Disinfectants and Disinfection Byproducts Rule

(Stage 1 & Stage 2 DBPR)

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Purpose of Disinfection

To kill or to inactivate disease-causing microorganisms that cause serious illness and death (for example: typhoid, hepatitis, and cholera)
Disinfectants can react with naturally occurring materials (NOM) in the water (e.g., natural organic matter, bromide, or DBP precursors) to form unintended disinfection by-products (DBPs)
Risk-Risk Trade off
A Delicate Balance

Microbes

Disinfection Byproducts
Stage 1 DBPR

12/16/1998 promulgated

Apply to Community (C) and Non-Transient Non-Community (NTNC) systems that add a chemical disinfectant in any part of the treatment process.
Key Element of the Stage 1

- **Maximum Residual Disinfectant Levels (MRDL)** – Chlorine residuals
- **Disinfection Byproducts (DBP)** - TTHM/HAA5
- **DBP Precursors (DBPP)** – Subpart H systems using conventional filtration as a final filtration barrier must monitor TOC and alkalinity to calculate TOC removal rate to meet Enhanced Coagulation requirement
- **Monitoring Plan**
MRDL

- Monitoring disinfectant residual level in the distribution system at the same time and same location as the Total Coliform Rule samples
- 4.0 mg/L (as Cl₂) for Chlorine or Chloramines
- Short-term exceedance of MRDL is allowed to control microbiological contamination problems
How to report MRDL?

• Record chlorine residual on the bact sampling sheet and ask your Lab to forward that information to EPA (electronically or paper copy)

• MRDL Form #2 – only when your lab cannot forward that information to EPA; this form must be reported to EPA quarterly.
DBPs

• MCL  TTHM = 0.080 mg/L
  HAA5 = 0.060 mg/L

• Dual samples at a location representing the maximum residence time (MRT) of the distribution system

• Must be analyzed by certified laboratories
How Are DBPs Formed?

Precursor in Water
- Natural Organic Matter (NOM)
- Bromide

Added Disinfectant
- Chlorine
- Chloramines
- Chlorine Dioxide
- Ozone

Disinfection Byproducts (DBP)
- TTHM
- HAA5
- Chlorite
- Bromate
Factors Affecting DBP Formation

- Disinfectant applied
- Disinfectant dosage and contact time
- Type and level of DBP precursors
- Disinfection point
- pH and water temperature
- Residence time in the distribution system
What are DBP Precursors?

• TOC – Total Organic Carbon
  - Natural Organic matter (NOM)
  - Algal Organic Matter
  - Effluent Organic Matter

• DOC – Dissolved Organic Carbon
Enhanced Coagulation

Conventional filtration must achieve specific percent reduction of TOC between source water and finished water by adding sufficient coagulant for improved removal of DBP precursors (TOC)
Why DBP Precursor Removal?

- Precursors react with disinfectants to form DBPs
- Removal of precursors will help control known and undiscovered DBPs
- Treatment technique requirements are based on TOC removal
TOC Monitoring

• 3-sample set per month
  ◦ one source water TOC
  ◦ one finished water TOC
  ◦ one source water alkalinity (@ same time and same location as source water TOC)

• Running annual average (RAA) of monthly TOC removal ratio must be reported to EPA every quarter
DBPR Reporting

- Compliance by RAA calculation
- DBP Form #4 (to calculate RAA) with Lab sheets attached (Lab sheet only if monitor less frequently than quarterly)
- DBPP Forms #2 & #4 (to calculate RAA) with lab sheet attached
- Must be reported quarterly (within 10 days following the end of each quarter)
High TTHM concentration

Organics

Disinfection
High HAA5 concentration

Organics

Disinfection
Stage 2 DBPR

- 01/4/2006 promulgated
- Apply to C and NTNC systems that deliver water that has been treated with a chemical disinfectant (Stage 2 also regulates consecutive systems)
The Differences Between Stage 1 & Stage 2

- Consecutive systems included
- Compliance calculation - locational RAA (LRAA)
- DBP monitoring - at the highest risk locations
- Sampling frequency - population based
- Monitor every 90 days (not quarterly)
- Precision of certified Lab (MDLs and acceptance limits)
Stage 2 DBPR
Early Implementation

Community* PWSs to conduct an Initial Distribution System Evaluation (IDSE) and use its results in conjunction with the Stage 1 monitoring results to select Stage 2 Compliance monitoring sites

* C and NTNC serving at least 10,000 population
IDSE Options

- Very Small System Waiver (VSS) – no IDSE plan required
- 40/30 Certification – no IDSE plan required
- Standard Monitoring
- System Specific Study
**Important Notes**

- Continue the Stage 1 monitoring until Stage 2 monitoring starts (2012 and beyond)
- Stage 2 only replaces TTHM/HAA5 part of the Stage 1
- DBP Form 4 for each location
- Develop a Stage 2 Compliance Monitoring Plan before Stage 2 monitoring starts (can be replaced by an IDSE Report), and
- Subpart H PWSs serving > 3,300 must submit a copy of the Stage 2 Monitoring Plan to EPA
Stage 2 DBPR additional requirements

