



Arkansas Department of Health

Arkansas Public Water System Compliance

Disinfectants and Disinfection Byproducts Rules

Disinfection Byproduct

Definition

An unintended result of drinking water disinfection



Disinfection Byproduct Rule

Terms & Acronyms

- TOC – Total Organic Carbon
- **Disinfectants**
- DBPs – Disinfection Byproducts
- TTHM – Total Trihalomethanes
- HAA5 – Haloacetic Acids
- MCL – Maximum Contaminant Level
- MRDL – Maximum Residual Disinfectant Level
- MCLG – Maximum Contaminant Level Goal
- MRDLG – Maximum Residual Disinfectant Level Goal
- **Entry point**
- RAA – Running Annual Average
- LRAA – Locational Running Annual Average
- OEL – Operational Evaluation Level
- **Subpart H water system**



Monitoring

DBP Precursors

- Total Organic Carbon
 - sampled same day as source alkalinity

Disinfectants

- Chlorine, Chloramine, ClO_2

DBPs

- Total Trihalomethanes, Total Haloacetic Acids, Chlorite, Bromate



Total Organic Carbon



Total Organic Carbon

Disinfection byproducts (DBPs) are formed when Total Organic Carbon (TOC) or naturally occurring bromide combines with a disinfectant.

Formation of DBPs is dependent upon:

- Amount of TOC
- Type and amount of disinfectant
- Contact time
- Temperature
- pH
- Various raw water qualities



Total Organic Carbon

General Requirements & Monitoring Requirements

All Community and Non-Transient Non-Community Subpart H systems using conventional filtration treatment must:

- Monitor TOC levels
- Monitor alkalinity
- Ensure that monitoring is done under normal operating conditions
- Comply with TOC removal requirements
- Be operated by qualified personnel
- Monitor magnesium levels in the raw water & in the finished water (softening plants only)



Total Organic Carbon

Monitoring Frequency

A complete TOC sample set consists of a pair of TOC samples (1 source water sample & 1 finished water sample) and a source water alkalinity sample.

- Routine monitoring: 1 sample set per month

A system may be placed on a reduced monitoring schedule if the treated water TOC level is < 2.0 mg/L for 2 years, or < 1.0 mg/L for 1 year.

- Reduced monitoring: 1 sample set per quarter



Total Organic Carbon

Alkalinity Monitoring

Alkalinity monitoring should be performed by water system personnel and must be done on the same day as TOC sample collection.

Acceptable Analytical Techniques:

- D1067-92 B, D1067-02 B, D1067-06 B, D1067-11 B (ASTM Int.)
- 2320 B (Standard Methods)
- I-1030-85 (USGS, 1989)



Total Organic Carbon

Alkalinity Reporting

The raw water alkalinity level must be recorded on the water system's Monthly Operating Report.

Alkalinity (ppm)			
Date	Raw	Set	Fin
1	54		
2	54		
3	52		
4	51		
5	52		
6	54		
7	54		
8	54		

Total Organic Carbon

Treatment Technique for the Removal of DBP Precursors

Enhanced Coagulation: the addition of sufficient coagulant for improved removal of disinfection byproduct precursors by conventional filtration treatment

Purpose: Remove Total Organic Carbon & reduce disinfection byproduct levels

Applies to: All conventional surface water systems

Requirements:

- Achieve Step 1 or Step 2 TOC removal, or
- Meet at least one of the Alternative Compliance Criteria, or
- Get a waiver from the State



Total Organic Carbon

Step 1 TOC Removal Requirements Enhanced Coagulation & Enhanced Softening

The raw water alkalinity and TOC levels determine the required removal percentage from the table.

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L as calcium carbonate)		
	0 – 60	> 60 – 120	> 120
> 2.0 – 4.0	35%	25%	15%
> 4.0 – 8.0	45%	35%	25%
> 8.0	50%	40%	30%

Note: Source waters with TOC levels less than 2.0 mg/L have no removal requirement.



