

## RESEARCH AND DEVELOPMENT OF ECOWASH™ – PREMIER OZONE LAUNDRY SYSTEMS

Linens, rags and mops are washed for two main reasons: to clean and to disinfect. During the research and development of the Ecowash™ - Premier Ozone Laundry Systems, The Ozone Company sought to find the most economical and practical way to achieve the goals of cleaning and disinfection through the use of ozone. Two independent testing laboratories performed oxidation tests to find the best way to oxidize soils from linen and disinfection tests to find the best way to eliminate microbes during the wash process. These independent tests focused on two key metrics: Soil Oxidation Rating and CT Value.

**Soil Oxidation Rating (SOR)** - Soil Oxidation Rating is based on a 0 – 100 point system, 100 points means oxidation of 100% of soils present before the wash process. This test identified the oxidation potential of the different ozone systems against ten typical soils found on linen, rags and mops. A spectrometer was used to measure the amount of light reflected back off the soil on the material. The more the soils were oxidized, the more light was reflected back, and the higher the equipment's oxidation rating.

**CT Credits** - Every microbe on planet Earth has a point at which it can be destroyed and eliminated with the use of ozone. Bacteria and viruses cannot build a tolerance to ozone because ozone destroys the microbes' cell structure through a process called lysis. CT Credits or Values are used to find the destruction point of a particular microbe. CT Values are the multiplication of ozone concentration and contact time (Concentration x Time). Below is a chart providing the CT Values for which bacteria and viruses are destroyed to a log reduction of that particular microbe.

MICROBE (BACTERIA OR VIRUS)	CT CREDIT FOR DISINFECTION	PERCENT REDUCTION	LOG REDUCTION
Salmonella Choleraesuis	6	99.9999%	6 log
Staphylococcus Aureus (MRSA)	20	99.9999%	6 log
Pseudomonas Aeruginosa	10	99.9999%	6 log
Trichophyton Mentagrophytes	1	99.9999%	6 log
Listeria Monocytogenes	6	99.99%	4 log
Campylobacter Jejuni	6	99.99%	4 log
Aspergillus Flavus	10	99.99%	4 log
Brettanomyces Bruxellensis	6	99.99%	4 log
Escherichia Coli	2	99.999%	5 log
Clostridium Difficile (C. Diff)	12	99.999%	5 log
Viruses	3	99.999%	5 log
Giardia	2	99.99%	4 log

\*CT Values according to US EPA and AOAC Official Method 961.02 and 960.09

## THE TEST RESULTS

Typically, traditional hot water washing methods have a Soil Oxidation Rating in the 70s. The SOR of traditional methods can vary slightly depending on temperature, chemical dosage and cycle time. Disinfection with traditional laundering methods relies on heat, which is adequate for disinfection of basic microbes. Superbugs like MRSA and C. Diff resist high temperatures and cannot be destroyed even with temperatures reaching 165°F or more.

When The Ozone Company started research and development for an ozone laundry system, we turned to the world's leading manufacturers of commercial laundry equipment for assistance. We used their laboratories to test several different types of ozone laundry systems. We wanted to find the safest and most effective way to inject ozone into a commercial washer.

We tested these systems by monitoring dissolved ozone levels in the wash liquor over a given wash time, ambient ozone levels inside and outside of the wash drum and through a process of stain oxidation testing.

As mentioned before, ozone is a powerful oxidizer — much stronger than chlorine and faster acting. Ozone attacks anything and everything it comes into contact with: water, linen, bacteria, viruses, rubber and metals.

## CONTROL WASH WITH COLD WATER

The control wash was used to test the recommended ozone wash cycles without the use of ozone during the wash process. The cycle used ambient water temperatures (55°F), reduced agitation time of 18 minutes and 30% reduction on the chemical provider's recommended dosage (recommended dosage when washing with ozone).

### COLD CONTROL WASH

CT Credits	0
Soil Oxidation Rating	54



Commercial Washer



## INDIRECT OR PASSIVE INJECTION SYSTEMS

Systems that inject ozone through the fill lines (connect a manifold to the water fill lines) are called indirect or passive injection systems. These are the easiest systems to install and the cheapest.

