ELECTRIC POWER RESEARCH INSTITUTE

Long Beach Medical Center Ozone Demonstration

Product ID Number

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Product ID Number

Final Report, July 2007

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Long Island Power Authority

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This document describes research sponsored by the Electric Power Research Institute (EPRI) and the Long Island Power Authority.

This publication is a corporate document that should be cited in the literature in the following manner:

Long Beach Medical Center Ozone Demonstration. EPRI, Palo Alto, CA and Long Island Power Authority, Hicksville, NY: 2007. <Product ID Number>.

ABSTRACT

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1
INTRODUCTION

Background

In 1923, the Washex Machinery Company of Brooklyn, NY designed and built the first wash machine that would both wash and extract. With this machine, called a washer-extractor, the laundry industry took a giant leap forward with a machine design that cut costs and increased production per square foot of floor space. As a result, the on-premise laundry industry was begun.

Following the increased mechanization of the laundry industry due to the washer-extractor, the role and types of laundry chemicals changed. To that point traditional soap had been used most commonly in laundry applications. However, traditional soaps did not clean well in hard water and deposited a residue of scum, or curds. The first synthetic detergents, typically composed of an alkyl sulfate, represented a breakthrough in that they could clean in hard water without scum formation. However, they were unable to clean heavily soiled clothes well.

Chemists at Proctor & Gamble (P&G) knew that synthetic detergents could clean better with addition of "builders," compounds that penetrate clothing more deeply to remove stains. However, the builders left clothes rough and stiff because the builders reacted with the water's hardness to form insoluble deposits that could not be rinsed away. After many years of research and many near failures, a P&G chemist found that, contrary to intuition, *more* of a certain type of builder worked to make the fabric softer and cleaner. This further led to the greater effectiveness of washer-extractors in on-premise and commercial laundry applications.

The Factors Influencing Wash Machine Operations

Typically, it was necessary to control four factors—all of which are mutually dependent—in order to effectively clean linens:

1. **Mechanical action**: Considered the most important factor in cleaning laundry. The squeezing action resulting from the tumbling of the linens during the agitation and spin in the washer-extractor removes the soil from the fibers.
2. **Cycle length**: In general, the longer the cycle, the cleaner the linen. Cycle time is dependent on water temperature, chemicals used, the degree to which the linens are soiled, etc.
3. **Chemical action**: The chemical action removes the soil and holds it in suspension until being eliminated during the drain cycles, so that it is not re-deposited back onto the linens.
4. **Water temperature**: Water temperature is determined by the type of load (light or heavy soil), the type and amount of chemicals used, and local law. Hotter water enhances the effectiveness of detergents because chemical reactions take place at an increased rate. At water temperatures below 65°F, little or no chemical activation takes place, meaning little

or no energy comes from the detergent and cleaning performance is decreased. Frequently, minimum wash and rinse temperatures (usually 160°F) and times ($\geq$25 minutes) are set by local or state law. Their purpose is to ensure that a sufficient number of microorganisms are destroyed to prohibit "grossly contaminated" linens.[1]

Water Use in Laundry

Typical water temperatures in wash cycles vary by the type of cycle and the type of items being washed. Most cold water is supplied at about 55°F-60°F. Where hot water is used, the typical temperature required is 160°F. Hot and cold water are mixed at varying ratios to provide warm water.

Typical water use in washer-extractor operations is three gallons for every pound of linen washed. Modern washer-extractors can process from 18 to 1,200 pounds per hour, which means water consumption of 54 to 3,600 gallons per hour per machine. A facility operating 500 lb washer-extractor 8-hours per day, 6-days per week, would consume approximately 3.74 million gallons of water per year. That is the volume of water held by 5.7 Olympic swimming pools.

