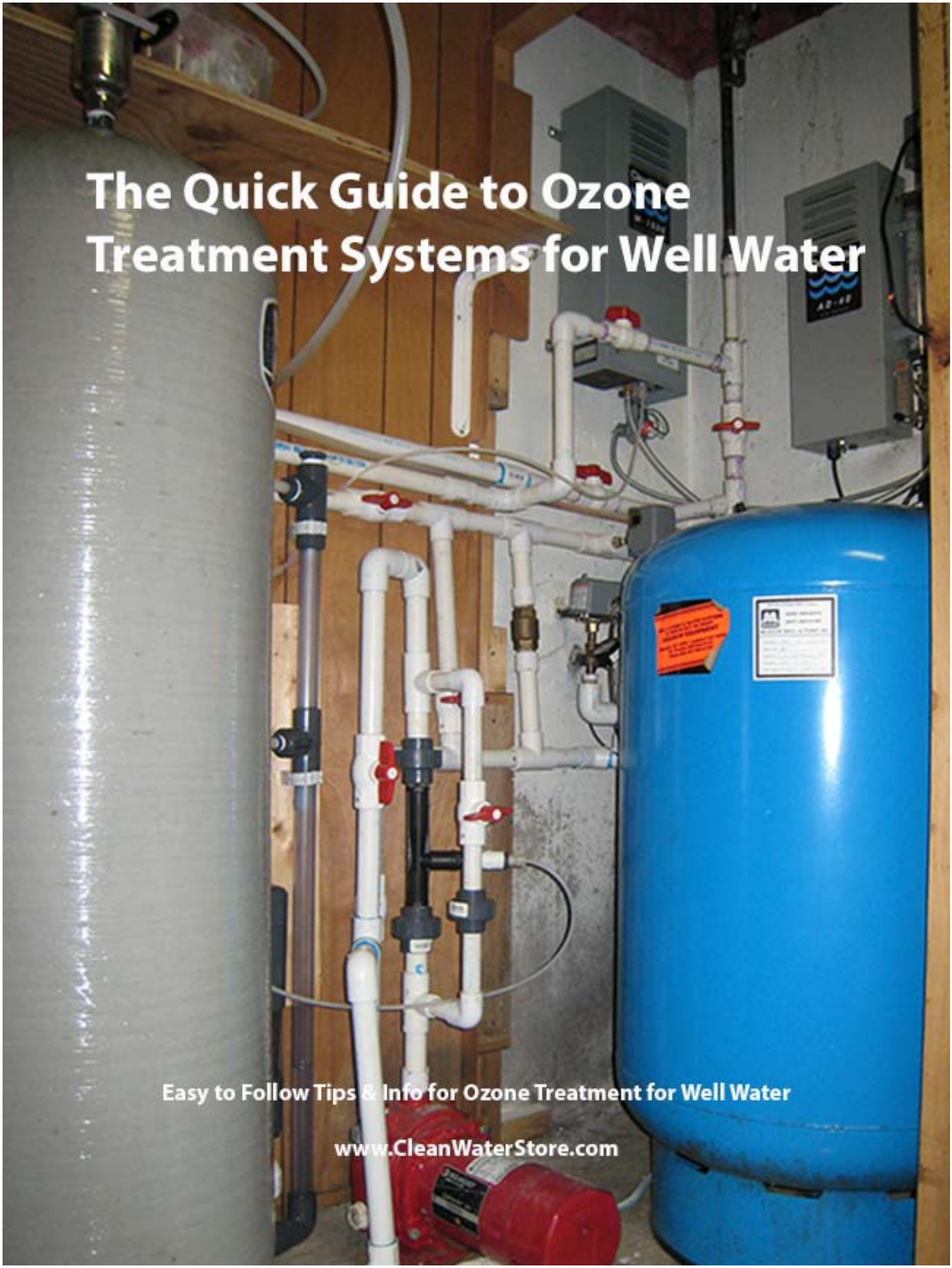

The Quick Guide to Ozone Treatment Systems for Well Water

Easy to Follow Tips & Info for Ozone Treatment for Well Water

www.CleanWaterStore.com

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Welcome to "The Quick Guide to Ozone Treatment for Well Water"

Our company Clean Water Systems & Stores has been providing solutions for thousands of problem water wells since 1985.

We have been recommending and using ozone systems to treat bad well water since 1989.

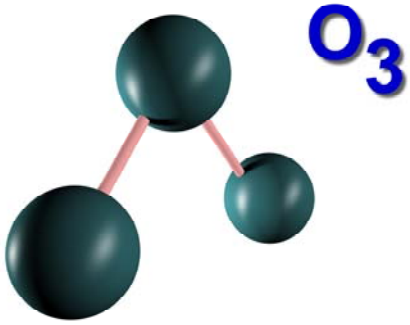
There have been a tremendous amount of improvement in ozone generators and designs over the years.

We put together this quick guide to give you an overview on how ozone works and the best ways to implement for your well water system.

If you have any questions about the material in this guide, or want to offer us feedback please contact us!

Toll-free: 888-600-5426

Email: support@cleanwaterstore.com



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What is Ozone?

Why Use Ozone to Treat Iron, Manganese, Sulfur Odor & Bacteria?

www.cleanwaterstore.com
Clean Water Made Easy.

