THE CAROMONT HEALTH OZONE LAUNDRY SYSTEM

Energy Savings, Improved Laundered Product Qualities and Return-on-Investment at Gaston Memorial Hospital, Gastonia, NC

by

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Abstract

Ozone generating equipment was retrofit into the laundry washroom of the Gaston Memorial Hospital in Gastonia, NC, and began operating in the early part of July, 2010. Three ozone generating systems service six washer-extractors in the washroom. The performance of this fine-bubble ozone diffusion laundering system has been monitored since that time, with various adjustments made to ensure optimum performance and production results. Since installing this ozone system, the laundry has realized $46,000 per year savings in utility costs as well as reduction in water consumption of more than one million gallons per year, and lower wastewater discharge fees. In addition, the ozone-washed linens are cleaner and brighter than ever and the rewash rate has been reduced by 1.5-2.5%. The apparent Return-On-Investment (R-O-I) of this ozone laundering system, calculated on the basis of just these benefits cited, is 16 months.

Key Words

Ozone, Laundry, Health Care, Skilled Nursing Facility, Wound Care Nursing, Retirement Community, Cost Savings, Improved Laundry Quality, Reduced Environmental Impacts, Return-On-Investment, Hospital Energy Savings

Introduction

CaroMont Health in Gastonia, North Carolina is a regional, independent, not-for-profit health care system. It encompasses Gaston Memorial Hospital with 435-beds; Courtland Terrace, a 96-bed skilled nursing facility; Gaston Hospice which includes the 12-bed Robin Johnson House inpatient facility, and CaroMont Medical Group, a network of 44 primary and specialty physician offices.

The CaroMont Heart Center provides a full range of life-saving cardiac care including open heart surgery. And, the CaroMont Cancer Center provides advanced 3-D radiation treatment planning and chemotherapy. An expansive, surgical suite offers the latest advancements such as stereotactic technology, a procedure using computer simulation, microscopic surgery and x-ray images for pinpoint accuracy. A level III neonatal intensive care unit for high risk infants and a pre-adolescent psychiatric center are among the latest services aimed at improving the health status of the community.

Established in 1946, Gaston Memorial Hospital opened in Gastonia, North Carolina as a memorial to all local soldiers who died in World War II. The present facility opened in 1973. A not-for-profit general and acute care facility, Gaston Memorial Hospital serves Gaston and surrounding counties. The hospital offers 435 licensed beds and features all private rooms.

Laundry at Gaston Memorial Hospital

Although Gaston Memorial Hospital contains 435 patient beds, it washes laundry from all of the units that make up CaroMont Health. This equates to some 3.2 million lbs annually of the usually encountered hospital linens, gowns, bed clothing, pads, mops, and washing cloths that contain the types of soils usually encountered in hospitals and health care facilities. Traditional laundering systems require large expenditures for heating water, for the water itself, for discharging laundry wastewaters to sewerage, for chemicals, and frequent replacements of the bedding, garments and cleaning mops and cloths laundered repeatedly.

Ozone Laundering

Ozone laundering is a recent commercial technology for which intriguing claims are made for energy and cost savings that can be obtained, in addition to incorporating the well-known excellent disinfection properties extant in water and wastewater systems that have been utilizing ozone technologies in many parts of the world for many decades. However, CaroMont Health was led to ozone laundering by the much less esoteric need to replace an aging, 30-year old hot water tank.

CaroMont Health contacted Texchine Inc. to provide a quote for a new hot water tank. Once obtaining the quote, CaroMont then began looking for alternatives because of the price of the job and logistics of getting the old tank out and new one in. Texchine Inc. proposed a promising alternative, ozone laundering, that offers the ability to launder using primarily ambient temperature water plus ozone, thus avoiding the need for the new hot water storage tank and heating coil. Once the initial R-O-I comparisons between the two alternatives were received it was obvious that ozone laundering presented the most beneficial long term rewards. It was then just a matter of gaining approval of the ozone laundering plan from the senior leadership at Caromont Health.

The hospital asked CaroMont Health to oversee the supply, installation, initial operation of an ozone laundry system retrofit onto each of the six washer-extractors located within the laundry room of the hospital. CaroMont also was asked to oversee the monitoring of the performance of these ozone laundering systems to gather energy and cost savings data from which to calculate a return-on-investment (R-O-I) figure. The ozone laundering systems were installed and began operation in early July, 2010.

Facilities and Equipment Employed

In the Gaston Memorial Hospital laundry room are four Braun Commercial Washers, each capable of handling 450 lbs of laundry per wash, and two 125 lbs per wash Continental Commercial Washers. At any health care facility, much of the laundry is considered light to medium soiled and a smaller percentage is heavily soiled. A significant fraction of laundry at this hospital is classified as medium to lightly soiled. Consequently, the two 125 lbs Continental washers are used for the heavier soiled laundry while the four larger Braun washers handle the medium to lightly soiled laundry. Thirty-seven (37) loads per day are laundered on the average, equating to 10,500 lbs per day of laundry.

The ozone system installed for this study is the EcoTex system manufactured by Clearwater Tech, LLC (San Luis Obispo, CA), consisting of one ECO2 ozone generator (maximum ozone output rating of 8 g/h at 3% concentration by weight), designed for smaller washers that handle the heavier soiled laundry, and two ECO4 ozone generators (maximum ozone output rating of 27 g/h at 6% concentration by weight), designed for larger washers that handle the light to medium soiled laundry. Each ozone generator is connected to a pair of washing machines -- the smaller ECO2 ozone generator being connected to the two 125-pound Continental washers. Each ozone generator is supported by an appropriately sized Sequal Technologies Workhorse 8c Oxygen Concentrator (to dry and concentrate oxygen from ambient air which is then fed to the ozone generator itself).

Three AeroQual 100 Ambient Air Ozone Monitors are mounted appropriately in the washer room close to each ozone generator and its piping that feeds this gas to its pair of washing machines. These ambient air ozone monitors serve three functions to ensure that laundry room workers are not exposed to potentially harmful concentrations of ambient ozone:

1. Detect any ozone that might appear in the room by leaking from any of the six washers. Should any of the ozone monitors detect ambient ozone concentrations above the current OSHA-specified Maximum Exposure Level (0.08 ppm) the ozone generator closest to that monitor is automatically shut down, thus ceasing the generation of ozone.

2. Detect any ozone that might appear in the room due to some catastrophic accident to any ozone generation or delivery system -- such as a wrench dropping on an ozone delivery pipe and causing a break in the piping. In such an event, the ozone generator is shut down, again ceasing the generation of ozone.

3. Provide positive feed-back control information to the ozone generator, essentially telling the ozone generator "keep working, all is well". To provide this function, the ozone generator MUST receive positive feedback (absence of ozone above the alarm set-point) at all times from the ambient ozone sensor in order to function, thus providing fail-safe operation.

In addition to the fail-safe ambient laundry room air ozone concentration monitoring, two other precautions are built into this hospital laundry room employing ozone:

1. Each ozone generation system is provided with a cooling fan, designed to move air around the vicinity of the ozone generation equipment at ca 100 cfm (cubic feet per minute), primarily to provide ambient air to the oxygen concentrator. By itself, this amount of laundry room air circulation (ca 100 cfm) will serve to bring

extraneous ozone that may be present to one or more of the three ambient air ozone monitors for detection, evaluation, and rapid shutdown in case of abnormal ozone leakage.

2. Laundry rooms often are the highest rated room for air exchanges in a facility housing any type of on-premises laundry systems, requiring as many as 10 exchanges per hour, by code (ANSI/ASHRAE/ASHE Standard 170, 2010 -- Tinker, 2010). A very significant benefit of these code-required air exchanges is that if an abnormal ozone leak were to occur, the total room air volume will be turned over quickly (10 times per hour by code), thus evacuating any extraneous ozone present in the occupied space. Caromont Health has decided to require 18.5 air changes per hour in the laundry room at Gaston Memorial Hospital, 8.5 more than required by the ANSI/ASHRAE/ASHE code. This increased volume of air has been provided to compensate for the make-up air required by the laundry dryers. This number of air changes per hour will reduce even high concentrations of accidentally leaked ozone to insignificant and perhaps even unmeasurable levels in a matter of a few minutes or possibly even seconds.

