Guidance for Determining Free Chlorine Contact (CT) Time to Establish 4-Log Inactivation of Viruses

This information is intended to supplement the NEW Mexico Drinking Water Regulations, 20.7.10 NMAC (“NMDWR”) and is only applicable to public water systems, as defined in the NMDWR.

GROUND WATER RULE INFORMATION[1]

This document is intended to give guidance for calculating CT utilizing free chlorine to meet 4-log inactivation of viruses as required under the Ground Water Rule for small water systems. The guidelines are subject to change in the future based upon the Groundwater Rule which will have an effective compliance date of December 1, 2009.

It will be necessary for the water system to obtain Drinking Water Bureau (DWB) approval prior to installing chlorination devices pursuant to NMDWR 20.7.10.200. Public Water Systems (PWS) designing chlorination systems should take into consideration any requirements that may be imposed by the Groundwater Rule. For more information please refer to EPA’s Groundwater Rule website at http://www.epa.gov/safewater/disinfection/gwr/index.html

CT PARAMETERS[1]

The CT value is the residual disinfectant concentration (in milligrams per liter (mg/L)) multiplied by the contact time (the time in minutes it takes the water to move between the point of disinfectant application and a point downstream before or at the first customer during peak hourly flow). The system compares the CT value achieved to the published CT value for a given level of treatment to determine the level of treatment attained. As long as the CT value achieved by the system meets or exceeds the CT value needed for 4-log inactivation or removal of viruses, the system meets the treatment technique requirement of the GWR. Table 1 presents the required CT values identified by the SWTR 4-log inactivation of viruses with chlorine. Note that much higher CTs are required to achieve 4-log inactivation at pH 10 than at pH 6 to 9. The contact time (the “T” in “CT”) is affected by baffling factors as depicted in Figure 1; in addition not all processes receive credit for the full “time” that it can take for water to go through the process.

Table 1. CT Values for Inactivation of Viruses by Free Chlorine (mg-min/L)

Temperature (°C)	Log Inactivation1	
	4.0	
	pH 6-9	pH 10
0.5	12	90
5	8	60
10	6	45
15	4	30
20	3	22
25	2	15

1. Information adapted from LT1ESWTR Disinfection Profiling and Benchmarking Technical Guidance Manual (EPA 816-R-03-004) and Ground Water Rule Corrective Actions Guidance Manual (EPA 815-R-08-011)