Chlorine is commonly used in well water to treat iron, manganese and odors, but it can leave a chlorine residual in the water.

Ozone has a greater ability to disinfect water of bacteria and viruses compared to chlorination.

In addition, the oxidizing properties can also reduce the concentration of iron, manganese, sulfur and reduce or eliminate taste and odor problems.

Ozone oxidizes iron, manganese, and sulfur in well water to form insoluble metal oxides or elemental sulfur.

These insoluble particles are then removed by post-filtration, typically activated carbon, manganese dioxide, or other filter media.

Ozone is faster at killing bacteria and oxidizing iron and manganese compared to chlorine or peroxide. For example, the CT value (Concentrate of the oxidizer multiplied by the Time in minutes) for disinfecting water of viruses is 6. 6 minutes at 1 PPM chlorine concentration. Whereas for ozone the CT value is less than 1.

This varies, of course, depending on the water temperature and the pH of the water, but it gives a good illustration that ozone works faster, which saves time and money on the size of the contact tank and equipment needed to do the job.

Ozone is quite unstable, and it will degrade over a time frame ranging from a few seconds to 30 minutes. The rate of how fast it will degrade is a function of water chemistry, pH, and water temperature.

Ozone Injection System for Private Well

Clean Water Systems has many thousands of satisfied customers worldwide since 1985. We are dedicated to provide our customers high quality water treatment systems at the lowest cost.

What is the Advantage of Using Ozone Versus Chlorine or Hydrogen Peroxide Injection?

Ozone has a greater ability to disinfect water of bacteria and viruses compared to chlorination. In addition, the oxidizing properties can also reduce the concentration of iron, manganese, sulfur and reduce or eliminate taste and odor problems.

Ozone is faster at killing bacteria and oxidizing iron and manganese compared to chlorine or peroxide. For example, the CT value (Concentrate of the oxidizer multiplied by the Time in minutes) for disinfecting water of viruses is 6. 6 minutes at 1 PPM chlorine concentration.

Whereas for ozone the CT value is less than 1 so disinfection and oxidation occurs faster than chlorine or peroxide.

This varies, of course, depending on the water temperature and the pH of the water, but it gives a good illustration that ozone works faster, which saves time and money on the size of the contact tank and equipment needed to do the job.

Ozone oxides the iron, manganese, and sulfur in the water to form insoluble metal oxides or elemental sulfur. These insoluble particles are then removed by post-filtration, typically activated carbon, manganese dioxide, or other filter media.

Ozone is quite unstable, and it will degrade over a time frame ranging from a few seconds to 30 minutes. It is produced on site automatically.

The rate of how fast it will degrade is a function of water chemistry, pH, and water temperature.

Chlorine bleach is used to disinfect and treat well water. Chlorine is cheaper to implement than ozone, but can leave a chlorine residual in the water .

Hydrogen peroxide is also used to treat odor and oxidize iron in well water. Chlorine and also peroxide solution must be regularly added and monitored. Ozone is automatic.

Corona Discharge Ozone Generators

How is Ozone Produced?

There are two methods of producing ozone:

- Corona discharge
- Ultraviolet light

Corona discharge (CD) is the most efficient and powerful type of ozone production.

In CD ozone generators, electricity is used to produce an electrical discharge across a dielectric (cathode/anode), and an air gap.

The technology behind how ozone is produced varies a bit, but all work basically the same by flowing dry air or oxygen through an electrical field.

A percentage of the oxygen molecules are “split” and then recombine to form ozone.

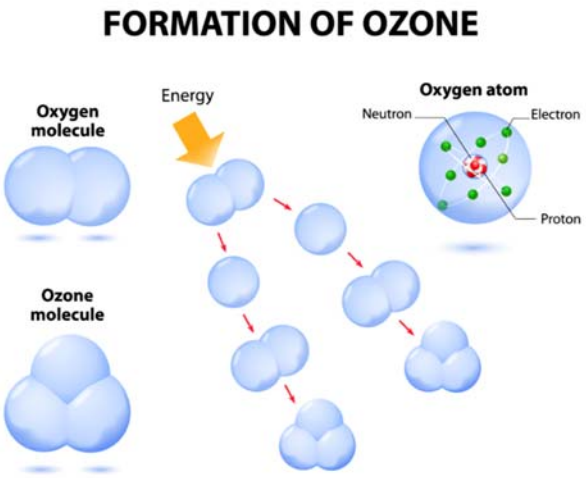
The dielectric is used to diffuse the discharge over a space, as opposed to single point like a normal spark. Basically its a high voltage electrical spark, in a chamber.

Air contains oxygen, so when air flows through the corona discharge chamber, some ozone is produced.

Using pure oxygen will create a lot more ozone than just air which is only about 20% oxygen. The air feeding the ozone generator needs to be relatively free of moisture, so some kind of air dryer is used prior to the CD ozone generator.

The oxygen molecules passing through the air gap are exposed to the electrical discharge and are split into ozone. Dielectric materials used are typically ceramic, glass, or quartz and the corona chamber itself can either be flat plate or a round conically shaped chamber.

The corona cell may house a dielectric that is a flat plate, or conical tube. The corona chambers are usually constructed of stainless steel, aluminum or other ozone resistant materials.



Corona Discharge Ozone Generator with venturi injector and vacuum break to prevent water from backing up.
Courtesy of Clearwater Tech Ozone.