Water shortages worldwide are being exacerbated by heavy demands from growth in population and industrial and agricultural activities. The laundry industry is one of the largest users of water and a major cause of water pollution in the US. According to the World Bank's *The Little Green Data Book 2007*, per capita supplies of freshwater decreased by 1.5% since 2005.[2]

Ozone Use in Laundry

Since the late 1970's, a series of environmental impact laws, including the Clean Water Act, have been passed at the national level. Their purpose is to minimize the impact of human activities upon the environment by the imposition of regulations on otherwise environmentally damaging activities. Violators can be heavily fined, which has resulted in businesses being shut down. As a result, operators of on-premise laundry facilities are very aware of their water discharges with regards to chemicals.

The 1990's initiated an even greater awareness to environmental issues that were affecting our lives in many differing ways. Our living conditions, global warming, control of infectious agents, along with general health and comfort were predominant. The buzz word in the healthcare and hospitality industry was ozone. Many thought that ozone was the magic bullet that did everything they wanted and then some. Others felt that ozone was a special chemical that was a tool in the arsenal of items that, when used properly, could provide many benefits.

Ozone is a form of oxygen formed by the breakdown of elemental, diatomic oxygen and the recombination of a percentage of the oxygen atoms into a gaseous triatomic molecule (0_3).

Ozone is created in nature by electric discharge in oxygen, such as lightning, and by the interaction of ultraviolet (UV) light with oxygen, as in the case of the upper atmosphere.

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[1] Centers for Disease Control and Prevention, US Department of Health and Human Services, *Laundry: Washing Infected Material*, 2000, http://www.cdc.gov/ncidod/dhqp/bp_laundry.html.
[2] World Bank, Development Data Group of the Development Economics Vice Presidency and the Environment Department, *The Little Green Data Book 2007*, Washington, DC, 2007.

Synthetically, ozone is created in the same ways, using either a corona discharge or UV lamps. Most ozone for laundry applications is created using the corona discharge method.

The corona discharge method involves passing dried air through an electrical field or corona. The electrical current causes diatomic oxygen molecules (O_2) to “split” into two oxygen atoms. These unstable oxygen atoms combine with diatomic oxygen molecules to form triatomic ozone molecules. The air feeding the ozone generator must be very dry because the presence of moisture affects ozone production and causes the formation of nitric acid, which is highly corrosive and can damage the ozone generator itself, as well as laundry equipment.

Although diatomic oxygen is a powerful oxidizing agent in its own right, ozone has much stronger oxidizing properties and reacts more quickly, often in fractions of a second, with a wide range of substances. In addition, ozone is one of the most effective biocides known to science, better even than chlorine, bromine, and other commonly used disinfectants.

In its role as a powerful oxidant and biocide, ozone works in the context of laundry facilities to boost the cleaning activity of the various chemicals and chemical compounds. It accomplishes this by:

- Replenishing oxygen in the wash water;
- Purifying and disinfecting the wash water;
- Softening the wash water;
- Decomposing fats, oil, and grease (FOG); and
- Preventing redeposition of soils.

To be used in laundry operations, ozone must be introduced into the wash water. There is a variety of ozone laundry systems available on the market today, as well as a variety of different methods for introducing the ozone into the wash water. The solubility of ozone—or its ability to dissolve in water—depends on the water temperature and the ozone concentration in the gas phase. The higher the concentration of ozone in the gas being introduced into the water, the more soluble it is. However, the reverse is true of water temperature. The higher the water temperature, the less soluble ozone is. As a result, ozone is more effective in cooler water than in hot. However, this does create problems in those jurisdictions where minimum hot water temperatures are specified in law. Other jurisdictions have realized that having minimum hot water temperature requirements significantly reduces the cost-effectiveness of ozone and have relaxed their temperature requirements for ozone systems.

The Benefits of Ozone in Laundry Applications

The benefits of ozone’s use in laundry can be categorized as either measurable or non-measurable. (These are sometimes also referred to as “hard” and “soft” benefits, respectively.) Measurable benefits typically accrue to the laundry system’s owner and can be valued and measured in dollars. Non-measurable benefits are typically qualitative in nature, but some can be quantified.

