The Effective Use of Ozone in Bottled Water Production

By John Swancarra

Ozone treatment of bottled water has been used in the consumer bottling industry for over 30 years. Ozonation of product water provides an efficient, safe method of disinfecting against pathogenic waterborne micro organisms and controlling other bacteria. And the process also contributes to good tasting water.

These bacteria may be present in the final water, the bottling equipment and the final filled bottles and caps without this disinfection. It is very important, however, that the ozone be injected into the water carefully and precisely for maximum effectiveness.

What does ozone do?

An unstable and colorless gas, ozone (O_3) is a powerful oxidizer and a very effective germicide. In fact, ozone is a more effective disinfectant than chlorine.

Shortly after ozone is generated in water, it breaks apart and forms many different oxidizing species, the primary one being the hydroxyl free radical OH. As this process occurs, the free atom of oxygen seeks out any foreign particles in the water (including micro organisms and organic molecules) and chemically reacts with them.

These reactions create an environment where bacteria and other organic matter break down when they come in contact with the free radicals. This protects the water from waterborne bacterial contamination. Ozone treatment also provides longer store shelf life without unfavorable tastes and odors associated with untreated waters or waters treated with chlorine.

Ozone decays as it oxidizes organic molecules (assuming there is sufficient ozone produced) and attacks the cell structure of microbes. Since there is no residual, however, there is a likelihood of bacterial re-growth in the water as it is stored. As a consequence in this application, it is important that ozone-treated water be bottled quickly.

The variables determining the effectiveness of ozone in killing bacteria are contact time and residual ozone concentration achieved in product water. This ozone concentration residual is first dependent on how much ozone is injected into the product water and then the amount of ozone demand in the water.

This is referred to as a CT value, although the ozone is not necessarily a residual, rather the concentration introduced following generation.

Ozone must be injected correctly to be safe and effective. Over-ozonation of the water, for example, may lead to taste problems due to a high level of ozone (0.40 ppm or more) and reactions with plastic in the plant piping and even with the bottle itself.

In ultrapure bottled water preparation, ozone inactivates organisms and makes the container sterile. But this protection disappears within 20 to 30 minutes and once the bottle is opened, disinfection is possible.

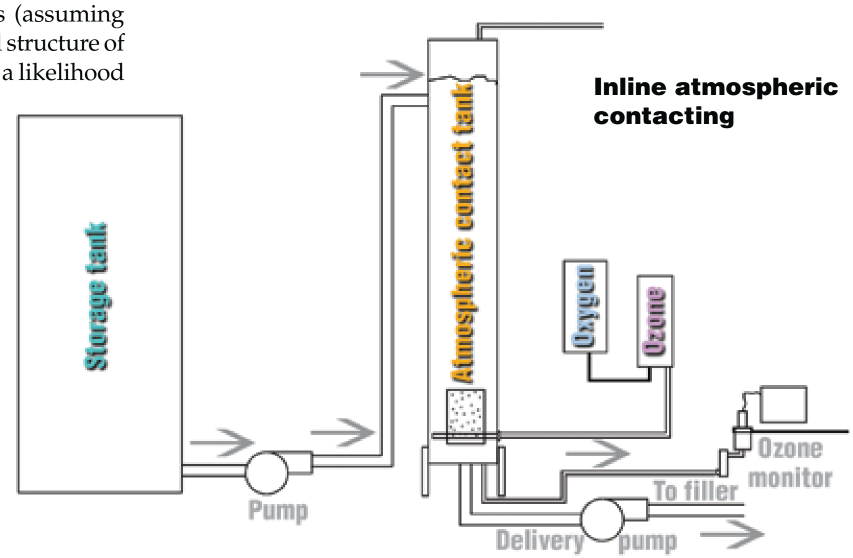
Sometimes, in the non-returnable market, too much ozone or improperly injected ozone may allow some ozone to outgas into the air layer between the water and the cap. If this bottle is opened soon after bottling, the consumer may notice a metallic taste in the water caused by the ozone smell.

The presence of bromide in some waters, especially spring water or well water, has become a major concern in recent years. Bromate, a suspected carcinogen in levels as low as 10 ppb, is formed by oxidation of the bromide ion during the ozone disinfection process.

Trihalomethanes (THMs) are byproducts in municipal waters caused by the chlorination process. They can be eliminated if the RO process includes carbon; moreover, some ROs require pre-carbon removal of chlorine and DBPs.

Ozone treatment will oxidize and remove THMs using up the ozone and lowering the residual levels in the final product water. Testing for THMs in feed water and removal by carbon filtration before or after the RO will prevent the problem and eliminate the need for a larger ozone system.

