

Appendix D: CT TABLES

D.1 CT TABLES FOR DISINFECTION WITH Cl_2

This appendix contains the CT tables you should use when inactivating *Giardia lamblia* and viruses with free chlorine. The information used to generate these tables and the associated notes was derived from Appendixes E and F of the EPA's *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*, Office of Drinking Water, Washington D.C., (March 1991) available at:

water.epa.gov/lawsregs/rulesregs/sdwa/swtr/upload/guidsws.pdf

Table D-1.1. CT values required for inactivation of *Giardia* cysts at 0.5°C or lower.

Chlorine Concentration (mg/L)	pH ≤ 6.0						pH = 6.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	23	46	69	91	114	137	27	54	82	109	136	163
0.6	24	47	71	94	118	141	28	56	84	112	140	168
0.8	24	48	73	97	121	145	29	57	86	115	143	172
1.0	25	49	74	99	123	148	29	59	88	117	147	176
1.2	25	51	76	101	127	152	30	60	90	120	150	180
1.4	26	52	78	103	129	155	31	61	92	123	153	184
1.6	26	52	79	105	131	157	32	63	95	126	158	189
1.8	27	54	81	108	135	162	32	64	97	129	161	193
2.0	28	55	83	110	138	165	33	66	99	131	164	197
2.2	28	56	85	113	141	169	34	67	101	134	168	201
2.4	29	57	86	115	143	172	34	68	103	137	171	205
2.6	29	58	88	117	146	175	35	70	105	139	174	209
2.8	30	59	89	119	148	178	36	71	107	142	178	213
≥ 3.0	30	60	91	121	151	181	36	72	109	145	181	217

Chlorine Concentration (mg/L)	pH = 7.0						pH = 7.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	33	65	98	130	163	195	40	79	119	158	198	237
0.6	33	67	100	133	167	200	40	80	120	159	199	239
0.8	34	68	103	137	171	205	41	82	123	164	205	246
1.0	35	70	105	140	175	210	42	84	127	169	211	253
1.2	36	72	108	143	179	215	43	86	130	173	216	259
1.4	37	74	111	147	184	221	44	89	133	177	222	266
1.6	38	75	113	151	188	226	46	91	137	182	228	273
1.8	39	77	116	154	193	231	47	93	140	186	233	279
2.0	39	79	118	157	197	236	48	95	143	191	238	286
2.2 ^a	40	81	121	161	202	242	50	99	149	198	248	297
2.4	41	82	124	165	206	247	50	99	149	199	248	298
2.6	42	84	126	168	210	252	51	101	152	203	253	304
2.8	43	86	129	171	214	257	52	103	155	207	258	310
≥ 3.0	44	87	131	174	218	261	53	105	158	211	263	316

^a The values shown in Table D-1.1 for pH = 7.5 and Cl₂ = 2.2 were precisely reproduced from the manual despite the apparent errors.

Table D-1.1 continues on the next page.

Table D-1.1—Continued

Chlorine Concentration (mg/L)	pH = 8.0						pH = 8.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	46	92	139	185	231	277	55	110	165	219	274	329
0.6	48	95	143	191	238	286	57	114	171	228	285	342
0.8	49	98	148	197	246	295	59	118	177	236	295	354
1.0	51	101	152	203	253	304	61	122	183	243	304	365
1.2	52	104	157	209	261	313	63	125	188	251	313	376
1.4	54	107	161	214	268	321	65	129	194	258	323	387
1.6	55	110	165	219	274	329	66	132	199	265	331	397
1.8	56	113	169	225	282	338	68	136	204	271	339	407
2.0	58	115	173	231	288	346	70	139	209	278	348	417
2.2	59	118	177	235	294	353	71	142	213	284	355	426
2.4	60	120	181	241	301	361	73	145	218	290	363	435
2.6	61	123	184	245	307	368	74	148	222	296	370	444
2.8	63	125	188	250	313	375	75	151	226	301	377	452
≥ 3.0	64	127	191	255	318	382	77	153	230	307	383	460
Chlorine Concentration (mg/L)	pH = 9.0						<p><i>Note:</i> No disinfection credit for <i>Giardia</i> cysts is allowed when using free chlorine if the pH within the disinfection zone is greater than 9.0.</p>					
	Log inactivations											
	0.5	1	1.5	2	2.5	3						
≤ 0.4	65	130	195	260	325	390						
0.6	68	136	204	271	339	407						
0.8	70	141	211	281	352	422						
1.0	73	146	219	291	364	437						
1.2	75	150	226	301	376	451						
1.4	77	155	232	309	387	464						
1.6	80	159	239	318	398	477						
1.8	82	163	245	326	408	489						
2.0	83	167	250	333	417	500						
2.2	85	170	256	341	426	511						
2.4	87	174	261	348	435	522						
2.6	89	178	267	355	444	533						
2.8	91	181	272	362	453	543						
≥ 3.0	92	184	276	368	460	552						