Figure 1 shows a schematic diagram of one of the three ozone generation systems connected to each of two laundry washing machines as installed in the Gaston Memorial Hospital laundering room. Each of the three systems consists of an oxygen concentrator, ozone generator, two laundry washers, and an ambient air ozone monitor/controller. The schematic is appropriate to the three units consisting of one ozone generation subsystem connected to two washers at the Gaston installation regardless of the sizes of the ozone generators or the sizes of the washers.

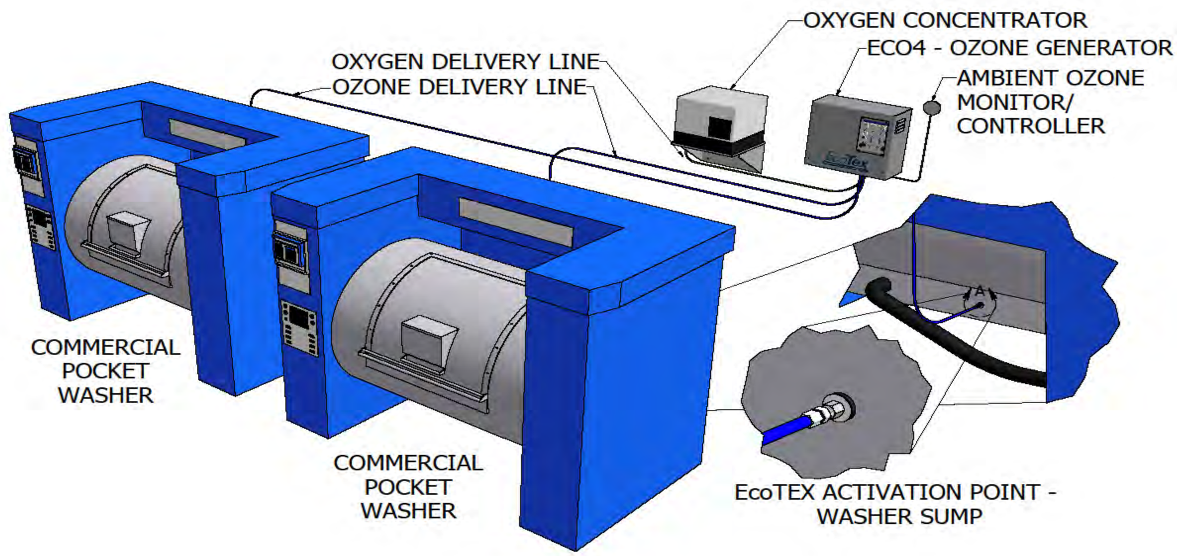

Figure 1. Schematic diagram of one of the three ozone system installations at the Gaston Memorial Hospital laundry facility.

Figure 2 is a schematic diagram of the laundry washroom at Gaston Memorial Hospital, showing the six washers and the positioning of the ozone subsystems within the room.

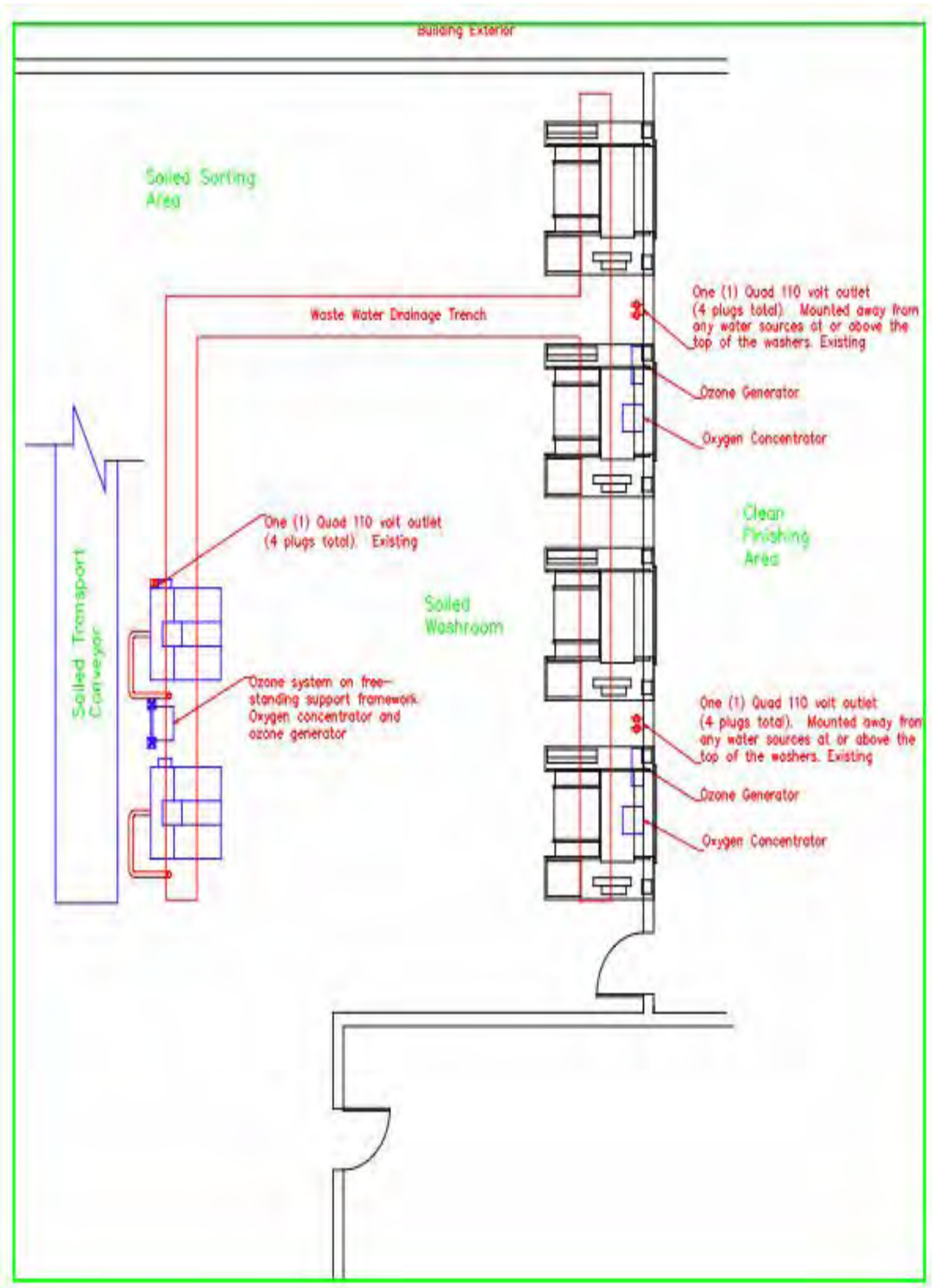

Figure 2. Schematic of Gaston Memorial Hospital laundry washroom.

Figure 3 shows the EcoTex™ ozone generation and supply equipment positioned above two of the Braun Washers.