Table 1-1 lists some of the measurable benefits of ozone in hospital laundry (the figures shown are ranges of manufacturers’ claims, but are relatively well documented). Reduced water heating energy costs result from the fact that ozone works better in cool water. Faster drying times result from the fact that ozone appears to "open" the fibers of linens, which enhances airflow through the fabric. Ozone reduces the need for some chemicals by boosting their effectiveness and eliminates the need for some chemicals completely, which has two-fold impact: 1) it reduces chemical costs and 2) it reduces the volume of water needed to rinse the chemicals from the linens. Rewashes of extremely soiled articles are reduced by the use of ozone, which reduces labor costs. Finally, ozone is gentler on linens, which increases linen life and lowers replacement costs.

Table 1-1
Measurable Cost Reductions from Ozone in Laundry Applications

Measurable Benefit	Cost Reductions
Reduced water heating energy costs	20% - 100%
Reduced drying time	10% - 30%
Reduced chemical and detergent costs	35% - 70%
Reduced water and sewer costs	10% - 75%
Reduced labor costs	10% - 45%
Reduced linen replacement costs	15% - 50%

Most of the non-measurable benefits of ozone are highly subjective, but they can be significant. The following non-measurable benefits are often realized by ozone laundry system owners:

- Ozone increases linen softness due to reduced residuals in the linen, which reduces the prevalence of bedsores (decubitus ulcers);
- Ozone improves linen smell;
- Ozone eliminates static cling;
- Ozone does not react with CHG (chlorhexadine gluconate) antiseptic present on linens (washing CHG-soaked linens with chlorine can cause permanent stains necessitating the replacement of the stained linen);
- Ozone allows mixing of white and colored linens in the same wash load, and
- Ozone improves linen availability.[3]

[3] *Operations Evaluation Report – Pressurized Ozonation System, North Mississippi Medical Center Laundry Operations*. EPRI, Palo Alto, CA and Tennessee Valley Authority, Chattanooga, TN: 2005. 1011591.

2
OZONE LAUNDRY PROJECT DESCRIPTION

In May 1999, Long Beach Medical Center in Long Beach, NY, along with the Long Island Power Authority (LIPA) and others undertook a project to evaluate a laundry ozone system to establish a statistical baseline of performance and document the benefits of ozone in hospital laundry operations.

Baseline Laundry Conditions at LBMC

Long Beach Medical Center (LBMC) in Long Beach, NY is licensed for 134 beds and includes community teaching hospital, a sub-acute and skilled nursing facility (the Komanoff Center for Geriatric and Rehabilitative Medicine), a Medicare-certified home health agency, and numerous outpatient services. Its on-premise laundry facility processes 5,040 pounds per day, or 1.84 million pounds per year.

Table 2-1 lists the three washer-extractor machines at LBMC and the laundry programs that each is assigned. All three machines operate 9-hours per day. The two Milnor machines handle a wider range of loads even though they are smaller capacity than the Braun machine. The Braun machine is reserved for the much more prevalent "medium soil" loads.

Table 2-1
Wash Machines at LBMC

Manufacturer	Type	Quantity	Hourly Capacity (Lbs)	Laundry Programs
Milnor	Washer-extractor	2	135	• Medium soil • Heavy soil • Colored linens • Table linen - colored • Rinse & spin • Rewash • Mops
Braun	Washer-extractor	1	450	• Medium soil

Prior to the initiation of this study, the Braun wash machine was controlled by a paper program card that was torn and inaccurate in its program functions. A discounted automatic wash machine controller was installed on the Braun wash machine at project initiation that would insure the replication of wash chemical formulas. This new controller offered a reliable format to evaluate the benefits of the proposed ozone system.

Table 2-2 details the laundry water temperatures used at LBMC. The water coming in to the laundry is from two general headers and has no monitoring devices in-line. A central recording system was to be installed to monitor the two water supplies as well as loads and temperature.

