	364
Test 3	86	287	372
Test 4	80	289	418
Average	76	278	378

As shown in Table 1-2, both units equipped with Water-Mizer equipment used less water than the sterilizer with no Water-Mizer equipment installed.

Conclusions from this testing are as follows:

- The installation of the Water-Mizer including the recirculation system can reduce Sterilizer Cycle water consumption between 73[1] and 80[2] percent. Comparable savings are anticipated for other cycles such as the Dart Test and Leak Test.

- The installation of the Water-Mizer including the recirculation system can reduce total sterilizer water consumption by more than 80 percent. Although not directly tested in this evaluation, these reductions could exceed 90 percent [3].

- The addition of the recirculation system to the Water-Mizer can reduce Sterilizer Cycle water consumption by 73[1] percent. Comparable savings are anticipated for other cycles such as the Dart Test and Leak Test.

- The installation of the Water-Mizer can drastically reduce standby losses.

- Depending upon the frequency of use, the manual valve settings, and the piping configuration of the condensate drains, sterilizer standby water losses will likely exceed the amount of water consumed during operational cycles (over prolonged periods).

- The cost of operating the electric pump associated with the Water-Mizer recirculation system is negligible when compared to the cost of water saved with its use.

- Considering water and sewer costs to be 5.0 $/kgal, electricity costs to be 6.0 ¢/kwh, and the total sterilizer water consumption savings to be 90 percent, the installation of the Water-Mizer equipment on Unit 3 at this location would save the owner 9,000 $/yr in utility costs[4]. This savings represents a typical application of a Water-Mizer installation.

2
Testing Parameters

The testing was performed at a major metropolitan hospital located in Denver, Colorado on April 5, 2005. The hospital facility staff was aware of and approved the testing exercise. On March 8, 2005, the Water-Mizer was installed on one of the hospital's sterilizers. On April 4, 2005, the Water-Mizer (including the recirculation system) was installed and commissioned on another of the hospital's sterilizers. A third sterilizer with no Water-Mizer equipment was also tested as a control device. The three sterilizers are located adjacent to one another and are of same make and model (AMSCO 3043 with Stage III Controller). See Appendix F for photographs of the units. Unit 1 was re-manufactured in 1995 and Units 2 and 3 were remanufactured in 1996. The three sterilizers involved in the testing are used on a regular basis to prepare surgical instruments and their operating schedules are considered representative for installations of this type.

This testing was performed to evaluate water consumptions only and did not evaluate the functional performance or design integrity of the Water-Mizer systems. TDK Consultants are not contracted to consult on design issues of this product.

Sterilizer Cycles and Water Consumptions

The three sterilizers are operated with three different cycles; a Dart Test, a Leak Test, and the Sterilization Cycle. The Dart Test is used to evaluate the sterilizer's ability to operate under a vacuum. The Leak Test is used to evaluate the integrity of the chamber seal. The Sterilizer Cycle is the functional cycle used to prepare surgical instruments. Printouts of operational logs for each of these three cycles are included in Appendix A. The programmed sequence of these three cycles is identical for each of the three machines. The sequences are not altered, except in rare occasions when the Sterilization Cycle (also referred to as Cycle 1) may be changed to accommodate special conditions. According to those familiar with the use of these machines, all three sterilizers run 6 to 8 Sterilization Cycles per day, Monday through Friday and one Dart Test and one Leak Test per night, seven nights per week. On the weekends, Unit 3 is generally not used for sterilization, and Units 1 and 2 run 4 to 5 Sterilzation Cycles each day. In preparation for this testing, the cycle counts and water consumption for each of the units was recorded starting March 10, 2005; these data are included in Appendix B. Prior to the installation of the Water-Mizer equipment, the three units consumed approximately the same quantity of water for each of the three cycles, as summarized in Table 2-1. Water consumption per cycle will vary slightly by unit, chamber contents, steam conditions, domestic water temperature, and other factors.

Table 2-1 Pre-Water-Mizer Cycle Water Consumptions

	Typical Water Consumption Per Cycle, gallons	*# of Annual Cycles (for all 3 Units, Typical)*
Leak Test	174	1,095
Dart Test	113	1,095
Sterilizer Cycle	372	6,417
Total (estimated)	2,701,389 (Per Year)	8,607

The jacket trap drain of Unit 3 is piped directly to the sewer system (floor drain). As a result, a constant stream of water, referred to as tempering water herein, is introduced into this drain to ensure the sewer discharge water temperature does not exceed 140°F. During testing this tempering water flow rate was measured at 3.1 gpm. As a result, Unit 3 experiences stand-by losses as shown in Table 2-2. Units 1 and 2 do not experience standby losses with the Water-Mizer systems installed and the associated tempering water needle valves on these units were removed during Water-Mizer installation. Prior to Water-Mizer installations, Units 1 and 2 experienced standby losses of 2.7 and 2.8 gpm respectively.

Table 2-2 Stand-by Water Consumption of Unit 3

	Typical Water Consumption, gpm	*# of Standby Minutes (Annual, Typical)*
Standby	3.1	400,285
Total (estimated)	1,240,884 (Gallons Per Year)	

Unit Configurations

Unit 1

Unit 1 was equipped with the Water-Mizer system including the recirculation system. The schematic of this testing configuration is shown in Appendix C. The recirculation system allows the water used to create the chamber vacuum, via the Bernoulli principle, to be captured and reused. The water will be recirculated with a pump as long as the temperature of the water to the tank remains below setpoint. For this test, the setpoint was 85°F. When the temperature of the water to the tank rises above the setpoint, the tank inlet valve closes and the valve to the Water-Mizer tank opens, sending the water to the drain. The Water-Mizer introduces tempering water as necessary to ensure that the discharge water temperature does not exceed 140°F .

Unit 2

Unit 2 was equipped with the Water-Mizer without the recirculation system. The schematic of this testing configuration is shown in Appendix C. The Water-Mizer will measure the sterilizer

discharge water temperature and temper that discharge with domestic cold water as necessary to maintain a maximum outlet temperature of 140°F.

Unit 3

Unit 3 did not have Water-Mizer equipment installed. As discussed under *Water Consumptions* above, the difference in piping between Unit 3 and Units 1 and 2 is the disposal of the jacket condensate to drain. On Units 1 and 2 the jacket condensate is directed to the boiler plant condensate system. On Unit 3 the jacket condensate is sent to the floor drain with a constant stream of tempering water added to ensure the sewer system is not subjected to water temperatures above 140°F. As a result, the sterilizer is consuming (and disposing of) the tempering water flow rate regardless of whether the sterilizer is being used.

Testing Equipment

The water consumption of each unit was measured with a positive displacement meter manufactured by Hayes Fluid Controls. The meters were installed in the domestic water supply line to each unit in anticipation of this testing. The serial numbers for the three meters were 31625014, 31625061, and 31625013, for Units 1,2, and 3 respectively. See Appendix F for photographs. The meters were manually read to the nearest gallon immediately before and after each testing cycle. Water consumption test data are presented in Section 3, Test Results.

The power consumption of the recirculation pump motor associated with the Water-Mizer installed on Unit 1 was manually read with a Fluke T5-600 electrical tester. The amperage was measured through one of the conductors with an OpenJaw current measurement device and the voltage was measured with probes inserted into the 120 volt receptacle. The amperage draw remained constant throughout testing: 6.9 amps when the recirculation system was dumping water to the drain and 7.2 amps when the recirculation system was delivering water to the recirculation tank. The voltage also remained constant throughout the test at 107 volts AC (single phase).

The temperature of the domestic water supplied to the units was measured at 49°F with a type K thermocouple. The pressure of the water was measured at 60 psig with a pressure gage installed downstream of the water consumption meter.

The conditions of the steam supply to the sterilizer and the discharge to drain were not measured.

Schedule

Four Sterilization Cycles were tested on each unit. The schedule of testing is provided in Table 2-3. Dart Test and Leak Test cycles were not evaluated in this effort.

Table 2-3 Testing Schedule -- April 5, 2005

	Unit 1	*Unit 2*	*Unit 3*
Test 1	09:19-10:04	09:08-09:53	08:51-09:36
Test 2	10:35-11:31	10:16-11:05	09:45-10:31
Test 3	12:33-13:30	13:36-14:26	10:56-11:43
Test 4	15:06-16:09	15:40-16:30	14:51-15:43

Test 1 on each unit was run with the chamber empty. Tests 2 - 4 on each unit were run with the chamber loaded by hospital staff. The operations of the sterilizers during testing are documented in Appendix D, Test Log Printouts.

3
Test Results

The testing was accomplished without incident. All three units successfully completed four Sterilization Cycles without operational difficulty. The water consumption of each test is provided in Table 3-1. Additional graphical representations of test data are presented in Appendix E.

Table 3-1 Test Results, gallons/Cycle

	Unit 1	*Unit 2*	*Unit 3*
Test 1	62	253	356
Test 2	74	281	364
Test 3	86	287	372
Test 4	80	289	418
Average	76	278	378

Unit 1

Of the three units tested, Unit 1 consumed the least amount of water, averaging 73 percent less than water consumed by Unit 2[1] and 80 percent less than water consumed by Unit 3[2] (during testing cycles). The reduction in water consumption is mainly attributable to the recycling of water used to create the chamber vacuum. This vacuum is needed for the majority of the conditioning period (9-25 minutes) and for the duration of the drying period (31-32 minutes).

The recirulation pump associated with the Water Mizer system ran for approximately 42 minutes of each test cycle, consuming an average of 0.67 kW or 0.47 kWh. Considering a range of electricity costs between 4 and 15 ¢/kWh this equates to between 1.9 and 7.1 ¢/cycle. The water saved by this recirculation system, compared to Unit 2, was an average of 202 gallons/cycle. Considering water/sewer costs between 4 and 10 $/kgal, the recirculation system saves between 81 to 202 ¢/cycle. The power consumption of the Water-Mizer system when the pump is not running is limited to controls circuits and was measured at less than 0.1 amps. Therefore, the cost to operate the pump is negligible when compared to the value of water saved with its use.

Unit 2

Unit 2 still consumed considerably less water during cycles than Unit 3. This is due in large part to the fact that there was no constant drain tempering water flow present in the Unit 2 configuration. The jacket drain of Unit 2 was returned to the boiler plant condensate system, and the chamber drain was tempered only as necessary by the Water-Mizer system.

Unit 3

Unit 3 was the only test configuration that utilized constant tempering water flow rates for jacket and chamber drains. This tempering water is a significant consumer and a wasteful means of protecting sewer drain temperatures. In fact, Unit 3 consumed more water in standby mode between Tests 3 and 4 (592 gallons), than it consumed during the Test 4 cycle (418 gallons). Furthermore, in a typical operating year for this sterilizer 1,240,900 gallons of water would be consumed in standby mode while 795,400 gallons would be consumed during Dart Test, Leak Test, and Sterilization Cycles[3]. This calculation is based upon a standby water flow rate of 3.1 gpm, 400,285 minutes of standby time, 365 Dart Tests and Leak Tests each, and 1,827 Sterilization Cycles.

The tempering water flow rate, which is manually adjusted by two needle valves near the vacuum venturi (see configuration in Appendix C), was unneccesarily high for the majority of time. During periods of jacket drain only, the discharge temperature was only slightly above the domestic water inlet temperature of 49°F. The non-regulated tempering water flow in this configuration is particularly wasteful during standy periods. If the Water-Mizer system had been installed on Unit 3, the standby water consumption would have been substantially reduced.

