

Appendix B

CT Tables

A.1 GLOSSARY

baffle. A flat board or plate, deflector, guide or similar device constructed or placed in flowing water or slurry systems to cause more uniform flow velocities, to absorb energy, and to divert, guide, or agitate liquids (water, chemical solutions, slurry).

baffling factor (BF). The ratio of the actual contact time to the theoretical detention time.

clarifier. A large circular or rectangular tank or basin in which water is held for a period of time, during which the heavier suspended solids settle to the bottom by gravity. Clarifiers are also called settling basins and sedimentation basins.

clearwell. A reservoir for the storage of filtered water with sufficient capacity to prevent the need to vary the filtration rate in response to short-term changes in customer demand. Also used to provide chlorine contact time for disinfection.

coagulant. A chemical added to water that has suspended and colloidal solids to destabilize particles, allowing subsequent floc formation and removal by sedimentation, filtration, or both.

coagulation. As defined in 40 CFR 141.2, a process using coagulant chemicals and mixing by which colloidal and suspended materials are destabilized and agglomerated into flocs.

community water system (CWS). A public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.

conventional filtration treatment. As defined in 40 CFR 141.2, a series of processes including coagulation, flocculation, sedimentation, and filtration resulting in substantial particulate removal.

Cryptosporidium. A disease-causing protozoan widely found in surface water sources. *Cryptosporidium* is spread by the fecal-oral route as a dormant oocyst from human and animal feces. In its dormant stage, *Cryptosporidium* is housed in a very small, hard-shelled oocyst form that is resistant to chlorine and chloramine disinfectants. When water containing these oocysts is ingested, the protozoan may cause a severe gastrointestinal disease called cryptosporidiosis.

CT or CT_{calc}. As defined in 40 CFR 141.2, the product of “residual disinfectant concentration” (C) in mg/l determined before or at the first customer, and the corresponding “disinfectant contact time” (T) in minutes, i.e., “C” x “T”. If a public water system applies disinfectants at more than one point prior to the first customer, it must determine the CT of each disinfectant sequence before or at the first customer to determine the total percent inactivation or “total inactivation ratio”. In determining the total inactivation ratio, the public water system must determine the residual disinfectant concentration of each disinfection sequence and corresponding contact time before any subsequent disinfection application point(s). “CT_{99.9}” is the CT value required for 99.9 percent (3-log) inactivation of *Giardia lamblia* cysts. CT_{99.9} for a variety of disinfectants and conditions appear in Tables 1.1- 1.6, 2.1, and 3.1 of §141.74(b)(3) in the Code of Federal Regulations. CT_{calc}/CT_{99.9} is the inactivation ratio. The sum of the inactivation ratios, or total inactivation ratio shown as $\Sigma [(CT_{calc}) / (CT_{99.9})]$ is calculated by adding together the inactivation ratio

for each disinfection sequence. A total inactivation ratio equal to or greater than 1.0 is assumed to provide a 3-log inactivation of *Giardia lamblia* cysts.

detention time. The average length of time a drop of water or a suspended particle remains in a tank or chamber. Mathematically, it may be determined by dividing the volume of water in the tank by the flow rate through the tank.

diatomaceous earth filtration. As defined in 40 CFR 141.2, a process resulting in substantial particulate removal, that uses a process in which: (1) a “precoat” cake of diatomaceous earth filter media is deposited on a support membrane (septum), and (2) while the water is filtered by passing through the cake on the septum, additional filter media, known as “body feed,” is continuously added to the feed water to maintain the permeability of the filter cake.

direct filtration. As defined in 40 CFR 141.2, a series of processes including coagulation and filtration, but excluding sedimentation, and resulting in substantial particulate removal.

disinfectant. As defined in 40 CFR 141.2, any oxidant, including but not limited to chlorine, chlorine dioxide, chloramines, and ozone added to water in any part of the treatment or distribution process, that is intended to kill or inactivate pathogenic microorganisms.

