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CT Values for Inactivation of Viruses by Free Chlorine¹²

Log Inactivation						
Temperature, °C	2.0-log		3.0-log		4.0-log	
	pH6-9	pH 10	pH6-9	pH 10	pH6-9	pH 10
0.5	6	45	9	66	12	90
5	4	30	6	44	8	60
10	3	22	4	33	6	45
15	2	15	3	22	4	30
20	1	11	2	16	3	22
25	1	7	1	11	2	15

Note: CT values can be adjusted to other temperatures by doubling the CT for each 10°C drop in temperature.

CT Values for Inactivation of Giardia Cysts by Chloramine Within the pH Range 6 to 9¹²

Inactivation	Temperature, °C					
	≤1	5	10	15	20	25
0.5-log	635	365	310	250	185	125
1-log	1270	735	615	500	370	250
1.5-log	1900	1100	930	750	550	375
2-log	2535	1470	1230	1000	735	500
2.5-log	3170	1830	1540	1250	915	625
3-log	3800	2200	1850	1500	1100	750

CT Values for Inactivation of Viruses by Chloramine*¹²

Inactivation	Temperature, °C					
	≤1	5	10	15	20	25
2-log	1243	857	643	428	321	214
3-log	2063	1423	1067	712	534	356
4-log	2883	1988	1491	994	746	497

*This table applies for systems using combined chlorine where chlorine is added prior to ammonia in the treatment sequence.

CT Values for Inactivation of Giardia Cysts by Chloramine Dioxide Within the pH Range 6 to 9¹²

Inactivation	Temperature, °C					
	≤1	5	10	15	20	25
0.5-log	10	4.3	4.0	3.2	2.5	2.0
1-log	21	8.7	7.7	6.3	5.0	3.7
1.5-log	32	13.0	12.0	10.0	7.5	5.5
2-log	42	17.0	15.0	13.0	10.0	7.3
2.5-log	52	22.0	19.0	16.0	13.0	9.0
3-log	63	26.0	23.0	19.0	15.0	11.0

U.S. EPA CT VALUES (mg/L x min) for the Inactivation of Giardia Cysts with Ozone at Different Temperatures and pH from 6 to 9.¹²

Inactivation	Temperature °C (°F)					
	0.5(32.1)	5(41)	10(50)	15(59)	20(68)	25(77)
0.5 log	0.48	0.32	0.23	0.16	0.12	0.08
1.0 log	0.97	0.63	0.48	0.32	0.24	0.16
1.5 log	1.50	0.95	0.72	0.48	0.36	0.24
2.0 log	1.90	1.30	0.95	0.63	0.48	0.32
2.5 log	2.40	1.60	1.20	0.79	0.60	0.40
3.0 log	2.90	1.90	1.40	0.95	0.72	0.48

CT Values for Inactivation of Viruses by Ozone¹²

Inactivation	Temperature, °C					
	≤1	5	10	15	20	25
2- log	0.48	0.32	0.23	0.16	0.12	0.08
3- log	0.97	0.63	0.48	0.32	0.24	0.16
4- log	1.50	0.95	0.72	0.48	0.36	0.24

CT Values for 3-log (99.9%) Inactivation of Giardia Cysts by Free Chlorine at Water Temperature 10.0 °C (50°F)¹²

Free Residual, Mg/L	pH						
	≤ 6.0	6.5	7.0	7.5	8.0	8.5	≤ 9.0
≤ 0.4	73	88	104	125	149	177	209
0.6	75	90	107	128	153	183	218
0.8	78	92	110	131	158	189	226
1.0	79	94	112	134	162	195	234
1.2	80	95	114	137	168	200	240
1.4	82	98	116	140	170	206	247
1.6	83	99	119	144	174	211	253
1.8	88	101	122	147	179	215	259
2.0	87	104	124	150	182	221	265

2.2	89	105	127	153	186	225	271
2.4	90	107	129	157	190	230	276
2.6	92	110	131	160	194	234	281
2.8	93	111	134	163	197	239	287
3.0	95	113	137	166	201	243	292

**CT Values for Inactivation of Viruses by Chloramine Dioxide
Within the pH Range 6 to 9¹²**

Inactivation	Temperature, °C					
	≤1	5	10	15	20	25
2-log	8.4	5.6	4.2	2.8	2.1	1.4
3-log	25.6	17.1	12.8	8.6	6.4	4.3
4-log	50.1	33.4	25.1	16.7	12.5	8.4

**Amounts of Various Agents Required to Oxidize 1 mg/L of
Ferrous Iron²¹**

Oxidizing Agent	Practical Amount Required to Oxidize 1 mg/L Fe ²⁺ (mg/L)	Theoretical Stoichiometry(mg/L)
Ozone(O ₃)	0.4 to 0.7	0.43
Chlorine(Cl ₂)	0.6 to 1.0	0.63
Potassium Permanganate (KmnO ₄)	0.9 to 2.0	0.94
Hydrogen Peroxide (H ₂ O ₂)	0.3 to 0.5	0.30
Oxygen(O ₂)*	0.86 to 1.1	0.14
Chlorine Dioxide ClO ₂	1.0 to 1.6	1.2

**Theoretical Amounts of Various Agents Required to Oxidize
1 mg/L of Manganous Ion to MnO(O H₂)**

Oxidizing Agent	Practical Amount Required to Oxidize 1 mg/L Mn ²⁺ (mg/L)	Theoretical Stoichiometry(mg/L)
Ozone	0.5 to 1.0	0.87
Chlorine(Cl ₂)	1.7 to 2.0	1.28
KmnO ₄	2.0 to 2.7	1.91
ClO ₂	2.4 to 3.0	2.46
H ₂ O ₂	0.8 to 1.0	0.6
Oxygen	2.5 to 3.3	0.29

**Theoretical Amounts of Various Agents Required to Oxidize
1 mg/L of Sulfide Ion**

Oxidizing Agent	Practical Amount Required to Oxidize 1 mg/L Mn ²⁺ (mg/L)	Theoretical Stoichiometry(mg/L)
Ozone	2.2 to 3.6	1.5

Chlorine(Cl ₂)	2.0 to 3.0	2.2
KmnO ₄	4.0 to 6.0	3.3
ClO ₂	7.2 to 10.8	4.2
H ₂ O ₂	1.0 to 1.5	1.1
Oxygen	2.8 to 3.6	0.5

Comparison of Percentages of Active Halogen Forms

<u>Bromine</u>		pH	<u>Chlorine</u>	
Percent as (Obr)	Percent as HOBr		Percent as HOCl	Percent as (OCI)
4	96	7.2	66	34
6	94	7.5	48	52
13	87	7.8	33	67
17	83	8.0	22	78