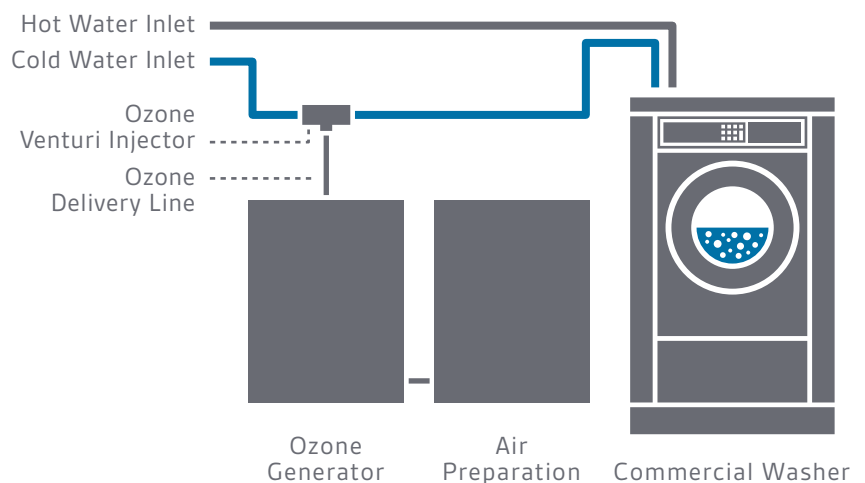
If you look at the water fill lines behind a washer, you will see black rubber hoses with brass couplings that connect the incoming municipal water to the water valve on the washer. Ozone systems that inject ozone through these fill lines pose many problems:

1. Ozone will oxidize soft rubbers (i.e. the hose).
2. The brass couplings and gasket inside the couplings will oxidize over time.
3. The water fill valves on the washer are made of brass and galvanized steel, over time, the ozone will oxidize these materials, essentially destroying your washer, voiding your warranty and producing unsightly stains on the linens.
4. It takes at least 30 seconds for the ozone generator to begin operating at full capacity. Washer fill times run anywhere from 3-8 minutes, leaving a minimal amount of time to inject enough ozone to effectively oxidize soils and obtain CT credits (CT credits are used to determine log reduction of bacteria and viruses, aka kill factor). With this type of system you are lucky to achieve 1ppm of dissolved ozone (DO3). According to the International Ozone Association (IOA), a starting (without replenishing continuously) dissolved ozone level 1ppm of ozone in 15 gallons of water at 75° that is vigorously agitated will revert back to oxygen with in 2-4 minutes. This does not take into consideration soil levels or pH levels, which are discussed below.

According to our testing, indirect or passive injection are basically washing with plain cold water. Because of the chemistry of ozone, there was no trace of ozone left in solution to clean or disinfect.

### INDIRECT OR PASSIVE INJECTION

CT Credits	4.5
Soil Oxidation Rating	53



## CHARGED OZONE SYSTEMS

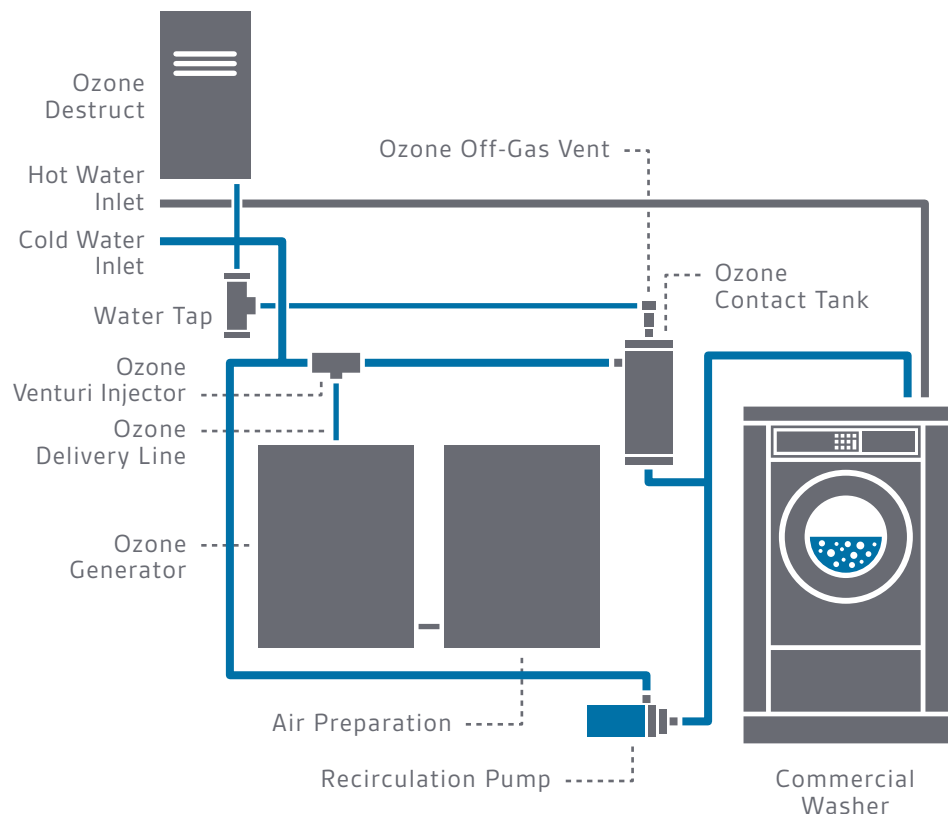
Charged ozone systems are commonly used for drinking water applications and have recently been adapted for laundry. Charged ozone systems have a tank or reservoir that keeps DO3 levels around 2 ppm. To do this properly a DO3 controller is required; most charged ozone laundry systems lack this feature. Some systems include an ORP monitor which is used in pools and water bottling plants to determine water quality.