Table D-1.2. CT values required for inactivation of *Giardia* cysts at 5°C.

Chlorine Concentration (mg/L)	pH ≤ 6.0						pH = 6.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	16	32	49	65	81	97	20	39	59	78	98	117
0.6	17	33	50	67	83	100	20	40	60	80	100	120
0.8	17	34	52	69	86	103	20	41	61	81	102	122
1.0	18	35	53	70	88	105	21	42	63	83	104	125
1.2	18	36	54	71	89	107	21	42	64	85	106	127
1.4	18	36	55	73	91	109	22	43	65	87	108	130
1.6	19	37	56	74	93	111	22	44	66	88	110	132
1.8	19	38	57	76	95	114	23	45	68	90	113	135
2.0	19	39	58	77	97	116	23	46	69	92	115	138
2.2	20	39	59	79	98	118	23	47	70	93	117	140
2.4	20	40	60	80	100	120	24	48	72	95	119	143
2.6	20	41	61	81	102	122	24	49	73	97	122	146
2.8	21	41	62	83	103	124	25	49	74	99	123	148
≥ 3.0	21	42	63	84	105	126	25	50	76	101	126	151
Chlorine Concentration (mg/L)	pH = 7.0						pH = 7.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	23	46	70	93	116	139	28	55	83	111	138	166
0.6	24	48	72	95	119	143	29	57	86	114	143	171
0.8	24	49	73	97	122	146	29	58	88	117	146	175
1.0	25	50	75	99	124	149	30	60	90	119	149	179
1.2	25	51	76	101	127	152	31	61	92	122	153	183
1.4	26	52	78	103	129	155	31	62	94	125	156	187
1.6	26	53	79	105	132	158	32	64	96	128	160	192
1.8	27	54	81	108	135	162	33	65	98	131	163	196
2.0	28	55	83	110	138	165	33	67	100	133	167	200
2.2	28	56	85	113	141	169	34	68	102	136	170	204
2.4	29	57	86	115	143	172	35	70	105	139	174	209
2.6	29	58	88	117	146	175	36	71	107	142	178	213
2.8	30	59	89	119	148	178	36	72	109	145	181	217
≥ 3.0	30	61	91	121	152	182	37	74	111	147	184	221

Table D-1.2 continues on the next page.