Figure 1. Example Baffling Efficiencies

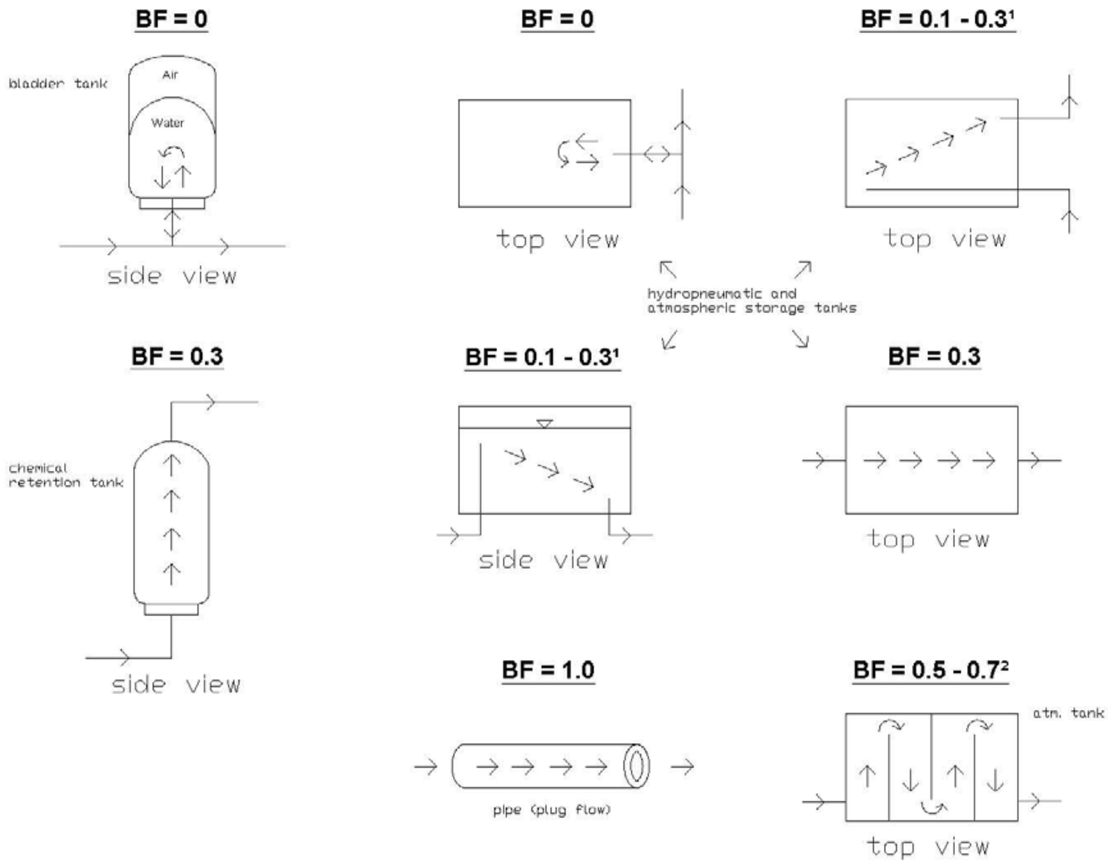


Table 2. Baffling Descriptions

Baffling Condition	Baffling Description	Baffling Factor
Unbaffled	Mixed flow, very low length-to-width ratio, high inlet and outlet flow velocities	0.1
Poor	Single or multiple unbaffled inlets and outlets, no intrabasin baffles	0.3
Average	Baffled inlet or outlet with some intrabasin baffles	0.5
Superior	Perforated inlet baffle, serpentine or perforated intrabasin baffles	0.7
Perfect	Plug flow; very high length-to-width ratio (pipeline flow), perforated inlet, outlet, and intrabasin baffles	1.0

Note that bladder tanks and atmospheric or hydropneumatic tanks with a single inlet and outlet are not given contact time credit since during a pump-on cycle, some of the water is bypassing the tank.

[1] The recommended BF for tank configurations with separate inlets and outlets is 0.1 if the inlet pipe is not extended in the tank and up to 0.3 if the inlet pipe is extended as far in the tank as possible.

Guidance for Determining Free Chlorine Contact (CT) Time to Establish 4-Log Inactivation of Viruses

CT CALCULATION

Public water systems must obtain the following information in order to calculate CT. An example calculation can be seen in Figure 2.

1. The sum of the CTs for each water system component, from the point where chlorine is added to the point where it is measured before the first customer
2. The volume and baffling efficiency of each component.
3. The peak flow through each component.
4. The free chlorine residual measured downstream of all the components and upstream or at the first customer.
5. The temperature and pH of the source ground water.

APPLICATION FOR APPROVAL

Water systems implementing free chlorine treatment to meet 4-log inactivation of viruses as required under the Ground Water Rule must complete and submit an application for groundwater 4-log certification to DWB for approval. Calculations need to be consistent with the guidance set forth in LT1ESWTR Disinfection Profiling and Benchmarking Technical Guidance Manual (EPA 816-R-03-004) and Ground Water Rule Corrective Actions Guidance Manual (EPA 815-R-08-011).

