Highland Tank | TechNews

Chlorine Contact Tanks Fight Forever Chemicals

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The key factor in the destruction of pathogens by chlorination is Chlorine Contact Time.

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PROTECTING OUR DRINKING WATER

Here in the United States, the Safe Drinking Water Act (SDWA) requires the EPA to publish primary drinking water regulations that:
1) specify criteria under which filtration would be required,
2) requiring disinfection as a treatment process for all public water systems, and
3) treatment requirements for the control of Giardia lamblia, viruses, legionella, bacteria, and turbidity.

There are 155,000 public water systems in the United States. EPA classifies these water systems based on population served and the source of their water.

Many of these public systems rely on surface water as a primary source for drinking water consumption. The EPA's ***Surface Water Treatment Rule (SWTR)*** dictates to public water systems using surface water, or ground water under the direct influence of surface water, requires minimum disinfection to Giardia Lambia, enteric viruses, and bacteria.

The treatment techniques are required to achieve at least 99.9% removal and/or inactivation of the pathogens listed above.

On March 16, 2023, the EPA added strict new limits on six types of **per- and polyfluoroalkyl substances (PFAS/PFOA)** in drinking water. These substances are known as forever chemicals. Teflon, water proofing, AFFF, and many other products. The recent models show over 57,000 locations in the US to have some sort of PFAS contamination.

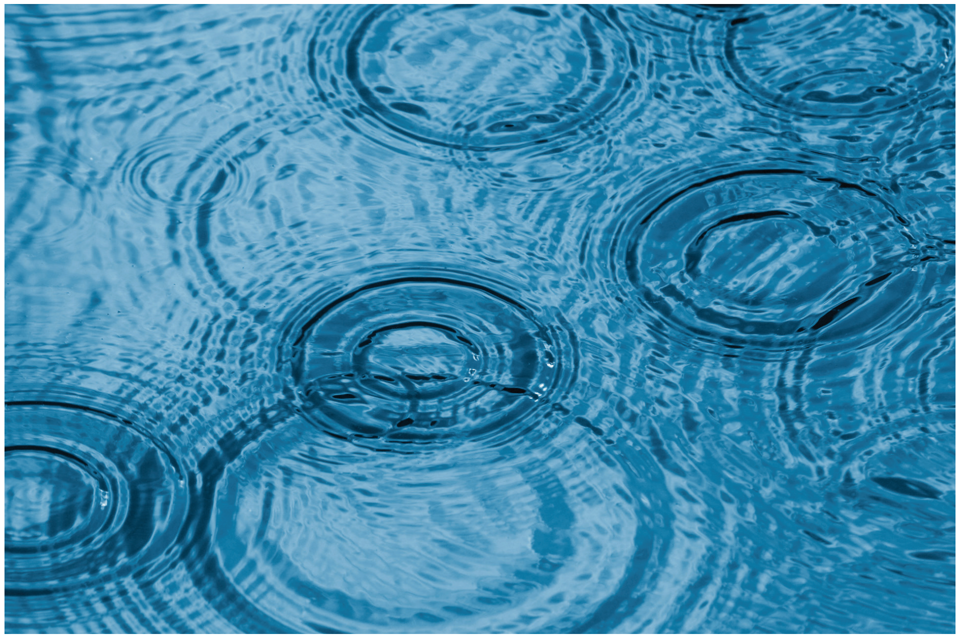
The EPA and US government have taken a number of steps to address these pollutants on the state and federal level.

Investments into our drinking water infrastructure has seen the need to include treatment of these forever chemicals.

New treatment train technology like hydrogen, UV, and carbon help in the cleanup and removal process.

To wrap up the treatment process and comply with 4 log disinfection, a Chlorine Contact Tank (CCT) is required to maintain a disinfection residual based on local, state, and federal regulations. Chlorine is the primary disinfectant used across the United States for surface water and ground water systems. Chlorination is the addition of chlorine (Cl_2) to water to form hypochlorous acid (HOCl). Benefits of chlorination include strong oxidizing powers, taste and odor control, prevention of algae growth, removal of iron and manganese, biofilm control, water main sterilization, and distribution system residual.

The chlorine reacts with pathogens to satisfy the chlorine demand. The chlorine remaining after the demand is the chlorine residual. The effective destruction of these pathogens by chlorination is dependent on a number of factors to include water temperature, pH, chlorine contact time (CT), turbidity and concentration of chlorine available after treatment (residual). The most key factor is the Chlorine Contact Time (CT).



CT measures the effectiveness of the disinfection process. This is important in complying with the 4-log treatment of pathogens standard found in SWTR.

CT = Concentration of free chlorine x contact time.
Free chlorine is measured in milligrams per liter (mg/L).