Table D-1.2—Continued

Chlorine Concentration (mg/L)	pH = 8.0						pH = 8.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	33	66	99	132	165	198	39	79	118	157	197	236
0.6	34	68	102	136	170	204	41	81	122	163	203	244
0.8	35	70	105	140	175	210	42	84	126	168	210	252
1.0	36	72	108	144	180	216	43	87	130	173	217	260
1.2	37	74	111	147	184	221	45	89	134	178	223	267
1.4	38	76	114	151	189	227	46	91	137	183	228	274
1.6	39	77	116	155	193	232	47	94	141	187	234	281
1.8	40	79	119	159	198	238	48	96	144	191	239	287
2.0	41	81	122	162	203	243	49	98	147	196	245	294
2.2	41	83	124	165	207	248	50	100	150	200	250	300
2.4	42	84	127	169	211	253	51	102	153	204	255	306
2.6	43	86	129	172	215	258	52	104	156	208	260	312
2.8	44	88	132	175	219	263	53	106	159	212	265	318
≥ 3.0	45	89	134	179	223	268	54	108	162	216	270	324
Chlorine Concentration (mg/L)	pH = 9.0						<p><i>Note:</i> No disinfection credit for <i>Giardia</i> cysts is allowed when using free chlorine if the pH within the disinfection zone is greater than 9.0.</p>					
	Log inactivations											
	0.5	1	1.5	2	2.5	3						
≤ 0.4	47	93	140	186	233	279						
0.6	49	97	146	194	243	291						
0.8	50	100	151	201	251	301						
1.0	52	104	156	208	260	312						
1.2	53	107	160	213	267	320						
1.4	55	110	165	219	274	329						
1.6	56	112	169	225	281	337						
1.8	58	115	173	230	288	345						
2.0	59	118	177	235	294	353						
2.2	60	120	181	241	301	361						
2.4	61	123	184	245	307	368						
2.6	63	125	188	250	313	375						
2.8	64	127	191	255	318	382						
≥ 3.0	65	130	195	259	324	389						

Table D-1.3. CT values required for inactivation of *Giardia* cysts at 10°C.

Chlorine Concentration (mg/L)	pH ≤ 6.0						pH = 6.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	12	24	37	49	61	73	15	29	44	59	73	88
0.6	13	25	38	50	63	75	15	30	45	60	75	90
0.8	13	26	39	52	65	78	15	31	46	61	77	92
1.0	13	26	40	53	66	79	16	31	47	63	78	94
1.2	13	27	40	53	67	80	16	32	48	63	79	95
1.4	14	27	41	55	68	82	16	33	49	65	82	98
1.6	14	28	42	55	69	83	17	33	50	66	83	99
1.8	14	29	43	57	72	86	17	34	51	67	84	101
2.0	15	29	44	58	73	87	17	35	52	69	87	104
2.2	15	30	45	59	74	89	18	35	53	70	88	105
2.4	15	30	45	60	75	90	18	36	54	71	89	107
2.6	15	31	46	61	77	92	18	37	55	73	98	110
2.8	16	31	47	62	78	93	19	37	56	74	93	111
≥ 3.0	16	32	48	63	79	95	19	38	57	75	94	113
Chlorine Concentration (mg/L)	pH = 7.0						pH = 7.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	17	35	52	69	87	104	21	42	63	83	104	125
0.6	18	36	54	71	89	107	21	43	64	85	107	128
0.8	18	37	55	73	92	110	22	44	66	87	109	131
1.0	19	37	56	75	93	112	22	45	67	89	112	134
1.2	19	38	57	76	95	114	23	46	69	91	114	137
1.4	19	39	58	77	97	116	23	47	70	93	117	140
1.6	20	40	60	79	99	119	24	48	72	96	120	144
1.8	20	41	61	81	102	122	25	49	74	98	123	147
2.0	21	41	62	83	103	124	25	50	75	100	125	150
2.2	21	42	64	85	106	127	26	51	77	102	128	153
2.4	22	43	65	86	108	129	26	52	79	105	131	157
2.6	22	44	66	87	109	131	27	53	80	107	133	160
2.8	22	45	67	89	112	134	27	54	82	109	136	163
≥ 3.0	23	46	69	91	114	137	28	55	83	111	138	166

Table D-1.3 continues on the next page.