Total Organic Carbon

Step 2 TOC Removal Requirements

- System failed to meet Step 1 removal requirements
- Application made to the State within 3 months of failure
- Jar testing to determine maximum TOC removal
- If maximum removal percentage is less than the Step 1 removal requirement, a new minimum removal requirement is set.
- State may make results retroactive



Total Organic Carbon

Alternative Compliance Criteria for TOC Removal

1. Source water TOC < 2.0 mg/L (annual average)
 2. Treated water TOC < 2.0 mg/L (annual average)
 3. Source water TOC < 4.0 mg/L, and
 - Source water alkalinity is > 60 mg/L, and
 - Total Trihalomethanes level is < 40 ug/L, and
 - Haloacetic Acids level is < 30 ug/L
 4. For systems using only chlorine as a disinfectant:
 - Total Trihalomethanes level is < 40 ug/L, and
 - Haloacetic Acids level is < 30 ug/L
- Note: 40 ug/L is half the MCL for Total Trihalomethanes
& 30 ug/L is half the MCL for Haloacetic Acids



Total Organic Carbon Removal Compliance Recap

To achieve compliance, systems must do one of the following:

- Achieve Step 1 TOC removal requirements
- Establish and Achieve Step 2 TOC removal requirements
- Meet one or more Alternative Compliance Criteria



Total Organic Carbon Removal Compliance Calculations

Requirement:

Running annual average removal ratio
of ≥ 1.0 .



Total Organic Carbon Removal Compliance Calculations

<i>TOC Removal</i>							
2013 Month	Raw Water TOC (mg/L)	Treated TOC (mg/L)	Actual % Removal	Raw Water Alkalinity (mg/L)	Required Removal (%)	Monthly Ratio	RAA Ratio
January	4.67	2.17	53.5	19.0	45.0	1.19	

Raw Water TOC (mg/L)	Raw Water Alkalinity (mg/L as calcium carbonate)		
	0 – 60	> 60 – 120	> 120
> 2.0 – 4.0	35%	25%	15%
> 4.0 – 8.0	45%	35%	25%
> 8.0	50%	40%	30%

Total Organic Carbon

Removal Compliance Calculations

<i>TOC Removal</i>							
2013 Month	Raw Water TOC (mg/L)	Treated TOC (mg/L)	Actual % Removal	Raw Water Alkalinity (mg/L)	Required Removal (%)	Monthly Ratio	RAA Ratio
January	4.67	2.17	53.5	19.0	45.0	1.19	
February	9.32	2.98	68.0	28.0	50.0	1.36	
March	6.97	2.39	65.7	21.0	45.0	1.46	
April	6.28	3.75	40.3	25.6	45.0	0.90	
May	8.93	3.09	65.4	21.0	50.0	1.31	
June	2.04	1.60	21.6	21.0	35.0	1.00	
July	6.07	2.49	59.0	27.3	45.0	1.31	
August	6.25	2.39	61.8	23.0	45.0	1.37	
September	5.40	2.22	58.9	38.0	45.0	1.31	
October	6.86	3.14	54.2	24.0	45.0	1.21	
November	5.97	2.97	50.3	22.3	45.0	1.12	
December	4.64	1.76	62.1	20.6	45.0	1.38	1.24



Total Organic Carbon Removal Compliance Calculations

<i>TOC Removal</i>	Raw	Treated		Raw Water	Required		
2013	Water TOC	TOC	Actual %	Alkalinity	Removal	Monthly	RAA
Month	(mg/L)	(mg/L)	Removal	(mg/L)	(%)	Ratio	Ratio
January	4.67	2.17	53.5	19.0	45.0	1.19	
February	9.32	2.98	68.0	28.0	50.0	1.36	
March	6.97	2.39	65.7	21.0	45.0	1.46	
April	6.28	3.75	40.3	25.6	45.0	0.90	
May	8.93	3.09	65.4	21.0	50.0	1.31	
June	2.04	1.60	21.6	21.0	35.0	1.00	
July	6.07	2.49	59.0	27.3	45.0	1.31	
August	6.25	2.39	61.8	23.0	45.0	1.37	
September	5.40	2.22	58.9	38.0	45.0	1.31	
October	6.86	3.14	54.2	24.0	45.0	1.21	
November	5.97	2.97	50.3	22.3	45.0	1.12	
December	4.64	1.76	62.1	20.6	45.0	1.38	1.24
<i>January, 2014</i>	8.93	3.09	65.4	21.0	50.0	1.31	
<i>February, 2014</i>	6.14	1.95	68.2	21.0	45.0	1.52	
<i>March, 2014</i>	6.07	2.49	59.0	27.3	45.0	1.31	1.25



Disinfectants



Disinfectants

Chlorine & Chloramines

Disinfectant	MRDL (mg/L)	MRDLG (mg/L)
Chlorine (as Cl ₂)	4.0 RAA	4.0
Chloramines (as Cl ₂)	4.0 RAA	4.0

- Compliance for chlorine and chloramines is based on a running annual average of all samples taken, calculated quarterly

Disinfectants

Chlorine & Chloramines, Monitoring & Reporting

Routine: Samples are collected at the same point & time as specified in the Total Coliform Rule

Reduced: Reduced monitoring is not allowed

The water system should monitor the residuals in the distribution system, and report them on its monthly Bacteriological Monitoring Report (BMR).