Other Comments

The operational cycle water savings benefits of the Water-Mizer (including the recirculation system) illustrated by this testing are two-fold: the reduction of water used to create a vacuum and the reduction of water used to temper discharge flows. The difference in cycle water consumptions between Units 1 and 2 (73 percent) quantify the savings of the first benefit[1]. The difference in cycle water consumptions between Units 1 and 3 (80 percent) quantify the savings of the second benefit as a maximum case (because jacket tempering present in Unit 3 is not neccesary for Unit 1 due to piping differences) [2]. Therefore, the cycle water savings associated with the installation of the Water-Mizer equipment can be concluded to lie somewhere between these two values (73-80 percent).

Based on these test results, if the Water-Mizer (including recirculation) was installed on Unit 3, cycle-related water savings would be anticipated near the high end of the 73 to 80 percent range. Additional savings associated with standby periods would increase overall water savings over the 80 percent mark, possibly exceeding 90 percent[3]. It is also likely that standby savings alone would exceed the cycle savings alone.

The water savings benefit of the installation of the Water-Mizer on Unit 2, was the reduction in chamber discharge tempering. Chamber discharge tempering is only necessary during operational cycles and is therefore minimal when compared to the jacket drain discharge tempering necessary on units that dump jacket condenstate to drain because this flow is necessary through standby periods. Therefore, the benefits of the Water-Mizer are maximized when it is installed on units that dump jacket condensate to drain.

Based on data presented in Table 3-1 the water consumption of this equipment during the Sterilization Cycle can be illustrated as shown in the figure entitled *Characterization of Water Consumption for Sterilizers Tested* contained in Appendix E. In this figure, the blue portion of the bar represents the water flow necessary to temper the sterilizer discharge adequately. This also represents the total cycle flow (80 gallons) if the Water-Mizer with recirculation system is installed (Unit 1). The red portion of the bar represents the quantity of water that is consumed generating a vacuum, and applies if the recirculation system is not installed. The total of the red and blue portions represents the total cycle flow (280 gallons) if the Water-Mizer without the recirculation system is installed (Unit 2). The yellow portion of the bar represents the quantity of water that is used in unnecessary sterilizer discharge tempering. The total of the red, blue, and yellow portions represents the total cycle flow (380 gallons) if the Water-Mizer system is not installed (Unit 3).

As mentioned above and as demonstrated by Unit 3, it is likely that, over prolonged periods, water consumed during standby periods will substantially exceed the water consumed during operational cycles. The greatest potential benefit of the Water-Mizer system, not considering the recirculation system, is the reduction of standby losses in these circumstances.

4
Conclusions

Conclusions from this testing are as follows:

- The installation of the Water-Mizer including the recirculation system can reduce Sterilizer Cycle water consumption between 73[1] and 80[2] percent. Comparable savings are anticipated for other cycles such as the Dart Test and Leak Test.

- The installation of the Water-Mizer including the recirculation system can reduce total sterilizer water consumption by more than 80 percent. Although not directly tested in this evaluation, these reductions could exceed 90 percent[3].

- The addition of the recirculation system to the Water-Mizer can reduce Sterilizer Cycle water consumption by 73[1] percent. Comparable savings are anticipated for other cycles such as the Dart Test and Leak Test.

- The installation of the Water-Mizer can drastically reduce standby losses.

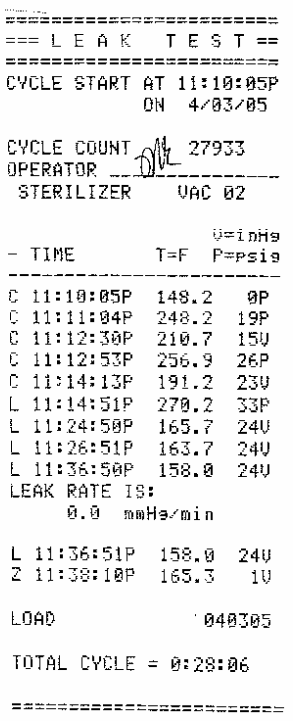
- Depending upon the frequency of use, the manual valve settings, and the piping configuration of the condensate drains, sterilizer standby water losses will likely exceed the amount of water consumed during operational cycles (over prolonged periods).

- The cost of operating the electric pump associated with the Water-Mizer recirculation system is negligible when compared to the cost of water saved with its use.

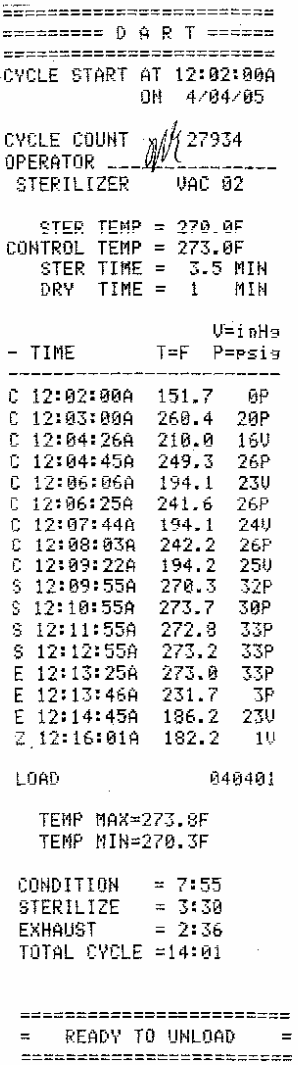
- Considering water and sewer costs to be 5.0 $/kgal, electricity costs to be 6.0 ¢/kwh, and the total sterilizer water consumption savings to be 90 percent, the installation of the Water-Mizer equipment on Unit 3 at this location would save the owner 9,000 $/yr in utility costs[4]. This savings represents a typical application of a Water-Mizer installation.

Appendix A

The 3 different cycles of the tested sterilizers



```
==========================
=== L E A K   T E S T ==
==========================
CYCLE START AT 11:10:05P
          ON  4/03/05

CYCLE COUNT    27933
OPERATOR ____________
 STERILIZER     VAC 02

                     V=inHg
- TIME        T=F   P=psig
--------------------------
C 11:10:05P  148.2    0P
C 11:11:04P  248.2   19P
C 11:12:30P  210.7   15V
C 11:12:53P  256.9   26P
C 11:14:13P  191.2   23V
L 11:14:51P  270.2   33P
L 11:24:50P  165.7   24V
L 11:26:51P  163.7   24V
L 11:36:50P  158.0   24V
LEAK RATE IS:
     0.0  mmHg/min

L 11:36:51P  158.0   24V
Z 11:38:10P  165.3    1V

LOAD              040305

TOTAL CYCLE = 0:28:06

==========================
```



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==========================
========= D A R T =======
==========================
CYCLE START AT 12:02:00A
          ON  4/04/05

CYCLE COUNT    27934
OPERATOR ____________
 STERILIZER     VAC 02

   STER TEMP = 270.0F
CONTROL TEMP = 273.0F
   STER TIME =  3.5 MIN
   DRY  TIME =  1   MIN

                     V=inHg
- TIME        T=F   P=psig
--------------------------
C 12:02:00A  151.7    0P
C 12:03:00A  260.4   20P
C 12:04:26A  210.0   16V
C 12:04:45A  249.3   26P
C 12:06:06A  194.1   23V
C 12:06:25A  241.6   26P
C 12:07:44A  194.1   24V
C 12:08:03A  242.2   26P
C 12:09:22A  194.2   25V
S 12:09:55A  270.3   32P
S 12:10:55A  273.7   30P
S 12:11:55A  272.8   33P
S 12:12:55A  273.2   33P
E 12:13:25A  273.0   33P
E 12:13:46A  231.7    3P
E 12:14:45A  186.2   23V
Z 12:16:01A  182.2    1V

LOAD              040401

  TEMP MAX=273.8F
  TEMP MIN=270.3F

CONDITION    = 7:55
STERILIZE    = 3:30
EXHAUST      = 2:36
TOTAL CYCLE =14:01

==========================
=   READY TO UNLOAD      =
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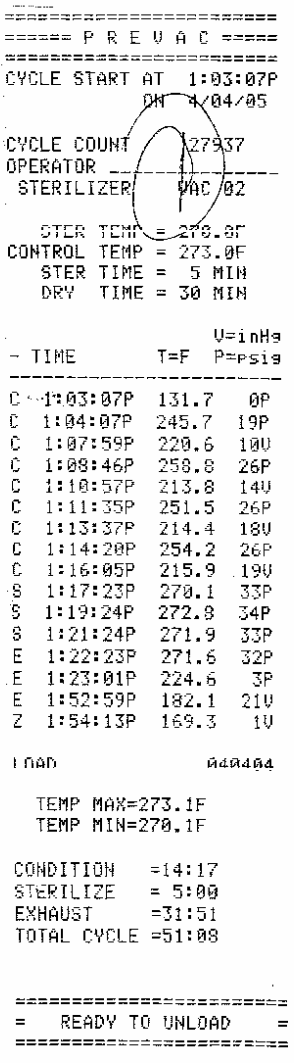


```
==========================
====== P R E V A C =====
==========================
CYCLE START AT  1:03:07P
          ON  4/04/05

CYCLE COUNT    27937
OPERATOR ____________
 STERILIZER     VAC 02

   STER TEMP = 270.0F
CONTROL TEMP = 273.0F
   STER TIME =  5 MIN
   DRY  TIME = 30 MIN

                     V=inHg
- TIME        T=F   P=psig
--------------------------
C  1:03:07P  131.7    0P
C  1:04:07P  245.7   19P
C  1:07:59P  220.6   10V
C  1:08:46P  258.8   26P
C  1:10:57P  213.8   14V
C  1:11:35P  251.5   26P
C  1:13:37P  214.4   18V
C  1:14:20P  254.2   26P
C  1:16:05P  215.9   19V
S  1:17:23P  270.1   33P
S  1:19:24P  272.8   34P
S  1:21:24P  271.9   33P
E  1:22:23P  271.6   32P
E  1:23:01P  224.6    3P
E  1:52:59P  182.1   21V
Z  1:54:13P  169.3    1V

LOAD              040404

  TEMP MAX=273.1F
  TEMP MIN=270.1F

CONDITION    =14:17
STERILIZE    = 5:00
EXHAUST      =31:51
TOTAL CYCLE =51:08

==========================
=   READY TO UNLOAD      =
==========================
```

Appendix B

179390

Unit 1 SJH Water Usage Chart

1 Dart & 1 Leak every 24 hours (approx. 12:00 a.m.)

Water Meter Installed 3/3/2005

Standby Water Usage 2.7 GPM

Dart Test		***Leak Test***		***Prevac #1***		
Start	33638	Start	33787	Start	33970	
Finish	33760	Finish	33965	Finish	34336	
Total	122	Total	178	Total	366	
Cycle CT.	30360	Cycle CT.	30361	Cycle CT.	30362	3/9/05