UV Ozone Generators

CD ozone generators use high voltage to create the corona discharge, and some type of transformer is used to create 600 to 20,000 volts depending on the type and design.

Ultraviolet (UV) ozone generators use UV light (typically a 185 nm UV lamp) to split the oxygen atom.

The molecule (O2) splits into two atoms (O), which then rapidly combines with another oxygen molecule (O2) to form ozone.

Basically there is a stainless steel or aluminum tube with a UV light inside. Air or oxygen is drawn or pumped through the UV chamber, where it is exposed to UV light and some ozone is produced.

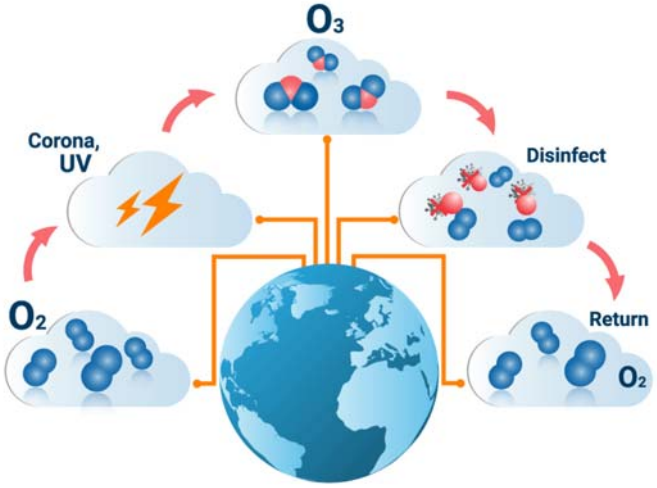
Because UV ozone generators produce much less ozone and in lower concentrations, often air dryers are not used.

UV light Ozone Generators are often less expensive than CD ozone generators, and are pretty simple in operation.

The basic items required for a UV generator are:

Stainless steel or aluminum tube or chamber to house the 185 nanometer UV lamp, a Ballast (a type of transformer) to power the UV lamp

A vacuum injector to suck or draw air through the UV ozone generator OR an air pump to push air through the generator (more common)



Ozone is created in Earth's atmosphere

UV Light Ozone Generator

UV Ozone Generator & Injector

Disadvantages of UV Ozone Generators

- Maximum ozone production rate is around two grams per hour, per UV lamp depending on size. Often much higher ozone concentrations are needed, depending on water quality and flow rate.
- The highest concentration of ozone that can be produced by a 185-nm UV lamp is 0.2 percent by weight, whereas 2.0 percent (or ten times the amount) is common with CD ozone generators.
- Much more electricity is needed to produce a given amount of ozone by UV generators, compared to CD generators.
- UV ozone generators need a lot more air volume to achieve basic disinfection or oxidation of odors and iron. This means greater quantity of air needs to be pumped into water and can create problems with off-gassing.
- The quartz glass of UV lamps gets solarized (where it looks it is coated with a smoky color) after about a year of operation, which then requires the UV lamps to be replaced, in order to continue to be effective.

UV lights (sometimes referred to as UV lamps) for ozone production are a bit different than UV used for water disinfection.

With UV ozone generators, the UV lamp shines into air, and air is drawn through the UV chamber. A small amount of oxygen is converted to ozone.

UV Ozone Generator

Small UV Light Ozone Generator

Effective Methods for Injecting Ozone Gas Into Water

- Ozone is a gas, so how is it transferred into water, which is a liquid?
- Ozone has been in use to treat water since the 1890's. During the first 75 years or so, the most common way to ozonate water was to bubble it into a column of water under pressure.
- This usually meant it was bubbled in to the bottom of a tall (20 to 30 feet high) non-pressurized water column through a bubbler diffuser ceramic stone or pipes with holes drilled into it.
- It is well known that the mass--transfer of ozone into a column or tank of water 20 foot high or shorter water is no more than 10% in a 20 foot or shorter water column.
- This means that 90% of the ozone being produced is wasted and needs to be vented off.
- Ozone bubbler systems are now common in well water storage tanks, and one can smell the ozone gas around these types of systems.
- One may think "the ozone is working great! I can smell it!", but actually this a sign of a poor design.

Mass Transfer of ozone, refers to the movement of the ozone (a gas) into water, a liquid.

Pressure is important for mass transfer of ozone to occur. That is, more ozone is transferred or dissolved into water, when that water is pressurized.

If a tank of water is pressurized to 50 PSI, a high rate of mass transfer of ozone can occur.

If the tank is open, such as an storage tank, very little, less than 10% of the available ozone is transferred, and the rest just vents off to atmosphere.

Bubbler Diffusers

Bubble Diffusers (often a ceramic diffuser stone, or a stainless steel mesh diffuser, or a PVC pipe with tiny holes drilled in it) work by emitting ozone through hundreds of bubbles beneath the water's surface.

Because the ozone gas does not transfer very well or dissolve well into the water, there is more of a problem with ozone off-gassing with this type of ozone system.

This type of ozone air bubbler system is more suitable for aerating storage tanks where there is a slight odor, or low levels of iron or manganese, before the filtration system.