Disinfectants

Chlorine Residual Reporting

Public Water System – Bacteriological Monitoring Record

Date	Sample Site #	Type – Regular or Resample	Chlorine Residual mg/L	Lab results	Day/Date Results Received	Resample Containers
						Day/Date Received
8/26/14	B1	reg	1.62	absent	9/5/14	
8/26/14	B2	reg	0.35	absent	9/5/14	
8/26/14	B3	reg	1.25	absent	9/5/14	



Disinfectants

Chlorine Dioxide

Disinfectant	MRDL (mg/L)	MRDLG (mg/L)
Chlorine Dioxide (as ClO ₂)	0.8 (Daily Entry Point)	0.8

Disinfectants

Chlorine Dioxide Monitoring

- Routine: Daily monitoring at the entry point to the distribution system
- Reduced: Reduced monitoring is not allowed
- Triggered: Required on the following day, when any daily sample exceeds 0.8 mg/L
- Systems without booster chlorination will collect 3 samples at > 6 hour intervals as close as possible to the first customer
 - Systems providing booster chlorination will monitor at the first customer, and at the average and maximum residence time locations

Disinfectants

Chlorine Dioxide MRDL Compliance

Non-acute violation:

- 2 consecutive entry point samples > 0.8 mg/L
- All distribution samples are < 0.8 mg/L

Acute violation is based on samples collected on consecutive days:

- Entry point sample is > 0.8 mg/L
- 1 or more distribution system samples > 0.8 mg/L

The water system will monitor the residuals at the entry point to the distribution system, and if triggered, in the distribution system, and report them on its Monthly Operating Report.



Disinfectants

Chlorine Dioxide Residual Reporting

ClO₂ Residual Monitoring				
Date	Entry Point	Distribution System		
		Point 1	Point 2	Point 3
1	0.11			
2	0.07			
3	0			
4	0.4			
5	0.9			
6	0.05	0.05	0.03	0.01
7	0.09			
8	0.12			
9	0.12			
10	0.10			



Disinfection Byproducts



Disinfection Byproducts

Regulated Disinfection Byproducts

For systems delivering disinfected water:

- Total Trihalomethanes (TTHM)
- Haloacetic Acids (HAA5)

For systems that add Chlorine Dioxide:

- Chlorite

For systems that add Ozone:

- Bromate

Maximum Contaminant Levels (MCLs) have been established for each of these disinfection byproducts under the Disinfectants & Disinfection Byproducts Rules.



Disinfection Byproducts

Suspected Health Hazards

Toxicological and Epidemiological evidence shows a strong possibility of DBPs in drinking water contributing to cancer and reproductive problems.

Reduction in exposure to:

- Total Trihalomethanes (TTHM)
- Haloacetic Acids (HAA5)
- Chlorite
- Bromate

Reduced risks from:

- Cancer
- Reproductive effects
- Developmental effects

TTHM & HAA5

Regulated for all community and non-transient non-community water systems delivering disinfected water



TTHM & HAA5 Formation

Trihalomethanes and Haloacetic Acids are formed when naturally occurring matter in the water react with the disinfectants, chlorine and chloramine.



TTHM & HAA5

Routine Monitoring Frequency

Source Type	Population	Number of Sites & Frequency
Surface	<500	2 per year*
	500 – 3,300	2 per quarter
	3,301 – 9,999	2 per quarter
	10,000 – 49,999	4 per quarter
	50,000 – 249,999	8 per quarter
	250,000 – 999,999	12 per quarter
	1,000,000 – 4,999,999	16 per quarter
	≥ 5,000,000	20 per quarter
Ground	< 500	2 per year*
	500 – 9,999	2 per year
	10,000 – 99,999	4 per quarter
	100,000 – 499,999	6 per quarter
	≥ 500,000	8 per quarter

Dual sample set = 1 THM & 1 HAA sample.

Quarterly monitoring is a dual sample set at each monitoring location every 90 days.

For systems serving < 500, only one site is needed if the highest THM & HAA levels occur at the same location.