Date	Water Meter Gal	Cycle Count			
3/10/05	41754	30372	10	4:10p	1 EA. DART/LEAK
3/11/05	44580	30375	24	1:15P	1 EA. DART/LEAK
3-14-05	60937	30392	17	12:00PM	3 EA DART/LEAK
3-15-05	67387	30399	7	2:00PM	1 EA DART/LEAK
3-16-05	71698	30405	6	8 AM	1 EA DART/LEAK
3-17-05	78901	30414	9	1:30p	1 EA DART/LEAK
3-18-05	83725	30421	7	8A	1 EA DART/LEAK
3-21-05	100523	30437	16	11:00A	3 EA DART/LEAK
3-22-05	106798	30445	8	12:00M	1 EA DART/LEAK
3-23-05	113490	30453	8	3:30p	1 EA " "
3-24-05	119504	30461	8	4:21p	1 EA " "
3-25-05	123156	30466	5	7AM	1 EA " "
3-28-05	140730	30485	19	11:20A	3 EA " "
3-29-05	146020	30492	7	8:30A	1 EA
3-31-05	159527	30508	16	4:20	2 EA " "
4-1-05	163320	30513	5	8AM	1 EA "
4-4-05	179294	30529	16	8:38A	3 EA " "
4-4-05	Recirc. System Installed	30530	1		
	179348				
	179359	30531	1		

Unit 2 SJH Water Usage Chart

1 Dart & 1 Leak every 24 hours (approx. 12:00 a.m.)

Water Mizer & Water Meter Installed: 3/8/2005

Standby Water Usage 2.8 GPM

Dart Test		***Leak Test***		***Prevac #1***		
Start	1443.5	Start	1523	Start	153.5	
Finish	1523	Finish	1623	Finish	401.5	
Total	79.5	Total	100	Total	248	
Cycle CT.	27785	Cycle CT.	27786	Cycle CT.	27779	3/9/05

Date	Water Meter Gal	Cycle Count			
3/10/05	3890	27795	9	4:10P	1 EA LEAK/DART
3-11-05	5524	27802	7	1:15P	1 EA LEAK/DART
3-14-05	7350	27811	9	12:00PM	3 EA LEAK/DART
3-15-05	8980	27818	7	2 PM	1 EA LEAK/DART
3-16-05	10334	27824	6	8 AM	1 EA LEAK/DART
3-17-05	12237	27832	8	1:30P	1 EA LEAK/DART
3-18-05	13565	27838	6	8 A	1 EA LEAK/DART
3-21-05	16981	27854	14	11:00A	3 EA Leak/Dart
3-22-05	18363	27860	6	12 PM	1 EA Leak/Dart
3-23-05	20484	27869	9	3:30P	1 EA " "
3-24-05	22109	27876	7	4:22	1 EA " "
3-25-05	22858	27880	4	7AM	1 EA " "
3-28-05	26491	27897	17	11:20A	3 EA " "
5-29-05	27778	27903	6	8:30	1 EA
3-31-05	30453	27916	13	4:20	2 EA " "
4-1-05	31498	27920	4	8AM	1 EA "
4-4-05	34476	27935	15	8:30A	3 EA

Unit 3 SJH Water Usage Chart

1 Dart & 1 Leak every 24 hours (approx. 12:00 a.m.)

Water Meter Installed 3/3/2005

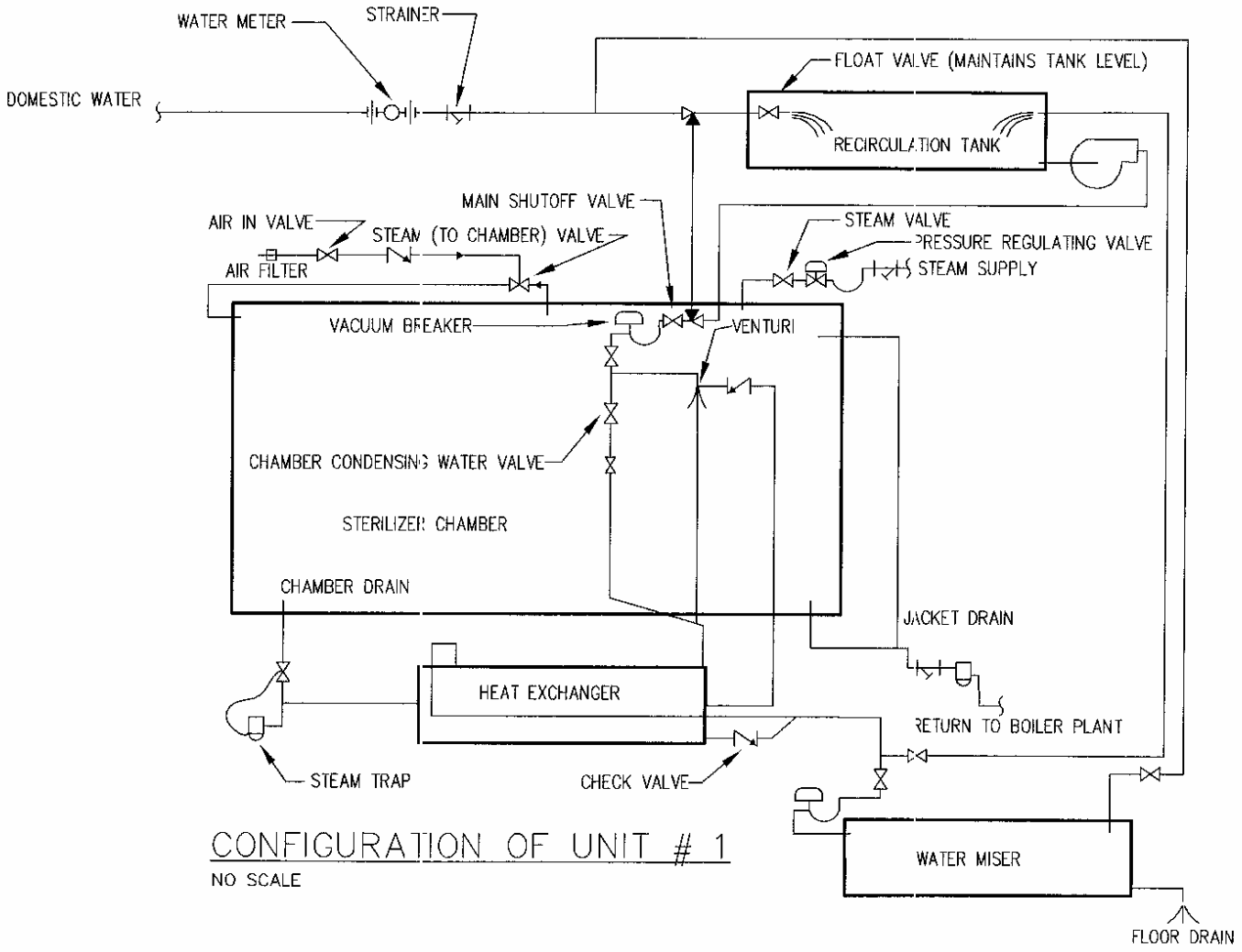
Standby Water Usage 2.8 GPM

Dart Test		***Leak Test***		***Prevac #1***	
Start	30268	Start	30381	Start	19960
Finish	30372	Finish	30551	Finish	20338
Total	104	Total	170	Total	378
Cycle CT.	17918	Cycle CT.	17919	Cycle CT.	17893

3/9/05

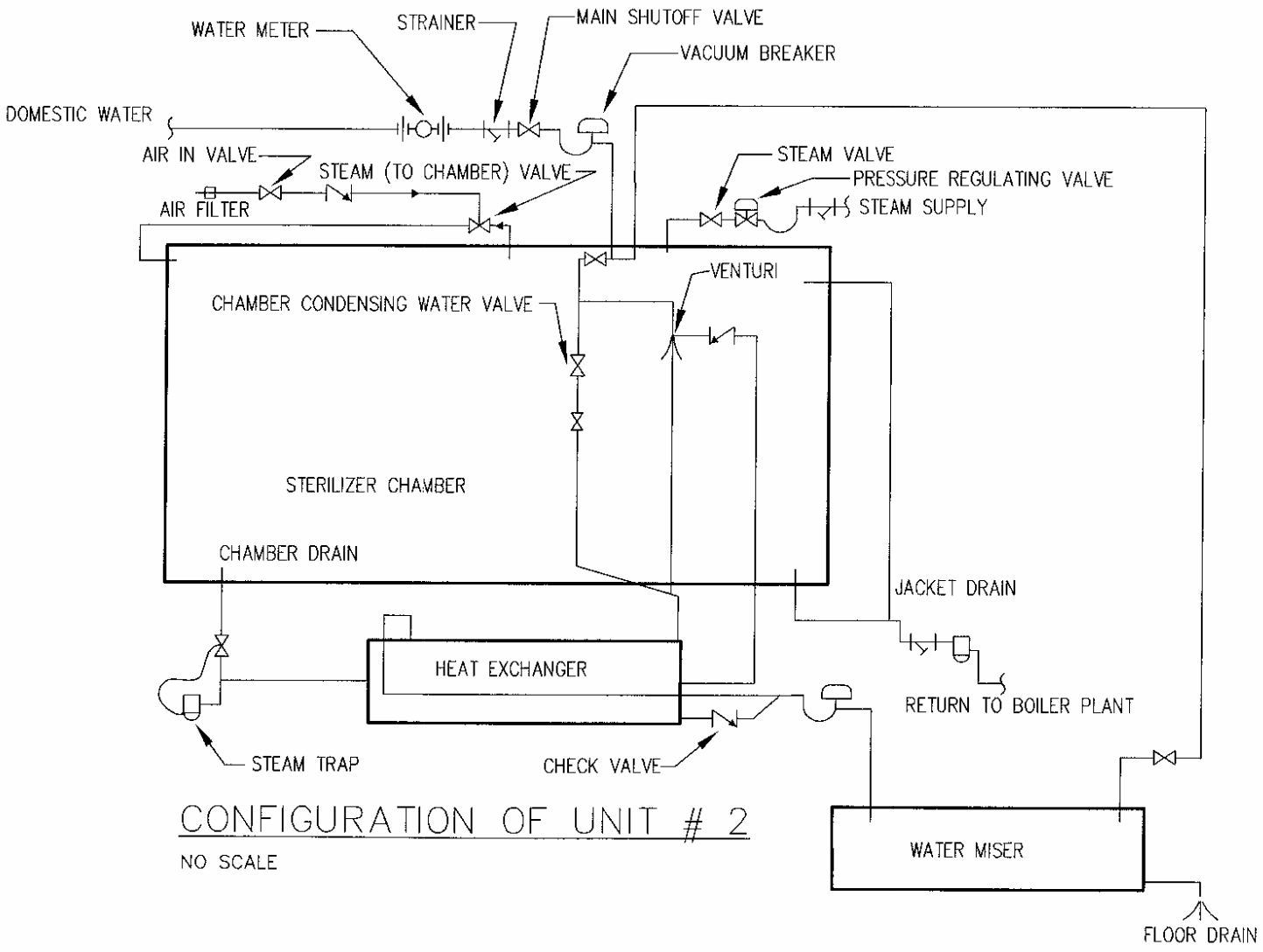
Date	Water Meter Gal	Cycle Count			
3/10/05	38597	17929	10	4:10 PM	1EA LEAK/DART
3-11-05	43889	17936	7	1:15 PM	1EA LEAK/DART
3-14-05	54842	17942	6	12:00 PM	3EA LEAK/DART
3-15-05	60923	17948	6	2 PM	1 EA LEAK/DART
3-16-05	65478	17954	6	8 AM	1 EA LEAK/DART
3-17-05	72710	17962	8	1:30P	1 EA LEAK/DART
3-18-05	77356	17968	6	8A	1EA LEAK/DART
3-21-05	93800	17975	7	11:00A	3EA LEAK/DART
3-22-05	98921	17981	6	12 PM	1EA LEAK/DART
3-23-05	105592	17988	7	3:30P	1EA " "
3-24-05	111883	17996	8	4:23	1EA " "
3-25-05	115607	18001	5	7AM	1EA " "
3-28-05	131077	18007	6	11:20A	3EA " "
3-29-05	136165	18013	6	8:30	1EA
3-31-05	149094	18026	13	4:20	2EA " "
4-1-05	152434	18029	3	8A	1EA
4-4-05	167021	18035	6	3:38A	3EA