Process vessels have been used for the application of chlorine in both large and small community water systems. One of the process tanks that have evolved since the introduction of chlorine is the chlorine contact tank. This tank was designed specifically to achieve sufficient contact time between the injected chlorine and the water that needs disinfection.

The CT rule was adopted to use a more representative value of actual contact time. The effective contact time is designated T_{10} and is the time required for 10% of the water to pass through the process vessel.

The formula for T_{10} is as follows:
T_{10} = Effective Contact Time = V/Q x BF
V = Volume of process vessel
Q = flow rate
BF = Baffling Factor

As you can see from above, the process vessel relies heavily on flow and the baffling factor to determine effective contact time for disinfection. The baffling factor will determine the actual residence time within the process vessel. By increasing the baffling factor, the overall efficiency of the process is increased.

Below is a table outlining estimating baffling efficiencies for various storage and pressure vessels. *This table can be found in US EPA's "Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources," 1991 edition.* *The guidance manual can be found here.*

Baffling Condition	**T10/T**	**Baffling Description**
Un-baffled (mixed flow)	0.1	None, agitated basin, incredibly low length to width ration, high inlet and outlet flow velocities
Poor	0.3	Single or multiple un-baffled inlets and outlets, no intra-basin baffles
Average	0.5	Baffled inlet or outlet with some intra-basin baffles
Superior	0.7	Perforated inlet baffle, serpentine or perforated intra basin baffles, outlet weir or perforated launders
Perfect (plug flow)	1.0	Very high length to width ratio (pipeline flow) perforated inlet, outlet, and intra-basin baffles

The "baffling efficiency" or circulation effectiveness of a tank is used to determine CT. If the raw water used to calculate disinfection moves through a process vessel or pipe too quickly the scenario is called short circuiting.

The CT_{10} requirements also influence tank size. An inefficient tank with a normalized T_{10} of 0.1 requires a tank 7 times the size of a normalized T_{10} of 0.7 if the same concentration is assumed. Therefore, it can be stated that for the same level of disinfection, tank size can be related to tank efficiency. Tank efficiency can in turn be related to the number of baffles (and placement) in the chlorine contact tank.

Other factors that contribute to tank system size are temperature and pH. In establishing a treatment train, to include PFAS/PFOA, media filtration plays a major role in the primary treatment of raw water. Filters like Multi-Media, AG and Birm are instrumental in the primary treatment process.

Tertiary treatment is done with Carbon and pH filters to include specialized treatment for the forever chemicals. The polishing phase of the process is the CCT system. The Highland Tank CCT system provides a level of disinfection required by the AHJ and sized according to the site-specific water chemistry parameters. Figure 1 shows a sizing calculator for CCT systems.

This table illustrates valeus of CT based on the temperature and pH of the ground water to be treated.

Requirements: Total of 99.99 percent reduction (4-log) of viruses through disinfection

Given:		**Unit**	**Basis**
Volume	13800	gallons	Required to Achieve CT(R) + FS while minimizing disinfectant
Lowest water temperature	26	°C	Lowest recorded water Temp
Highest pH	7.8	pH	pH range was given as 6.8-7.8
Peak flowrate	800	gpm	Maximum estimated pump output under lowest total dynamic head conditions
Assumed free Cl residual	0.2	mg/L	Required to Achieve CT(R) + FS while minimizing Tank Size
Baffling Factor	0.7	-	Baffling Factor of Higland Tank CCT

Contact Time: Time in Contact (T) = Pipe Volume / Maximum Flow
T= 17.3 minutes

CT (Achieved): CT(A) = Chlorine Residual x Time in Contact (T) x Baffling Factor
CT(A) = 2.4 min*mg/L

CT (Required): CT(R) = 2 min*mg/L (see Table 1)

