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The Clean Streams™ Ozone Treatment System: Ozone Systems for Beginners

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This paper is intended for people who know cooling towers when they see them but have little or no experience with their care or what part ozone plays. I have tried to make this as simple as possible and there is even a block diagram on the last page to help you out. Ready? Okay, here is what you need to know first:

The sole function of ozone use in evaporative cooling towers is to disinfect water. That's all. Period. There are many strange ideas about ozone. It is not magic. It will not destroy the ozone layer. It does not prevent corrosion or scale, not directly, anyway. Ozone just disinfects water and makes it clean. *Very* clean. The magic is in what you can do with very clean water.

Ozone is a unique chemical in that it is made from the oxygen in the air, and turns back into oxygen after about twenty minutes in the average cooling tower. So ozone can't be stored; it must be generated on-site. Ozone is an oxidizing biocide, which means it kills all microbes, such as bacteria, viruses, spores and algae. An important difference between ozone and traditional chemicals is that ozone kills by oxidation (burning) rather than poisoning, which is how chemicals work, so no organism can become immune to ozone, as often happens with conventional chemicals. Incidentally, pound for pound, ozone is about 5 times more effective than chlorine.

An ozone treatment system is composed of components to compress room air, dry it, concentrate it to 90-95% oxygen, and from that oxygen generate ozone and mix it with the water in the cooling tower. A side stream is established between the cooling tower sump and the ozone system with PVC pipe. (please refer to the block diagram) A circulating pump in the ozone system runs continuously to circulate water through the side stream. The pump moves water from the tower sump to the ozone system, past a conductivity probe and an ORP probe, through the ozone injector, then back to the tower basin. There are two controllers: a conductivity controller and an ORP controller, and a probe is connected to each.

Okay so far? Then let's see what all these components do and how they work together. The ORP probe measures the amount of ozone in the water and reports it to the ORP controller, a small, cube-shaped, industrial computer. ORP means Oxygen Reduction Potential. It is basically a measure of the ability of ozonated water to oxidize organic matter, and serves as a reliable indicator of how much ozone is in the water at any given instant. When the ORP reaches "setpoint" (the low or high preset limit), the controller responds by adjusting the output of the ozone generator to bring the ORP back within limits. This throttling of the ozone generator occurs constantly to insure that exactly the right amount of ozone is always present in the water (cruise control for your cooling tower!).

Now about the conductivity controller and what it does. This controller is another little computer that looks about like the ORP controller except that most have only one setpoint adjustment. Its purpose is to control the concentration of dissolved solids – mineral salts, like calcium carbonate - in the condenser loop, which is the path the water takes from the tower to the chillers or whatever needs cooling, and back to the tower. These minerals occur naturally in makeup water. The important thing is that water evaporates as it falls through the tower but the mineral salts do not. They remain suspended in the water. Controlling the concentration of minerals is accomplished by blowing down (opening a valve and partially emptying) the tower sump.

We are going to use these minerals, but first we need to build up the correct concentration. We will do that by making use of the fact that they conduct electric current in proportion to their concentration. Ocean water, for instance, is a good conductor, but distilled water does not conduct current at all. The conductivity probe measures the ability of the water to conduct current and reports it to the conductivity controller, which initiates blowdown at the desired setpoint.

Here is the sequence of events: Evaporation occurs and minerals accumulate until setpoint is reached, then the conductivity controller triggers blowdown. The blowdown valve opens and allows water and the minerals in it to discharge. The makeup water valve senses that the sump water level has dropped, and opens to allow makeup water to flow in. This dilutes the minerals and causes the conductivity to drop back below setpoint. The conductivity controller closes the blowdown valve. The makeup water valve remains open until the sump is full again. This process repeats as necessary to hold the conductivity at the desired setpoint. Note that there is nothing in the blowdown water but water, no chemicals and therefore no discharge restrictions.

