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Ozone Laundry Technology for Water and Energy Savings

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ABSTRACT

Commercial laundering operations are the largest aggregate polluter of water in the United States today. Consider the vast numbers of commercial laundries scattered across the country including those in hotels, motels, hospitals, elderly care, athletic facilities, and prisons.

Not only is ozone laundering safe, environmentally friendly but it saves users thousands of dollars each year by reducing water/wastewater consumption, energy consumption, chemical cost, and it has been proven that fabric lasts longer thereby reducing replacement costs.

This article will give the reader a background on ozone, why it is used, how it is produced and applied into the laundering system and typical savings results.

HISTORY

Ozone is not new. It was first discovered by a scientist in Paris in 1840 named C.F. Schoenbein. The first industrial ozone generator was produced in 1857 by Werner Von Slemans that eventually evolved into the modern generators being used today. The first practical use of ozone was in water purification in Europe. The first full scale water treatment plant using ozone was built in Holland in 1893, however the water treatment plant built in Nice, France in 1906 is considered the birthplace of ozone for drinking water treatment and is still in operation today.

The first U.S. plant was built Niagara, NY, (1903). A plant built in Whiting, IN, in 1940 is still operational today. Ozone gained wide acceptance in Europe prior to World War I, however the chemical industry developed very inexpensive methods of producing chlorine that then became the primary method of water sterilization in the United States.

Many water treatment facilities use ozone as the primary disinfectant in Europe today especially in Germany, France and Switzerland. Ozone is gaining wider acceptance in the treatment of water in the United States today.

WHAT IS OZONE?

Ozone is a triatomic molecule composed of three oxygen atoms having the chemical symbol O_3 and an atomic weight of 47.998. Ozone has a dark blue color in high concentrations and has a pungent odor when present. After oxidation has taken place, however, there is no odor. The half-life of ozone is relatively short, about 20 minutes and about 4 to 6 minutes in typical commercial wash applications. Ozone reverts back to pure oxygen as it breaks down.

There is some debate about exactly how ozone de-soils and plays a role in cleaning fabric. Some believe that ozone chemically reacts with insoluble soils, oxidizing them turning them into smaller molecules or soluble soils that are easily freed with mechanical agitation and discharged in the drain water. Others believe that water surface tension is reduced, resulting in "wetter" water, and a better solvent. Yet another idea supports the use of ozone in combination with detergents because of its ability to amplify the effects of alkalis and surfactants in the wash formula.

We do know that ozone is a relatively unstable molecule and is highly reactive. The ozone molecule is electron deficient (positive charge) and is attracted to negatively charged particles in soil, and other organic matter such as greases, fats and oils which all carry a negative charge. The soil then bonds with one of the oxygen atoms, oxidizing it and allowing it to be dissolved into solution in the wash water.

Ozone has an oxidizing power or oxidation reduction potential (ORP) about 1-Ω times greater than chlorine and is second only to fluorine in this regard. It takes chlorine from about 30 to 60 minutes to sterilize and is not effective against all bacteria, cysts and viruses. The chlorine atom must be ingested or diffused through the cell membrane and causes death by deactivation of the cells enzymes.

On the other hand, ozone utilizes a form of cell lysing, which is 3,000 times faster than chlorine as a bactericide, to destroy the cell membrane. Once the cell membrane is ruptured, the cell cytoplasm to is dispersed into the surrounding water thus destroying the cell and prohibiting reproduction. The chart below shows the relative ORP levels for the most common disinfectants:

Oxidant	*Oxidation Potential (in Volts)*	*Oxidation Potential (In Relation to Chlorine)*
Fluorine	3.05	2.25
Ozone	2.07	1.52
Hydrogen Peroxide	1.78	1.30
Potassium Permanganate	1.68	1.25
Chlorine Dioxide	1.57	1.15
Chlorine	1.36	1.00
Bromine	1.07	0.79

Ozone, as stated earlier, is a potent bactericide. Ozone is also a very effective virucide. There have been extensive studies done with ozone on *E. Coli*, polio virus, salmonella and mycobacterium. Ozone concentrations in the studies ranged from 0.22 to 0.26 mg/ml and kill rates were in the 99.98 to 100 percent range in all cases. In actuality, the ozone concentrations in ozone laundering applications will be 2.5 to 3.0 mg/ml, more than ten times higher than required for inactivation.