Charged systems also inject on fills only, but they achieve an initial higher ppm of DO3. Ozone is injected into the main water fill line bypassing the fill valves and hoses. However, the main fill line connects to a 4" galvanized steel nipple at the base of the wash drum. This is where ozone will oxidize metal and cause staining in the linen.

1. This system has slightly higher CT credits to disinfect than the system discussed above (although there isn't a charged ozone laundry system on the market that has proven to disinfect anything in the laundry).
2. Another physical characteristic of ozone is that, without continuously injecting ozone into water, it is impossible to dissolve ozone in water with a pH of 8.5 or higher. This means after the charged ozone water that was introduced into the washer during the fill will immediately off gas when detergent and/or bleach is added. And because sour isn't added until the last step of the wash, your pH throughout the wash cycle will always be higher than 8.5 thus causing the ozone to off gas almost instantly when it comes into contact with the linen.

### CHARGED OZONE INJECTION

CT Credits	8
Soil Oxidation Rating	61

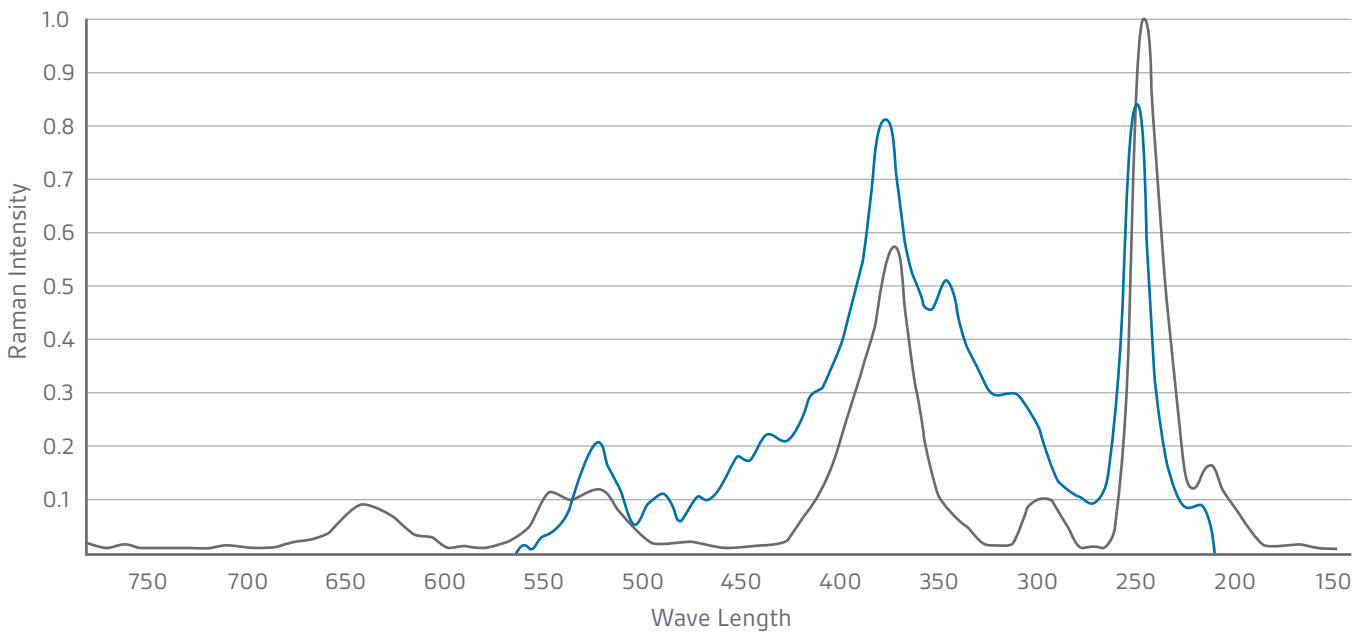


## CHARGED OZONE SYSTEMS (CONTINUED)

This system tested slightly better than the previous, but did not impress any of the engineers, because it had a poor performance for oxidizing soils and caused iron oxide staining. The graph below is an iron-oxide stain sample taken from the linen after this system was installed.