There is an important reason why I went into such detail about conductivity and setpoints and all. What we are doing is called "cycling up" a tower, a technique that can save a *lot* of water. How much savings depends on the chemistry of the makeup water and other things, but I will give you an example of what cycling can do. This example does not represent any particular site, but it was done with our economic analysis software and the numbers are realistic:

A tower of 1,000 tons capacity is running at 3 cycles of concentration on chemical treatment. The water is of good quality. The tower runs 24 hours per day, every day of the year, with an average annual loading of 55% and uses 35,600 gallons of water per day (13 million gallons per year), 23,700 gallons from evaporation and 11,900 from blowdown. Changing the water treatment to ozone allows operation at 7 cycles of concentration. Water usage drops to 27,600 gallons per day, 23,700 gallons from evaporation and 3,900 from blowdown. This reduction represents an annual savings of 2.9 million gallons. Note that evaporation accounts for the same amount of water, regardless of whether it is treated with ozone, chemicals or nothing at all. It is the consumption of water through blowdown that drops dramatically.

Here is where it gets interesting. If the tower owner is paying, say, $4.00 per 1,000 gallons for water and $5.00 to discharge it, for a total "round trip" charge of $9.00, he is going to save $26,100 per year in water alone. With everything considered (no chemicals to buy, more efficient operation, less tower clean-outs, etc), the total annual savings is about $40,800, and the ozone system will pay for itself in less than 20 months.

Now you understand the primary reason why people put ozone treatment systems on their towers. The savings can be enormous but everything depends on the makeup water quality. A water analysis will predict how much cycling up is possible, and an economic analysis will reveal the savings in gallons and dollars.

Another important thing about cycling up a tower is that the minerals in the water are alkaline. This drives the water chemistry—we're talking high school pH here—away from an acid, or corrosion-causing condition, to a base, or alkaline, or scaling condition. General corrosion is greatly reduced with the water in that state.

But if the water is in a scaling condition, why doesn't scale occur? Well, the answer is the water itself. Remember that it is very clean. There are few if any bacteria in it, living or dead, or what they eat, or what they secrete, all of which is called biomass, and it is a sticky, slimy mess. Scale, in comparison, is a hard white or off-white rock-like substance composed of calcium carbonate crystals. Given the opportunity, scale can grow to the point where it completely plugs up tubes and pipes. This, obviously, is very destructive, and an acid cleaning will be necessary to get the condenser loop back in decent shape. But as harmful as these scale crystals are, they have a weak spot in that they can't stick to cool, clean surfaces. They need a layer of glue to adhere themselves to pipes and tubes. Biomass makes up this glue, if present, but as biomass is almost completely absent in an ozone-treated system, scale does not occur. The crystals have nothing to stick to, except each other, so they remain suspended in the water and are flushed out with the blowdown water.

There is another important benefit of getting rid of biomass, and that is improved chiller operation. Biomass is a very good insulator, and if a layer of it is allowed to build up in the chiller, heat transfer will suffer and the chiller will have to work extra hard to overcome this unwanted insulation. Head pressure in the chillers will run higher than necessary, increasing the use of electricity, increasing maintenance and, ultimately, shortening the life of the chiller. As a rule of thumb, 0.15 inches of biomass will increase a chiller's electrical consumption by 15%.

It's worth pausing here to note that we're accomplishing four things at once here: (1) controlling blowdown to cycle up the tower and reduce water use (2) altering the water chemistry to prevent corrosion (3) cleaning the water with ozone to eliminate biomass, and therefore scale, and (4) saving a lot of energy and water which results in significant money savings.