TTHM & HAA5

Maximum Contaminant Levels & Maximum Contaminant Level Goals

Disinfection Byproduct	mg/L
Total Trihalomethanes (TTHM) MCL	MCL = 0.080
• Chloroform	MCLG = 0.07
• Bromodichloromethane	MCLG = 0
• Bromoform	MCLG = 0
• Dibromochloromethane	MCLG = 0.06

80 ppb

Haloacetic Acids (HAA5) MCL	MCL = 0.060
• Monochloroacetic Acid	MCLG = 0.07
• Dichloroacetic Acid	MCLG = 0
• Trichloroacetic Acid	MCLG = 0.02
• Bromoacetic Acid	No MCLG established
• Dibromoacetic Acid	No MCLG established

60 ppb



Disinfection Byproducts

Compliance with TTHM & HAA5 MCLs

Compliance will be based on Locational Running Annual Averages (LRAAs).

TTHM <i>Results in ug/L (ppb)</i>	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	LRAA
Site 1	45	50	59	49	51
Site 2	78	84	88	79	82
Site 3	42	48	57	50	49
Site 4	55	62	81	75	68

TTHM MCL = 80 ppb

HAA5 MCL = 60 ppb

calculated quarterly as a locational running annual average



Disinfection Byproducts

TTHM & HAA5

Operational Evaluation Levels (OELs)

Operational Evaluation Level formula:

$$\frac{[(2 \times \text{current quarter THM or HAA results}) + \text{previous two quarters THM or HAA results}]}{4} = \text{OEL}$$

The OEL should not exceed the Maximum Contaminant Level.

TTHM MCL = 80 ppb

HAA5 MCL = 60 ppb



Disinfection Byproducts

TTHM & HAA5

Operational Evaluation Levels (OELs)

Operational Evaluation Level example for TTHM:

$$\frac{[(2 \times Q1) + Q4 + Q3]}{4} = \text{OEL}$$

TTHM Results in ug/L (ppb)	Third Quarter (Q3)	Fourth Quarter (Q4)	First Quarter (Q1)		OEL
Site 1	46	51	52 x 2	/4 =	50
Site 2	72	79	87 x 2	/4 =	81

TTHM MCL = 80 ppb



Disinfection Byproducts

TTHM & HAA5

Operational Evaluation Levels (OELs)

What does the OEL tell us?

TTHM <i>Results in ug/L (ppb)</i>	Third Quarter (Q3)	Fourth Quarter (Q4)	First Quarter (Q1)		OEL
Site 1	46	51	52 x 2	/4 =	50
Site 2	72	79	87 x 2	/4 =	81

TTHM MCL = 80 ppb

Site 1 is OK

Site 2 needs improvement



Disinfection Byproducts

TTHM & HAA5

Operational Evaluation Levels (OELs)

Site 2 TTHM OEL = 81 ppb

When an OEL is exceeded, the water system must:

- Conduct an *Operational Evaluation* to determine the cause of the exceedance
- Submit a written *Operational Evaluation Report* to the State no later than 90 days after being notified of the analytical result that caused the exceedance
- Keep a copy of the OEL Report and make it available to the public upon request



Disinfection Byproducts

TTHM & HAA5

Operational Evaluation Levels (OELs)

The Operational Evaluation must include an examination of system treatment and distribution operational practices that may contribute to TTHM & HAA5 formation, including:

- Sources of supply and source water quality
- Treatment processes and finished water quality
- Storage tank operations and excess storage capacity
- Distribution system flushing

The Operational Evaluation must also include what steps could be considered to minimize future exceedances.



Disinfection Byproducts

Best Available Technology (BAT)

EPA has identified the following as the best technologies, treatment techniques, or other means available for achieving compliance with the maximum contaminant levels for TTHM & HAA5.

For systems treating their own source water:

- Enhanced coagulation or enhanced softening
- GAC 10
- GAC 20
- Nanofiltration

Consecutive systems serving at least 10,000 people

- Chloramination
- Management of hydraulic flow and storage to minimize residence time in the distribution system

Consecutive systems serving fewer than 10,000 people

- Management of hydraulic flow and storage to minimize residence time in the distribution system



Chlorite

Regulated for all community and non-transient non-community water systems that use chlorine dioxide as an oxidant or disinfectant



Chlorite Formation

Chlorine dioxide rapidly decomposes into chlorite, chlorate and chloride ions in treated water, chlorite being the predominant species.



Chlorite

Maximum Contaminant Level & Maximum Contaminant
Level Goal

MCL = 1.0 mg/L

MCLG = 0.8 mg/L



Chlorite

Routine Monitoring

- Daily - at entry point
- Monthly - first customer, average and maximum residence times
- Triggered - if daily sample $>$ MCL, immediately notify the health department, and monitor the following day at the monthly monitoring points

Disinfection Byproducts

Chlorite Monitoring and Reporting

The entry point chlorite levels must be recorded on the system's Monthly Operating Report.