disinfectant contact time. As defined in 40 CFR 141.2, the time in minutes that it takes for water to move from the point of disinfectant application or the previous point of disinfectant residual measurement to a point before or at the point where residual disinfectant concentration (“C”) is measured. Where only one “C” is measured, “T” is the time in minutes that it takes for water to move from the point of disinfectant application to a point before or at where residual disinfectant concentration (“C”) is measured. Where more than one “C” is measured, “T” is (a) for the first measurement of “C”, the time in minutes that it takes for water to move from the first or only point of disinfectant application to a point before or at the point where the first “C” is measured and (b) for subsequent measurements of “C”, the time in minutes that it takes for water to move from the previous “C” measurement point to the “C” measurement point for which the particular “T” is being calculated. Disinfectant contact time in pipelines must be calculated based on “plug flow” by dividing the internal volume of the pipe by the maximum hourly flow rate through that pipe. Disinfectant contact time within mixing basins and storage reservoirs must be determined by tracer studies or an equivalent demonstration.

disinfection. As defined in 40 CFR 141.2, a process which inactivates pathogenic organisms in water by chemical oxidants or equivalent agents.

disinfection benchmark. The lowest monthly average microbial inactivation during the disinfection profile time period.

disinfection byproduct precursors. Substances that can be converted into disinfection byproducts during disinfection. Typically, most of these precursors are constituents of natural organic matter. In addition, the bromide ion (Br^-) is a precursor material.

disinfection byproducts (DBPs). Inorganic and organic compounds formed by the reaction of the disinfectant, natural organic matter, and the bromide ion during water disinfection processes. Regulated DBPs include trihalomethanes, haloacetic acids, bromate, and chlorite.

disinfection profile. As stated in 40 CFR 141.530, a graphical representation of your system's level of *Giardia lamblia* or virus inactivation measured during the course of a year.

disinfection segment. A section of the system beginning at one disinfectant injection or monitoring point and ending at the next disinfectant injection or monitoring point.

effluent. Water or some other liquid that is raw, partially or completely treated that is flowing from a reservoir, basin, treatment process or treatment plant.

enhanced coagulation. As defined in 40 CFR 141.2, the addition of sufficient coagulant for improved removal of disinfection byproduct precursors by conventional filtration treatment.

enhanced softening. As defined in 40 CFR 141.2, the improved removal of disinfection byproduct precursors by precipitative softening.

filtration. As defined in 40 CFR 141.2, a process for removing particulate matter from water by passage through porous media.

finished water. Water that has passed through a water treatment plant such that all the treatment processes are completed or "finished" and ready to be delivered to consumers. Also called product water.

flocculation. As defined in 40 CFR 141.2, a process to enhance agglomeration or collection of smaller floc particles into larger, more easily settleable particles through gentle stirring by hydraulic or mechanical means.

Giardia lamblia. Flagellated protozoan, which is shed during its cyst-stage with the feces of man and animals. When water containing these cysts is ingested, the protozoan causes a severe gastrointestinal disease called giardiasis.

ground water under the direct influence of surface water (GWUDI). As defined in 40 CFR 141.2, any water beneath the surface of the ground with significant occurrence of insects or other macroorganisms, algae, or large-diameter pathogens such as *Giardia lamblia* or *Cryptosporidium*, or significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions. Direct influence must be determined for individual sources in accordance with criteria established by the State. The State determination of direct influence may be based on site-specific measurements of water quality and/or documentation of well construction characteristics and geology with field evaluation.

haloacetic acids five (HAA5). As defined in 40 CFR 141.2, the sum of the concentrations in milligrams per liter of the haloacetic acid compounds (monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid), rounded to two significant figures after addition.

influent water. Raw water plus recycle streams.

interpolation. A technique used to determine values that fall between the marked intervals on a scale.

log inactivation. The percentage of microorganisms inactivated through disinfection by a given process.

log reduction. The percentage of microorganisms reduced through log removal added to the log inactivation. One log reduction means that 90% of the microorganisms are removed or inactivated. Two log corresponds to 99%, three log is 99.9% and four log corresponds to 99.99%.

log removal. The percentage of microorganisms physically removed by a given process.

maximum contaminant level (MCL). As defined in 40 CFR 141.2, the maximum permissible level of a contaminant in water which is delivered to any user of a public water system.

membrane filtration. A filtration process (e.g., reverse osmosis, nanofiltration, ultrafiltration, and microfiltration) using tubular or spiral-wound elements that exhibits the ability to mechanically separate water from other ions and solids by creating a pressure differential and flow across a membrane.