HOW IS OZONE PRODUCED?

Ozone can be produce commercially in two ways; by using ultraviolet light and by corona discharge. Because of the generally higher requirements for ozone in laundering applications, only the corona discharge method is used.

The typical system consists of an air preparation system (air compressor, particulate and coalescing filters, desiccant dryer, and a pressure regulator/after filter), corona discharge ozone generator, variable speed drive, ozonated water storage tank, transfer pump, and a microprocessor controller complete with phone modem for remote communications and monitoring.

Ozonated water is produced and stored in a skid mounted tank (at a predetermined ORP) and is directly mass-transferred into the wash equipment upon a call for either wash or rinse water. Both are ozonated. Some manufactures utilize a technique that distributes ozonated water directly into the wash wheel with ozone concentrations determined by the length of time that ozone is added. Generally compact in size, ozone equipment occupies about 8 square feet on larger machines and can be wall hung on smaller applications.

City water is pumped into a storage tank as determined by level controls and is continuously recirculated through the ozone generator until the desired ORP level is obtained. The ORP level can be adjusted as determined by the quantity of desired ozone fir the given application.

Distance of the ozone generator from the wash line, ORP of the source water, and the type of laundry application (retirement home applications require more ozone that typical hotels, for example) will all have an effect on the desired ORP. Generally speaking the ORP is set between 850 milivolts and 950 milivolts.

With a storage tank of approximately 100 gallons, most applications have plenty of water in high demand situations. A mixer head with multiple venturi openings quickly distributes ozone back into the tank as source water is added.

Washers are reprogrammed to add ozone wash cycles. The original wash cycles are left intact. This is done in case they are needed in an emergency upon occasional ozone system failure or heavy soil loads, where high temperature wash cycles may be required.

Chemical feeders are checked for accuracy and chemical titrations are done to establish the correct chemical formulations. Some iteration is typically required to adjust to the best combination of chemistry and wash cycle combinations. This process takes approximately two to five days depending upon the laundry size and complexity.

SAFETY

One concern of system users is safety of their operating personnel. Ozone is not dangerous to humans in the concentrations typical of ozone laundries. Precautions can be taken in ozone laundry applications to mitigate any potential problem with ozone exposure:

1) Add an ozone destruct unit on the top of the storage tank which is open to the atmosphere or ventilate/exhaust the air to the outside of the building or exhaust duct in the laundry.

2) Add an optional ozone monitor to the area which will alarm and automatically shut off ozone generation at the level of 0.03 ppm and higher if ozone is present for a minimum of five minutes.

3) Make sure that the building internal exhaust system is working properly in the laundry.

Actual measured ozone levels immediately following a wash or rinse have been read with very accurate electronic sensing equipment (with the sensing probe inside the washer) to be no higher than 0.0032 ppm. This level drops very quickly to about 0.001 ppm within 2 to 3 seconds when the door to the washer is opened.

The level of ozone in a quality installation is negligible. Although a major consideration, it is not a major obstacle in most installations. Some of the chemicals currently used today in most laundries are considered safe to use.

However, what is not talked about is that liquefied chlorine is stored in tanks under pressure at approximately 30 atmospheres. Ozone is generated at low pressures of about 1 to 2 atmospheres. Exposure to 1,000 ppm of ozone for 30 seconds would be mildly irritating, but the equivalent exposure to chlorine is often fatal.

The table on the following page shows exposure limitations and common ozone levels found.