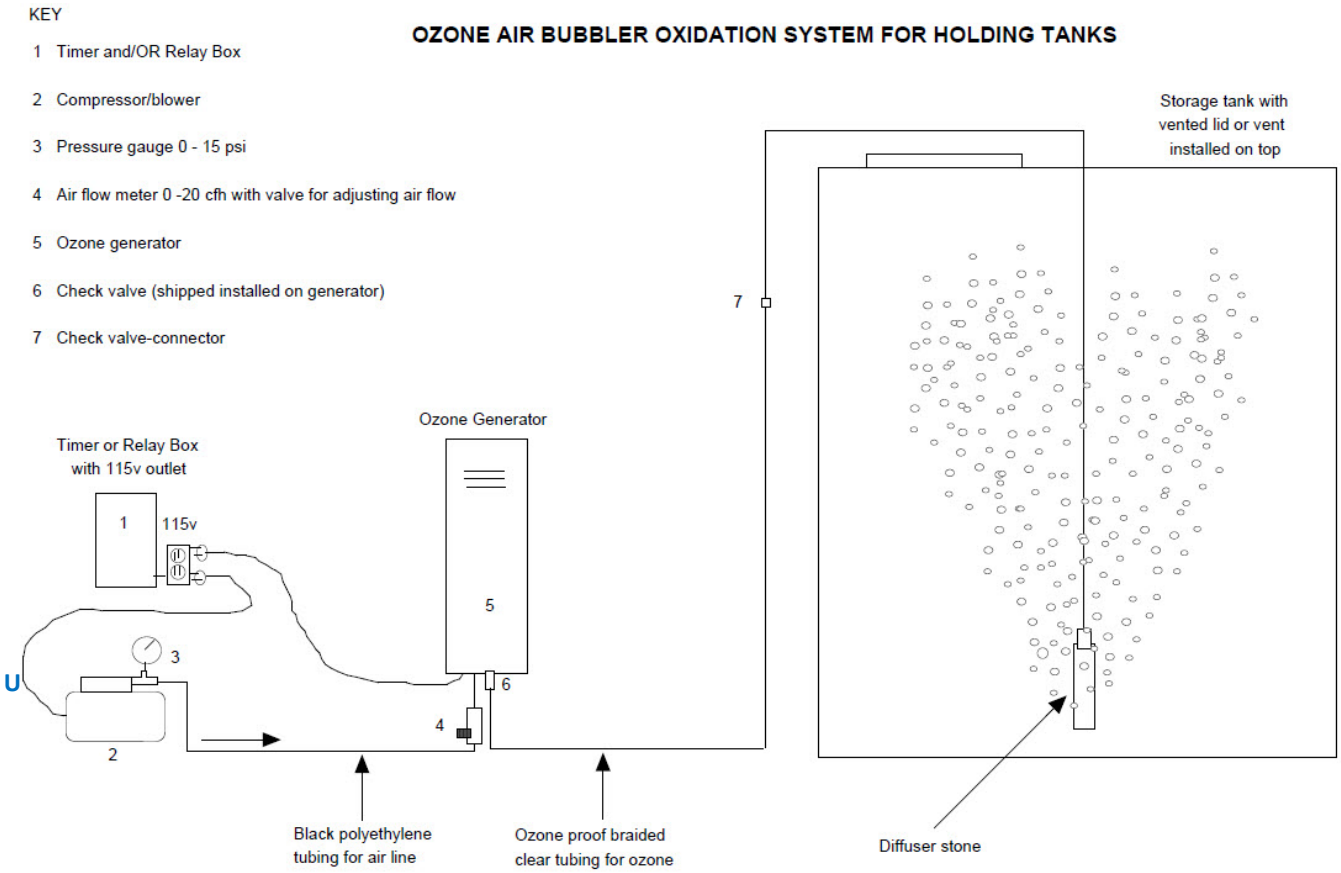
In the past 20 years or so, venturi injection and advances in venturi design have allowed a system with mass transfer of the ozone greater than 90%.

Bubbler Diffuser Fun Facts

Much lower levels of ozone actually ends up in the water (the “mass transfer” using bubbler is usually around 10-15%). The lower the storage tank height is.. the worse the mass transfer is.

A 20 to 30 feet high tank is minimum recommend height when using bubbler diffuser types.

Bubbler diffuser holes can become fouled over time… decreasing transfer efficiency.



Venturi Injectors

Venturi Injectors work by water flowing through a pipe, where the water is forced through a small orifice.

This allows a pressure differential between the inlet and outlet sides of the injector.

This creates a vacuum inside the injector, which then draws in ozone gas through the suction port.

Typically a booster pump is required to deliver the higher pressure needed to drive the water through the injector, depending on the application.

Advantages of Venturi Injectors

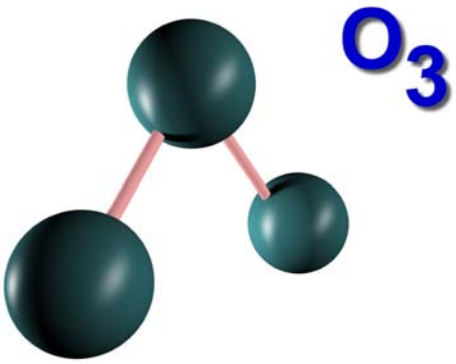
- High efficient ozone mass transfer rate (up to 98% if pressurized, 50-70% without pressure)
- Efficiency won't decrease over time, unless the venturi injector gets fouled
- Less air or oxygen is injected into the water, which means less bubbly water, and less off-gassing.