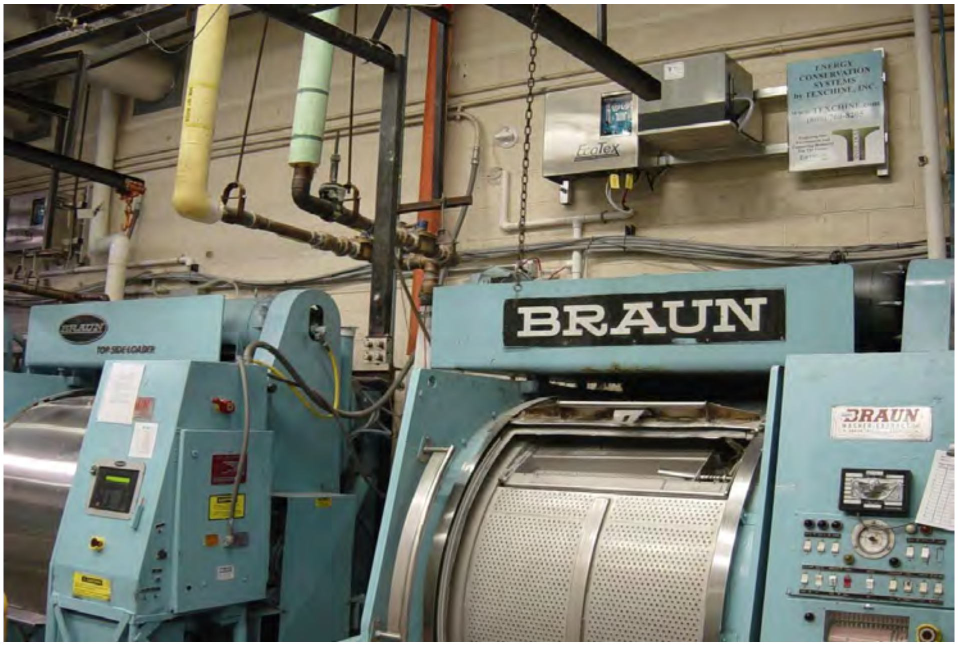

Figure 3. EcoTex™ ozonation equipment (wall-mounted) above two Braun Washers.

Cycle Changes Made for Ozone Laundering

Once the installation of ozone equipment had been completed, a new set of wash programs was created and entered into the washing machine controllers. All of the wash programs at this laundry were modified as a result of installing ozone, and each of the loads processed daily contributes to the accumulated cost savings. These new programs eliminated the need for hot water in most of the washing steps and reduced the rinse cycle times.

Table 1 shows a comparison of the before and after ozone installation data obtained during the first five months of operation for the laundering of various linen categories. Specific data presented are for wash cycle times, gallons of water per wash load and the therms of energy required for heating water used for laundering. Note that in all wash categories, the magnitude of the numbers is almost always lower following installation of ozone laundering. These reductions in cycle time, water used, and particularly the therms used for water heating will be translated into dollar cost savings below.

Commodities/Consumables Used

Consumables used with each major category of laundered item are shown in Tables A1-A8 in the Appendix. The amounts required for each laundry category are essentially the same before and after the installation of the ozone system, except for the lowered amounts of alkali and a slight increase in detergent. A more significant change resulting from switching to ozone laundering was the elimination of the CO_2 injection system used in the conventional process to lower the pH of discharged wastewaters below a maximum of 9.5 specified by the City of Gastonia. The use of ozone has lowered the amount of alkali required to adjust pH to 9.5 in one or two of the wash steps. The overall result is that the pH of the accumulated wastewaters from the laundering operation no longer exceeds 9.5, thus eliminating the need for reducing the pH level of discharged laundry wastewaters, which had been accomplished prior to ozone treatment being installed by addition of carbon dioxide to the combined laundry wastewaters.

Washroom chemistries remain the same and no additional operating costs have been experienced since the introduction of the ozone system. Caromont laundry management is monitoring the potential savings in linen replacement. However, this will require at least 12 months to identify the impact or improvement in this aspect and to quantify specific dollar savings.

Table 1. Before and After Ozone Comparison of Ozone Laundering at Gaston Memorial Hospital -- first five months of operation

WASHING FORMULAS -------- COMPARISON DATA

		Previous Parameters Per load washed			Parameters with Ozone Per load washed			
Wash Category	Average number of Loads per day	Cycle Time Minutes	Water per Load Gallons	Water Heating Therms	Cycle Time Minutes	Water per Load Gallons	Water Heating Therms	Percentage Reduction of Therms
Bed Sheets	9	39	853	10	36	755	4	62%
Patient Gowns	4	49	995	9	46	853	4	59%
Bed Pads	4	75	1377	14	60	1279	5	62%
New Linens	1	31	740	7	29	598	2	70%
Blankets/Spreads	7	38	897	7	38	897	2	67%
Bath Towels	8	51	995	9	48	853	3	63%
Stain Wash	2	76	1377	14	73	1235	9	32%
Microfibre Mops	2	38	799	6	38	799	3	50%

Note!
Water and Therms have been rounded in the above numbers.
Loads per day have been rounded in the above numbers.
New Linens are any type of textiles being introduced into the "in use" linen inventory.
Stain Wash is a re-wash formula to process goods a second time to remove any heavy stains.
Microfibre Mops are used in janitorial functions throughout the Hospital facility.
Number of loads per day per category can change based on patient occupancy level.

This table shows that after installation of ozone:

1. the cycle times (except for Microfibre Mops) were lowered by a few minutes depending on the wash category,
2. the volume of water used per load (except for Microfibre Mops) was reduced,
3. of greatest significance, the numbers of water heating therms for all categories were reduced.

Note: Cycle times for microfibre mops were not reduced after installation of ozone because these items usually contain very heavy soil contents. Additionally, the daily quantity of such mops laundered is rather low.

Results and Benefits Obtained From Ozone Laundering

Many tables of washing formula "before and after installation of ozone" data have been compiled and are presented in the Appendix. The major findings of these tables are presented and discussed in the main body of this report.

The installation of ozone in the Gaston Memorial Hospital laundry facility has resulted in six significant performance benefits:

1. Cost Savings; Calculation of Return-On-Investment
2. Significantly Improved Laundered Product Qualities,
3. Better Sanitation (Microorganism Kill/Inactivation) in the Linen,
4. Lowered Impacts on the Environment,
5. Reduced Radiant Heat in the Wash Room, and
6. Decreased Wash Times, Allowing Increased Throughput of Laundry and Redistribution of Laundry Labor.

COST SAVINGS

The cost savings obtained after collecting five months of operation of the new EcoTex ozone system have been projected on an annualized basis in order to provide an apparent R-O-I figure. This is a reliable projected extrapolation because the patient/services volume and other variables at Gaston Memorial Hospital stay very constant throughout the year.

1. **Reduced Consumption of Natural Gas**

Table 1 shows that the installation of ozone laundering resulted in a significant reduction in the number of therms required to heat water for all items laundered. In actuality, on the very first day of operating the newly installed ozone laundering system, the laundering staff was satisfied within a few hours that laundering with ambient temperature water was providing acceptable quality washed linens. The staff then instructed Hospital Engineering to shut off the steam valve feeding the hot water tank and to date, there has not been a need to turn the steam valve back on.

Figure 4 is a photo of the temperature gauge installed on the water supply line feeding the Gaston laundry room washers. During operation of the conventional laundering process, this gauge was set at 160˚F (71˚C). Since installing ozone, the water temperature is lower for much of the washing cycles. The reading of this gauge shown in the photo is 56˚F (13˚C) and was taken in early February 2011. This is ground water temperature from the city and subject to change based on ambient temperature changes during the seasons.

Savings in natural gas have been significant (more than 61%) as shown in Figure 5.

2. **Reduced Consumption of Fresh Water**

When the ozone laundering system was installed at Gaston Memorial Hospital, new washing formulas were programmed into the control equipment which reduced the number of rinse cycles in most of the wash programs. In turn, this change reduced the fresh water consumption. Water savings experienced as a result (more than 14%) are shown in Figure 6.

Figure 4. Laundry water feed line temperature gauge,
after installation and operation of ozone laundering system.