Many, if not all, of these benefits and drawbacks associated with ozonation are directly related to the quality of the ozonation equipment and the method used.



The ozonation process

The bottled water industry uses several methods of introducing ozone into the final product water before bottling. In general, the three main methods used are inline atmospheric contacting, batch processing and inline pressure contacting. Each type has its benefits and weaknesses.

Choosing the right method can prevent many problems. *(Editor's note: The following method titles are the author's descriptions and are not an official industry designation.)*

Inline atmospheric contacting

This ozonation method involves drawing the product water out of the storage tanks with a pump and delivering the water to a large atmospheric stainless steel contact tank. The ozone is then introduced into the water either by Venturi injection inline with the water flow, or by bubbling into the contact tank with a diffusion stone.

In the contact tank, the water requires a specified length of contact time with the ozone to be treated effectively and is then delivered directly to the bottle filler by another pump. This process is considered real time in that, as soon as the contact tank fills and both pumps are delivering water at the same flow rate, the bottle filler can operate continuously without waiting for the right ozone concentration level to be achieved.

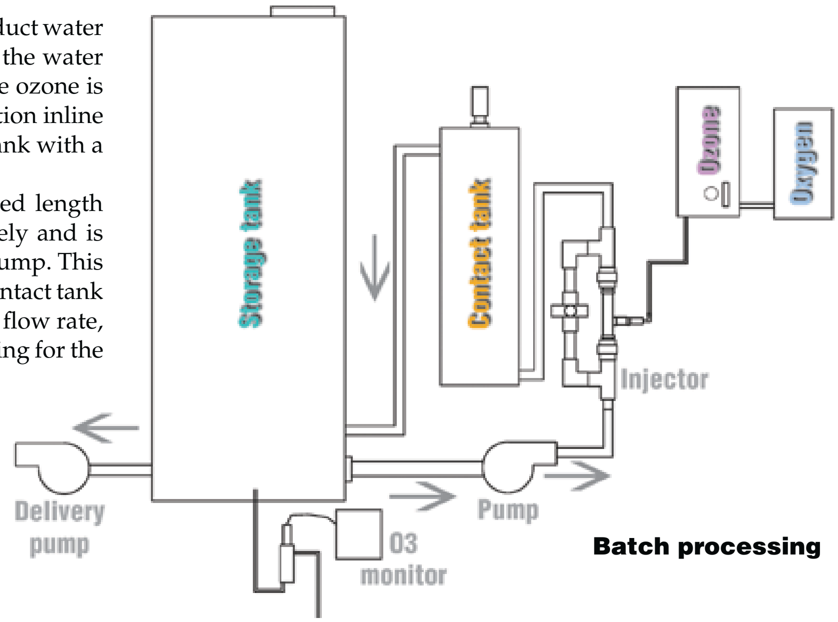
Many large bottled water companies currently use this form of ozonation. Having the appropriately sized contact tank is very important, especially if ozone is bubbled into the tank. Design of contact chambers is a complex study, requiring knowledge of hydraulic flows and ozone gas solution rates.

This process may also require considerable fine-tuning to balance the pumps. This system generally requires an ozone monitor/controller unit to insure proper ozone levels.

Batch processing

The batch processing method starts by ozonating a large storage tank until the desired ozone level is reached. Two possible methods of storage tank ozonation include circulation and bubbling.

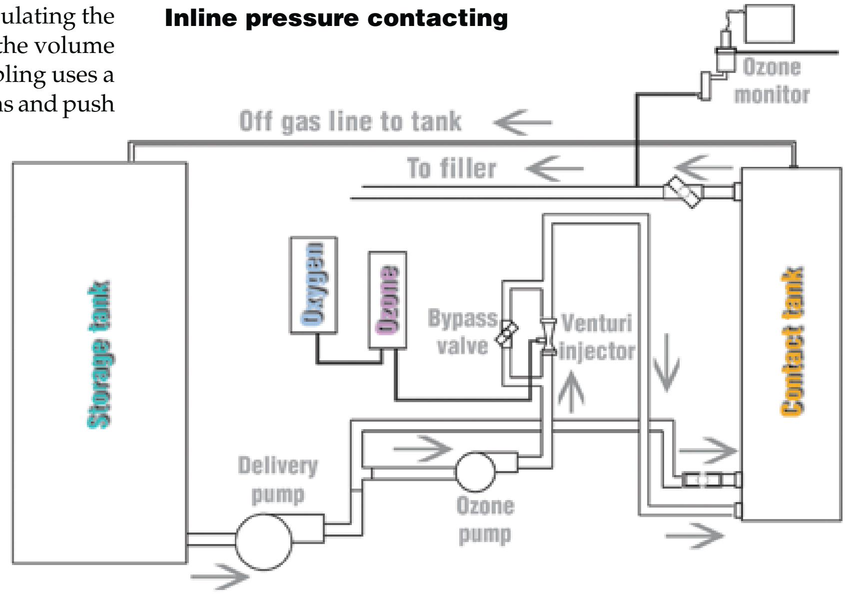
Circulation uses a small circulating pump, a small ozone generator and a Venturi injector to create and entrain ozone gas