Table D-1.3—Continued

Chlorine Concentration (mg/L)	pH = 8.0						pH = 8.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	25	50	75	99	124	149	30	59	89	118	148	177
0.6	26	51	77	102	128	153	31	61	92	122	153	183
0.8	26	53	79	105	132	158	32	63	95	126	158	189
1.0	27	54	81	108	135	162	33	65	98	130	163	195
1.2	28	55	83	111	138	166	33	67	100	133	167	200
1.4	28	57	85	113	142	170	34	69	103	137	172	206
1.6	29	58	87	116	145	174	35	70	106	141	176	211
1.8	30	60	90	119	149	179	36	72	108	143	179	215
2.0	30	61	91	121	152	182	37	74	111	147	184	221
2.2	31	62	93	124	155	186	38	75	133	150	188	225
2.4	32	63	95	127	158	190	38	77	115	153	192	230
2.6	32	65	97	129	162	194	39	78	117	156	195	234
2.8	33	66	99	131	164	197	40	80	120	159	199	239
≥ 3.0	34	67	101	134	168	201	41	81	122	162	203	243
Chlorine Concentration (mg/L)	pH = 9.0						<p><i>Note:</i> No disinfection credit for <i>Giardia</i> cysts is allowed when using free chlorine if the pH within the disinfection zone is greater than 9.0.</p>					
	Log inactivations											
	0.5	1	1.5	2	2.5	3						
≤0.4	35	70	105	139	174	209						
0.6	36	73	109	145	182	218						
0.8	38	75	133	151	188	226						
1.0	39	78	117	156	195	234						
1.2	40	80	120	160	200	240						
1.4	41	82	124	165	206	247						
1.6	42	84	127	169	211	253						
1.8	43	86	130	173	216	259						
2.0	44	88	133	177	221	265						
2.2	45	90	136	181	226	271						
2.4	46	92	138	184	230	276						
2.6	47	94	141	187	234	281						
2.8	48	96	144	181	239	287						
≥ 3.0	49	97	146	195	243	292						

Table D-1.4. CT values required for inactivation of *Giardia* cysts at 15°C.

Chlorine Concentration (mg/L)	pH ≤ 6.0						pH = 6.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	8	16	25	33	41	49	10	20	30	39	49	59
0.6	8	17	25	33	42	50	10	20	30	40	50	60
0.8	9	17	26	35	43	52	10	20	31	41	51	61
1.0	9	18	27	35	44	53	11	21	32	42	53	63
1.2	9	18	27	36	45	54	11	21	32	43	53	64
1.4	9	18	28	37	46	55	11	22	33	43	54	65
1.6	9	19	28	37	47	56	11	22	33	44	55	66
1.8	10	19	29	38	48	57	11	23	34	45	57	68
2.0	10	19	29	39	48	58	12	23	35	46	58	69
2.2	10	20	30	39	49	59	12	23	35	47	58	70
2.4	10	20	30	40	50	60	12	24	36	48	60	72
2.6	10	20	31	41	51	61	12	24	37	49	61	73
2.8	10	21	31	41	52	62	12	25	37	49	62	74
≥ 3.0	11	21	32	42	53	63	13	25	38	51	63	76
Chlorine Concentration (mg/L)	pH = 7.0						pH = 7.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	12	23	35	47	58	70	14	28	42	55	69	83
0.6	12	24	36	48	60	72	14	29	43	57	72	86
0.8	12	24	37	49	61	73	15	29	44	59	73	88
1.0	13	25	38	50	63	75	15	30	45	60	75	90
1.2	13	25	38	51	63	76	15	31	46	61	77	92
1.4	13	26	39	52	65	78	16	31	47	63	78	94
1.6	13	26	40	53	66	79	16	32	48	64	80	96
1.8	14	27	41	54	68	81	16	33	49	65	82	98
2.0	14	28	42	55	69	83	17	33	50	67	83	100
2.2	14	28	53	57	71	85	17	34	51	68	85	102
2.4	14	29	43	57	72	86	18	35	53	70	88	105
2.6	15	29	44	59	73	88	18	36	54	71	89	107
2.8	15	30	45	59	74	89	18	36	55	73	91	109
≥ 3.0	15	30	46	61	76	91	19	37	56	74	93	111

Table D-1.4 continues on the next page.