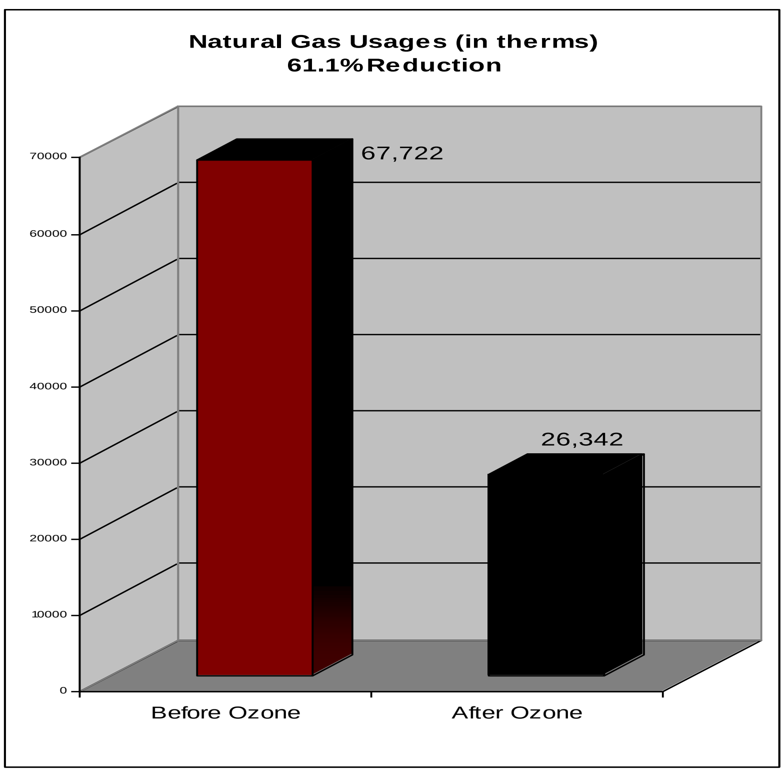

Figure 5. Natural gas reductions at Gaston Memorial Hospital due to ozone usage.

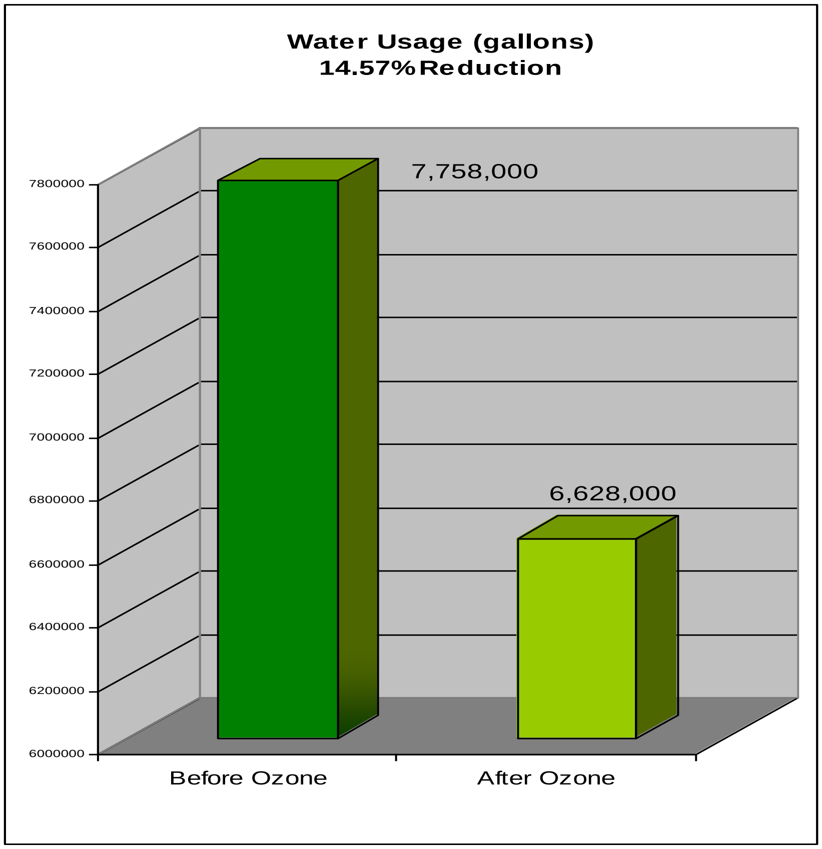

Figure 6. Reductions in water usage at Gaston Memorial Hospital.

3. **Reduced Consumption of Electricity**

Reducing the number of rinse cycles means that the washers are in operation for shorter time periods, thereby reducing the amount of electricity consumed. Savings from reduced electricity consumption have totaled more than 13% (see Figure 7).

4. Elimination of Carbon Dioxide for pH Lowering

Costs for applying CO_2 to wastewaters from the old laundry process that were discharged to the Gastonia wastewater treatment plant were $6,000. This need for CO_2 has been eliminated by the use of ozone, and an additional $6,000 of annual expense is being saved.

Two of the steps (flush and break) for laundering of textiles require addition of alkali to bring the wash water in the laundering machines up to 10.5 to 11. When discharged from the washing machines, wastewaters from the laundry are combined prior to discharge and the pH is measured because the City of Gastonia specifies a maximum wastewater discharge pH of 9.5. Before the ozone system was installed, considerable carbon dioxide was required to ensure that the combined wastewater stream did not exceed the specified pH level of 9.5.

Following installation of ozone laundering systems, the amount of alkali for most of the wash formulas has been reduced in order to lower wash water to pH 9.5. Moreover, combined laundry room wastewaters over the first five months after ozone installation now average pH 9 and the necessity for addition of carbon dioxide has been eliminated.

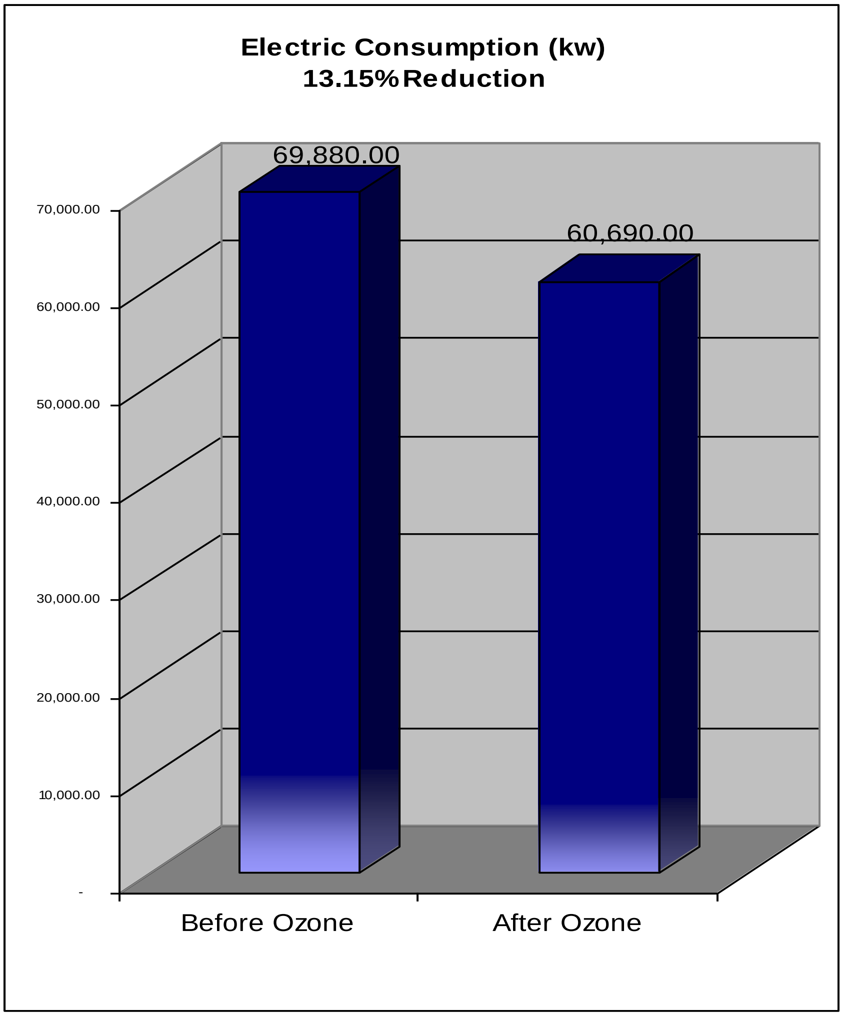

Figure 7. Electricity consumption at Gaston Memorial Hospital after ozone installation.