Ozone Venturi Injector

Injectors from the Mazzei Injector Company are our preferred injector to use for injecting ozone gas.

How To Size Ozone Systems for Well Water

Small ozone generators are sized in terms of output in Grams Per Hour of ozone.



Ozone (O_3)has 3 oxygen atoms. Ozone is a more powerful oxidizer than oxygen (O_2)

Ozone Demand Calculations:

Ozone generators are sized in terms of output in Grams Per Hour, as well as concentration of ozone produced by weight.

It is important to know however not only the grams per hour but also the concentration by weight that a particular ozone generator can produce.

A simple formula to find out how many grams per hour of ozone generator you need is: Gallons Per Minute x Liters Per Gallon x 60 x PPM / 1000 = Grams/ Hour of Ozone.

(GPM x 3.78 x 60 x PPM) / 1,000 = g/hr ozone

Oxygen Separator generates 90% pure oxygen, which can be used to feed ozone generators in place of dry air.

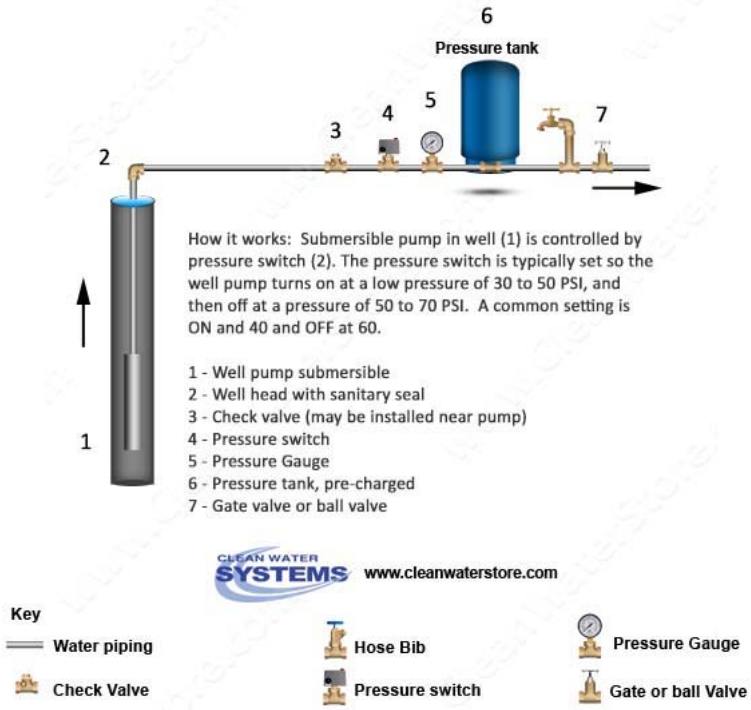
5 Gram Per Hour Ozone Generator (with dry air feed gas)

Four Steps to Calculate Ozone Demand

Step 1

- The first step is to figure the flow rate of the stream of water you are injecting to, as Liters Per Hour.
- If the flow rate is in Gallons Per Minute (GPM) it must be converted to Liters Per Hour (L/hour).
- Simply multiply the rate in GPM by 60 to get gallons per hour and then multiply that figure by 3.785 to get the equivalent flow in L/hr.

Measure the flow rate between your well pump and the pressure tank for well head installations. For other applications such as storage tank recirculation use the booster pump flow rate.



Need to find out your well pumps flow rate? Flow rate is simply how many gallons in one minute, your well pump can pump.

Click Here to see our Easy Well Water Flow Rate Calculator.

Calculate Ozone Demand Step 2

Next determine the contaminant “Ozone Demand” for the ozone by multiplying the mg/L (same as saying parts per million, or PPM) for each contaminant found in the source.

Use the corresponding equivalents below:

- Iron (Fe) demand = X x 0.43 = mg/L
- Manganese (Mn) demand = X x 0.87 = mg/L
- Hydrogen Sulfide (H2S) demand = X x 3.0 = mg/L
- Bacteria (add 0.5 mg/L)

Sum total = mg/L = mg/L(O3) demand = O3D

Calculate the ozone demand required…

Depending on the water chemistry. Iron, manganese and hydrogen sulfide are commonly found in residential wells and can cause stains, bad tastes and odors.

The proper amount of ozone injected, followed by a backwash manganese dioxide iron filter removes iron and manganese, and eliminates odors.

Calculate Ozone Demand Step 3

Multiply the ozone demand by Liters Per Hour (from Step 2)… to calculate mg/L (PPM) of ozone required.

Convert to Grams Per Hour Step 4

Divide by 1,000 to convert to grams per hour needed to treat the water.

Example Calculation

Say you had a water test, and discovered you have 1.4 mg/L of iron; 0.4 mg/L of manganese and 1.0 mg/L of hydrogen sulfide. Basically rusty, smelly well water with a lot of iron and manganese!

You know the flow rate coming out of the well pump is 10 gallons per minute (GPM).

Step 1: Convert Gallons Per Minute to Liters Per Hour:
10 gpm x 60 x 3.785 = 2271 L/hr.