• Consecutive systems subject to this rule must monitor MRDL effective beginning April/01/2009
• Reduced TTHM/HAA5 monitoring is determined by LRAA at all compliance monitoring locations
• New criteria to qualify for reduced Bromate (RAA ≤ 0.025 mg/L) monitoring using Method 317.0 Revision 2, 326.0, or 321.8
## Stage 2 DBPR Schedule

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Service Population</th>
<th>Stage 2 monitoring starts</th>
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<tbody>
<tr>
<td>1</td>
<td>&gt; 100,000</td>
<td>April/01/2012</td>
</tr>
<tr>
<td>2</td>
<td>50,000-99,999</td>
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<tr>
<td>3</td>
<td>10,000-49,999</td>
<td>October/01/2013</td>
</tr>
<tr>
<td>4</td>
<td>&lt; 10,000</td>
<td>October/01/2013</td>
</tr>
</tbody>
</table>

October/01/2014 if Cryptosporidium monitoring is required
Operational Evaluation Level (OEL)

- Applies to Stage 2 DBPR systems which monitor quarterly
- Peaks in TTHM/HAA5 will sometimes occur, even when systems are in full compliance with the Stage 2 DBPR
- At any monitoring location
Formulation for Determining OEL Exceedance

\[
(A + B + (2 \times C))/4 = D
\]

A = TTHM/HAA5 results for two quarters prior to current quarter
B = TTHM/HAA5 results for one quarter prior to current quarter
C = TTHM/HAA5 results for the current quarter
D = your Operational Evaluation Value

If D for TTHM/HAA5 is > 0.080/0.060 mg/L, you have an OEL exceedance
OEL exceedance is not a violation, but failure to take the following action is a Tier 3 violation:

- Conduct an operational evaluation to determine the cause of exceedance
- Submit a written evaluation report to EPA within 90 days after being notified of the analytical results
- Keep a copy of the operational evaluation report for public review upon request
BAT for TTHM/HAA5

- GAC 10 – Granular activated carbon filter beds with an empty-bed contact time of 10 minutes based on average daily flow and a carbon reactivation frequency of every 120 days
- GAC20
- Nanofiltration (NF) – Membrane molecular weight cutoff of 1000 Daltons or less
- Chloramination – for consecutive systems
Strategies to Reduce TTHM/HAA5

- Operational changes (less costly)
- Equipment change (Capital improvement)
Strategies to Reduce TTHM/HAA5

- Improve precursor (TOC) removal – EC/ES, oxidant addition
- Adjust finished water pH
- Reduce water age in the distribution system (increase tank circulation rate, or distribution system flushing program, etc.)
- Move chlorination point to later in the treatment process
- Change disinfectant – $O_3$, $ClO_2$, $Cl_2$, UV, or Chloramines
Distribution System Flushing Program

Regular flushing program in the distribution system to remove accumulated sediments and stagnant organic material/biofilm that is reacting with the disinfectant to form DBPs
Water Age Reduction

- Stagnant water or long storage time promotes loss of chlorine residual, and higher DBP formation.

- Recommendations:
  1. Clean tanks regularly (once/5 years)
  2. Turn over at least 30 to 50% of tank storage each day
  3. Keep less than 5 to 7 days of hydraulic retention time ...decrease storage while meeting fire protection requirements
Types of significant disinfection changes to reducing DBPs

• Changing type of disinfectant (e.g. switch from chlorine to chloramines or install UV prior to chlorination)

• Significantly decreasing the dosage of current disinfectant.

• Changing the point(s) of disinfectant application
Things to consider in making a significant change to disinfection practices

• If prechlorinate (before filters) to control biological growth .....or to oxidize/precipitate out metals...can alternative oxidants address these problems, yet not to create regulated DBP levels (e.g. use potassium permanganate or hydrogen peroxide)
Things to consider in making a significant change to disinfection practices (cont.)

• If you switch disinfectants, will you create additional problems? Evaluate the chemistry of these disinfectants when applied to your water. (this should not be a problem if you install UV).

• Switching from chlorine to chloramines adds ammonia, increasing nutrients for nitrifying bacteria in your distribution system. Also, changes to the water chemistry from chloramines may increase leaching of lead or copper from pipes, pinhole leaks in brass, accelerate deterioration of rubber materials, etc.
Things to consider in making a significant change to disinfection practices (cont.)

- If you change your type of filter aid/chemical pretreatment, or change the order in which the chemicals are added to improve TOC removal, this can affect other processes.
- For example, adding lime for alkalinity/pH adjustment at the same location as your iron or aluminum based coagulants can hurt turbidity removal since the coagulant reacts with the lime.
Things to consider in making a significant change to disinfection practices (cont.)

- Treatment changes can affect:
  -- Turbidity of finished water
  -- Lead and Copper in pipes
  -- Total Coliform Compliance
  -- CT Inactivation rates (from pH changes, etc.)
Things to consider in making a significant change to disinfection practices (cont.)

• Are you greatly overdosing your chlorine – look at disinfection profile for logs of inactivation. Rerun the profile with the lower dosage of Chlorine you are proposing, and check if you still meet SWTR inactivation requirements (compare to benchmark).

• Is your chlorine dose erratic? Large surges in chlorine may increase DBP formation.

• REMEMBER – consult with EPA before making these significant changes.