5. Labor and Production Savings

One of the most interesting benefits found in this (Gaston Memorial Hospital) study is that of labor and/or production savings, which also can be quantified as facility efficiency. This efficiency can be equated to the overall reduction of cycle time saved by the ozone laundry system. This does not necessarily mean that the facility now pays less in staff labor, but rather that the staff now is available to perform other housekeeping duties that can be charged to different hospital projects thereby accounting for their time spent in different activities. Another significant consideration is that the existing laundry facility will be able to absorb additional workload as the Health System expands with future population growth, but without additional capital investment.

The efficiencies of less water and fewer rinsing cycles resulting from ozone laundering have allowed the Gaston Memorial Hospital the luxury of being able to launder nearly 1,071 more loads per year than with their traditional wash cycles.

Savings Summation

The evaluation and addition of the Ozone Injection System to the washroom operation at Gaston Memorial Hospital laundry was undertaken with the objective of improving operational efficiency, reducing utility consumption, reducing costs and serving the Hospital's "Green" objectives of saving money and helping reduce its impact on the environment. Some of the benefits of this system have been realized in the savings shown in Table 2.

Table 2. Gaston Hospital Laundry - Projected Annual Savings Summation

Category	Annual Reduction	Annual Volume Reduction	Units	Cost per Unit	Annual Savings
Natural Gas[1]	61.10%	41,380	Therms	$0.7740	$32,029
Fresh Water[2]	14.57%	1,130,000	Gallons	$0.0058	$6,554
Sewer Discharge[3]	14.57%	1,084,800	Gallons	$0.0058	Included in water savings[6]
Electricity[4]	13.15%	9,190	kWh	$0.0600	$551
Washer Operational Time[5]		1,232	Hours		Labor is not eliminated
Linen Rewash @ 3%[7]	1.50%	48,000	Pounds	$0.2000	$965
CO_2 Injection to Effluent[8]	100%		Monthly Rent Fee	$500/month	$6,000
				Total of all Savings	**$ 46,099**

NOTES:

1. Reduced consumption of gas for generating steam used for heating of hot water
2. Reduction in number of baths in various wash formulas
3. Reduction in effluent volume by decreasing fresh water consumption
4. Reduction in electricity consumption resulted in shortening wash formulas
5. Shortening wash formulas results in less washer extractor run times, allowing greater poundage output or reassignment of washroom labor
6. Savings not assigned as labor is not eliminated. Would allow additional washroom production of ca 450,000 pounds of laundry annually
7. Rewash reduction has reduced double handling, reduced machine run time, and reduced utility consumption
8. CO_2 injection system was used to regulate wastewater pH level of wastewater; system has been eliminated

6. Calculation of Return On Investment

Ozone laundry systems not only provide microbiological benefits, but through reduced cycles times, water, and energy, they can also pay for themselves and typically within short time periods. As shown in Figures 5, 6 and 7, the ozone laundry system has saved the Gaston Memorial Hospital about 6.0% of the annual overall recorded costs related to the washing of linens in their laundry facility. These savings of approximately $3,833 per month or $46,000 annually paid for the ozone laundering system in approximately 16 months.

The rate of return on a system such as this may increase dramatically through cooperation with state and local energy providers and water companies, who provide grants, rebates and other incentives to facilities that install energy and water saving technologies and equipment.

IMPROVED PRODUCT QUALITIES OBTAINED BY OZONE LAUNDERING

Less tangible, but additional benefits, also have been shown as a result of applying ozone to the washroom process -- these are as follows:

1. Improved Smell of the Cleaned Linen

It is well-known within the health care industry that when linens are laundered by conventional procedures, occasionally some laundered linens may exude a slight off-odor. Thanks to ozone laundering, that occasionally-encountered odor has been eradicated over the several months of initial use. Ozone seems to be providing a fail-safe method of odor-elimination.

2. Improvement in Whiteness Appearance

An observation made by the laundry staff at Gaston Memorial Hospital who process and dispatch linen each day to the various departments of the Hospital is that the whiteness of all ozone-laundered linens has improved from pale-white to stark white. Although these statements are not quantifiable, the increased whiteness of laundered materials has a distinctly positive impact upon presentation to patients and nursing staff, as shown by the photographs below (Figures 8 -10) showing the whiteness of pillow cases, towels, and blankets after installation of ozone washing.

Figure 8. Gaston laundry pillow cases on assembly conveyor -- after ozone washing.

Figure 9. Hospital towels after ozone laundering

Figure 10. Hospital blankets being discharged from an automatic folder after ozone laundering.

3. Textile Life Extension

The combination of shorter wash cycle times plus lowered chemical requirements obtained through ozone laundering results in less rinsing, thus lowering the time in "mechanical action" in the washer of textile fibers as they are laundered. Additionally, ozone is believed to better open the soiled cloth fibers thus allowing improved adsorption of laundering chemicals and release of soils into the wash water. In turn, this reduces the rate of breakdown of (especially) cotton fibers, thus extending the life of laundered textiles, in turn reducing the cost of linen replacement. However, this benefits can only be considered as an "anticipated benefit" as of this writing, since the ozone system has not been in operation at the Gaston Memorial Hospital long enough for this benefit to quantified as yet.

IMPROVED SANITATION (MICROORGANISM KILL/INACTIVATION) IN LINENS

The ozonation system installed at Gaston Memorial Hospital is of the same basic design (ozone diffusion principle of adding ozone directly to the sump water in the washer throughout each laundering cycle step that involves the addition of water) as evaluated in studies conducted in the United Kingdom and reported by Cardis et al., 2007; Reid et al., 2007; Rice et al., 2009a, 2009b; Allison et al., 2009. As a result of the demonstrated increased microbiological kills, the United Kingdom's Health Protection Agency in September 2009 approved the use of the direct diffusion method of adding ozone to laundry washer water with the following wording (Rice et al., 2010):

> "September 09 **JLA Ltd** – OTEX Laundry System
>
> **Basic research and development, validation and recent in use evaluations have shown benefits that should be available to NHS bodies to include as appropriate in their cleaning, hygiene or infection control protocols. (recommendation 1)**
>
> *This product is a commercial laundry system that uses ozone in all of the wash cycles*
>
> *Evidence shows that it is more effective in decontamination than current laundry systems."*

Based on this approval of this ozone laundering system design, the Gaston staff believes that the same improvements in microbiological benefits found during the UK evaluations and studies and in UK hospitals and healthcare facilities are to be anticipated.

LOWERED IMPACTS ON THE ENVIRONMENT

1. **Decreased amounts of chemicals flushed to the sewers.**

Because ozone performs some of the functions of some laundering chemicals (oxidation, some bleaching), when converting to ozone laundering, some savings in chemicals can be expected (up to about 20% -- Rice et al., 2009a). The Gaston facility recognized very little reduction in chemicals as a result of installing ozone. Therefore, data on chemicals savings has not been included in this report. Gaston Hospital's laundry management has been very diligent about chemical utilization and had kept chemical use to a very tight minimum even before installing ozone. With the addition of ozone, the volume of alkali required has been reduced and this has helped to lower pH levels. However, a slight increase in detergent has been applied to maintain wash quality requirements and the net result is relatively little change in the use of chemicals before and after ozone installation.

2. **Reduced Volume of Laundry Wastewaters Discharged.**

Less water required for the washers per cycle has resulted in decreased volumes of wastewaters that are discharged to waste, which results in less loading entering the local sewage treatment facility. In turn, this reduces the wastewater discharge fees charged to the laundry.

3. **Reduced Overall Carbon Footprint of the Gaston Laundry Operation.**

By no longer having to heat the water to sanitize the linen, the Gaston Memorial Hospital now burns less natural gas to make steam. By burning less natural gas, less carbon dioxide is emitted into the atmosphere, in turn reducing the organization's overall carbon footprint. Similarly, elimination of CO_2 formerly discharged into laundry wastewaters also lowers the carbon footprint.