Step 2: Calculate Ozone Demand, Based on Your Water Chemistry:
1.4 Fe mg/l x 0.43 = 0.60 mg/L
+ 0.4 mg/L Mn x 0.87 = 0.35 mg/L
+ 1 mg/L x 3.0 mg/L = 3 mg/L
Add those up and you get:
= 3.95 (lets round to 4) mg/L of Ozone Demand + 0.5 for disinfection, so 4.5 total.

Step 3: Multiply Liters Per Hour flow rate times the total Ozone Demand to get Milligrams per Hour ozone needed:
2271 L/hr. x 4.5 = 10,219 mg/hr.

Divide Milligrams per Hour by 1000 to get Grams Per Hour (typically small ozone generators are sized by grams per hour output)

Step 4. 10,219 mg/hour divided by 1,000 = 10.2 grams per hour, total ozone demand.

This means, that if you wanted to treat this water at 10 gallon per minute flow rate, you would need an ozone generator that was capable of 10.2 grams per hour.

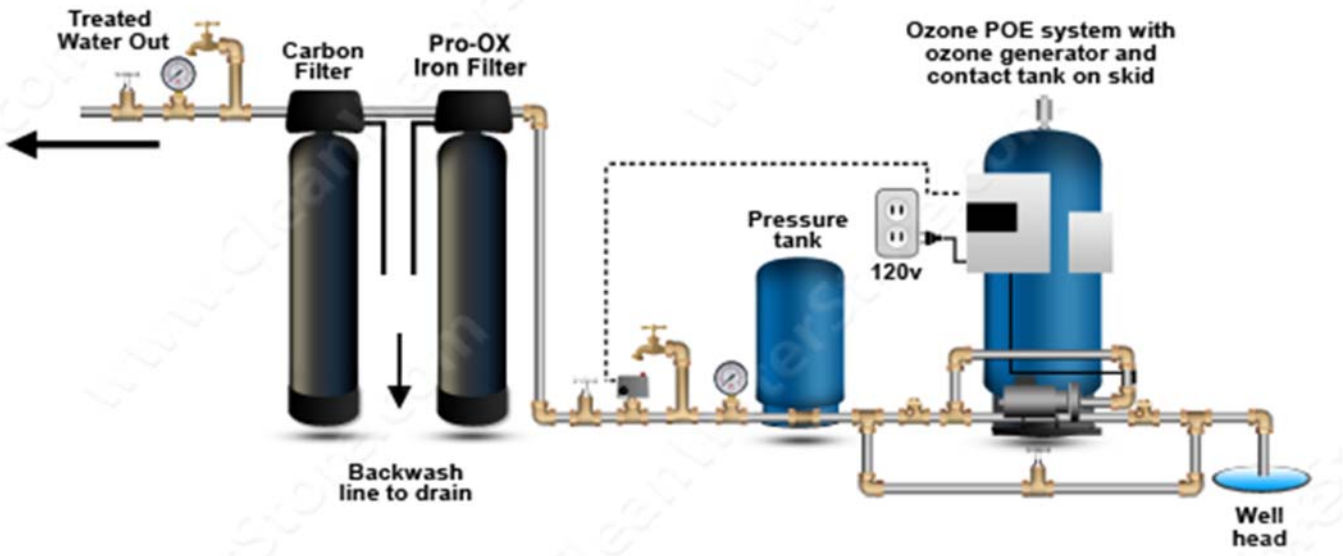
However, this is theoretical and is considered to be a one-pass system, that is the ozone is being injected as the water flows past the injector.

If you use a recirculating system, and a contact tank, you can achieve oxidation and build up the ozone concentration in the water in the contact tank with a smaller output ozone generator.

For example, in this application above, at 10 GPM, a 2 to 5 gram an hour system would work well, because of the recirculation in the contact tank.

ClearWater Tech POE15 ozone recirculation skid . Pre-piped and pre-wired.

How To Set Up a Recirc Ozone Injection System on a Well System



- In order to use a venturi injector to draw in ozone on a well system, you can use a one-pass in-line venturi injector OR a multi-pass recirculation system.
- A multi-pass recirculation ozone system works best.
- If the ozone system is to be used on a well system with a pressure tank, we rarely found conditions that a one pass system would work well.
- This type of ozone system injects ozone but does not affect the pressure or flow rate of the well pump, because the ozone recirc pump is what is driving the venturi injector.

Disadvantages of One-Pass Injector Ozone Systems

Single pass ozone injection with large oxygen-fed ozone generator and contact tank.

- **Pressure drop and flow restriction:** There is a considerable pressure drop through the injector, in order to create the venturi effect (suction). This can cause back pressure on the well pump, and cause loss of pressure downstream of the injector.
- **An inline injector for a well system must be carefully and narrowly sized** and selected and care must be taken regarding inlet pressure to the injector and outlet pressure, otherwise the selected injector will not work properly.
- **If you need to backwash a filter system after the ozone** (which is a common necessity) the injector may restrict the flow too much so that there is no enough backwash available to properly backwash the filter system.
- **If the well has rust, sediment or sand**, this can seriously and rapidly degrade and foul the inline injector.
- **A one pass system may require a very large ozone generator,** in order generate enough ozone to meet the ozone demand (iron, manganese, hydrogen sulfide, bacteria etc) in the well water.

Advantages of Recirculating Ozone Venturi Injector Systems

In this design a small stainless steel ozone resistant booster pump pulls water from the contact tank, drives it through the injector and is able to create very good air flow and suction.