Table 2-2
Laundry Water Temperatures at LBMC

Laundry Water	Water Temperature (°F)
Cold water	55°F
Hot water to laundry	160°F
Hot/Cold water mix	108°F

The air compressor that supplied the laundry system and would supply the ozone generators was overloading the air with heavy oil residue. As a result, it was necessary to install an automatic drain on the air compressor to reduce or eliminate the high level of oil in the compressed air. The ozone generating units would need to be installed with a coalescing filter as part of the air dryer system to insure air dryness.

The ozone systems selected for the study, EnviroSaver II's built by Wet-Tech of Worcester, MA, were installed at the beginning of November 2001. Three EnviroSaver II's, one for each wash machine, were mounted on the wall of the laundry room. Each of the ozone generators was sized to match the wash capacity of the wash machine to which it was dedicated.

Beginning of Ozone System Operations

Operation of the ozone laundry system at LBMC began in early 2002, but the project was plagued by a series of setbacks that hindered data collection.

The original wash chemical formulas were established by LBMC's chemical vendor with the original cost analyses based on these wash formulas. Shortly after the ozone equipment was installed and new wash chemical formulas were in place for ozone system operation, the chemical supplier was changed and a new laundry manager brought in. As a result, the dynamics the demonstration project changed considerably.

This required a complete review of the new wash formulas as they related to quality and production along with the reestablishment of ozone formulas based on the new wash room chemistry. As data gathering began on this new chemical system, there were some service issues with the new chemical vendor. Consequently, the chemical supplier was again changed.

The third chemical vendor, as opposed to the previous vendors, gave the impression of being on board with LBMC and genuinely interested in evaluating the pros and cons of ozone laundry systems. New wash formulas were once again established along with new ozone formulas. Data were again recorded and evaluated.

Several meetings took place during this period to put the data into a manageable format. Nonetheless, problems with the disk drive on the equipment monitoring device resulted in missing and illegible data. The problem was resolved by manually retrieving the data collection disks and replacing them with new disks each week.

The wash machine performance data were beginning to move in the right direction until a boiler failure at LBMC interrupted hot water availability.

To allow washing with only cold water until the boiler could be replaced, mechanical modifications had to be made to the Braun machine. The Melnor machines, on the other hand, worked well without any modifications. As a result, LBMC was washing with ozone in cold water with few quality problems.

Unfortunately, yet another data problem arose during an evaluation of the recorded wash information. The monitoring equipment had measured hot water flow during the wash cycles even while the boiler was out of service. It appeared that the equipment had been measuring cold water flow instead. This deviation raised doubts about the statistical quality of the data and the data were ultimately discarded.

To this point, no problems with the ozone generators had been encountered. However, problems with the ozone generators arose later as a result of the recirculation pumps and filters not being cleaned regularly as well as the coalescing filter not being drained of oil collected from the compressed air. These two items began to impact the quality of the laundry from the ozone wash system and raised some issues.

Starting Over, Again

Wet-Tech, the ozone generator manufacturer, was asked to install a new upgraded ozone system that did not require regular manual cleaning of recirculation pumps and filters. This new system was installed in April 2004.

The wash formulas were reformulated in conjunction with the chemical vendor to get the wash quality and operating costs back in line with expectations. Under the guidance of LBMC's Director of Environmental Services, the team established a "daily soiled linen processed" report and established records of actual loads run for the period December 2004 through March 2005.

Some time after this process was completed, LBMC decided to eliminate the use of reusable diapers and replace them with disposable diapers. This change had significant impacts on fuel, water, and chemical consumption, as well as labor and linen replacement costs.

Findings

As discussed in Section 1, there are many benefits resulting from the use of ozone in laundry operations. Some of these benefits can be measured directly, others not. This section presents and quantifies the measurable benefits of ozone use in the laundry operations at LBMC based on the data collected during an average 30-day period during 2005. Appendix A details these calculations.

Daily operations at LBMC produce almost three-tons of laundry, as shown in Table 2-3. LBMC's three wash machines can wash a day's worth of laundry in 9 hours.