4. **Lowered Wastewater pH Level**

In the initial wash programs, before ozone was installed, the specified quantities of alkali raised the pH level to a range of 10.5 to 11.0 to meet wash quality objectives. As described earlier, as a result of installing ozone, considerably less alkali now is required to elevate the pH to 9.5 in two of the laundering steps (flush and break). Prior to installing ozone, it was necessary to treat the combined laundry wastewaters with carbon dioxide to lower their pH levels below 9.5. However, following the installation of ozone and the consequential reduction in alkali dose, the pH of the combined laundry wastewaters now averages 9, and the necessity for addition of carbon dioxide has been eliminated.

REDUCED RADIANT HEAT IN WASHROOM AREA

The laundry facility is divided into two primary areas, the finishing/dispatch area (Clean Side) and the soiled linen washroom area (Soiled Side). The body of the washers are housed in the Soiled Side and when using mostly hot water there is radiant heat generated from the body of the washer which must be overcome by the air conditioning system. Although specific studies have not been conducted to determine energy savings, the staff sorting and washing linens have noticed a considerable drop in the ambient air temperature and also a drop in the amount of vapor emitted from the drainage trenches. Overall a more comfortable environment exists for the Soiled Side staff.

DECREASED WASH TIMES

In this facility the primary focus for adding ozone was reduction in energy and very little reduction in chemistry. The resulting benefits of ozone in combination with established doses of chemicals has resulted in a lower rewash volume because of the improved wash quality. This reduction has varied between 1.5% and 2.5% depending on the mix of linen for any given day. Reduction in rewash means that some of the linens have a potentially longer life if they are not subjected to the wear and tear caused by chemistry, washing and drying. Lower rewash also means less consumption of utilities and labor, allowing some members of the laundry staff to be assigned temporarily to other duties.

Summary

Ozone generating equipment was retrofit into the laundry washroom of the Gaston Memorial Hospital in Gastonia, NC, and began operating in the early part of July, 2010. Since installing this ozone system, the laundry has realized $46,000 per year savings in utility costs as well as reduction in water consumption of more than one million gallons per year, and lower wastewater discharge fees. In addition, the ozone-washed linens are cleaner and brighter than ever and the rewash rate has been reduced by 1.5%. The apparent Return-On-Investment (R-O-I) of this ozone laundering system, calculated on the basis of just these benefits cited, is 16 months.

Acknowledgements

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APPENDIX

Performance Tables -- Laundering Cycles Before Ozone Laundering and After

In this Appendix are eight tables of laundering steps and parameters (laundry formulas) before and after installation of ozone laundering equipment for washing of specific items:

Table A-1 - Pads,
Table A-2 - Blankets/Spreads,
Table A-3 - Linen,
Table A-4 - Gowns,
Table A-5 - Towels,
Table A-6 - Sheets,
Table A-7 - Rewash formula for Stain Removal
Table 8-A - Microfibre Mops

Data obtained over the first five months of operation support the statements made in the body of the document.

All Appendix tables show the significant reduction in hot water therms required as a result of ozone being added to the Gaston Laundry. These therm data benefits from installing ozone laundering are summarized in Table 1 and Figure 5 of the paper. Other effects observed upon switching to ozone laundering are discussed under each type of item laundered.

TABLE A-1 -- PADS

1. The number of laundering steps has been reduced from 22 to 20.

2. On the other hand, Cycle Time was reduced from 75 minutes before ozone to 60 minutes with ozone.

3. The amount of alkali required to increase the pH to 9.5 is reduced in the flush step (#1) from 36 oz to 28 oz, and in the break step from 120 oz to 100 oz. However, the amount of detergent required in the break step increased from 27 oz before ozone to 37 oz after ozone to off-set the reduction in alkali.

4. The amount of chlorine required in the bleach step was the same, 84 oz, before and after ozone. This was required to maintain stain removal standards.

5. The amount of sour required in the Sour step decreased from 8 oz to 6 oz after ozone -- because of the reduced amount of alkali required.

6. Total Water Volume was reduced from 1,377 gal before ozone to 1,279 gal after ozone by eliminating one rinse and one drain step.

TABLE A-2 -- BLANKETS/SPREADS

1. Number of cycle steps remains the same (14) before and after ozone.

2. Total cycle time remains the same (38 minutes) before and after ozone.

3. The amount of alkali required to raise the pH to 9.5 in the break step fell from 28 oz before ozone to 20 oz with ozone. Also, the amount of detergent used in the break step before ozone was 20 oz and 16 oz after ozone.

4. Sour and softener (in the sour step) each were reduced from 6 oz before ozone to 5 oz after ozone was installed.

5. Total water volume was the same before and after ozone.

TABLE A-3 -- NEW LINENS

1. The number of cycle steps was reduced from 12 before ozone to 10 after ozone (eliminating one rinse and one drain step.) Total cycle time was reduced from 31 min to 29 min following ozone installation.

2. The amount of alkali required to raise the pH to 9.5 in the break step decreased from 20 oz before ozone to 16 oz after ozone.

3. The amount of detergent added before ozone (15 oz) increased to 16 oz after ozone installation.

4. The amount of sour decreased from 6 oz before ozone to 4 oz after ozone.

5. Water volume was reduced from 740 gal before ozone to 598 gal after ozone was installed.

TABLE A-4 -- GOWNS

1. The number of cycle steps decreased from 16 before ozone to 14 after ozone was installed, eliminating one rinse and one drain step.

2. Cycle time was reduced from 49 to 46 minutes after ozone addition, reflecting the time saved by eliminating the two cycle steps.

3. The amount of alkali required to raise the pH to 9.5 decreased in the flush step from 20 oz before ozone to 16 oz after ozone, and in the break step from 48 oz before ozone to 32 oz after ozone.

4. Detergent added in the break step was lowered from 20 oz to 18 oz after ozone.

5. Chlorine use in the bleach step remained the same, 36 oz, before and after ozone to maintain stain removal standards.

6. Water volume was reduced from 995 gal before ozone to 853 gal after ozone was installed.

TABLE A-5 -- TOWELS

1. The number of cycle steps was reduced by two steps -- one drain and one rinse step. The cycle time was reduced accordingly by 3 minutes, from 51 to 48 minutes after ozone was installed.

2. The amount of alkali required to raise the wash water pH in the flush and break steps to 9.5 was reduced from 28 oz before ozone to 20 oz after ozone in the flush step, and from 92 oz to 80 oz in the break step,

3. On the other hand, the amount of detergent in the break step increased from 20 oz before ozone to 28 oz after ozone installation to offset the reduction in alkali.

4. The amount of chlorine added in the bleach step was the same, 56 oz before and after ozone, to maintain stain removal standards.

5. Water volume was reduced from 995 gal before ozone to 853 gal after ozone was installed

TABLE A-6 -- SHEETS

1. The number of cycle steps was reduced from 15 before ozone to 13 after ozone was installed. After ozone was installed, one rinse and one drain step were removed. Total cycle time was reduced from 39 min to 36 min after ozone installation.

2. The amount of alkali required in the break step before ozone was installed was 28 oz; this remained the same after ozone was installed.

3. The amount of sour required to lower the pH to 7.0 dropped from 6 oz before ozone to 5 oz.

4. Detergent was increased from 20 oz before ozone to 28 oz after ozone. Chlorine dose in the bleach step remained the same after ozone was installed to maintain stain removal standards.

5. Water volume was reduced from 853 gal before ozone to 755 gal after ozone was installed.

TABLE A.7 -- REWASH PROGRAM FOR STAIN REMOVAL (all laundered categories)

1. The number of cycle steps was reduced from 22 to 20 after ozone was installed because a rinse and drain step could be eliminated.

2. Elimination of two cycle steps also resulted in a reduction of total washing time from 76 to 73 minutes and a reduction of 142 gallons of water (from 1,377 gallons before ozone to 1,235 gallons).

3. Hot water therms were reduced from 14 to 9 following ozone installation. This resulted from water temperatures being reduced in all rinse steps following the break.