Chlorite Monitoring (For Systems using Chlorine Dioxide)		D A T E
Entry Point Chlorite	Dist. Samples Collected (Y/N)	
0.52	N	1
0.61	N	2
0.67	N	3
0.75	N	4
0.35	N	5
0.49	N	6



Disinfection Byproducts

Compliance with Chlorite MCL

Chlorite compliance is based on an Arithmetic Average of each monthly 3 sample set.

Chlorite <i>Results in mg/L (ppm)</i>	Nearest to First Customer Site	Average Residence Time Site	Maximum Residence Time Site	Distribution System Arithmetic Average
January	0.863	0.766	0.694	0.8
February	0.392	0.394	0.609	0.5
March	0.572	0.598	0.606	0.6
April	0.526	0.417	0.491	0.5
May	0.598	0.530	0.541	0.6
June	0.492	0.500	0.441	0.5
July	0.222	0.220	0.213	0.2
August	0.246	0.139	0.178	0.2
September	0.526	0.020	0.020	0.2
October	0.310	0.300	0.069	0.2
November	1.070	0.561	0.563	0.7
December	0.659	0.562	0.575	0.6



Bromate

Regulated for all community and non-transient non-community water systems using ozone as an oxidant or disinfectant



Bromate

Formation

Bromate is formed when ozone used to disinfect drinking water reacts with naturally occurring bromide found in source water.



Bromate

Maximum Contaminant Level, Maximum Contaminant Level
Goal, & Monitoring

MCL = 10 ppb

MCLG = 0

Monthly - at entry point



Disinfection Byproducts

Compliance with Bromate MCL

Bromate compliance is based on a Running Annual Average of monthly samples computed quarterly.

Month	Entry Point Bromate (ppb)	Running Annual Average
January	4.0	
February	5.6	
March	2.0	
April	2.0	
May	2.0	
June	2.0	
July	2.0	
August	2.0	
September	4.5	
October	2.0	
November	2.0	
December	3.0	2.8
January	3.8	
February	2.5	
March	3.5	2.6



Disinfection Byproducts

General Monitoring Information

- Samples must be collected under normal operating conditions
- ADH provides sample collection and analyses for TOC, TTHM, HAA5, Bromate, and distribution Chlorite.
- The water system will provide sample collection and analyses for disinfection residuals, and where applicable, entry point Chlorite.
- All systems must develop a monitoring plan.
- Monitoring must be performed according to the plan, and the plan must:
 - Include monitoring locations & schedule
 - Explain compliance calculation methodology
 - Reflect the entire distribution system



Disinfectants and Disinfection Byproducts Rules

There are 2 rules:

The Stage 1 Rule, which became effective January 1, 2002.

The Stage 2 Rule, which began to go into effect April 1, 2012.



The Stage 1 Disinfectants and Disinfection Byproducts Rule

- Total Organic Carbon
- Chlorine
- Chloramines
- Chlorine Dioxide
- Chlorite
- Bromate



The Stage 2 Disinfectants and Disinfection Byproducts Rule

Applies to:

All Community water systems, and Non-transient Non-community water systems, that deliver water which has been treated with a primary or residual disinfectant other than ultraviolet light.



Review Questions



What is TOC?

- A. Treated Organic Compounds
- B. Total Organic Carbon
- C. Tertiary Ozone Classification



Who performs TOC and DBP sampling and analyses?

- A. The Water System
- B. USGS
- C. Health Department



What is the MRDL for chlorine in the distribution system?

- A. 80 ppb
- B. 0.8 mg/L
- C. 4.0 mg/L



What is the MCL for TTHMs?

- A. 80 ppb
- B. 8 ppb
- C. 4 mg/L



Compliance for TOCs, TTHMs, and HAAs is based on what?

- A. Monthly sample results
- B. Chlorine residual
- C. Running Annual Averages (RAAs)



What are some disinfection byproducts other than TTHMs & HAAs?

- A. Chlorine, Chloramines
- B. Lime
- C. TOC
- D. Bromate, Chlorite



D/DPBRs Guidance:

Safe Drinking Water Hotline at (800) 426-4791

or

<https://www.epa.gov/dwreginfo/stage-1-and-stage-2-disinfectants-and-disinfection-byproducts-rules>

Technical information on the D/DPBRs :

ADH-Engineering Section

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