1. Information adapted from LT1ESWTR Disinfection Profiling and Benchmarking Technical Guidance Manual (EPA 816-R-03-004) and Ground Water Rule Corrective Actions Guidance Manual (EPA 815-R-08-011)

CT Calculation

Volume of water:
(Must be available at all times during non-emergency conditions):

Pipe $\text{Volume}_{\text{Gallons}} = \textit{Length}_{\textit{Feet}} \times \pi \times (\textit{Diameter}_{\textit{Inches}} / 2)^2 \times (7.48_{\textit{Gal/Cu. ft.}} / 144_{\textit{sq. in./sq. ft.}})$

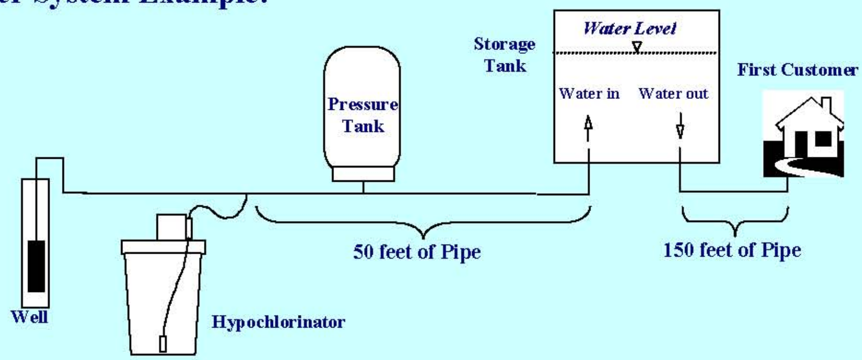
Storage $\text{Volume}_{\text{Gallons}} = \textit{Baffling Efficiency}_{\%} \times (\textit{Fire Suppression Storage}_{\textit{Gallons}} + \textit{Dead Storage}_{\textit{Gallons}})$ ***or***

Storage $\text{Volume}_{\text{Gallons}} = \textit{Baffling Efficiency}_{\%} \times (\textit{Standby Storage}_{\textit{Gallons}} + \textit{Dead Storage}_{\textit{Gallons}})$

Time it takes to move a volume of water to the first customer:

$\text{Time(T)}_{\text{Minutes}} = \textit{Total Volume}_{\textit{Gallons}} / \textit{Peak Flow Rate}_{\textit{Gallons per Minute}}$

Water System Example:



Storage Tank

Baffling Efficiency = 10% (*estimated rating*)
Total Storage Tank Volume = 30,000 gallons
Standby Storage Volume = 10,000 gallon
Dead Storage Volume = 1,000 gallons

Pipe

50 ft. of 3-inch diameter pipe
150 ft. of 3- inch diameter pipe
3.69 gallons per 10 ft

Pump Capacity

50 gallons/minute (GPM)

Peak Flow

160 gallons/minute (GPM)

Required Free Chlorine Residual based on this example:

Pipe Volume $= 50\,ft. \times \pi \times (3\ inches/2)^2 \times (7.48\ gallons\ per\ cu.\ ft. / 144\ sq.\ in.\ per\ sq.\ ft.)$
$= 18\ Gallons$

Storage Volume $= 10\% \times (10{,}000\ gallons + 1{,}000\ gallons)$
$= 1{,}100\ gallons$

Pipe Volume $= 150\,ft. \times \pi \times (3\ inches/2)^2 \times (7.48\ gallons\ per\ cu.\ ft. / 144\ sq.\ in.\ per\ sq.\ ft.)$
$= 55\ gallons$

Time(T) $= (18\ gallons / 50\ GPM) + (1{,}100\ gallons / 160\ GPM) + (55\ gallons / 160\ GPM)$
$= 0.4\ Minutes + 6.9\ Minutes + 0.3\ Minutes$
$= 7.6\ Minutes$

$\text{CT}_{\text{required}} = 6\ mg\text{-}min/L$

Required Free Chlorine Residual (C) $= 6\ mg\text{-}min/L / 7.6\ minutes = 0.8\ mg/L$

For this example, the free chlorine residual at the first service connection must be at least 0.8 mg/L to adequately inactivate bacteria and viruses.