4. In the break step, alkali required dropped slightly, from 40 oz before ozone to 38 oz after ozone; however the alkali required in the break step remained the same, as did the detergent in the break step.

TABLE A.8 -- MICROFIBRE MOPS

1. Because microfibre mops usually contain very heavy soil contents and because the daily quantities of such mops laundered has been low, the cycle time for laundering microfibre mops was not reduced after ozone was installed. As a result,

2. Water volumes before and after ozone installation remain the same.

3. On the other hand, heating therms were reduced 50%, from 6 prior to ozone being installed, to 3 following ozone installation.

CONCLUSIONS FROM APPENDIX DATA (5 Months) SUMMATIONS

Effects of Ozone on Number of Cycle Steps

In many, but not all, laundering cycles, a rinse and drain step can be eliminated.

Effects of Ozone on Laundering Cycle Times

Drain steps require one minute and rinse steps typically require two minutes. Thus, three minutes (less than 10%) of overall cycle time can be saved for most items laundered. For pads, 14 minutes were saved, representing about 20% in total cycle time.

Effects of Ozone on Amounts of Alkali Required to Elevate pH to 9.5 in Flush and/or Break Steps

Except for sheets, ozone laundering reduces the amount of alkali required to be added by about 35%.

Effects of Ozone on Amounts of Detergents Required

No clear pattern was observed in this laundering parameter. With pads, new linen, towels and sheets, increases in detergent addition were required after ozone installation. However with the other categories, slightly less detergent was required following ozone installation. After a considerable amount of test washing these quantities were established based on an acceptable level of results approved by CaroMont Health's Laundry Management.

Effects of Ozone on Amounts of Sour Chemicals Required

The amount of sour added before ozone was 6 oz for all categories reported, except for Stains and Microfibre Mops that do not have sour steps. This requirement dropped to either 5 or 4 oz of sour for all six categories. This result is to be expected, since the amount of sour required to lower pH is dictated by the amount of alkali required to adjust the pH to a level of 9.5.

A reasonable explanation for this apparently conflicting result is that the use of ozone in laundering is claimed to open fibers better than they are opened by conventional laundering procedures. Consequently, rinsing of soils and added chemicals (such as alkali) becomes more effective, and the amount of sour required to lower pH levels following the alkali and bleaching steps is the same or even slightly lower, as has been observed in this installation.

Effects of Ozone on Amounts of Chlorine Bleach Required

Chlorine bleach has been required only in the laundering of pads, gowns, towels, sheets, and rewash for stain removal. These categories used the same amount of bleach before as well as after ozone was installed.

Effects of Ozone on Water Volumes

Use of ozone laundering has allowed the elimination of at least one rinse and drain step in most of the cycles for which data are reported. Elimination of these two steps results in about 12-15% less water being required. A compelling reason for this reduction in water is the ability of ozone to better open linen fibers during laundering, allowing more effective rinsing to occur. Specific water volume cost savings obtained by the use of ozone are quantified in Figure 6 and Table 2 of this paper.

Effects of Ozone on Heating Water Therms

In all cases, ambient temperature water can be used with ozone laundering, except in a few bleaching (steam) steps. Total savings in natural gas at this facility are quantified in Figure 5 and Table 2 in the main body of this paper.

Table A-1. Pad Laundering Results, Before Ozone (top) and After Ozone (bottom)

TABLE A-1. PADS

Pads	Old Cycle																						
Fill #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Totals
	Flush	Drain	Flush	Drain	Break	Drain	Rinse	Drain	Rinse	Drain	Bleach	Drain	Rinse	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shake	
Time (min)	5	1	2	1	15	1	5	1	2	1	16	1	2	1	2	1	2	1	5	1	8	1	75
Water Level (in)	13		13		7		7		13		7		13		13		13		7				
Water Temp (F)	100		120		165		160		150		155		130		110		90		90				
pH																							
Alkali (oz)	36				120																		
Detergent (oz)					27																		
Chlorine (oz)											84												
Sour (oz)																			8				
Softener (oz)																							
Volume (gallons)	275		142		98		98		142		98		142		142		142		98				1377
Hot Water (therms)	2		1		2		2		2		1		2		1		1		1				14

Pads	New Cycle Using EcoTex Ozone System																						
Fill #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20			
	Flush	Drain	Flush	Drain	Break	Drain	Rinse	Drain	Rinse	Drain	Bleach	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shake			
Time (min)	5	1	2	1	14	1	2	1	2	1	8	1	2	1	2	1	5	1	8	1			60
Water Level (in)	13		13		7		7		13		7		13		13		7						
Water Temp (F)	95		120		120		86		86		140		86		86		86						
pH level desired	9.5				9.5																		
Alkali (oz)	28				100																		
Detergent (oz)					37																		
Chlorine (oz)											84												
Ozone.....(min)	5		2		14		2		2		0		2		2		5						
Sour (oz)																	6						
Softener (oz)																							
Volume (gallons)	275		142		98		98		142		98		142		142		142						1279
Hot Water (therms)	2		1		1		0		0		1		0		0		0						5

Table A-2. Blankets/Spreads Laundering Results, Before Ozone (top) and After Ozone (bottom)

TABLE A-2. BLANKETS/SPREADS

Blankets/Spreads	Old Cycle														
Fill #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Totals
	Flush	Drain	Break	Drain	Rinse	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shakeout	
Time (min)	2	1	10	1	2	1	2	1	2	1	5	1	8	1	38
Water Level (in)	13		7		13		13		13		7				
Water Temp (F)	100		155		130		110		90		90				
pH															
Alkali (oz)			28												
Detergent (oz)			20												
Chlorine (oz)															
Sour (oz)											6				
Softener (oz)											6				
Volume (gallons)	275		98		142		142		142		98				897
Hot Water (therms)	2		1		2		1		1		1				7

Blankets/Spreads	New Cycle Using EcoTex Ozone System														
Fill #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
	Flush	Drain	Break	Drain	Rinse	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shakeout	
Time (min)	2	1	10	1	2	1	2	1	2	1	5	1	8	1	38
Water Level (in)	13		7		13		13		13		7				
Water Temp (F)	90		120		86		86		86		86				
pH level desired			9.5								7.0				
Alkali (oz)			20												
Detergent (oz)			16												
Chlorine (oz)															
Ozone.....(min)	2		10		2		2		2		5				
Sour (oz)											5				
Softener (oz)											5				
Volume (gallons)	275		98		142		142		142		98				897
Hot Water (therms)	1		1		0		0		0		0				2

Table A-3. New Linen Laundering Results, Before Ozone (top) and After Ozone (bottom)

TABLE A-3. NEW LINEN

New Linen	Old Cycle													
Fill #	1	2	3	4	5	6	7	8	9	10	11	12		Totals
	Break	Drain	Rinse	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shakeout		
Time (min)	6	1	2	1	2	1	2	1	5	1	8	1		31
Water Level (in)	7		13		13		13		7	0	0	0		
Water Temp (F)	150		130		110		90		90	0	0	100		
pH														
Alkali (oz)	20													
Detergent (oz)	15													
Chlorine (oz)														
Sour (oz)									6					
Softener (oz)														
Volume (gallons)	216		142		142		142		98					740
Hot Water (therms)	3		2		1		1		1	0	0	0	0	7

New Linen	New Cycle Using EcoTex Ozone System													
Fill #	1	2	3	4	5	6	7	8	9	10				
	Break	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shakeout				
Time (min)	6	1	2	1	3	1	5	1	8	1				29
Water Level (in)	7		13		13		7							
Water Temp (F)	120		86		86		86							
pH level desired	9.5						7.0							
Alkali (oz)	12													
Detergent (oz)	16													
Chlorine (oz)														
Ozone…..(min)	6		2		3		5							
Sour (oz)							4							
Softener (oz)														
Volume (gallons)	216		142		142		98							598
Hot Water (therms)	2		0		0		0							2

Table A-4. Gown Laundering Results, Before Ozone (top) and After Ozone (bottom)