Appendix C



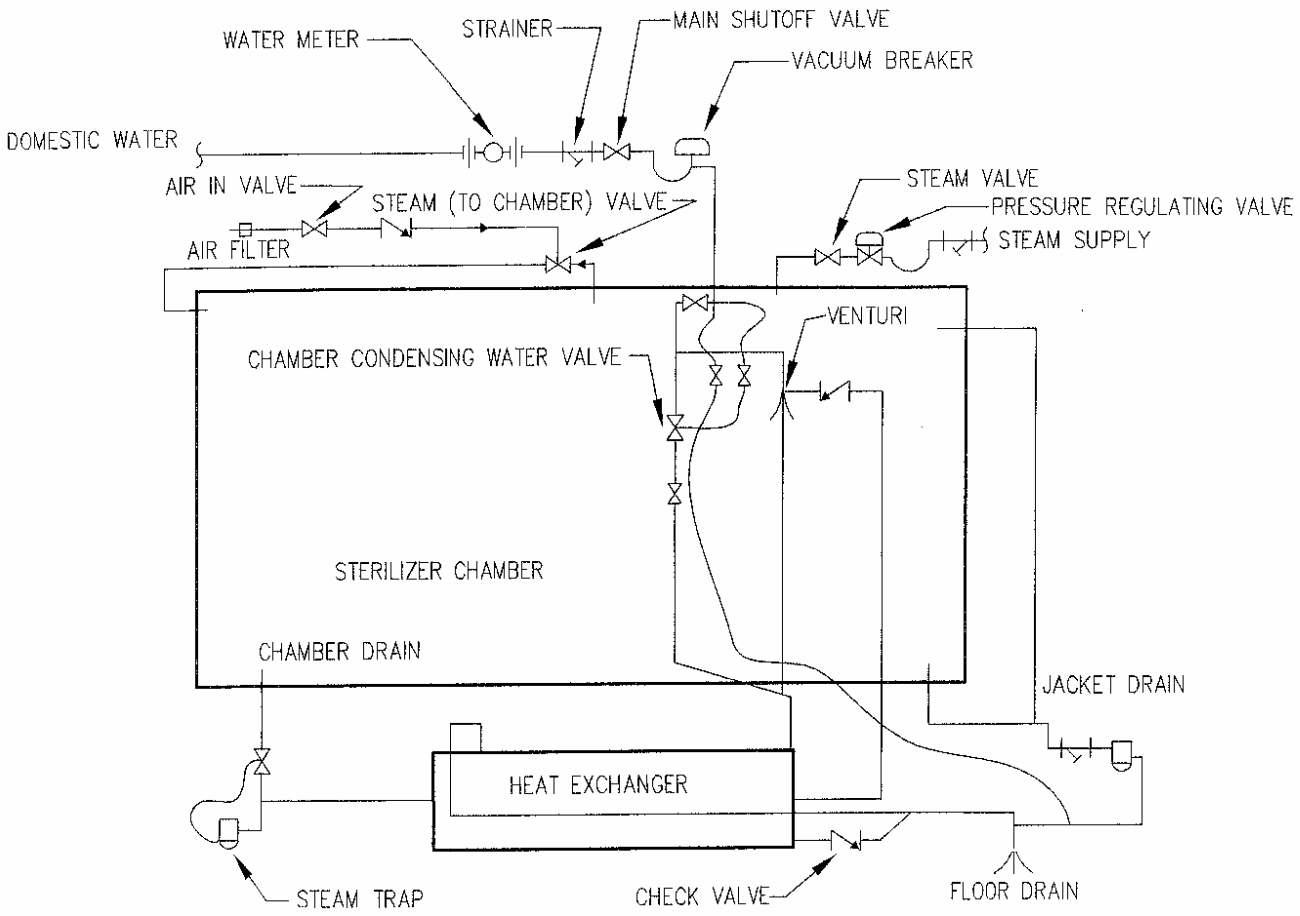
CONFIGURATION OF UNIT # 1

NO SCALE



CONFIGURATION OF UNIT # 2

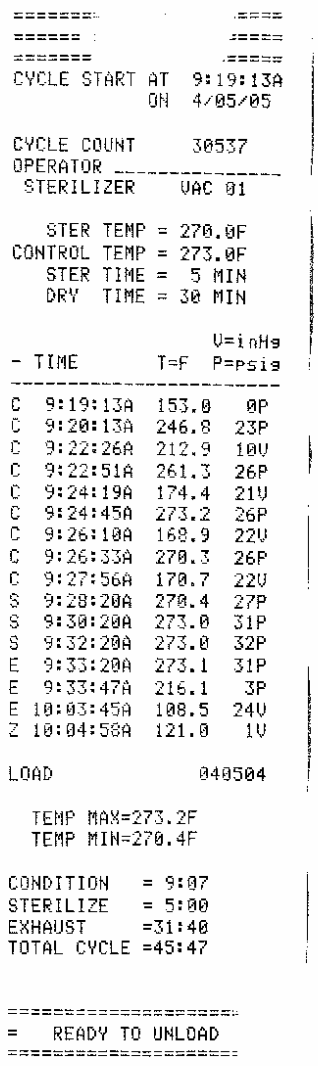
NO SCALE



CONFIGURATION OF UNIT # 3

NO SCALE

Appendix D



```
CYCLE START AT  9:19:13A
             ON  4/05/05

CYCLE COUNT      30537
OPERATOR _______________
 STERILIZER     VAC 01

   STER TEMP = 270.0F
CONTROL TEMP = 273.0F
   STER TIME =  5 MIN
   DRY  TIME = 30 MIN

                      V=inHg
- TIME        T=F   P=psig
-------------------------
C  9:19:13A  153.0    0P
C  9:20:13A  246.8   23P
C  9:22:26A  212.9   10V
C  9:22:51A  261.3   26P
C  9:24:19A  174.4   21V
C  9:24:45A  273.2   26P
C  9:26:10A  168.9   22V
C  9:26:33A  270.3   26P
C  9:27:56A  170.7   22V
S  9:28:20A  270.4   27P
S  9:30:20A  273.0   31P
S  9:32:20A  273.0   32P
E  9:33:20A  273.1   31P
E  9:33:47A  216.1    3P
E 10:03:45A  108.5   24V
Z 10:04:58A  121.0    1V

LOAD              040504

  TEMP MAX=273.2F
  TEMP MIN=270.4F

CONDITION    = 9:07
STERILIZE    = 5:00
EXHAUST      =31:40
TOTAL CYCLE =45:47

=   READY TO UNLOAD
```

```
CYCLE START AT 10:35:35A
             ON  4/05/05

CYCLE COUNT      30538
OPERATOR _______________
 STERILIZER     VAC 01

   STER TEMP = 270.0F
CONTROL TEMP = 273.0F
   STER TIME =  5 MIN
   DRY  TIME = 30 MIN

                      V=inHg
- TIME        T=F   P=psig
-------------------------
C 10:35:35A  105.9    0P
C 10:36:34A  238.2   19P
C 10:44:06A  219.2   10V
C 10:45:00A  258.8   26P
C 10:47:28A  211.8   10V
C 10:48:17A  261.9   26P
C 10:50:12A  211.3   14V
C 10:51:02A  261.7   26P
C 10:52:55A  214.6   15V
S 10:54:11A  270.1   30P
S 10:56:11A  273.1   32P
S 10:58:11A  273.0   32P
E 10:59:11A  273.1   32P
E 11:00:04A  211.0    3P
E 11:30:02A  217.4   23V
Z 11:31:16A  173.0    1V

LOAD              040505

  TEMP MAX=273.2F
  TEMP MIN=270.1F

CONDITION    =18:37
STERILIZE    = 5:00
EXHAUST      =32:07
TOTAL CYCLE =55:44

READY TO UNLOAD    =
```

```
CYCLE START AT 12:33:12P
             ON  4/05/05

CYCLE COUNT      30539
OPERATOR _______________
 STERILIZER     VAC 01

   STER TEMP = 270.0F
CONTROL TEMP = 273.0F
   STER TIME =  5 MIN
   DRY  TIME = 30 MIN

                      V=inHg
- TIME        T=F   P=psig
-------------------------
C 12:33:12P  148.3    0P
C 12:34:11P  239.8   20P
C 12:43:28P  206.6   10V
C 12:44:22P  258.4   26P
C 12:46:36P  210.1   10V
C 12:47:23P  261.2   26P
C 12:49:15P  207.5   16V
C 12:50:02P  260.1   26P
C 12:51:51P  209.8   17V
S 12:53:03P  270.1   30P
S 12:55:03P  272.9   32P
S 12:57:03P  273.0   32P
E 12:58:03P  273.1   31P
E 12:58:52P  209.7    3P
E  1:28:50P  177.5   23V
Z  1:30:03P  156.7    1V

LOAD              040506

  TEMP MAX=273.2F
  TEMP MIN=270.1F

CONDITION    =19:52
STERILIZE    = 5:00
EXHAUST      =32:02
TOTAL CYCLE =56:54

READY TO UNLOAD    =
```

```
====== P R E V A C ======
CYCLE START AT  3:06:23P
             ON  4/05/05

CYCLE COUNT      30540
OPERATOR _______________
 STERILIZER     VAC 01

   STER TEMP = 270.0F
CONTROL TEMP = 273.0F
   STER TIME =  5 MIN
   DRY  TIME = 30 MIN

                      V=inHg
- TIME        T=F   P=psig
-------------------------
C  3:06:23P  108.1    0P
C  3:07:23P  233.4   17P
C  3:20:07P  203.6   10V
C  3:21:13P  259.5   26P
C  3:24:08P  210.1   10V
C  3:25:08P  260.8   26P
C  3:27:14P  208.5   14V
C  3:28:11P  260.0   26P
C  3:30:14P  211.9   14V
S  3:31:51P  270.1   31P
S  3:33:52P  273.0   32P
S  3:35:51P  273.1   31P
E  3:36:51P  273.0   31P
E  3:37:52P  220.2    3P
E  4:07:50P  202.4   23V
Z  4:09:03P  167.0    1V

LOAD              040507

  TEMP MAX=273.2F
  TEMP MIN=270.1F

CONDITION    = 0:25:29
STERILIZE    = 0:05:00
EXHAUST      = 0:32:14
TOTAL CYCLE = 1:02:43

=   READY TO UNLOAD    =
```