Batch processing

into the water stream circulating into the tank. In circulating the water, the whole tank is presumed to be exposed by the volume of water through the pump and Venturi system. Bubbling uses a small ozone generator and air pump to create ozone gas and push it through a diffusion stone into the storage tank.

Inline pressure contacting



When the desired ozone level is reached, a separate pump delivers ozonated water from the storage tank to the filling operation. The tank is ozonated continually by whichever batch processing method is used.

This is done to maintain an acceptable ozone level. Batch processing is usually good for small bottling operations that do not require large amounts of processed water.

Inline pressure contacting

This method of ozonation is considered a real-time system and can be handled in one of two ways.

The first method uses one pump to deliver water from the storage tanks through a Venturi injection assembly with a large amount of bypass into a pressurized contact tank and then out to the bottle filler. This requires a return line back from the filler to the storage tanks.

This technique is ideal for small bottling operations and for small fillers that do not require high pressures to fill. If sized correctly, an ozone monitor/controller may not be needed.

The second method uses two pumps. A main pump is used to draw product water out of the storage tanks and to push it through the contact tank and into the filler. A smaller pump is used to boost some of this pressurized water through a Venturi injector assembly to draw the correct amount of ozone into the water stream.

The two streams of water merge and mix together in the pressurized contact tank on their way to the filler. This method is also called *side-stream ozonation*.

If sized correctly, an ozone monitor/controller may not be needed; however, it is best to have one to ensure that the correct level of ozone is supplied to the filler. This is a good method for intermediate-sized bottling operations.

Ozone equipment and methods

The most important factor in the ozonation process is the equipment and the method used to introduce ozone into the water. Equipment, such as the following, is recommended to create ozone and to inject ozone into product water:

Oxygen concentrator

A good, pressure-swing adsorption system is highly recommended. This equipment removes nitrogen and moisture from the air stream and delivers a 90 percent-plus dry oxygen stream to the ozone generator for higher ozone concentrations.

Ozone generator

A good, high-frequency corona discharge unit is recommended. These units are capable of producing ozone concentrations in the air stream, from four to six percent by weight. The ozone is created as the oxygen stream travels through the ozone generator's corona discharge dielectric cell.

The proper electrical charge with the right frequency will create a high-quality ozone concentration. Generators are usually rated in grams per hour or pounds of O_3 per day, which allows a designer to specify the correct generator for an application.

Some equipment manufacturers do not rate their generators accurately and there are no real ozone unit industry standards that can be reliably used to judge unit output. The NSF has issued a revised standards statement on ozone generators. For more information, contact that organization for document *NSF/ANSI 222—2066e*.

Venturi injector

A good, properly sized Venturi-type injector is absolutely necessary to ensure the formation of small micro-sized bubbles as the ozonated stream of air is sucked into the product water stream. A well-designed assembly is capable of entraining ozone into the water with an efficiency of 95 percent or better.

Contact tank

A properly sized contact tank is necessary to allow more gas into the solution. It also permits adequate contact time for the water with the ozone to oxidize contaminants, or to disinfect the water and release any excess gas that did not go into the solution.

Summary

Ozone treatment is an effective disinfectant for water being used in bottled water operations. The process requires careful, precise operation and quality equipment, to ensure that bottled water is properly disinfected and tastes good throughout its shelf life.

The best system for introducing ozone into the final bottled water products depends on many factors. These include the size of the operation, the type of water to be treated, the level of ozone required and the current or proposed bottling equipment.

To get the best quality ozonated bottled water, it is best to consult a company that deals with complete bottled water plant systems and that supplies complete integrated systems.

About the author

♦ *John Swancarra is an engineer with Norland International, Inc. and has worked in the bottled water industry for over 20 years.*

About the company

♦ *Norland International is a leading producer of state-of-the-art equipment for the bottled water industry. Based in Lincoln, NE, Norland specializes in designing and manufacturing a full range of bottled water equipment for the small- to mid-sized bottling operations. Founded in 1993, the company's equipment is being used profitably across the US and around the world.*