The well pump or flow does not have any effect on venturi performance so it works well in all conditions.

Water can flow from the well through the contact tank without experiencing back pressure.

Excess sand or silt or rust can be trapped in the bottom of the contact tank, and automatically be drained out (with a timer equipped motorized ball valve) OR be manually drained periodically through the bottom port ball valve.

Since the recirc pump can pass water many times through the injector, an ozone residual can be built up in the contact tank.

Recirculating Pressurize Contact Tank Ozone Injection System

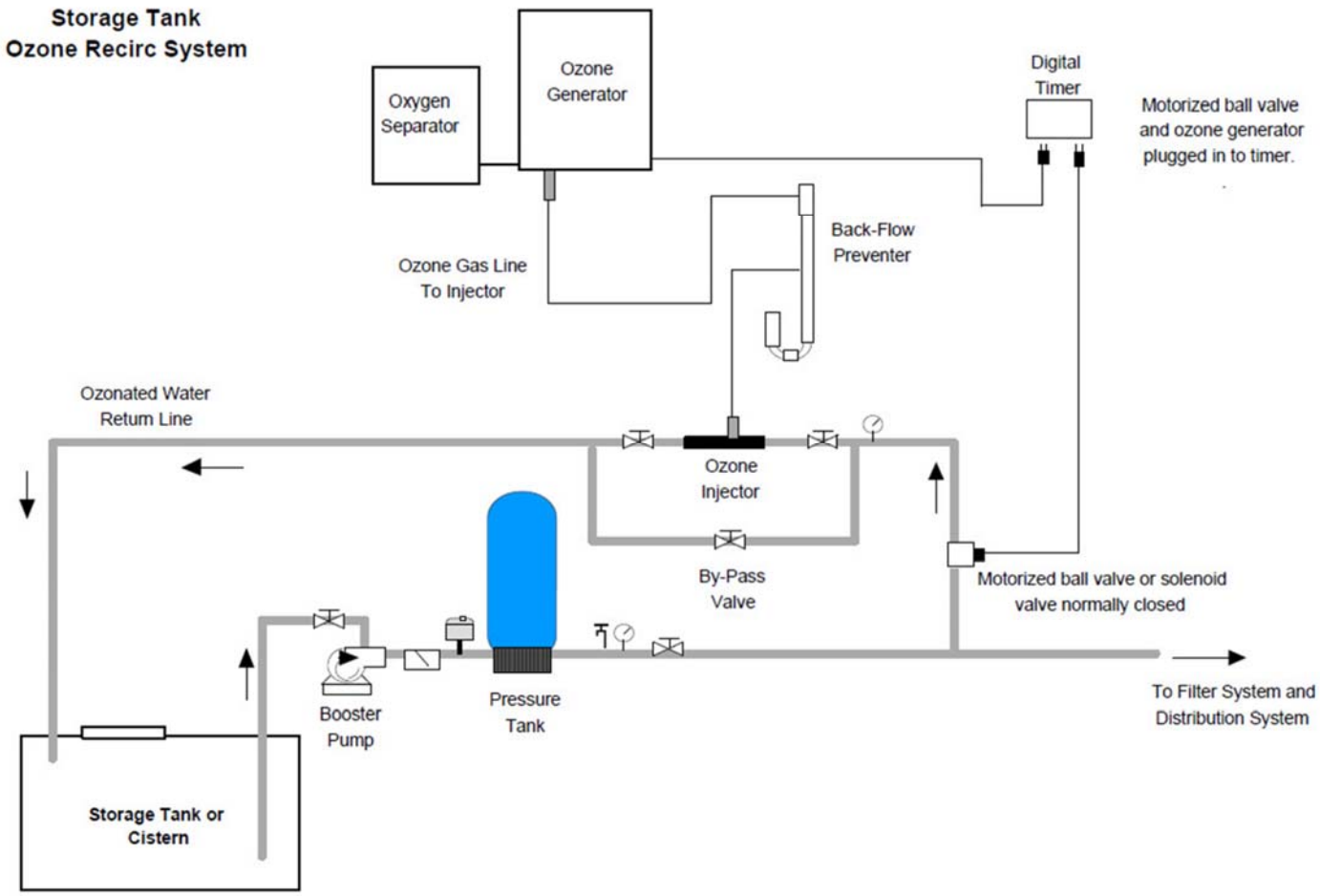
The ozone can be injected prior to the well pump turning on with a start-delay timer relay, or after the well pump has built up pressure in the pressure tank and shut off (with a stop-delay timer relay).

It is more effective to regulate the pressure in a contact tank recirc ozone system to achieve more efficient mass transfer of the ozone.

Using a pressurized contact tank of 50 PSI works ideal to get a good mass transfer of the ozone gas into the water.

A recirc system with a properly sized contact tank can efficiently off-gas the excess air or gasses introduced into the water, keeping the water free of bubbles and gasses.