Table D-1.4—Continued

Chlorine Concentration (mg/L)	pH = 8.0						pH = 8.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	17	33	50	66	83	99	20	39	59	79	98	118
0.6	17	34	51	68	85	102	20	41	61	81	102	122
0.8	18	35	53	70	88	105	21	42	63	84	105	126
1.0	18	36	54	72	90	108	22	43	65	87	108	130
1.2	19	37	56	74	93	111	22	45	67	89	112	134
1.4	19	38	57	76	95	114	23	46	69	91	114	137
1.6	19	39	58	77	97	116	24	47	71	94	118	141
1.8	20	40	60	79	99	119	24	48	72	96	120	144
2.0	20	41	61	81	102	122	25	49	74	98	123	147
2.2	21	41	62	83	103	124	25	50	75	100	125	150
2.4	21	42	64	85	106	127	26	51	77	102	128	153
2.6	22	43	65	86	108	129	26	52	78	104	130	156
2.8	22	44	66	88	110	132	27	53	80	106	133	159
≥ 3.0	22	45	67	89	112	134	27	54	81	108	135	162
Chlorine Concentration (mg/L)	pH = 9.0						<p><i>Note:</i> No disinfection credit for <i>Giardia</i> cysts is allowed when using free chlorine if the pH within the disinfection zone is greater than 9.0.</p>					
	Log inactivations											
	0.5	1	1.5	2	2.5	3						
≤ 0.4	23	47	70	93	117	140						
0.6	24	49	73	97	122	146						
0.8	25	50	76	101	126	151						
1.0	26	52	78	104	130	156						
1.2	27	53	80	107	133	160						
1.4	28	55	83	110	138	165						
1.6	28	56	82	133	141	169						
1.8	29	58	87	115	144	173						
2.0	30	59	89	118	148	177						
2.2	30	60	91	121	151	181						
2.4	31	61	92	123	153	184						
2.6	31	63	94	125	157	188						
2.8	32	64	96	127	159	191						
≥ 3.0	33	65	98	130	163	195						

Table D-1.5. CT values required for inactivation of *Giardia* cysts at 20°C.

Chlorine Concentration (mg/L)	pH ≤ 6.0						pH = 6.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	6	12	18	24	30	36	7	15	22	29	37	44
0.6	6	13	19	25	32	38	8	15	23	30	38	45
0.8	7	13	20	26	33	39	8	15	23	31	38	46
1.0	7	13	20	26	33	39	8	16	24	31	39	47
1.2	7	13	20	27	33	40	8	16	24	32	40	48
1.4	7	14	21	27	34	41	8	16	25	33	41	49
1.6	7	14	21	28	35	42	8	17	25	33	42	50
1.8	7	14	22	29	36	43	9	17	26	34	43	51
2.0	7	15	22	29	37	44	9	17	26	35	43	52
2.2	7	15	22	29	37	44	9	18	27	35	44	53
2.4	8	15	23	30	38	45	9	18	27	36	45	54
2.6	8	15	23	31	38	46	9	18	28	38	46	55
2.8	8	16	24	31	39	47	9	19	28	37	47	56
≥ 3.0	8	16	24	31	39	47	10	19	29	38	48	57
Chlorine Concentration (mg/L)	pH = 7.0						pH = 7.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	9	17	26	35	43	52	10	21	31	41	52	62
0.6	9	18	27	36	45	54	11	21	32	43	53	64
0.8	9	18	28	37	46	55	11	22	33	44	55	66
1.0	9	19	28	37	47	56	11	22	34	45	56	67
1.2	10	19	29	38	48	57	12	23	35	46	58	69
1.4	10	19	29	39	48	58	12	23	35	47	58	70
1.6	10	20	30	39	49	59	12	24	36	48	60	72
1.8	10	20	31	41	51	61	12	25	37	49	62	74
2.0	10	21	31	41	52	62	13	25	38	50	63	75
2.2	11	21	32	42	53	63	13	26	39	51	64	77
2.4	11	22	33	43	54	65	13	26	39	52	65	78
2.6	11	22	33	44	55	66	13	27	40	53	67	80
2.8	11	22	34	45	56	67	14	27	41	54	68	81
≥ 3.0	11	23	34	45	57	68	14	28	42	55	69	83

Table D-1.5 continues on the next page.