We ran the samples on a Raman spectrometer. The staining seemed to be a decent (but not perfect) match for a compound called lepidocrocite. This is an iron oxyhydroxide a type of rust that form on iron materials that are underwater, (<http://en.wikipedia.org/wiki/Lepidocrocite>) shows that rust scale inside steel water pipes and tanks is the possible source.

In the graph below there is an image of the sample spectra and a known spectra of lepidocrocite, a type of rust. The blue line is the sample received when test the charged ozone system, the gray line is the library standard material. You can see there are several peaks that match, proving that charged ozone systems will harm your washers and stain your linen.



## RECIRCULATION SYSTEMS

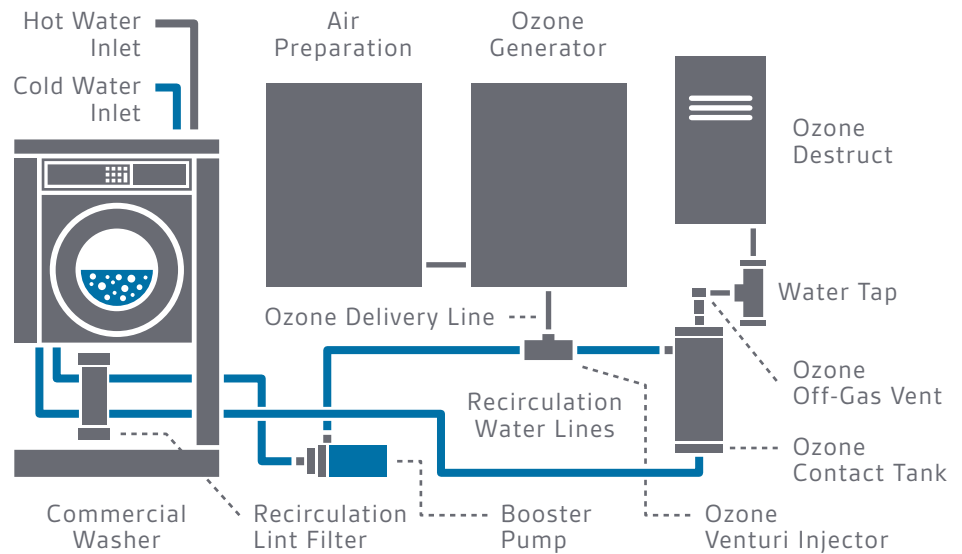
Recirculation systems are a good way to continually maintain ozone in the wash liquor to achieve high CT credits and oxidize soils. This system consists of booster pumps, lint traps, plumbing, tanks, more plumbing, ozone destructs, dissolved ozone controllers — the list goes on and on. The recirculation system tested pretty well when the impellers on the pumps weren't clogged with lint. Problems with the system include:

1. Expensive to install.
2. Must be a licensed plumber in the state of installation.
3. Lint clogs the pumps, major maintenance on this system.
4. Need to clean lint traps multiple times a day.

This system tested well, but the cost of installation and maintenance outweighed the savings.

