Disinfection: Virus Log Inactivation Calculations

Drinking Water Reference Guide: Colorado Department of Public Health and Environment
Water Quality Control Division - Engineering Section http://www.cdphe.state.co.us/wq/ 303-692-3500 June 2011

What do I need to know before I start calculating?

- **Peak Hourly Flow, Q (gpm)**
- **Residual Disinfectant Concentration, C (mg/L)**
- **Temperature (°C)**
- **pH (standard units, s.u.)**
- **Basin Geometry**
- **Baffle Configuration**

Ground Water Rule and Log Inactivation Overview

Under the Groundwater Rule, groundwater systems that can demonstrate:

- 4 log inactivation of viruses, are exempt from the triggered source water monitoring.

This reference guide takes you step by step through the virus log inactivation calculation procedure.

The design of new or improved disinfection system(s) must be capable of providing four (4) log inactivation of viruses. The system must show it is possible to achieve 4-log inactivation with the equipment on-site.

"Log inactivation" is a convenient way to express the number or percent of microorganisms inactivated (killed or unable to replicate) through the disinfection process. For example, a 4 log inactivation value means that 99.99% of viruses have been inactivated. Log inactivation measures the effectiveness of the disinfection process, which is influenced by variables including disinfectant concentration, temperature, pH and disinfectant type (e.g., lower temperature results in less inactivation since the reactions slow down as temperature decreases).

CT and Log Inactivation Calculation Steps

Step 1: Calculate Detention Time

Step 1-A: Calculate Theoretical Detention Time (TDT)

$TDT = V/Q$

TDT = Theoretical Detention Time (minutes)
V = Volume, based on low water level (gallons)
Q = Peak hourly flow (gpm) - not average over one day

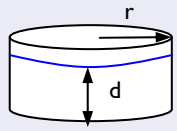
Step 1-B: Calculate Actual Detention Time (T)

$T = TDT \times BF$

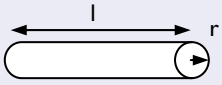
T = Actual Detention Time (minutes)*
TDT = Theoretical Detention Time (minutes)
BF = Baffling Factor (measure of short circuiting)

Volume Equations:

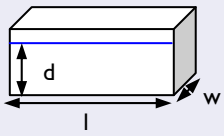
Cylindrical: $\pi \times r^2 \times d$



Pipeline: $\pi \times r^2 \times l$
Flowing full



Rectangular: $l \times w \times d$



d = minimum water depth
π = 3.1416

* The Actual Detention Time also may be available from site-specific tracer tests conducted at all possible flowrates.

Baffling Condition	Baffling Factor	Baffling Description
Unbaffled (mixed flow)	0.1	None, agitated basin, very low length-to-width ratio, high inlet and outlet flow velocities
Poor	0.3	Single or multiple unbaffled 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 intrabasin baffles

Source and for more information:

U.S. Environmental Protection Agency. 2003. *LT1ESWTR Disinfection Profiling and Benchmarking Technical Guidance Manual.* EPA 816-R-03-004
http://www.epa.gov/safewater/mdbp/pdf/profile/lt1profiling.pdf

Step 2: Calculate CT_{CALC}

$CT_{CALC} = C \times T$

CT_{CALC} = Concentration Time, Calculated Value (minutes•mg/L)

C = Residual disinfectant concentration measured during peak flow (mg/L)

T = Actual Detention Time (minutes)

Conversion Factors:

1 cu-ft = 7.48 gallons

1 MGD = 694 gpm

1 gal water = 8.34 lbs

°C = 5/9 x (°F – 32)

Step 3: Calculate virus log inactivation

Step 3-A: Determine CT required for Virus 4 log reduction ($CT_{99.99}$)

The CT required for 4 log inactivation of viruses (designated as $CT_{99.99}$) for free chlorine is presented in the table below. The virus $CT_{99.99}$ is dependent on temperature and pH.

$CT_{99.99}$ 4 log inactivation of viruses w/ free chlorine (minutes•mg/L)

Temperature° C	pH 6-9
0.5	12
5	8
10	6
15	4
20	3
25	2

EPA Spreadsheet Calculator

The EPA has developed a spreadsheet calculator that calculates the viruses log inactivation. The spreadsheet can be downloaded from: http://water.epa.gov/lawsregs/rulesregs/sdwa/stage1/index.cfm

Step 3-B: Calculate Virus Log Inactivation

Virus Log Inactivation = 4 log × (CT_{CALC} / $CT_{99.99}$)

CT_{CALC} = Concentration Time, Calculated Value (minutes•mg/L)

$CT_{99.99}$ = Concentration Time to inactivate 4 log of virus (minutes•mg/L) from table

Calculation Summary

Measured at Peak Flow:

Peak Flow, Q = _____ gpm

Free chlorine residual, C = _____ mg/L

pH = _____ s.u.

Temperature = _____°C

Basin Information:

Baffle Factor, BF = _____

Minimum Volume, V = _____ gallons

TDT = V / Q

TDT = _____ gals / _____ gpm

TDT = _____ minutes

T = TDT × BF

T = _____ minutes × ___

T = _____ minutes

$CT_{CALC} = C \times T$

CT_{CALC} = _____mg/L x _____minutes

CT_{CALC} = _____mg/L—minutes

$CT_{99.99}$ from CT Table = _____ mg/L– minutes

Virus Log Inactivation = 4 log × (CT_{CALC} / $CT_{99.99}$)

Virus Log Inactivation = 4 log× (_____ / _____)

Virus Log Inactivation = _____ log