Table D-1.5—Continued

Chlorine Concentration (mg/L)	pH = 8.0						pH = 8.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	12	25	37	49	62	74	15	30	45	59	74	89
0.6	13	26	39	51	64	77	15	31	46	61	77	92
0.8	13	26	40	53	66	79	16	32	48	63	79	95
1.0	14	27	41	54	68	81	16	33	49	65	82	98
1.2	14	28	42	55	69	83	17	33	50	67	83	100
1.4	14	28	43	57	71	85	17	34	52	69	86	103
1.6	15	27	44	58	73	87	18	35	53	70	88	105
1.8	15	30	45	59	74	89	18	36	54	72	90	108
2.0	15	30	46	61	76	91	18	37	55	73	92	110
2.2	16	31	47	62	78	93	19	38	57	75	94	113
2.4	16	32	48	63	79	95	19	38	58	77	96	115
2.6	16	32	49	65	81	97	20	39	59	78	98	117
2.8	17	33	50	66	83	99	20	40	60	79	99	119
≥ 3.0	17	34	51	67	84	101	20	41	61	81	102	122
Chlorine Concentration (mg/L)	pH = 9.0						<p><i>Note:</i> No disinfection credit for <i>Giardia</i> cysts is allowed when using free chlorine if the pH within the disinfection zone is greater than 9.0.</p>					
	Log inactivations											
	0.5	1	1.5	2	2.5	3						
≤ 0.4	18	35	53	70	88	105						
0.6	18	36	55	73	91	109						
0.8	19	38	57	75	94	113						
1.0	20	39	59	78	98	117						
1.2	20	40	60	80	100	120						
1.4	21	41	62	82	103	123						
1.6	21	42	63	84	105	126						
1.8	22	43	65	86	108	129						
2.0	22	44	66	88	110	132						
2.2	23	45	68	90	113	135						
2.4	23	46	69	92	115	138						
2.6	24	47	71	94	118	141						
2.8	24	48	72	95	119	143						
≥ 3.0	24	49	73	97	122	146						

Table D-1.6. CT values required for inactivation of *Giardia* cysts at 25°C.^a

Chlorine Concentration (mg/L)	pH ≤ 6.0						pH = 6.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	4	8	12	16	20	24	5	10	15	19	24	29
0.6	4	8	13	17	21	25	5	10	15	20	25	30
0.8	4	9	13	17	22	26	5	10	16	21	26	31
1.0	4	9	13	17	22	26	5	10	16	21	26	31
1.2	5	9	14	18	23	27	5	11	16	21	27	32
1.4	5	9	14	18	23	27	6	11	17	22	28	33
1.6	5	9	14	19	23	28	6	11	17	22	28	33
1.8	5	10	15	19	24	29	6	11	17	23	28	34
2.0	5	10	15	19	24	29	6	12	18	23	29	35
2.2	5	10	15	20	25	30	6	12	18	23	29	35
2.4	5	10	15	20	25	30	6	12	18	24	30	36
2.6	5	10	16	21	26	31	6	12	19	25	31	37
2.8	5	10	16	21	26	31	6	12	19	25	31	37
≥ 3.0	5	11	16	21	27	32	6	13	19	25	32	38
Chlorine Concentration (mg/L)	pH = 7.0						pH = 7.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤ 0.4	6	12	18	23	29	35	7	14	21	28	35	42
0.6	6	12	18	24	30	36	7	14	22	29	36	43
0.8	6	12	19	25	31	37	7	15	22	29	37	44
1.0	6	12	19	25	31	37	8	15	23	30	38	45
1.2	6	13	19	25	32	38	8	15	23	31	38	46
1.4	7	13	20	26	33	39	8	16	24	31	39	47
1.6	7	13	20	27	33	40	8	16	24	32	40	48
1.8	7	14	21	27	34	41	8	16	25	33	41	49
2.0	7	14	21	27	34	41	8	17	25	33	42	50
2.2	7	14	21	28	35	42	9	17	26	34	43	51
2.4	7	14	22	29	36	43	9	17	26	35	43	52
2.6	7	15	22	29	37	44	9	18	27	35	44	53
2.8	8	15	23	30	38	45	9	18	27	36	45	54
≥ 3.0	8	15	23	31	38	46	9	18	28	37	46	55

^a For temperatures above 25°C, CT_{required} drops by a factor of two for each 10°C rise in temperature—that is, the CT_{required} at 30°C is one-half the CT_{required} at 20°C.