Table 2-3
Daily Laundry Production at LBMC

Soil Type	**Daily Production** (Pounds/day)
Light soil	675
Medium soil	3,600
Heavy soil	1,485
Total	5,760

Table 2-1 showed that the two 135-lb Melnor wash machines have seven laundry programs, depending on the type of items being washed and the degree of dirtiness. Each program varies by having different water temperatures, number and types of cycles, cycle durations, chemical amounts, etc. With the introduction of the ozone system, each program was modified to change all these factors.

Hot water use is reduced significantly by ozone use. Conversely, cold water use typically increases. Overall, however, water use is reduced, as shown in the examples of water savings by program type in Table 2-4. The first four formulas listed in Table 2-4 apply to the two 135-lb Melnor wash machines. In each of the first three formulas, total water use is reduced by 92 gallons per load. However, the varying ratios of hot and cold water used in each formula change the relative volumes of hot and cold water savings. For example, the change to ozone in the "Operating Room Formula" reduces hot water consumption by 208 gallons (76%), but increases cold water consumption by 116 gallons (170%). Overall, water consumption is reduced 92 gallons (27%). On the other hand, the change to ozone in the "Medium Soil Formula" reduces hot water consumption by 160 gallons (78%) while cold water consumption increases by 68 gallons (151%). Yet, overall water consumption is reduced 92 gallons (37%).

The medium soil formula for the significantly larger 450-lb Braun wash machine saves more hot water (344 gallons or a 70% reduction) while using a little more cold water (80 gallons or a 29% increase). The net savings is 264 gallons or a 35% reduction.

Table 2-4
Examples of Laundry Water Consumption at LBMC—Original vs. Ozone Formulas

Formula	Water Temp	Water Consumption per Load		Water Consumption Reduction per Load (Gallons / load)
		Original (Gallons / load)	Ozone (Gallons / load)	
Operating Room Formula 1 load @ 113 lbs/day	Hot Cold	274 68	66 184	208 (116)
	Total	342	250	92
Medium Soil Formula 9 loads @ 135 lbs/day in Milnor 135 lb/hour Washer	Hot Cold	205 45	45 113	160 (68)
	Total	250	158	92
Rewash Formula 1 load @ 100 lbs/day	Hot Cold	205 45	45 113	160 (68)
	Total	250	158	92
Personal Formula 3 loads @ 100lbs/day	Hot Cold	34 174	11 151	23 23
	Total	208	162	46
Medium Soil Formula 7 loads @ 450 lbs/day in Braun 450 lb/hour Washer	Hot Cold	490 278	146 358	344 (80)
	Total	768	504	264

The reductions in chemical costs resulting from the introduction of ozone at LBMC are shown in Table 2-5. Chlorine bleach costs were not decreased at LBMC. Typically chlorine bleach use is reduced, but by how much is highly dependent upon the laundry operations and hospital management.

Table 2-5
Chemical Savings Resulting from Ozone Use in Laundry at LBMC

Chemical	Reduction
Alkali	25%
Detergent	20%
Chlorine bleach	0%
Sour	50% - 100%
Softener	50% - 100%
Average for all chemicals	25%

Table 2-6 presents the water and energy savings at LBMC by month and year. Using these data, the laundry input cost data shown in Table 2-7, and some general assumptions regarding electricity use and linen replacement results in the projected annual savings figures shown in Table 2-8.

Table 2-6
Water and Energy Savings from Ozone Use in Laundry at LBMC

Savings	Total Water Saved (Gallons)	Total Natural Gas Saved (Therms)
Per Month	89,940	1,224.0
Per Year	1,079,280	14,687.7

Table 2-7
Laundry Input Costs at LBMC, 2006

Input	Cost per Unit
Natural gas	$1.223 / therm
Electricity	$0.15 / kWh
Water	$6.58 / 1,000 gallons
Sewer	$6.58 / 1,000 gallons

Table 2-8
Projected Yearly Dollar Savings at LBMC

Commodity	Yearly Savings
Water	$ 7,100
Sewer	$ 7,100
Natural gas	$ 17,960
Chemicals	$ 2,400
Linen replacement	$ 13,400
Electricity	$ 1,980
Total Projected Annual Savings	**$ 49,940**

Total project annual savings due to the ozone laundry system at LBMC is just under $50,000, as shown in Table 2-8. The greatest portion of total savings (36% of total) is due to reduced natural gas consumption. If wash water is heated using electricity or other fuel, the savings—in relative terms—would be similar. The three largest savings components are water/sewer, natural gas, and linen replacement, which comprise over 90% of the total savings. As noted previously, savings for each commodity will vary by site, depending on the size of the operations, energy costs, chemical use, and characteristics of the laundry, among others. Appendix A provides more detail of the cost analyses.