Unit # 1 Test Log Printouts

Unit # 2 Test Log Printouts

A C

CYCLE STAR[illegible] AT 9:08:58A
ON 4/05/05

CYCLE COUNT 27944
OPERATOR ______________
STERILIZER VAC 02

STER TEMP = 270.0F
CONTROL TEMP = 273.0F
STER TIME = 5 MIN
DRY TIME = 30 MIN

-	TIME	T=F	V=inHg P=psig
C	9:08:58A	136.1	0P
C	9:09:57A	248.3	20P
C	9:11:26A	209.3	14V
C	9:11:52A	260.7	26P
C	9:13:15A	188.6	23V
C	9:13:36A	244.8	26P
C	9:14:56A	192.1	25V
C	9:15:17A	243.8	26P
C	9:16:36A	191.6	25V
S	9:17:13A	270.1	32P
S	9:19:13A	272.6	33P
S	9:21:13A	272.2	33P
E	9:22:13A	272.2	32P
E	9:22:34A	231.4	3P
E	9:52:32A	143.1	25V
Z	9:53:47A	152.2	1V

LOAD 040504

TEMP MAX=273.4F
TEMP MIN=270.1F

CONDITION = 8:15
STERILIZE = 5:00
EXHAUST =31:37
TOTAL CYCLE =44:52

= READY TO UNLOAD

====== P R E V A C =====

CYCLE START AT 10:16:07A
ON 4/05/05

CYCLE COUNT 27945
OPERATOR ______________
STERILIZER VAC 02

STER TEMP = 270.0F
CONTROL TEMP = 273.0F
STER TIME = 5 MIN
DRY TIME = 30 MIN

-	TIME	T=F	V=inHg P=psig
C	10:16:07A	140.9	0P
C	10:17:37A	242.7	17P
C	10:20:34A	217.0	10V
C	10:20:55A	258.9	26P
C	10:22:49A	216.1	13V
C	10:23:30A	252.7	26P
C	10:25:15A	217.3	17V
C	10:25:59A	254.8	26P
C	10:27:41A	219.5	18V
S	10:29:03A	270.1	33P
S	10:31:03A	272.5	33P
S	10:33:03A	272.9	33P
E	10:34:03A	272.9	33P
E	10:34:45A	224.5	3P
E	11:04:43A	216.9	23V
Z	11:05:56A	191.3	1V

LOAD 040505

TEMP MAX=273.0F
TEMP MIN=270.1F

CONDITION =12:56
STERILIZE = 5:00
EXHAUST =31:55
TOTAL CYCLE =49:51

READY TO UNLOAD =

====== P R E C =====

CYCLE START AT 1:36:06P
ON 4/05/05

CYCLE COUNT 27946
OPERATOR ______________
STERILIZER VAC 02

STER TEMP = 270.0F
CONTROL TEMP = 273.0F
STER TIME = 5 MIN
DRY TIME = 30 MIN

-	TIME	T=F	V=inHg P=psig
C	1:36:06P	134.7	0P
C	1:37:05P	241.1	17P
C	1:40:29P	218.0	10V
C	1:41:19P	258.7	26P
C	1:43:14P	213.4	13V
C	1:43:55P	252.5	26P
C	1:45:39P	212.1	17V
C	1:46:21P	254.1	26P
C	1:48:03P	213.1	18V
S	1:49:24P	270.1	33P
S	1:51:25P	272.8	34P
S	1:53:25P	272.9	34P
E	1:54:24P	272.8	33P
E	1:55:04P	225.1	3P
E	2:25:02P	181.3	21V
Z	2:26:13P	169.8	1V

LOAD 040506

TEMP MAX=273.1F
TEMP MIN=270.1F

CONDITION =13:19
STERILIZE = 5:00
EXHAUST =31:50
TOTAL CYCLE =50:09

DY TO UNLOAD =

===== P R E V A C =====

YCLE START AT 3:40:05P
ON 4/05/05

YCLE COUNT 27947
PERATOR ______________
STERILIZER VAC 02

STER TEMP = 270.0F
ONTROL TEMP = 273.0F
STER TIME = 5 MIN
DRY TIME = 30 MIN

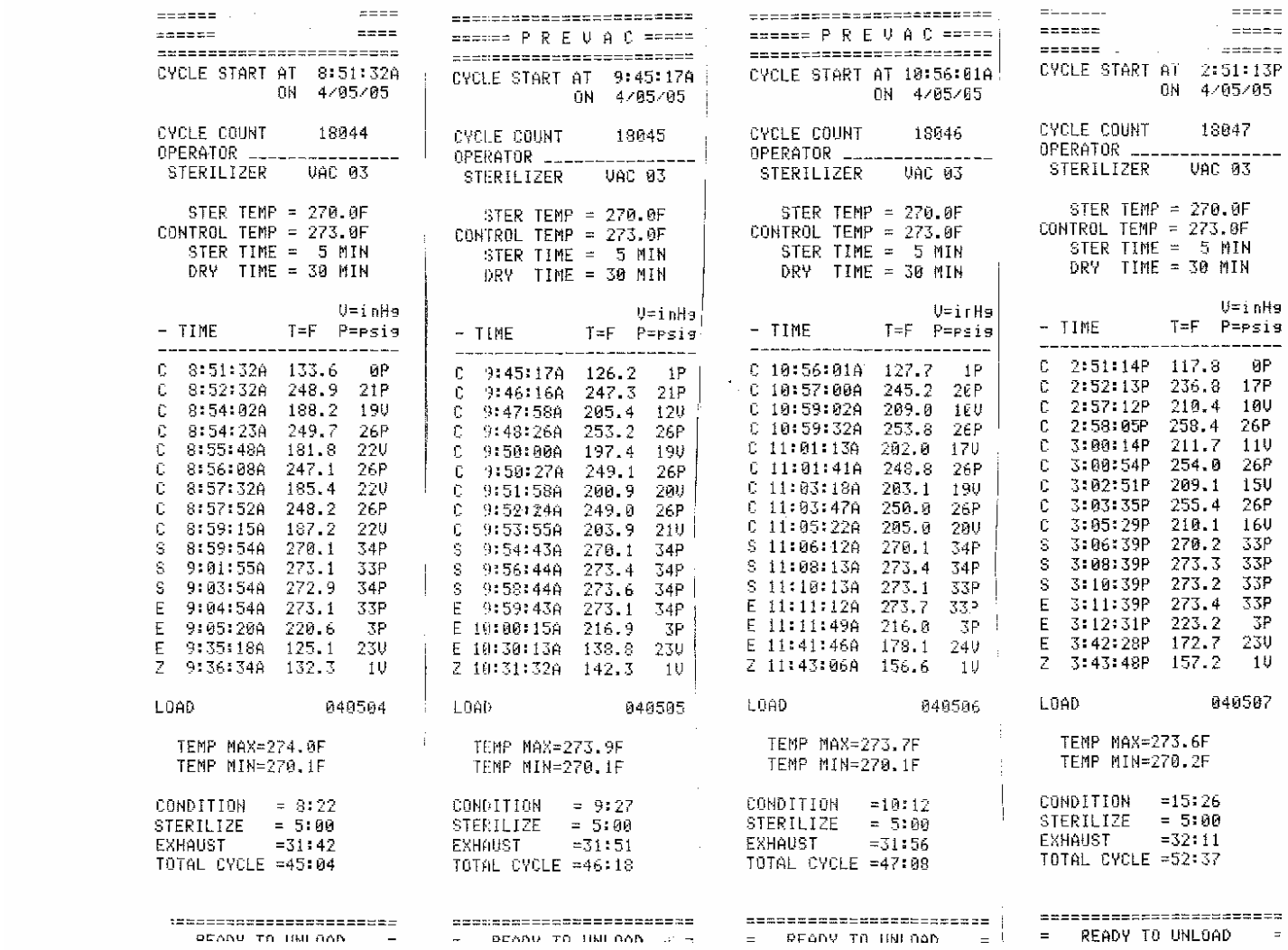
-	TIME	T=F	V=inHg P=psig
	3:40:05P	141.0	0P
	3:41:04P	241.6	17P
	3:44:30P	218.7	10V
	3:45:22P	259.1	26P
	3:47:17P	217.8	12V
	3:47:56P	252.9	26P
	3:49:40P	215.1	18V
	3:50:22P	253.9	26P
	3:52:04P	217.1	19V
	3:53:24P	270.1	33P
	3:55:24P	272.1	33P
	3:57:24P	272.4	33P
E	3:58:24P	272.6	33P
E	3:59:04P	224.5	3P
E	4:29:02P	188.3	21V
Z	4:30:12P	177.8	1V

OAD 040507

TEMP MAX=272.6F
TEMP MIN=270.1F

CONDITION =13:19
STERILIZE = 5:00
EXHAUST =31:49
TOTAL CYCLE =50:09

= READY TO UNLO



```
======                  ====
======                  ====
========================
CYCLE START AT  8:51:32A
           ON  4/05/05

CYCLE COUNT     18044
OPERATOR ---------------
 STERILIZER    VAC 03

   STER TEMP = 270.0F
CONTROL TEMP = 273.0F
   STER TIME =  5 MIN
   DRY  TIME = 30 MIN

                     V=inHg
- TIME       T=F   P=psig
------------------------
C  8:51:32A  133.6   0P
C  8:52:32A  248.9  21P
C  8:54:02A  188.2  19V
C  8:54:23A  249.7  26P
C  8:55:48A  181.8  22V
C  8:56:08A  247.1  26P
C  8:57:32A  185.4  22V
C  8:57:52A  248.2  26P
C  8:59:15A  187.2  22V
S  8:59:54A  270.1  34P
S  9:01:55A  273.1  33P
S  9:03:54A  272.9  34P
E  9:04:54A  273.1  33P
E  9:05:20A  220.6   3P
E  9:35:18A  125.1  23V
Z  9:36:34A  132.3   1V

LOAD            040504

  TEMP MAX=274.0F
  TEMP MIN=270.1F

CONDITION   = 8:22
STERILIZE   = 5:00
EXHAUST     =31:42
TOTAL CYCLE =45:04

========================
=   READY TO UNLOAD    =
```