Table D-1.6 continues on the next page.

Table D1.6—continued

Chlorine Concentration (mg/L)	pH = 8.0						pH = 8.5					
	Log inactivations						Log inactivations					
	0.5	1	1.5	2	2.5	3	0.5	1	1.5	2	2.5	3
≤0.4	8	17	25	33	42	50	10	20	30	39	49	59
0.6	9	17	26	34	43	51	10	20	31	41	51	61
0.8	9	18	27	35	44	53	11	21	32	42	53	63
1.0	9	18	27	36	45	54	11	22	33	43	54	65
1.2	9	18	28	37	46	55	11	22	34	45	56	67
1.4	10	19	29	38	48	57	12	23	35	46	58	69
1.6	10	19	29	39	48	58	12	23	35	47	58	70
1.8	10	20	30	40	50	60	12	24	36	48	60	72
2.0	10	20	31	41	51	61	12	25	37	49	62	74
2.2	10	21	31	41	52	62	13	25	38	50	63	75
2.4	11	21	32	42	53	63	13	26	39	51	64	77
2.6	11	22	33	43	54	65	13	26	39	52	65	78
2.8	11	22	33	44	55	66	13	27	40	53	67	80
≥ 3.0	11	22	34	45	56	67	14	27	41	54	68	81
Chlorine Concentration (mg/L)	pH = 9.0						<i>Note:</i> No disinfection credit for <i>Giardia</i> cysts is allowed when using free chlorine if the pH within the disinfection zone is greater than 9.0.					
	Log inactivations											
	0.5	1	1.5	2	2.5	3						
≤0.4	12	23	35	47	58	70						
0.6	12	24	37	49	61	73						
0.8	13	25	38	50	63	75						
1.0	13	26	39	52	65	78						
1.2	13	27	40	53	67	80						
1.4	14	27	41	55	68	82						
1.6	14	28	42	56	70	84						
1.8	14	29	43	57	72	86						
2.0	15	29	44	59	73	88						
2.2	15	30	45	60	75	90						
2.4	15	31	46	61	77	92						
2.6	16	31	47	63	78	94						
2.8	16	32	48	64	80	96						
≥ 3.0	16	32	49	65	81	97						

Table D-1.7. CT values required for inactivation of viruses.^{a,b}

Temperature	Log inactivations					
	2		3		4	
	pH		pH		pH	
	5.5–9.49	9.5–10.49	5.5–9.49	9.5–10.49	5.5–9.49	9.5–10.49
0.5°C	6	45	9	66	12	90
5°C	4	30	6	44	8	60
10°C	3	22	4	33	6	45
15°C	2	15	3	22	4	30
20°C	1	11	2	16	3	22
25°C	1	7	1	11	2	15

^a No disinfection credit is allowed for pH above 10.49.

^b For temperatures above 25°C, CT_{required} drops by a factor of two for each 10°C rise in temperature—that is, the CT_{required} at 30°C is one-half the CT_{required} at 20°C.