micrograms per liter ($\mu\text{g/L}$). One microgram of a substance dissolved in each liter of water. This unit is equal to parts per billion (ppb) since one liter of water is equal in weight to one billion micrograms.

micron. A unit of length equal to one micrometer (μm). One millionth of a meter or one thousandth of a millimeter. One micron equals 0.00004 of an inch.

milligrams per liter (mg/L). A measure of concentration of a dissolved substance. A concentration of one mg/L means that one milligram of a substance is dissolved in each liter of water. For practical purposes, this unit is equal to parts per million (ppm) since one liter of water is equal in weight to one million milligrams. Thus a liter of water containing 10 milligrams of calcium has 10 parts of calcium per one million parts of water, or 10 parts per million (10 ppm).

non-community water system (NCWS). As defined in 40 CFR 141.2, a public water system that is not a community water system. A non-community water system is either a “transient non-community water system (TWS)” or a non-transient non-community water system (NTNCWS).”

non-transient non-community water system (NTNCWS). As defined in 40 CFR 141.2, a public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year.

organics. Carbon-containing compounds that are derived from living organisms.

oxidant. Any oxidizing agent; a substance that readily oxidizes (removes electrons from) something chemically. Common drinking water oxidants are chlorine, chlorine dioxide, ozone, and potassium permanganate. Some oxidants also act as disinfectants.

oxidation. A process in which a molecule, atom, or ion loses electrons to an oxidant. The oxidized substance (which lost the electrons) increases in positive valence. Oxidation never occurs alone, but always as part of an oxidation-reduction (redox) reaction.

pathogens, or pathogenic organisms. Microorganisms that can cause disease (such as typhoid, cholera, or dysentery) in other organisms or in humans, animals and plants. They may be bacteria, viruses, or protozoans and are found in sewage, in runoff from animal

farms or rural areas populated with domestic and/or wild animals, and in water used for swimming. There are many types of microorganisms which do not cause disease. These microorganisms are called non-pathogens.

pH. pH is an expression of the intensity of the basic or acid condition of a solution. Mathematically, pH is the negative logarithm (base 10) of the hydrogen ion concentration, [H⁺]. [pH = log (1/H⁺)]. The pH may range from 0 to 14, where 0 is most acidic, 14 most basic, and 7 neutral. Natural waters usually have a pH between 6.5 and 8.5.

plug flow. The water travels through a basin, pipe, or unit process in such a fashion that the entire mass or volume is discharged at exactly the theoretical detention time of the unit.

pre-disinfection. The addition of a disinfectant to the treatment train prior to the primary disinfectant injection location. Generally, the purpose of pre-disinfection is to obtain additional inactivation credits, to control microbiological growth in subsequent treatment processes, to improve coagulation, or to reduce tastes and odors.

primary disinfection. The disinfectant used in a treatment system to achieve the necessary microbial inactivation.

public water system (PWS). As defined in 40 CFR 141.2, a system for the provision to the public of water for human consumption through pipes or, after August 5, 1998, other constructed conveyances, if such system has at least fifteen service connections or regularly serves an average of at least twenty-five individuals daily at least 60 days out of the year. Such term includes: any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system; and any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system. Such term does not include any “special irrigation district.” A public water system is either a “community water system” or a “non-community water system”.

reservoir. Any natural or artificial holding area used to store, regulate, or control water.

secondary disinfection. The disinfectant application in a treatment system to maintain the disinfection residual throughout the distribution system.

sedimentation. As defined in 40 CFR 141.2, a process for removal of solids before filtration by gravity or separation.

short-circuiting. A hydraulic condition in a basin or unit process that occurs when the actual flow time of water through the basin is less than the basin or unit process volume divided by the peak hourly flow.