### RECIRCULATION

CT Credits	28
Soil Oxidation Rating	72



## DIFFUSION

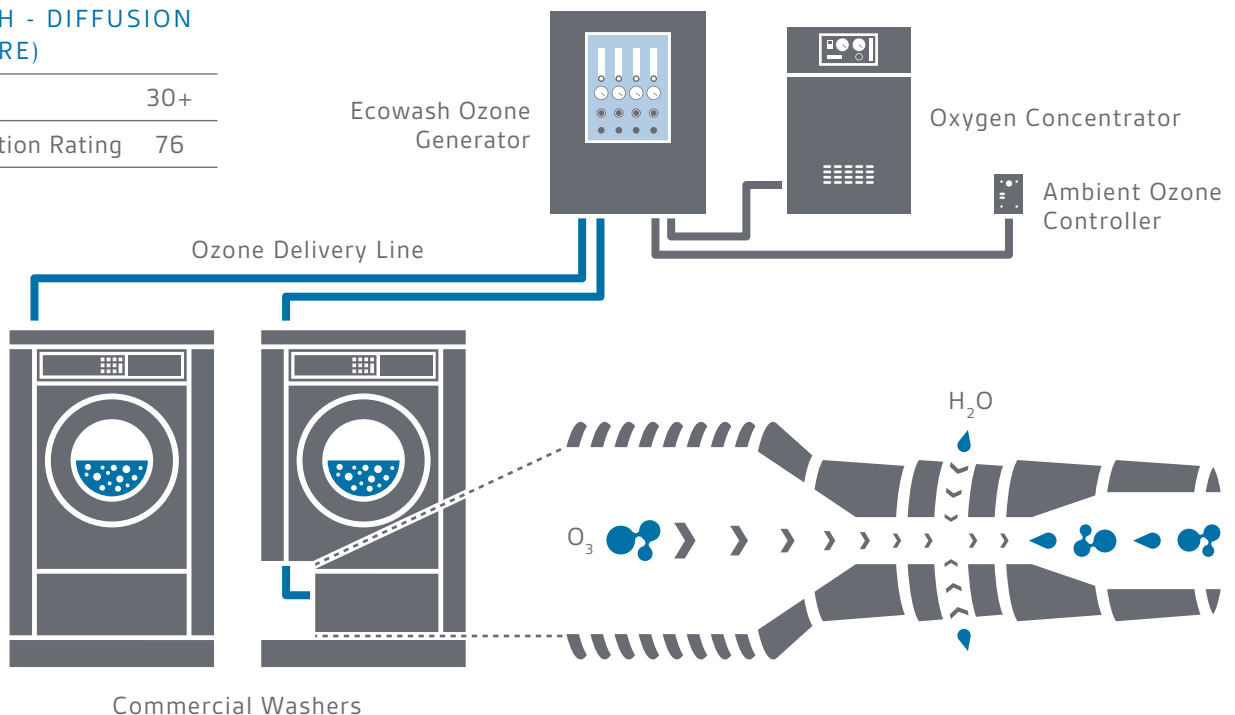
The final system tested was the diffusion or direct injection system. This system injects ozone gas directly into the sump of the washer continuously throughout each step of the wash cycle. The diffusion tip/nozzle makes all the difference because they allow ozone to dissolve into the water in the wash basin and control off-gassing. Some predecessors of the diffusion system used diffusion stones that would produce micron bubbles in the basin. This worked, but the diffusion stone would corrode after time due to the caustic chemicals in the wash liquor.

To work around this problem, The Ozone Company invented a nozzle using Bernoulli's principle by creating a micro submersible venturi that is plumbed directly into the basin of the washer. This provides many great advantages:

1. WILL NOT DAMAGE WASHER, PERIOD.
2. High CT credits, proven ability to destroy microbes on linen in the wash cycle.
3. Great soil and stain oxidation.
4. Continuous ozone applied throughout entire wash cycle combats high pH levels.
5. Ability to control ozone levels in the water, drum and ambient air.
6. Ease of installation, cost effective.
7. Little maintenance, save money on service calls.

### ECOWASH - DIFFUSION (PRESSURE)

CT Credits	30+
Soil Oxidation Rating	76



## DIFFUSION (CONTINUED)

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The Ozone Company has perfected the Ecowash ozone diffusion method for laundry applications. Their method is designed to introduce ozone gas continuously into the washer during the entire wash process; supplying 20 minutes of ozone throughout the laundry cycle. That means over 400% more ozone introduced into the washer than other methods. As the ozone gas enters the washer, a portion of the gas is dissolved (1 – 1.5 ppm) into the water basin of the washer. Then, the wet linen folds into the remaining gas, trapping it and providing a second layer of oxidation and microbe kill (which is essential to destroying MRSA and C.dif).

With the Ecowash ozone laundry systems, the ozone gas that enters the washer is controlled via an oxygen-flow meter, gas pressure regulator and digital ozone output control, which prevents ozone escaping to the ambient air in the facilities occupied space. An ambient ozone monitor provides another layer of protection. This monitor will shut down ozone production if ozone levels in the ambient air are greater than OSHA limits and then automatically restarts when approved levels are determined.

Ecowash is the most practical, cost effective system and provides the best results. It's soil oxidation rating is equivalent to traditional wash methods and better than all other ozone wash methods. With dual layered disinfection protection, Ecowash disinfects all linens throughout the entire wash process. Maintenance on the Ecowash system is simple and less costly than other methods. Ecowash hangs on a wall near the washers and is safe for the operators.

The Ecowash premier ozone laundry system provides the best results with the latest technology, proven reliability and a guaranteed return on your investment. Why choose a different ozone laundry system?

The Ozone Company – [Saving you money and natural resources with ozone technology.](#)