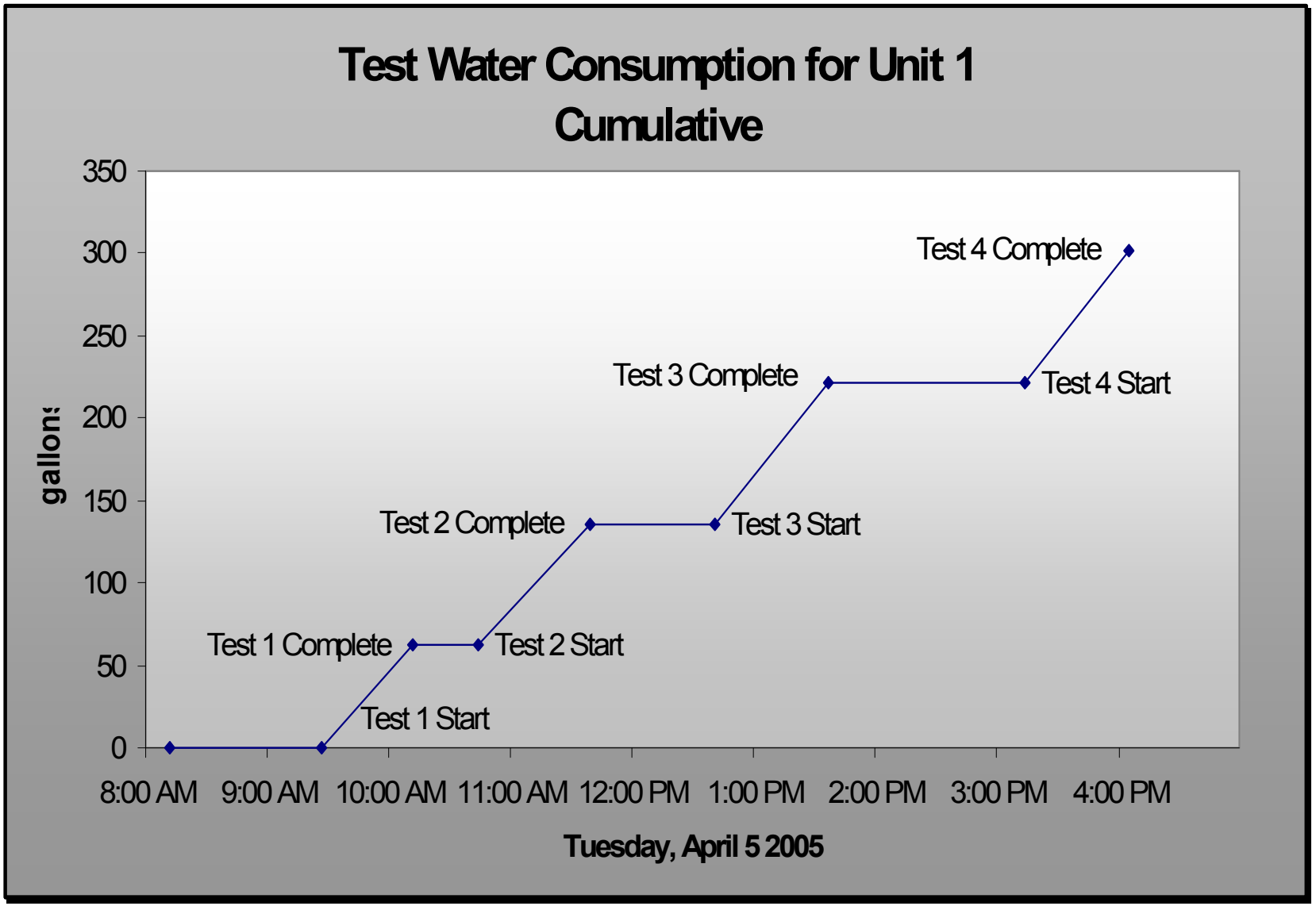
```
========================
====== P R E V A C =====
========================
CYCLE START AT  9:45:17A
           ON  4/05/05

CYCLE COUNT     18045
OPERATOR ---------------
 STERILIZER    VAC 03

   STER TEMP = 270.0F
CONTROL TEMP = 273.0F
   STER TIME =  5 MIN
   DRY  TIME = 30 MIN

                     V=inHg
- TIME       T=F   P=psig
------------------------
C  9:45:17A  126.2   1P
C  9:46:16A  247.3  21P
C  9:47:58A  205.4  12V
C  9:48:26A  253.2  26P
C  9:50:00A  197.4  19V
C  9:50:27A  249.1  26P
C  9:51:58A  200.9  20V
C  9:52:24A  249.0  26P
C  9:53:55A  203.9  21V
S  9:54:43A  270.1  34P
S  9:56:44A  273.4  34P
S  9:58:44A  273.6  34P
E  9:59:43A  273.1  34P
E 10:00:15A  216.9   3P
E 10:30:13A  138.8  23V
Z 10:31:32A  142.3   1V

LOAD            040505

  TEMP MAX=273.9F
  TEMP MIN=270.1F

CONDITION   = 9:27
STERILIZE   = 5:00
EXHAUST     =31:51
TOTAL CYCLE =46:18

========================
=   READY TO UNLOAD    =
```

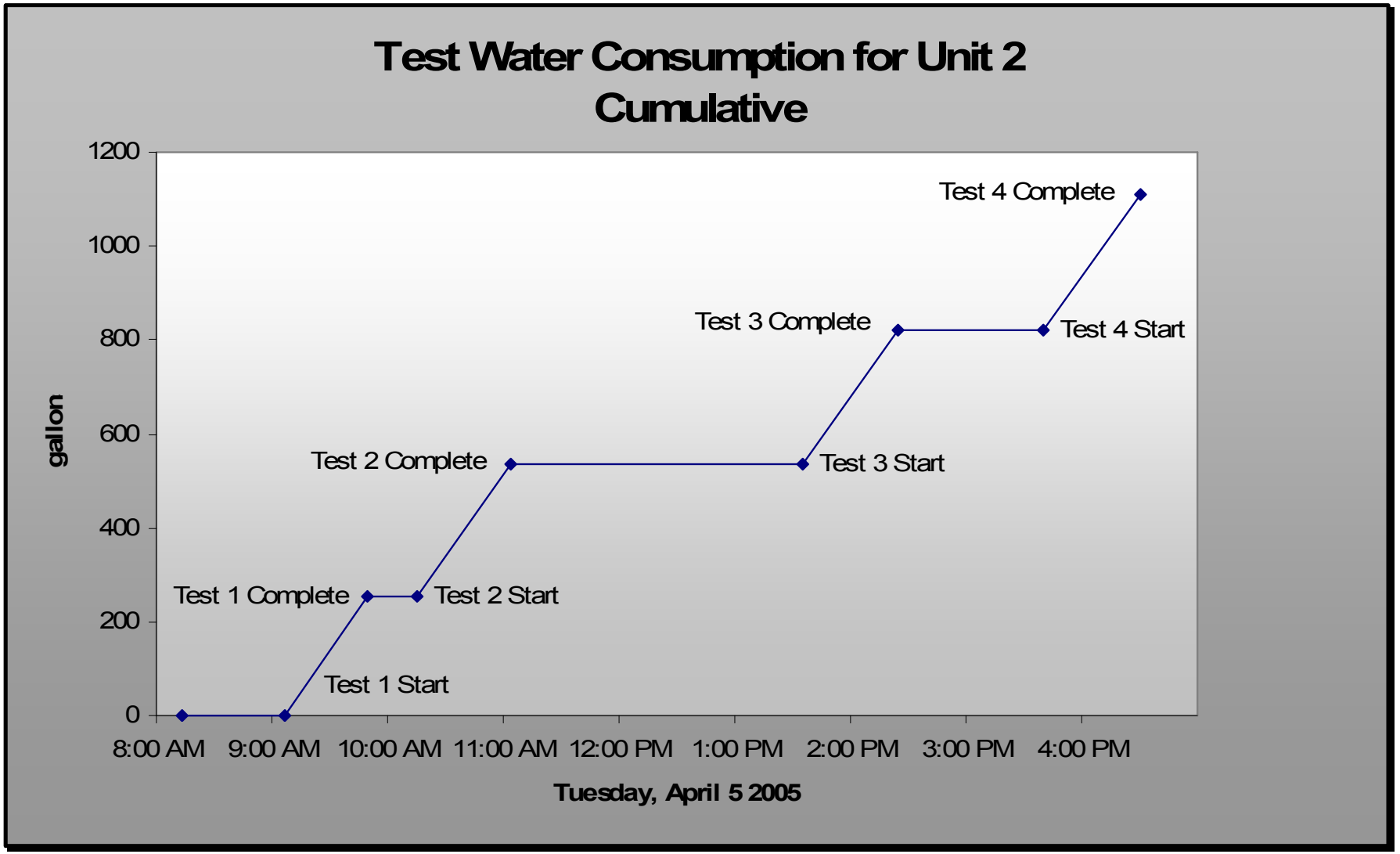
```
========================
====== P R E V A C =====
========================
CYCLE START AT 10:56:01A
           ON  4/05/05

CYCLE COUNT     18046
OPERATOR ---------------
 STERILIZER    VAC 03

   STER TEMP = 270.0F
CONTROL TEMP = 273.0F
   STER TIME =  5 MIN
   DRY  TIME = 30 MIN

                     V=inHg
- TIME       T=F   P=psig
------------------------
C 10:56:01A  127.7   1P
C 10:57:00A  245.2  20P
C 10:59:02A  209.0  16V
C 10:59:32A  253.8  26P
C 11:01:13A  202.0  17V
C 11:01:41A  248.8  26P
C 11:03:18A  203.1  19V
C 11:03:47A  250.0  26P
C 11:05:22A  205.0  20V
S 11:06:12A  270.1  34P
S 11:08:13A  273.4  34P
S 11:10:13A  273.1  33P
E 11:11:12A  273.7  33P
E 11:11:49A  216.0   3P
E 11:41:46A  178.1  24V
Z 11:43:06A  156.6   1V

LOAD            040506

  TEMP MAX=273.7F
  TEMP MIN=270.1F

CONDITION   =10:12
STERILIZE   = 5:00
EXHAUST     =31:56
TOTAL CYCLE =47:08

========================
=   READY TO UNLOAD    =
```