BENEFITS

Water Heating

Standard wash chemistry requires 140°F and sometimes as high as 160°F to fully activate. Chlorine bleach, and to a lesser extent, alkalis

Ozone in Air	*Parts Per Million (ppm)*	*Time Limit (If Applicable)*
Amount Measured in Typical Country Air	0.01	
Noticeable Odor Threshold for People	0.01	
FDA/ASHRAE/UL Indoor Limit	0.05	24 Hours
Amount Measured in City Air	0.06	
Long Term Human Safe Level	0.10	8 Hours
EPA Standard for Outdoor City Air	0.12	
Short Term Human Exposure	0.30	15 Minutes
Amount Often Measured in Los Angeles	1.0	
Amount Sometimes Measured at Welders	9.0	

require high temperature activation. California State law requires such temperatures by law in laundering operations in health care facilities that come under the state OSHPOD jurisdiction. This is done to ensure high bacterial kill rates and good disinfection that is absolutely necessary in health care facilities.

However, with the introduction of ozone, high temper washing is no longer required. Ozone works best in ambient temperature or sometimes, warm water in some higher soiled loads. High temperatures prematurely dissipate the ozone, negating its power whereas low temperature water has a higher saturation level of ozone.

Typical reductions of energy are in the 80 to 90% range for most laundries. Heavy soil loads usually consisting of oily rags, food and beverage, and some uniforms may have to be washed in standard chemistry and warm or possibly high temperature water to get the quality required.

Water Volume

Water/sewer consumption is reduced primarily by the elimination of rinse cycles. Because fewer chemicals are used, the need for three and four rinses can typically be reduced to one or two. Wash and rinse levels are often times reduced thus reducing the water consumption even farther.

Typical reduction of water/sewer consumption is approximately 15 to 25%. Depending upon the existing situation, some applications are reduced by as much as 50%.

Chemical Use

Typical laundries utilize several chemicals including alkali (spreads the fabric weave), surfactants (detergent which helps to keep dissolved soil in solution), softeners, sour (neutralizes excess alkali), and brighteners (chlorine bleach). In most applications chemicals can be reduced to three; detergent, sour and oxygenated bleach.

Because the complexity of the chemical administration is reduced and the amount of chemicals and the quantity of chemical usage is reduced, cost for them is typically reduced by a minimum of 10% but in certain applications the cost can be reduced by a full 50%. Most of the cost for the chemical suppliers is for the personnel to administer the chemicals, not the cost of the chemicals. A very conservative approach to chemical savings must be taken and the cooperation of the chemical supplier is required to attain larger savings.

Many ozone laundry applications are using relatively new chemical formulations specially developed for low temperature ozone applications. These chemicals greatly enhance the cleaning and brightening ability over standard formulations and help ensure the savings of water and energy without warm or hot water washes.

Shorter Wash Time

By minimizing wash and rinse cycles and the time of these functions, wash cycles can be reduced by 10 to 40% per load. Stated in other words, the productivity of a given machine can be increased or total wash time reduced by these percentages. Opportunities to reduce labor costs now present themselves although it is a very important to consult with the customer before any labor savings are accounted for.

Enhanced Fabric Life

High temperature tends to break down the integrity of synthetic fibers while chlorine bleach destroys cotton fibers. This can be seen in the dryer filters. However, when low temperature ozone is used, chlorine bleach can be eliminated and most wash cycles are done in ambient temperature water. Dryer filters show substantially less lint accumulation.

There is some disparity in savings projections regarding this issue. Some support savings as high as 30% but we believe that projections of 10% are very realistic. Linen replacement costs are traditionally much lager than water, chemical, and energy costs. Savings in this area can be significant.

Case Study Results: J.W. Marriott —Washington, DC

	Before Retrofit	*After Retrofit*	*Savings*
Energy	$26,900	$2,152	$24,748
Water & Sewer	$39,264	$22,773	$16,491
Chemical	$45,000	$31,500	$13,500
Linen Replacement	$169,068	$155,543	$13,525
Totals	$280,232	$211,968	$68,264

Savings like the ones shown in the case history above can be replicated in every case where traditional laundering technologies are being used. These savings extend well beyond those gained in energy and water conservation. And these savings extend beyond industrial and commercial laundering operations, down to residential applications.

ABOUT THE AUTHOR

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Previous engineering activities included work with a HVAC design/build mechanical contracting firm, and engineering support for ventilation and filtration systems, including thermal energy storage and high-efficiency HVAC equipment and systems.

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