Conclusions

Like has been the case in many similar hospital laundry operations that began using ozone, there were problems getting the balance between ozone, chemicals, and water volume and temperature at the beginning of operations. In the case of LBMC, however, the problems were not with the ozone generator, but with ancillary systems, such as the air compressor, controller, and data monitoring device.

The ozone generator installed in April 2004 did not require regular manual cleaning of recirculation pumps and filters. As a result, it was the appropriate technology for the situation and conditions. This shows that as ozone generator manufacturers gain operating experience, they will add features that improve the performance and longevity of their equipment. This will reduce the delays often encountered during the startup of ozone laundry operations.

The cost savings experienced at LBMC are typical for a facility of this size. An EPRI report from 2005, *Operations Evaluation Report – Pressurized Ozonation System, North Mississippi Medical Center Laundry Operations* (1011591), documents similar positive findings from demonstrations of ozone used in a tunnel washer serving a large regional medical center and in washer-extractors serving a nursing home. In both these cases, the local energy costs were significantly lower than those at LBMC and the ozone system were still cost-effective as shown by their short payback periods (8- and 6-months, respectively).

A
OZONE LAUNDRY ANALYSIS DETAILS

Laundry Production

- Light soil: 5 loads @ 135 lbs/load = 675 lbs/day
- Medium soil: 8 loads @ 450 lbs/load = 3,600 lbs/day
- Heavy soil: 11 loads @ 135 lbs/load = 1,485 lbs/day
  - Total laundry production (daily) = 5,760 lbs/day
  - Total laundry production (weekly) = 40,320 lbs/week
  - Total laundry production (avg month) = 174,720 lbs/month

Laundry Equipment Capacity

- Two 135 lb/hour Milnor Washer-Extractors:
  Total wash capacity for 9 hour day = 2 units * 135 lbs/hour
  = 270 lbs/hour less 10% for soil & moisture
  = 243 lbs/hour * 9
  = 2,187 lbs/day
- One 450 lb/hour Braun Washer-Extractor:
  Total wash capacity for 9 hour day = 450 lbs/hour less 10% for soil & moisture
  = 405 lbs/hour * 9
  = 3,645 lbs/day
  - Total wash capacity (9 hour day) = 5,832 lbs/day (2,187 lbs/day + 3,645 lbs/day)
  - Total wash capacity (week) = 40,824 lbs/week
  - Total wash capacity (avg month) = 176,904 lbs/month

Water and Chemical Savings Resulting from Ozone Use

Table A-1
Examples of Laundry Water Consumption at LBMC—Original vs. Ozone Formulas

Formula	Water Temp	Water Consumption per Load		Water Consumption Reduction per Load (Gallons / load)
		Original (Gallons / load)	**Ozone** (Gallons / load)	
Operating Room Formula 1 load @ 113 lbs/day	Hot	274	66	208
	Cold	68	184	(116)
	Total	342	250	92
Personal Formula 3 loads @ 100lbs/day	Hot	34	11	23
	Cold	174	151	23
	Total	208	162	46
Rewash Formula 1 load @ 100 lbs/day	Hot	205	45	160
	Cold	45	113	(68)
	Total	250	158	92
Medium Soil Formula 9 loads @ 135 lbs/day in Milnor 135 lb/hour Washer	Hot	205	45	160
	Cold	45	113	(68)
	Total	250	158	92
Medium Soil Formula 7 loads @ 450 lbs/day in Braun 450 lb/hour Washer	Hot	490	146	344
	Cold	278	358	(80)
	Total	768	504	264