A word about LSI. Sooner or later you will hear of LSI, or the Langelier Saturation Index. It is a formula that predicts how high a concentration of minerals can be maintained before they come out of solution and scale up everything. LSI is very useful, and this is how we use it. Clean Streams ™ systems require a monthly service call to clean the probes and the ozone injector, run some tests on the water to make sure the chemistry is where it should be, clean air filters in system components and do a visual inspection. These service visits are extremely important, and without them the performance of an ozone system will suffer. While the service technician is performing service, he will work the LSI formula on his calculator using the numbers obtained from the water chemistry tests he just ran. If the answer he gets is within a certain range, everything is okay. Otherwise, he is to call the Zentox home office immediately and get some help from one of the engineers. It’s usually just something out of adjustment, but whatever, it needs to be corrected. LSI is a great tool for verifying the correct operation of an ozone system.

Okay, now let’s take a look at a tower on ozone treatment. The water is beautiful, just like in a well-maintained swimming pool. We have even found coins in sumps, but I can’t promise that cooling towers grant wishes. Other than crystal clear water, the only thing in the sump is a small amount of inorganic matter on the bottom that looks like sand, and probably is. By the way, many ozone system users who used to clean out their sumps twice a year now only need to do it maybe every other year. Clean-outs require labor and cost money, and doing them less represents even more savings.

People purchase our Clean Streams™ ozone treatment systems primarily for three reasons:

(1) Dollar savings. Most ozone treatment systems pay for themselves in 12 to 30 months, and that’s a good capital investment. An economic analysis will predict savings of water and money, and payback time. And don’t forget, the ozone system is protecting some hugely expensive machinery!

(2) Water savings. Water is getting more expensive, and in some instances is hard or even impossible to get in the quantities needed, regardless of what companies are willing to pay for it. Much of the United States is in long-term drought and the demand for water is growing constantly. The savings produced by our systems is immediate and welcome.

(3) No chemicals. Traditional chemicals run from harmless to very toxic, and most are certainly not good for you. School administrators get very sensitive about this when they read the labels on those drums that are sharing the same building with perhaps a few hundred children. Rupturing a chemical drum may mean evacuation of the building and a lot of furious parents. Hospital management folks feel the same way because it is impossible to quickly evacuate a hospital. Then there is the matter of handling the drums, removing empty ones and wrestling in full ones. Not much fun, and disposing of empty drums can be very costly.

There are some applications that ozone can’t fill, and the most common is where water temperatures exceed about 115 degrees F. The process water used for cooling molds in a factory making plastic products, for example, is often too hot for ozone, and old-fashioned chemicals must be used. The reason is that the life of ozone varies inversely with temperature, and at high temperatures it turns back into oxygen too quickly to do anything useful. Another example is in closed systems. Ozone, remember, is made from oxygen and shares most of its characteristics. Both oxygen and ozone are corrosive, and either will corrode the plumbing in closed systems because these systems don’t vent to the atmosphere as happens in evaporative tower systems. Zentox ozone treatment systems are designed so that no more than harmless trace amounts of ozone will ever be found inside metal pipes and tubing. There are also situations where a manufacturing process adds contaminants to the cooling water in such great amounts that ozone is not a good solution.

Finally, is ozone dangerous? Yes, in high concentrations, just like oxygen. But the human nose is extremely sensitive to ozone and can detect less than a tenth part per million, so an ozone leak is not likely to sneak up on you. Thunderstorms produce trace amounts of ozone, a clean, pleasant smell we all know, but even low concentrations of ozone very irritating to the nose and eyes. As a practical matter, leaks are almost never a problem because the ozone injection part of our systems operates in a partial vacuum to prevent ozone leaking into the room. Further, there is a safety device that will shut down the whole system if necessary. But just to keep the issue in perspective, think about a forklift truck piercing a drum of some toxic liquid chemical. Ozone treatment systems have an OFF button but chemical containers don’t, and with nasty stuff spreading all over the floor, someone may have a full-blown emergency on their hands.

The end. Now go back and read this again, and you will know as much about ozone treatment of water in evaporative cooling towers as most of the people who operate them

For more technical information on ozone systems, read “Stand Alone Ozone Treatment of Cooling Towers” and “Ozone Treatment for Cooling Towers.” Both documents are in the Resource Center section of this website.