State. As defined in 40 CFR 141.2, the agency of the State or Tribal government which has jurisdiction over public water systems. During any period when a State or Tribal government does not have primary enforcement responsibility pursuant to Section 1413 of the Safe Drinking Water Act, the term “State” means the Regional Administrator, U.S. Environmental Protection Agency.

surface water. As defined in 40 CFR 141.2, all water which is open to the atmosphere and subject to surface runoff.

total organic carbon (TOC). As defined in 40 CFR 141.2, total organic carbon in mg/L measured using heat, oxygen, ultraviolet irradiation, chemical oxidants, or combinations of these oxidants that convert organic carbon to carbon dioxide, rounded to two significant figures.

total trihalomethanes (TTHM). As defined in 40 CFR 141.2, the sum of the concentration in milligrams per liter of the trihalomethane compounds (trichloromethane [chloroform], dibromochloromethane, bromodichloromethane and tribromomethane [bromoform]), rounded to two significant figures.

trihalomethane (THM). As defined in 40 CFR 141.2, one of the family of organic compounds, named as derivatives of methane, wherein three of the four hydrogen atoms in methane are each substituted by a halogen atom in the molecular structure.

tracer. A foreign substance mixed with or attached to a given substance for subsequent determination of the location or distribution of the foreign substance.

tracer study. A study using a substance that can readily be identified in water (such as a dye) to determine the distribution and rate of flow in a basin, pipe, ground water, or stream channel.

transient non-community water system. As defined in 40 CFR 141.2, means a non-community water system that does not regularly serve at least 25 of the same persons over six months per year.

virus. As defined in 40 CFR 141.2, a virus of fecal origin which is infectious to humans by waterborne transmission.

water supply system. The collection, treatment, storage, and distribution of potable water from source to consumer.

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TABLE B-1
CT VALUES* FOR 3-LOG INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE

Chlorine Concentration (mg/L)	Temperature ≤0.5°C							Temperature =5°C							Temperature = 10°C						
	pH							pH							pH						
	≤6.0	6.5	7.0	7.5	8.0	8.5	9.0	≤6.0	6.5	7.0	7.5	8.0	8.5	9.0	≤6.0	6.5	7.0	7.5	8.0	8.5	9.0
≤0.4	137	163	195	237	277	329	390	97	117	139	166	198	236	279	73	88	104	125	149	177	209
0.6	141	168	200	239	286	342	407	100	120	143	171	204	244	291	75	90	107	128	153	183	218
0.8	145	172	205	246	295	354	422	103	122	146	175	210	252	301	78	92	110	131	158	189	226
1.0	148	176	210	253	304	365	437	105	125	149	179	216	260	312	79	94	112	134	162	195	234
1.2	152	180	215	259	313	376	451	107	127	152	183	221	267	320	80	95	114	137	166	200	240
1.4	155	184	221	266	321	387	464	109	130	155	187	227	274	329	82	98	116	140	170	206	247
1.6	157	189	226	273	329	397	477	111	132	158	192	232	281	337	83	99	119	144	174	211	253
1.8	162	193	231	279	338	407	489	114	135	162	196	238	287	345	86	101	122	147	179	215	259
2.0	165	197	236	286	346	417	500	116	138	165	200	243	294	353	87	104	124	150	182	221	265
2.2	169	201	242	297	353	426	511	118	140	169	204	248	300	361	89	105	127	153	186	225	271
2.4	172	205	247	298	361	435	522	120	143	172	209	253	306	368	90	107	129	157	190	230	276
2.6	175	209	252	304	368	444	533	122	146	175	213	258	312	375	92	110	131	160	194	234	281
2.8	178	213	257	310	375	452	543	124	148	178	217	263	318	382	93	111	134	163	197	239	287
3.0	181	217	261	316	382	460	552	126	151	182	221	268	324	389	95	113	137	166	201	243	292
Chlorine Concentration (mg/L)	Temperature = 15°C							Temperature = 20°C							Temperature = 25°C						
	pH							pH							pH						
	≤6.0	6.5	7.0	7.5	8.0	8.5	9.0	≤6.0	6.5	7.0	7.5	8.0	8.5	9.0	≤6.0	6.5	7.0	7.5	8.0	8.5	9.0
≤0.4	49	59	70	83	99	118	140	36	44	52	62	74	89	105	24	29	35	42	50	59	70
0.6	50	60	72	86	102	122	146	38	45	54	64	77	92	109	25	30	36	43	51	61	73
0.8	52	61	73	88	105	126	151	39	46	55	66	79	95	113	26	31	37	44	53	63	75
1.0	53	63	75	90	108	130	156	39	47	56	67	81	98	117	26	31	37	45	54	65	78
1.2	54	64	76	92	111	134	160	40	48	57	69	83	100	120	27	32	38	46	55	67	80
1.4	55	65	78	94	114	137	165	41	49	58	70	85	103	123	27	33	39	47	57	69	82
1.6	56	66	79	96	116	141	169	42	50	59	72	87	105	126	28	33	40	48	58	70	84
1.8	57	68	81	98	119	144	173	43	51	61	74	89	108	129	29	34	41	49	60	72	86
2.0	58	69	83	100	122	147	177	44	52	62	75	91	110	132	29	35	41	50	61	74	88
2.2	59	70	85	102	124	150	181	44	53	63	77	93	113	135	30	35	42	51	62	75	90
2.4	60	72	86	105	127	153	184	45	54	65	78	95	115	138	30	36	43	52	63	77	92
2.6	61	73	88	107	129	156	188	46	55	66	80	97	117	141	31	37	44	53	65	78	94
2.8	62	74	89	109	132	159	191	47	56	67	81	99	119	143	31	37	45	54	66	80	96
3.0	63	76	91	111	134	162	195	47	57	68	83	101	122	146	32	38	46	55	67	81	97