Non-Pressurized Storage Tank Recirculating Ozone Systems

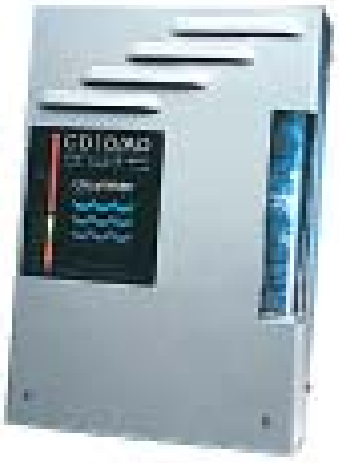


- The water in cisterns or storage tanks can be automatically circulated and injected with ozone, to kill bacteria, oxidize iron and manganese and keep water fresh.
- The digital timer is set to run for a certain number of minutes or hours per day.
- When timer activates the ozone generator turns on and a valve opens, allowing water to flow past the injector.
- The venturi injector creates a vacuum and draws ozone in to the water in the storage tank or cistern.
- As an option, the system can be wired to turn on when water flows into the storage tank from the well or spring, automatically.

Air Dryers and Oxygen Separators Boost Ozone Concentrations

- If we use dry air in corona discharge system, we can get up to 3-4% by weight of ozone gas concentration.
- But if you use oxygen we can get up to 16% by weight. That is a huge difference and generally the reason we often recommend having an oxygen separator to feed oxygen instead of dry air to the corona discharge ozone generator.
- If you think about it, the air we breathe contains only about 19% to 20% oxygen, so using pure oxygen works much better and generates a lot more ozone concentration.
- This means you can inject less gas into the water to get the same effect, and/or have a higher flow rate of water using the same ozone generator.

Oxygen Separator Generates > 90% Pure Oxygen



ClearWater Tech CD10-AD Ozone Generator with Built-in Automatic Air Dryer.

Air Drier Cartridges. Changes from blue to red color when it needs changing.

Filtration Options After Ozone

- After the water has been injected with ozone and after the contact tank and pressure tank, filtration is recommended to remove oxidized sulfides, iron, manganese or to remove any excess ozone dissolved in the water.
- An excellent and long lasting filter media for ozonated water is high purity manganese dioxide. Some manganese dioxide media are not solid ore, but are have a coating of a thin layer of manganese dioxide over some other type of media such as silica, greensand or other media.
- The ozone can degrade this type of coated media, especially in higher concentrations of ozone, whereas solid manganese ore granules work well and last for many years.
- A catalytic reaction occurs with the ozone gas and ozone is converted back to oxygen.
- An advantage of manganese dioxide media is that it will continue to remove iron and manganese even if the ozone system were to fail for any reason, so it keeps the water cleaner than if filter sand or activated carbon were used for filtration after the ozone.
- In some cases if there is excess ammonia or organics in the water, a two stage approach using manganese dioxide filtration followed by activated carbon works well.

Pro-OX Manganese Dioxide Auto Backwash Filter System removes odor, rust, sediment and residual ozone from water.

Pro-OX natural manganese dioxide filter media lasts for many years. Unlike other media that is coated with a thin layer of manganese dioxide, Pro-OX is a solid media. It works well with ozone feed and removes any residual ozone from the water as well as filtering and clarifying.

Test Your Water Chemistry

If you are experiencing iron or rust staining, and want to implement ozone injection, the first step is to test the water.

Take the sample of the water right from the well before it enters the house. If this is not possible, then run the water for 5 to 10 minutes so you know the water is coming right from the well.

Tests should include alkalinity, hardness, hydrogen sulfide, iron, manganese, pH, total dissolved solids. If the water has a tea color to it, or has a yellowish clear color to it, then a tannin test is recommended as well.

It should always include a pH test, which indicates if the water is acidic or alkaline. The ideal pH for iron filters to work properly is between 7.0 and 8.0, which is considered neutral and not acidic.

For health-related concerns include a test for total coliform, e-coli (fecal coliform) and nitrate. If infants and children will be drinking the water, a complete mineral, metals and bacteriological tests from a State certified laboratory is recommend.

After Ozone System is Installed:

It is important to check ozone residual in water. Check for level of ozone (PPM or mg/L) in the water after the contact tank, and also again after filtration. Generally one wants to see a slight ozone residual after the contact tank of 0.2 to 0.4 PPM (same as saying 0.2 to 0.4 mg/L). After filtration system though, no ozone residual should be detected in the water.

Easy Well Water Test Kit tests for hardness, pH, bacteria, iron, manganese, total dissolved solids, nitrate, nitrite, sulfate, chlorine, alkalinity.

Hach Ozone Test Kit tests for residual ozone in water quickly and easily. Monitor your ozone levels after contact tank and also after filtration.

Summary Quick Guide to Ozone Treatment

- ⇒ While upfront costs are higher with ozone, ozone is a great alternative to chlorination or peroxide.
- ⇒ No need to fuss with mixing chemicals, or having residuals of chlorine or chemicals in your water if you don't want or need chlorine.
- ⇒ Use corona-discharge generator with an air dryer or preferably an oxygen feed for best results.
- ⇒ Use a venturi injector recirculating pump system and inject the ozone into the water under pressure for best results.
- ⇒ Use filtration of manganese dioxide (and/or some catalytic activated carbon) after ozonation to remove excess ozone, metals, tastes and odors from water.
- ⇒ Test your water for general minerals such as iron, manganese, hardness, alkalinity and dissolved solids, as well as pH and bacteria.

If you have any questions about ozone systems, the material in this guide, or want to offer us feedback please contact us!

Toll-free: 888-600-5426 Email: support@cleanwaterstore.com