TABLE A-4. GOWNS

Gowns	Old Cycle																
Fill #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Totals
	Flush	Drain	Break	Drain	Bleach	Drain	Rinse	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shake	
Time (min)	5	1	8	1	9	1	2	1	2	1	2	1	5	1	8	1	49
Water Level (in)	13		7		7		13		13		13		7				
Water Temp (F)	100		160		160		130		110		90		90				
pH																	
Alkali (oz)	20		48														
Detergent (oz)			20														
Chlorine (oz)					36												
Sour (oz)													6				
Softener (oz)													6				
Volume (gallons)	275		98		98		142		142		142		98				995
Hot Water (therms)	2		2		2		2		1		1		1				9

Gowns	New Cycle Using EcoTex Ozone System																
Fill #	1	2	3	4	5	6	7	8	9	10	11	12	13	14			
	Flush	Drain	Break	Drain	Bleach	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shake			
Time (min)	5	1	8	1	9	1	2	1	2	1	5	1	8	1			46
Water Level (in)	13		7		7		13		13		7						
Water Temp (F)	90		120		140		55		55		55						
pH level desired			9.5								7.0						
Alkali (oz)	16		32														
Detergent (oz)			18														
Chlorine (oz)					36												
Ozone.....(min)	5		12		0		2		2		5						
Sour (oz)											4						
Softener (oz)											4						
Volume (gallons)	275		98		98		142		142		98						853
Hot Water (therms)	1		1		1		0		0		0						4

Table A-5. Towel Laundering Results, Before Ozone (top) and After Ozone (bottom)

TABLE A-5. TOWELS

Towels	Old Cycle																	
Fill #	1	2	3	4		5	6	7	8	9	10	11	12	13	14	15	16	Totals
	Flush	Drain	Break	Drain	Steam	Bleach	Drain	Rinse	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shake	
Time (min)	5	1	8	1	1	10	1	2	1	2	1	2	1	5	1	8	1	51
Water Level (in)	13		7			7		13		13		13		7				
Water Temp (F)	100		160			160		130		110		90		90				
pH																		
Alkali (oz)	28		92															
Detergent (oz)			20															
Chlorine (oz)						56												
Sour (oz)														6				
Softener (oz)														6				
Volume (gallons)	275		98			98		142		142		142		98				995
Hot Water (therms)	2		2			2		2		1		1		1				9

Towels	New Cycle Using EcoTex Ozone System																	
Fill #	1	2	3	4		5	6	7	8	9	10	11	12	13	14			
	Flush	Drain	Break	Drain	Steam	Bleach	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shake			
Time (min)	5	1	8	1	1	10	1	2	1	2	1	5	1	8	1			48
Water Level (in)	13		7			7		13		13		7						
Water Temp (F)	90		120			120		86		86		86						
pH level desired			9.5									7.0						
Alkali (oz)	20		80															
Detergent (oz)			28															
Chlorine (oz)						56												
Ozone.....(min)	5		8			0		2		2		5						
Sour (oz)												5						
Softener (oz)												6						
Volume (gallons)	275		98			98		142		142		98						853
Hot Water (therms)	1		1			1		0		0		0						3

Table A-6. Sheets Laundering Results, Before Ozone (top) and After Ozone (bottom)

TABLE A-6. SHEETS

Sheets	Old Cycle															
Formula #1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Totals
	Flush	Drain	Steam	Break	Drain	Rinse	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shakeout	
Time (min)	2	1	1	10	1	2	1	2	1	2	1	5	1	8	1	39
Water Level (in)	13			7		7		13		13		7				
Water Temp (F)	100			155		130		110		90		90				
pH																
Alkali (oz)				28												
Detergent (oz)				20												
Chlorine (oz)				24												
Sour (oz)												6				
Softener (oz)												6				
Volume (gallons)	275			98		98		142		142		98				853
Hot Water (therms)	2			1		1		1		1		1				7

Sheets	New Cycle using EcoTex Ozone System															
Formula #21	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Totals
	Flush	Drain	Steam	Break	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shakeout			
Time (min)	2	1	1	9	1	2	1	2	1	5	1	9	1			36
Water Level (in)	13		7			13		13		7						
Water Temp (F)	86		140			86		86		86						
pH level desired			9.5							7.0			6.5			
Alkali (oz)				28												
Detergent (oz)				28												
Chlorine (oz)				48												
Ozone (min)	2		0			2		2		5						
Sour (oz)										5						
Softener (oz)										5						
Volume (gallons)	275			98		142		142		98						755
Hot Water (therms)	0		3	0		0		0		0						3

Table A-7. Rewash Formula for Stain Removal

TABLE A-7. REWASH FORMULA FOR STAIN REMOVAL

Stain	Old Cycle																						
Fill #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Totals
	Break	Drain	Rinse	Drain	Break	Drain	Rinse	Drain	Rinse	Drain	Bleach	Drain	Rinse	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shake	
Time (min)	5	1	2	1	17	1	5	1	2	1	16	1	2	1	2	1	2	1	5	1	7	1	76
Water Level (in)	13		13		7		7		13		7		13		13		13		7				
Water Temp (F)	100		120		165		160		150		155		130		110		90		90				
pH																							
Alkali (oz)	32				140																		
Detergent (oz)					28																		
Chlorine (oz)											72												
Sour (oz)																			9				
Softener (oz)																			9				
Volume (gallons)	275		142		98		98		142		98		142		142		142		98				1377
Hot Water (therms)	2		1		2		2		2		1		2		1		1		1				14

Stain	New Cycle Using EcoTex Ozone System																						
Fill #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20			
	Break	Drain	Rinse	Drain	Break	Drain	Rinse	Drain	Rinse	Drain	Bleach	Drain	Rinse	Drain	Rinse	Drain	Sour	Drain	Extract	Shake			
Time (min)	5	1	2	1	17	1	5	1	2	1	16	1	2	1	2	1	5	1	7	1			73
Water Level (in)	13		13		7		7		13		7		13		13		7						
Water Temp (F)	100		120		140		125		125		140		110		86		86						
pH level desired					9.5												7.0						
Alkali (oz)	30				140																		
Detergent (oz)					28																		
Chlorine (oz)											72												
Ozone.....(min)	5		2		17		5		2		16		2		2		5						
Sour (oz)																							
Softener (oz)																							
Volume (gallons)	275		142		98		98		142		98		142		142		98						1235
Hot Water (therms)	2		1		1		1		1		1		1		0		0						9

Table A-8. Microfibre Mops

TABLE V-8. MICROFIBRE MOPS

Micro Fiber Mops	Old Cycle													
Fill #	1	2	3	4	5	6	7	8	9	10	11	12		Totals
	Wash	Drain	L.S.Extract	Wash	Drain	Rinse	Drain	Rinse	Drain	Rinse	Drain	Extract	Shakeout	
Time (min)	3	1	3	8	1	2	1	2	1	2	1	12	1	38
Water Level (in)	13			7		13		13		13				
Water Temp (F)	100			130		120		100		90				
pH														
Alkali (oz)				16										
Detergent (oz)														
Chlorine (oz)														
Sour (oz)														
Softener (oz)														
Volume (gallons)	275			98		142		142		142				799
Hot Water (therms)	2			1		1		1		1				6

Micro Fiber Mops	New Cycle using EcoTex Ozone System													
Fill #	1	2	3	4	5	6	7	8	9	10	11	12		Totals
	Wash	Drain	L.S.Extract	Wash	Drain	Rinse	Drain	Rinse	Drain	Rinse	Drain	Extract	Shakeout	
Time (min)	3	1	3	8	1	2	1	2	1	2	1	12	1	38
Water Level (in)	13			7		13		13		13				
Water Temp (F)	100			120		86		86		86				
pH														
Alkali (oz)				16										
Detergent (oz)														
Chlorine (oz)														
Sour (oz)														
Softener (oz)														
Volume (gallons)	275			98		142		142		142				799
Hot Water (therms)	2			1		0		0		0				3

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