CT (Required) + FS CT(R) + FS = CT(R)*1.2
CT(R) + FS = 2.4 min*mg/L

CT (A) >= CT (R) + FS **CT Acceptable**

CCT Volume
CT=V/Q *BF*Dosage=T10*Dosage
12 minutes
13714.29 Required volume

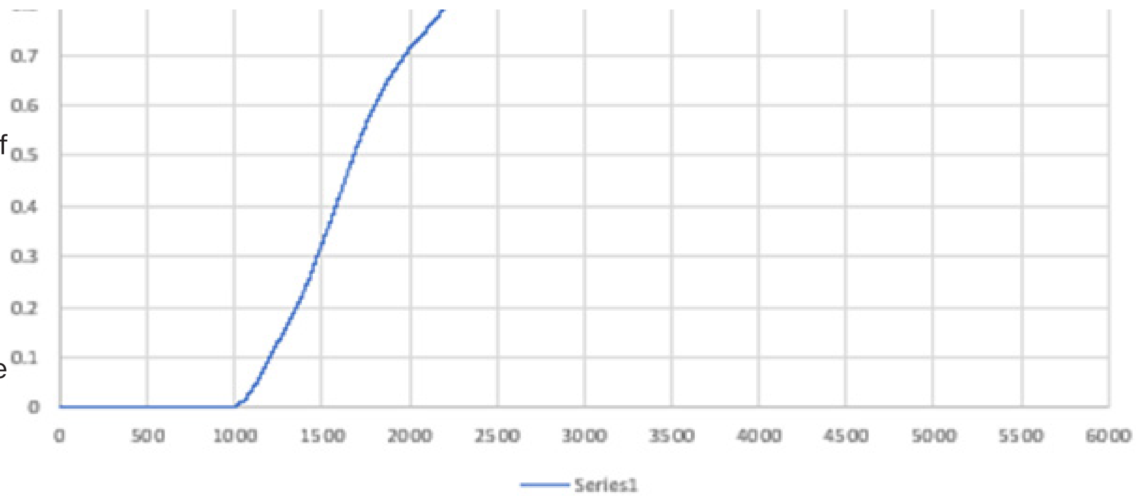
Highland Tank has developed a Chlorine Contact Tank (CCT) that meets the 0.7 baffling factor. By utilizing the length to width ratio and by implementing flow dispersion techniques, Highland Tank was able to produce a vessel that has obtained approval for PA, NJ, and NY DEP Bureau of Water Management for Ground Water Rule 4-Log Treatment Demonstration.

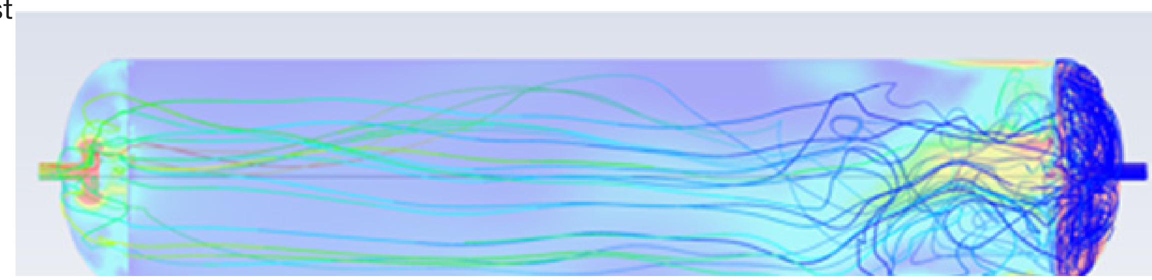
Use of this improved CCT results in superior CT, decreased treatment costs, and a reduction in the probability of disinfectant/disinfectant by-products.

Highland Tank has also implemented the use of CFD modeling to validate the CCT systems performance rating. This has become a useful tool in establishing the most economical and efficient disinfection system for the designated application. HT CCT systems are becoming an integral part of all municipal water treatment upgrades for proper system operation.

The design and operation of the Highland Tank CCT is simple. Highland Tank vessels are pressurized ASME vessels utilizing a vortex breaker as well as porous media to create a laminar flow pattern in the CCT. This is a benefit when calculating chlorination requirements.

Chlorine is injected on the inlet side of the vessel and the flow carries it to the point of application. Because Highland Tank CCT is under pressure, the minimum residence time, based on raw water temperature (see table B-2), is adequate to achieve the treatment and subsequent residual at the first test point.





The inlet and outlet structures in the CCT are designed to distribute the water flow uniformly within the cross-sectional area of the contact chamber. Strategically positioned porous media within the contact chamber aid in achieving the minimum residence time requirements. The Highland Tank CCT hydraulic flow characteristics are proven to meet or exceed industry standards by providing an efficient engineered system to meet requirements of the EPA's Surface Water Treatment Rule.

The alternative to a CCT, based on table C-5, is the 1.0 baffling factor which would require hundreds of feet of transmission main to achieve a perfect plug flow. This is no longer a cost-effective means of chlorination nor is it viable in today's modern treatment process. In summary, and as a rule, hydraulically inefficient tanks are not suited for chlorine contact tanks as their use will result in ineffective disinfection and higher disinfection dosage to meet the CT_{10} requirement. Various state governments are now requiring all community water systems, either derived from surface and/or ground water, to comply with the 4-log treatment of viruses, as well as per and polyfluoroalkyl substances, prior to the first customer for each of their groundwater sources.

This will require municipalities to allocate the necessary funds towards proper vessels and equipment for compliance. A smaller more efficient system is not only more cost effective but will provide the municipality and its customer's years of uninterrupted service for its precious water supply.

Call 814-893-5701 today or visit us at www.highlandtank.com for more information.

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