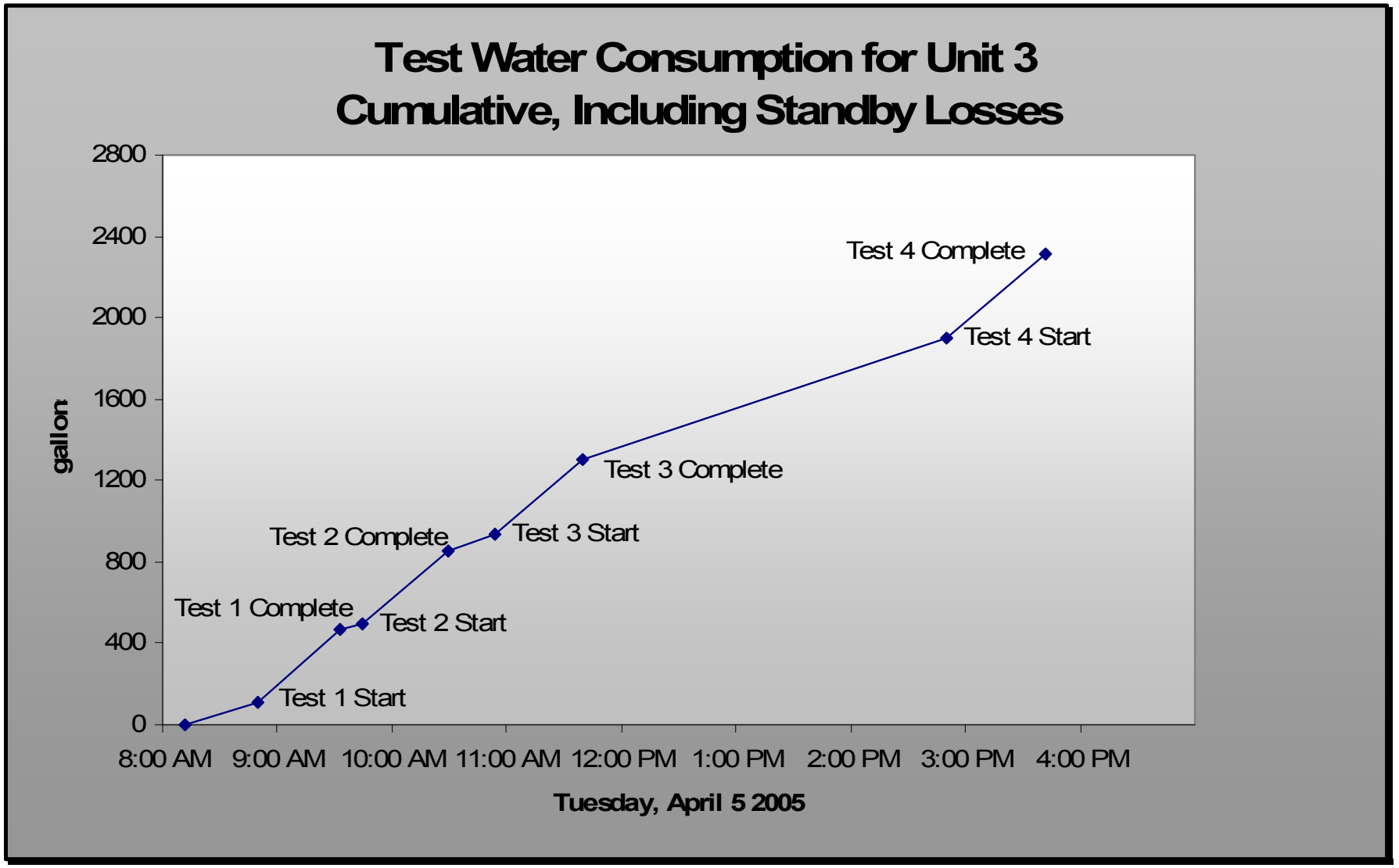
```
========================
======                  =====
======                  =====
======                  ======
CYCLE START AT  2:51:13P
           ON  4/05/05

CYCLE COUNT     18047
OPERATOR ---------------
 STERILIZER    VAC 03

   STER TEMP = 270.0F
CONTROL TEMP = 273.0F
   STER TIME =  5 MIN
   DRY  TIME = 30 MIN

                     V=inHg
- TIME       T=F   P=psig
------------------------
C  2:51:14P  117.8   0P
C  2:52:13P  236.0  17P
C  2:57:12P  210.4  10V
C  2:58:05P  258.4  26P
C  3:00:14P  211.7  11V
C  3:00:54P  254.0  26P
C  3:02:51P  209.1  15V
C  3:03:35P  255.4  26P
C  3:05:29P  210.1  16V
S  3:06:39P  270.2  33P
S  3:08:39P  273.3  33P
S  3:10:39P  273.2  33P
E  3:11:39P  273.4  33P
E  3:12:31P  223.2   3P
E  3:42:28P  172.7  23V
Z  3:43:48P  157.2   1V

LOAD            040507

  TEMP MAX=273.6F
  TEMP MIN=270.2F

CONDITION   =15:26
STERILIZE   = 5:00
EXHAUST     =32:11
TOTAL CYCLE =52:37

========================
=   READY TO UNLOAD    =
```

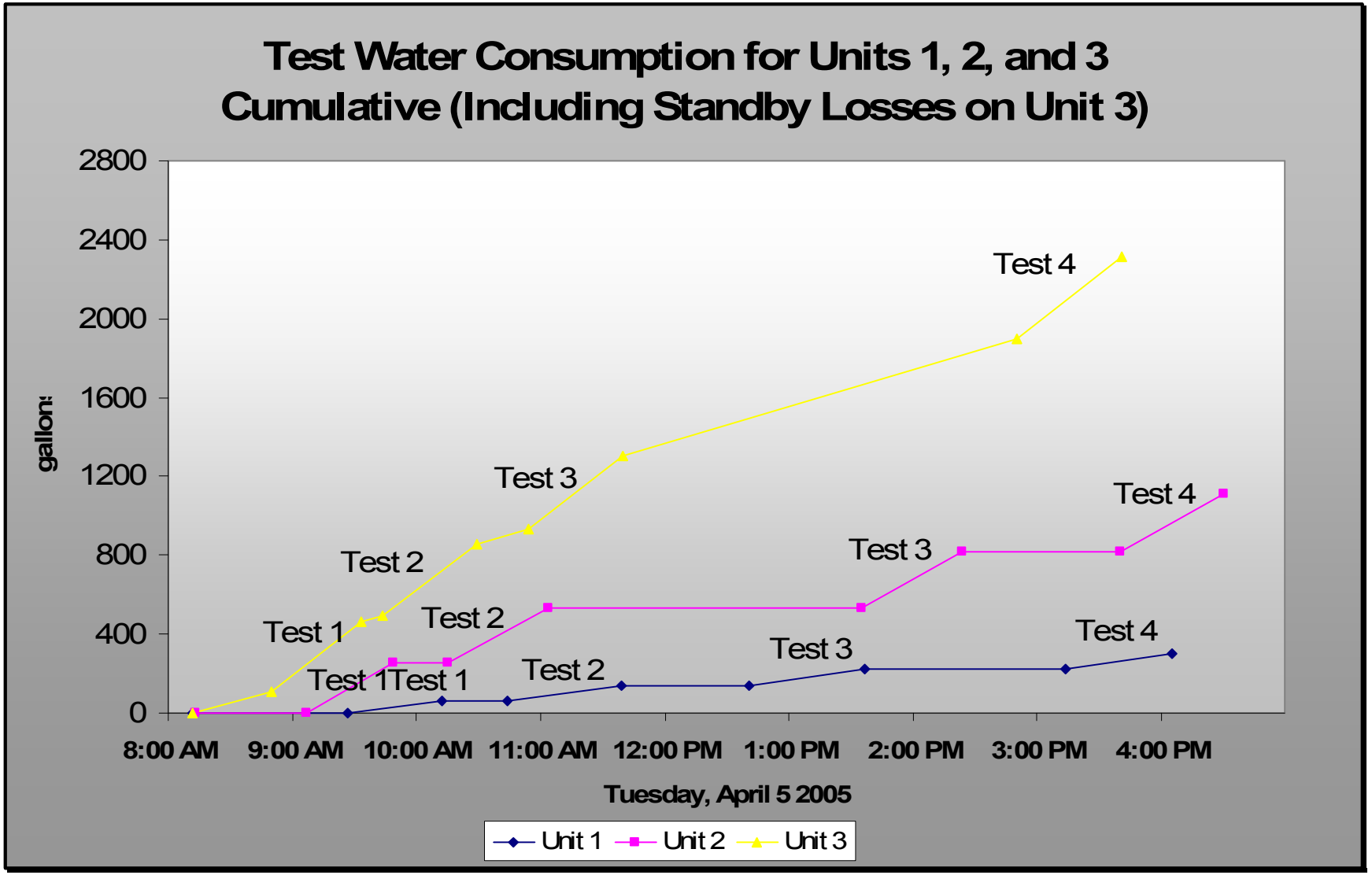
Unit # 3 Test Log Printouts

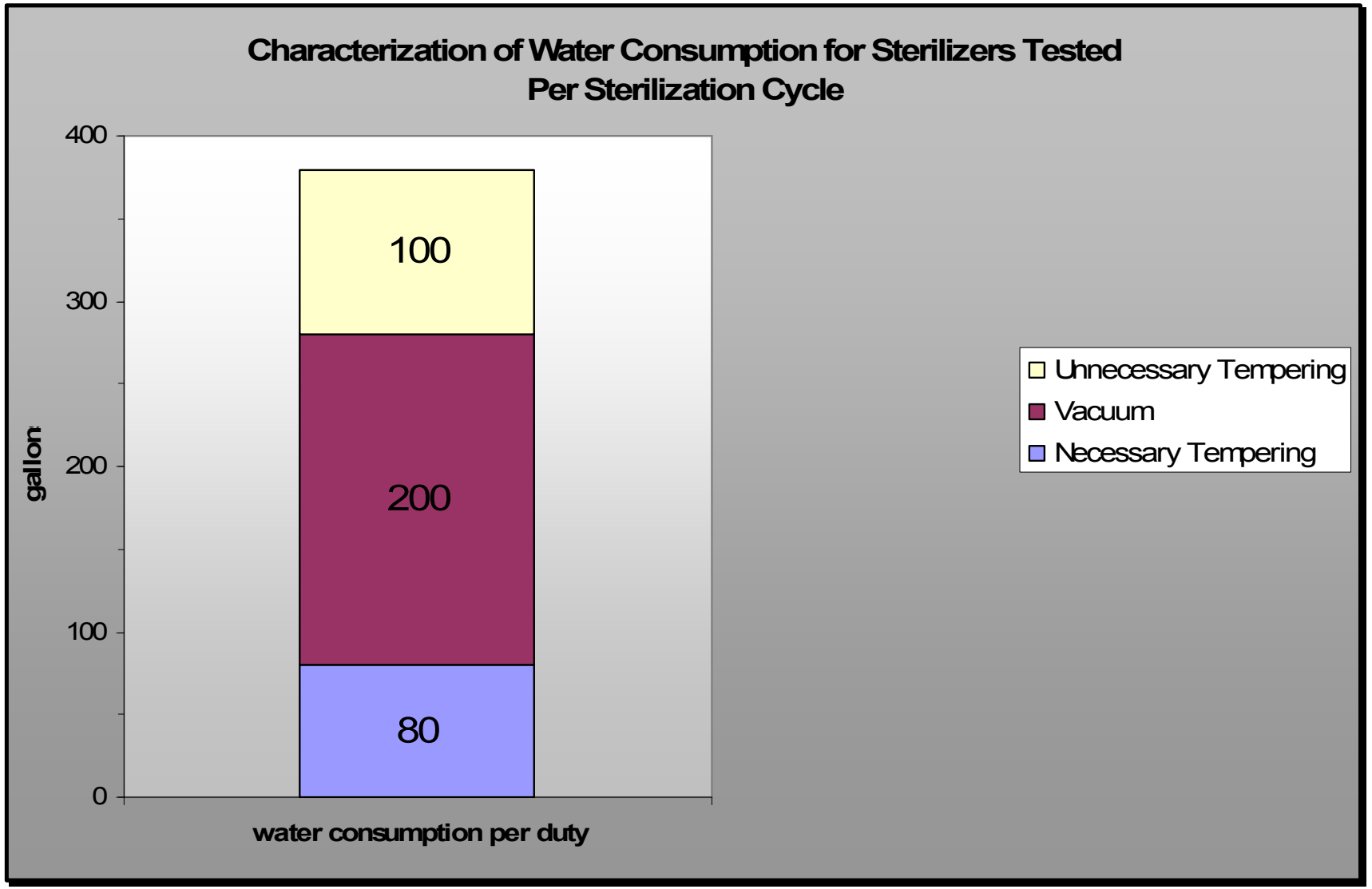
Appendix E


Test Water Consumption for Unit 1
Cumulative
350
300
250
200
150
100
50
0
gallons
Test 4 Complete
Test 3 Complete
Test 4 Start
Test 2 Complete
Test 3 Start
Test 1 Complete
Test 2 Start
Test 1 Start
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
Tuesday, April 5 2005


Test Water Consumption for Unit 2
Cumulative
gallon
1200
1000
800
600
400
200
0
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
Tuesday, April 5 2005
Test 1 Start
Test 1 Complete
Test 2 Start
Test 2 Complete
Test 3 Start
Test 3 Complete
Test 4 Start
Test 4 Complete