D.2 CT TABLES FOR DISINFECTION WITH CLO₂

This appendix contains the CT tables you should use when inactivating *Giardia lamblia* and viruses with chlorine dioxide. The information used to generate these tables and the associated notes was derived from Appendixes E and F of the EPA's *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*, Office of Drinking Water, Washington (March 1991), available at:

water.epa.gov/lawsregs/rulesregs/sdwa/swtr/upload/guidsws.pdf

Table D-2.1. CT values required for inactivation of *Giardia* cysts at pH between 6.0 and 9.49.^a

Inactivation	Temperature (°C)					
	≤ 1	5	10	15	20	25
0.5-log	10.0	4.3	4.0	3.2	2.5	2.0
1.0-log	21.0	8.7	7.7	6.3	5.0	3.7
1.5-log	32.0	13.0	12.0	10.0	7.5	5.5
2.0-log	42.0	17.0	15.0	13.0	10.0	7.3
2.5-log	52.0	22.0	19.0	16.0	13.0	9.0
3.0-log	63.0	26.0	23.0	19.0	15.0	11.0

^a No disinfection credit is allowed for pH above 9.49.

Table D-2.2. CT values required for inactivation of viruses at pH between 6.0 and 9.49.^{a,b}

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

^a No disinfection credit is allowed for pH above 9.49.

^b For temperatures above 25°C, CT_{required} drops by a factor of two for each 10°C rise in temperature—that is, the CT_{required} at 30°C is one-half the CT_{required} at 20°C.

D.3 CT TABLES FOR DISINFECTION WITH O₃

This appendix contains the CT tables you should use when inactivating *Giardia lamblia* and viruses with ozone. The information used to generate these tables and the associated notes was derived from Appendixes E and F of the EPA's *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*, Office of Drinking Water, Washington (March 1991), available at:

water.epa.gov/lawsregs/rulesregs/sdwa/swtr/upload/guidsws.pdf

Table D-3.1. CT values required for inactivation of *Giardia* cysts at pH between 6.0 and 9.49.^{a,b}

Inactivation	Temperature (°C)					
	≤ 1	5	10	15	20	25
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	1.43	0.95	0.72	0.48

^a No disinfection credit is allowed for pH above 9.49.

^b For temperatures above 25°C, CT_{required} drops by a factor of two for each 10°C rise in temperature—that is, the CT_{required} at 30°C is one-half the CT_{required} at 20°C.

Table D-3.2. CT values required for inactivation of viruses at pH between 6.0 and 9.49.^{a,b}

Inactivation	Temperature (°C)					
	≤ 1	5	10	15	20	25
2-log	0.90	0.60	0.50	0.30	0.25	0.15
3-log	1.40	0.90	0.80	0.50	0.40	0.25
3-log	1.80	1.20	1.00	0.60	0.50	0.30

^a No disinfection credit is allowed for pH above 9.49.

^b For temperatures above 25°C, CT_{required} drops by a factor of two for each 10°C rise in temperature—that is, the CT_{required} at 30°C is one-half the CT_{required} at 20°C.

D.4 CT TABLES FOR NH₂CL (CHLORAMINES)

This appendix contains the CT tables you should use when inactivating *Giardia lamblia* and viruses with chloramine. The information used to generate these tables and the associated notes was derived from Appendixes E and F of the EPA's *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*, Office of Drinking Water, Washington (March 1991), available at:

water.epa.gov/lawsregs/rulesregs/sdwa/swtr/upload/guidsws.pdf

Table D-4.1. CT values required for inactivation of *Giardia* cysts at pH between 6.0 and 9.49.^{a,b}

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

^a Table D-4.1 applies only if a well-mixed chlorine residual is present prior to the application of ammonia in the treatment process.

^b No disinfection credit is allowed for pH above 9.49.

Table D-4.2. CT values required for inactivation of viruses at pH between 6.0 and 9.49.^{a,b,c}

Inactivation	Temperature (°C)					
	≤ 1	5	10	15	20	25
2-log	1245	857	643	428	321	214
3-log	2063	1423	1067	712	534	356
4-log	2883	1988	1491	994	746	497

^a Table D-4.2 applies only if a well-mixed chlorine residual is present prior to the application of ammonia in the treatment process.

^b No disinfection credit is allowed for pH above 9.49.

^c For temperatures above 25°C, CT_{required} drops by a factor of two for each 10°C rise in temperature—that is, the CT_{required} at 30°C is one-half the CT_{required} at 20°C.