*Although units did not appear in the original tables, units are min-mg/L.

TABLE B-2
CT VALUES* FOR
4- LOG INACTIVATION OF VIRUSES BY FREE CHLORINE

<u>Temperature (°C)</u>	pH	
	<u>6-9</u>	<u>10</u>
0.5	12	90
5	8	60
10	6	45
15	4	30
20	3	22
25	2	15

*Although units did not appear in the original tables, units are min-mg/L.

TABLE B-3
CT VALUES* FOR
3-LOG INACTIVATION OF *GIARDIA* CYSTS
BY CHLORINE DIOXIDE

Temperature (°C)					
<u>< = 1</u>	<u>5</u>	<u>10</u>	<u>15</u>	<u>20</u>	<u>25</u>
63	26	23	19	15	11

*Although units did not appear in the original tables, units are min-mg/L.

TABLE B-4
CT VALUES* FOR
4-LOG INACTIVATION OF VIRUSES
BY CHLORINE DIOXIDE pH 6-9

Temperature (°C)					
<u><= 1</u>	<u>5</u>	<u>10</u>	<u>15</u>	<u>20</u>	<u>25</u>
50.1	33.4	25.1	16.7	12.5	8.4

*Although units did not appear in the original tables, units are min-mg/L.

TABLE B-5
CT VALUES* FOR
3-LOG INACTIVATION OF *GIARDIA* CYSTS
BY OZONE

Temperature (°C)					
<u>< = 1</u>	<u>5</u>	<u>10</u>	<u>15</u>	<u>20</u>	<u>25</u>
2.9	1.90	1.43	0.95	0.72	0.48

*Although units did not appear in the original tables, units are min-mg/L.

TABLE B-6
CT VALUES* FOR
4-LOG INACTIVATION OF VIRUSES BY OZONE

Temperature (°C)					
<u><= 1</u>	<u>5</u>	<u>10</u>	<u>15</u>	<u>20</u>	<u>25</u>
1.8	1.2	1.0	0.6	0.5	0.3

*Although units did not appear in the original tables, units are min-mg/L.

TABLE B-7
CT VALUES* FOR
3-LOG INACTIVATION OF *GIARDIA* CYSTS
BY CHLORAMINE pH 6-9

Temperature (°C)					
<u>≤ 1</u>	<u>5</u>	<u>10</u>	<u>15</u>	<u>20</u>	<u>25</u>
3,800	2,200	1,850	1,500	1,100	750

*Although units did not appear in the original tables, units are min-mg/L.

TABLE B-8
CT VALUES* FOR
4-LOG INACTIVATION OF VIRUSES BY CHLORAMINE

Temperature (°C)					
<u>< = 1</u>	<u>5</u>	<u>10</u>	<u>15</u>	<u>20</u>	<u>25</u>
2,883	1,988	1,491	994	746	497

*Although units did not appear in the original tables, units are min-mg/L.

TABLE B-9
CT VALUE* FOR
INACTIVATION OF VIRUSES BY UV

<u>Log Inactivation</u>	
<u>2.0</u>	<u>3.0</u>
21	36

*Although units did not appear in the original tables, units are min-mg/L.