Table A-2
Chemical Savings Resulting from Ozone Use in Laundry at LBMC

Chemical	Reduction
Alkali	25%
Detergent	20%
Chlorine bleach	0%
Sour	50% - 100%
Softener	50% - 100%
Average for all chemicals	25%

Calculations for One Month (Average 30-Day) Work Period

Water Temperatures

- Old formulas
  - Incoming cold water temperature: ....55°F
  - Hot water temperature.....................160°F
  - Heat input required from boiler ......105°F
- New formulas
  - Incoming cold water temperature: ....55°F
  - Hot water temperature.....................135°F
  - Heat input required from boiler ....80°F

Operating Room Formula (1-113 lb load per day)

- Total water savings: ....92 gallons/load
- Cold water savings:................................ -116 gallons/load
- Hot water savings:...................................208 gallons/load
- Total monthly water savings:................2,760 gallons/month (92 * 30)
- Total monthly energy savings:....................5.9 MMBtu (8.34 * 30) * [(274 * 105) - (66 * 80)]

Personnel Formula (3-100 lb loads per day)

- Total water savings: ....46 gallons/load
- Cold water savings:...................................23 gallons/load
- Hot water savings:.....................................23 gallons/load
- Total monthly water savings:................4,140 gallons/month (46 * 3 * 30)
- Total monthly energy savings:................2.0 MMBtu (8.34 * 30 * 3) * [(34 * 105) - (11 * 80)]

Rewash (1-100 lb load per day)

- Total water savings: ....92 gallons/load
- Cold water savings:................................. -68 gallons/load
- Hot water savings:...................................160 gallons/load
- Total monthly water savings:................2,760 gallons/month (92 * 30)
- Total monthly energy savings:....................4.5 MMBtu (8.34 * 30) * [(205 * 105) - (45 * 80)]

Medium Soil (7 loads @ 450 lbs/load)

- Total water savings: ....264 gallons/load
- Cold water savings:.................................. -80 gallons/load
- Hot water savings:...................................344 gallons/load
- Total monthly water savings:..............55,440 gallons/month (264 * 30 * 7)
- Total monthly energy savings:..........69.7 MMBtu (8.34 * 30 * 7) * [(490 * 105) - (146 * 80)]

Medium Soil (9 loads @ 135 lbs/load)

- Total water savings: ....92 gallons/load
- Cold water savings:................................. -80 gallons/load
- Hot water savings:...................................344 gallons/load
- Total monthly water savings:.............24,840 gallons/month (92 * 30 * 9)
- Total monthly energy savings:............40.4 MMBtu (8.34 * 30 * 9) * [(205 * 105) - (45 * 80)]

Water and Energy Savings Resulting from Ozone Use in Laundry at LBMC

Table A-3
Water and Energy Savings at LBMC

Savings	**Total Water Saved** (Gallons)	**Total Energy Saved** (MMBtu)	**Total Energy Saved** (Therms)
Per Month	89,940	122.4	1,224.0
Per Year	1,079,280	1,468.8	14,687.7

Projected Yearly Dollar Savings from Ozone Use in Laundry at LBMC

Table A-4
Projected Yearly Dollar Savings at LBMC

Commodity	**Calculations**	**Yearly Savings**
Water	1,079,280 gals * $6.58/1,000 gallons	$ 7,100
Sewer	1,079,280 gals * $6.58/1,000 gallons	$ 7,100
Natural gas	14,687.7 therms * $1.223/therm	$ 17,960
Chemicals	600,000 lbs * $1.60/cwt * 25% savings	$ 2,400
Linen replacement	$200/bed (industry avg) * 134 beds * 50% savings	$ 13,400
Electricity	27 hp of motors * 0.7457 kW/hp * 9 hrs/day * 365 days/year * $0.15/kWh * 20% savings	$ 1,980
Total Projected Annual Savings		**$ 49,940**

Export Control Restrictions

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