Test Water Consumption for Unit 3
Cumulative, Including Standby Losses
gallons
2800
2400
2000
1600
1200
800
400
0
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
Tuesday, April 5 2005
Test 1 Start
Test 1 Complete
Test 2 Start
Test 2 Complete
Test 3 Start
Test 3 Complete
Test 4 Start
Test 4 Complete


Test Water Consumption for Units 1, 2, and 3
Cumulative (Including Standby Losses on Unit 3)
2800
2400
2000
1600
1200
800
400
0
gallons
Test 4
Test 3
Test 4
Test 2
Test 3
Test 1
Test 2
Test 4
Test 1
Test 1
Test 3
Test 2
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
Tuesday, April 5 2005
Unit 1
Unit 2
Unit 3


Characterization of Water Consumption for Sterilizers Tested Per Sterilization Cycle
400
300
200
100
0
gallon
100
200
80
water consumption per duty
Unnecessary Tempering
Vacuum
Necessary Tempering

Appendix F


AMSCO
Renaissance Series
3043
VACAMATIC
Hospital
Shared
Services
PREVENTIVE MAINTENANCE PROGRAM
ASSET/
I.D. #
SJH107
For Service Call (303) 778-5445
PM RECORD
COMPLETE DATE
NEXT INSP.
8-20-04
10-5-04
12-9-04
2-8-05
Y2K
INSPECTED

Unit 1

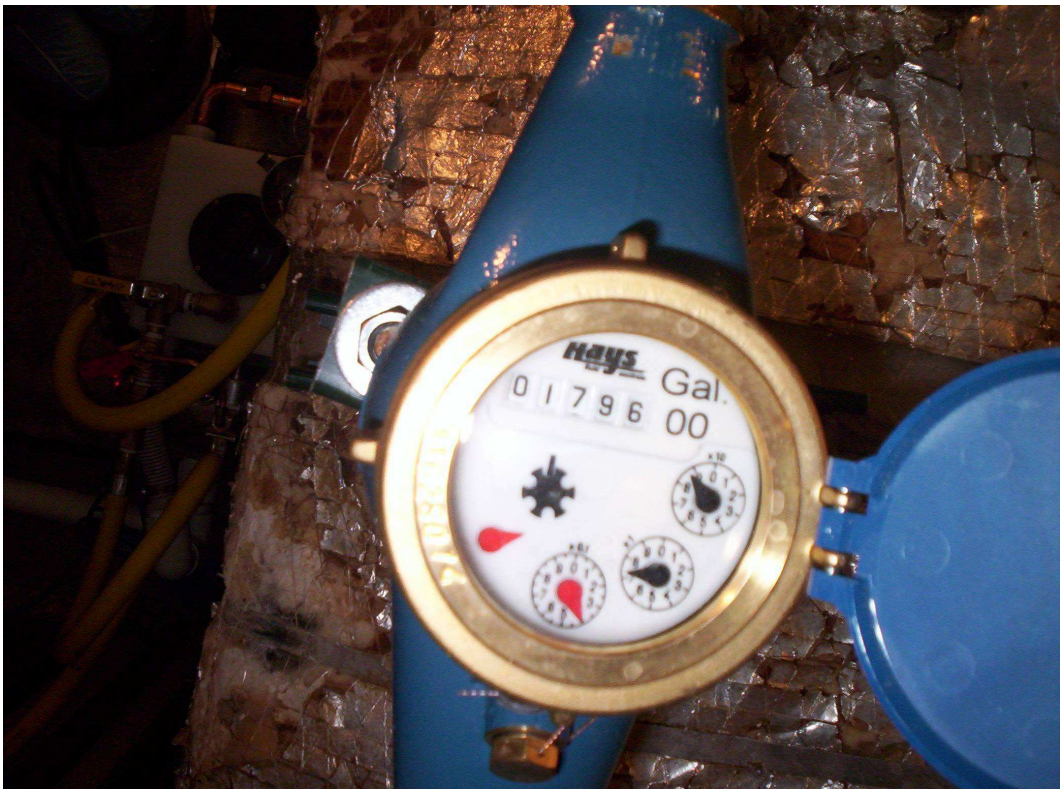

AMSCO
Renaissance Series
3043
VACAMATIC
Hospital
Shared
Services
PREVENTIVE MAINTENANCE PROGRAM
ASSET/
I.D. #
SJH 108
For Service Call (303) 778-5445
PM RECORD
COMPLETE DATE
NEXT INSP.
8-20-04
10-5-04
12-9-04
2-8-05
Y2K
INSPECTED

Unit 2


AMSCO
Renaissance Series
3043
VACAMATIC
PM RECORD
COMPLETE DATE
NEXT INSP.
8-20-04
10-5-04
12-9-04
2-3-05
Hospital Shared Services
#41516
PREVENTIVE MAINTENANCE PROGRAM
ASSET/ I.D. #
SJH 109
For Service Call (303) 778-5445
Y2K
INSPECTED

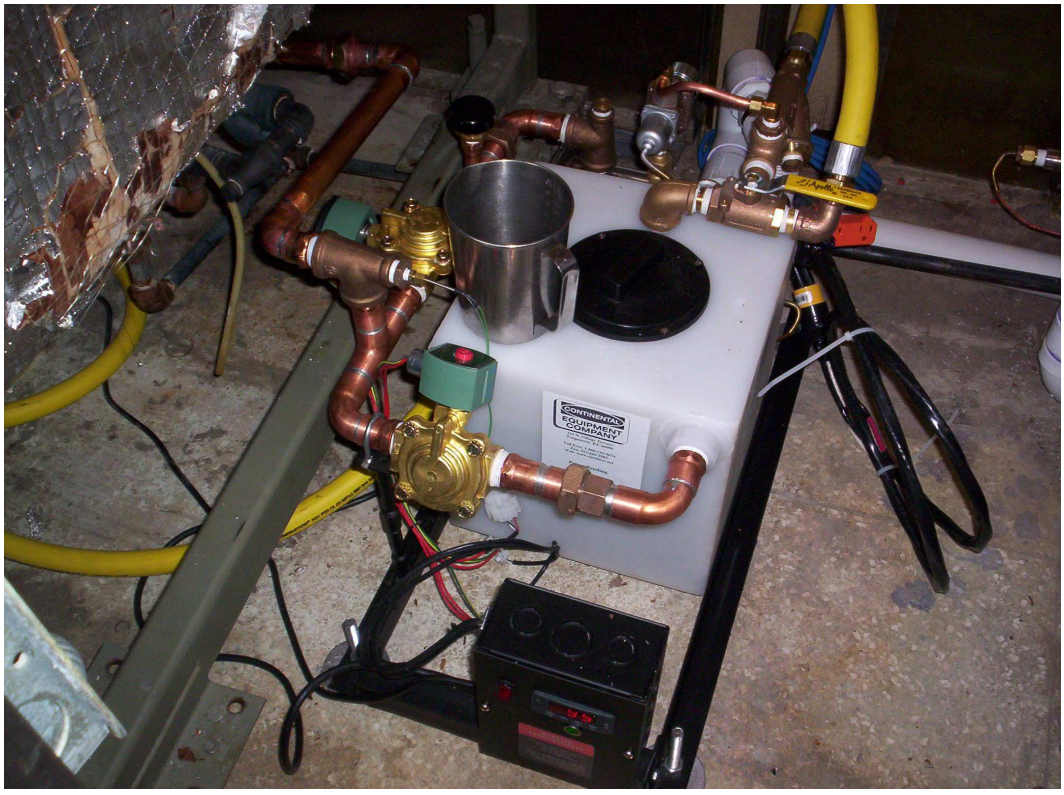
Unit 3

The Sterilizers Tested



Water Meter (Typical of 3)

Power Consumption Measurement



Water-Mizer Recirculation Tank Installed on Unit 1

Appendix G

Footnote Calculation	Cycle Water Savings Low Range Result
1	Average Water Consumption Unit 1, per cycle 76 gallons Average Water Consumption Unit 2, per cycle 278 gallons Average Water Savings with Retrofit (Unit 1 vs Unit 2) 73 percent

Footnote Calculation	Cycle Water Savings High Range Result
2	Average Water Consumption Unit 1, per cycle 76 gallons Average Water Consumption Unit 3, per cycle 378 gallons Average Water Savings with Retrofit (Unit 1 vs Unit 3) 80 percent

Measured Parameters and Assumptions

Assumed Water/Sewer Rate	**5.00** $/kgal	Measured kW draw of pump	**0.67** kW
Assumed Electricity Utility Rate	**0.06** $/kWh		
Typical Dart Test Water Consumption, Pre-Retrofit		Typical Dart Test Cycle Time	
113 gallons		**30** minutes	
Typical Leak Test Water Consumption, Pre-Retrofit		Typical Leak Test Cycle Time	
174 gallons		**13** minutes	
Typical Sterilization Cycle Water Consumption, Pre-Retrofit		Typical Sterililzation Cycle Time	
378 gallons		**60** minutes	
Assumed Number of Dart Tests per Year		Entering Domestic Water Temperature	
365 (once per day)		**49** degrees F	**17.05** Btu/lb
Assumed Number of Leak Tests per Year		Drain Discharge Temperature during Standby Pre-Retrofit	
365 (once per day)		**54** degrees F	**22.05** Btu/lb
Assumed Number of Sterilization Cycles per Year		Drain Discharge Temperature during Standby Post-Retrofit	
1827 (7 per workday/261 workdays per year)		**140** degrees F	**107.98** Btu/lb
Cycle Water Savings with Retrofit (maximum of calculations one above)		Jacket Condensate Drain (Saturated Liquid at atmospheric pressure)	
80 percent		**212** degrees F	**180.81** Btu/lb
Typical Standby Water Flow Pre-Retrofit			
3.1 average gpm	1,562 average lb/h		

Footnote Calculation	Annual Water Consumptions and Estimated Savings
3	Calculated Time Spent in Cycles (Total Number of Dart, Leak, and Sterilization Cycles multiplied by the time for each) 125,315 minutes Calculated Standby Time per year (Total Minutes per year, 525,600 minus times spent in cycles) 400,285 minutes Calculated Flow of Jacket Condensate Drain During Standby (before tempering) (via heat balance) 49 average lb/h 0.097 average gpm Calculated Standby Water Flow Post-Retrofit (via heat balance) 39 average lb/h 0.077 average gpm Calculated Annual Water Consumption, Pre-Retrofit (Dart, Leak, and Sterilization Cycles plus Standby Losses) 795,361 gallons during cycles 1,240,884 gallons during standby 2,036,245 gallons total Calculated Annual Water Consumption, Post-Retrofit (Dart, Leak, and Sterilization Cycles plus Standby Losses) 189,894 gallons Calculated Annual Water Savings Resulting from Retrofit 1,846,351 gallons 1,846 kgal 91 percent 9,230 dollars

Footnote Calculation	Annual Utility Savings Considering Cost to Operate Pump
4	Pump Operating Time For Each Cycle (the pump was observed to operate 42 minutes of each 60 minute cycle) 70 percent Calculated Annual Pump Operating Time 1,462 hours Calculated Annual Pump Power Consumption 980 kWh 59 dollars Calculated Annual Overall Utility Savings (Water Utility Savings minus Costs to Operate Pump) 9,171 dollars