**REGULATORY REQUIREMENTS**

1. **Plan Review**
   - Pilot Study
   - Approval to Construct
   - Final Approval

2. **Operator Certification**
   - Water Treatment 1 (Typical)

3. **Monitoring**
   - Chlorine/CT
   - Turbidity

4. **Reporting/Recordkeeping**
   - Monthly Reporting (NTU, Chlorine, CT, etc.)

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**REGULATORY REQUIREMENTS – OTHER**

N/A - TNC = Transient Non-Community water systems that are required to have their operator(s) attend a 1-time only class (0.6 CEU class).

---

**REGULATORY REQUIREMENTS – PATHOGEN RMVL**

Applicability: PWSs that use SW or GWUDI that practice SSF, DE, or Alternative Filtration

<table>
<thead>
<tr>
<th>Regulated Pathogen</th>
<th>Turbidity Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>99.99% (4-log) removal/inactivation of viruses (SWTR)</td>
<td>Turbidity readings are to be monitored/recorded at the combined filter effluent (CFE) at a frequency of at least once every 4 hours*</td>
</tr>
<tr>
<td>99.9% (3-log) removal/inactivation of Giardia lamblia (SWTR)</td>
<td>95% of CFE turbidity readings ≤ 1 NTU (≤ 1.49 NTU)</td>
</tr>
<tr>
<td>99% (2-log) removal of Cryptosporidium (IESWTR/LT1) (&gt; 2-log if Bin 2 or higher under LT2)</td>
<td>All CFE turbidity readings ≤ 5 NTU (≤ 5.49 NTU)</td>
</tr>
</tbody>
</table>

* Frequency may be reduced by the State to once per day.

Slow sand filtration is credited with removing:
- 2.0-log Giardia & 2-log Cryptosporidium
- 1.0-log Giardia inactivation is needed through disinfection, a 0.5-log of which must be obtained after filtration.

---

**REGULATORY REQUIREMENTS – TURBIDITY**

Turbidity Limits

<table>
<thead>
<tr>
<th>Turbidity</th>
<th>Turbidity readings are to be monitored/recorded at the combined filter effluent (CFE) at a frequency of at least once every 4 hours*</th>
</tr>
</thead>
<tbody>
<tr>
<td>95% of CFE turbidity readings ≤ 1 NTU (≤ 1.49 NTU)</td>
<td>All CFE turbidity readings ≤ 5 NTU (≤ 5.49 NTU)</td>
</tr>
</tbody>
</table>

* Frequency may be reduced by the State to once per day.
REGULATORY REQUIREMENTS – NTU REPORTING

<table>
<thead>
<tr>
<th>Turbidity Reporting</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity reporting required within 10 days after the end of the month:</td>
<td></td>
</tr>
<tr>
<td>Total # of Monthly Measurements</td>
<td></td>
</tr>
<tr>
<td>Number and percent less than or equal to 95th percentile turbidity limit</td>
<td></td>
</tr>
<tr>
<td>Date and Value Exceeding 5 NTU</td>
<td></td>
</tr>
<tr>
<td>Turbidity reporting required within 24 hours:</td>
<td></td>
</tr>
<tr>
<td>Exceedances of 5 NTU for CFE</td>
<td></td>
</tr>
</tbody>
</table>

TURBIDIMETERS

- Turbidimeters
  - Online, portable or bench-top
  - Must be calibrated per manufacturer or at least quarterly with a primary standard
    - Formazin solution
    - StablCal® (stabilized formazin)
  - Secondary standards used for day-to-day check
    - Check is used to determine if calibration with a primary standard is necessary
    - Gelex
    - Manufacturer provided (e.g. Hach ICE-PIC)

LONG-TERM 2 ESWTR (LT2)

<table>
<thead>
<tr>
<th>40 CFR 141.701(c) Monitoring Schedule</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial and second round monitoring must begin no later than the month beginning with the date listed in the table below.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Systems that serve...</th>
<th>1st Round</th>
<th>2nd Round</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>At least 100,000 people</td>
<td>October 1, 2006</td>
<td>April 1, 2015</td>
</tr>
<tr>
<td>2</td>
<td>From 50,000 to 99,999 people</td>
<td>April 1, 2007</td>
<td>October 1, 2015</td>
</tr>
<tr>
<td>3</td>
<td>From 10,000 to 49,999 people</td>
<td>April 1, 2008</td>
<td>October 1, 2016</td>
</tr>
<tr>
<td>4 (Crypto)</td>
<td>Fewer than 10,000, not a wholesale system, and monitors for E. coli*</td>
<td>October 1, 2008</td>
<td>October 1, 2012</td>
</tr>
<tr>
<td>4 (Crypto)</td>
<td>Fewer than 10,000, not a wholesale system, and monitors for Cryptosporidium</td>
<td>April 1, 2010</td>
<td>April 1, 2013</td>
</tr>
</tbody>
</table>

* Applies only to filtered systems.

LONG-TERM 2 ESWTR (LT2)

- Filtered System Additional Cryptosporidium Treatment Requirements (based on their bin classification as determined under § 141.710 and according to the schedule in § 141.713)

<table>
<thead>
<tr>
<th>bin</th>
<th>Conventional Filtration (including softening), Slow Sand, or Diatomaceous Earth</th>
<th>Direct filtration</th>
<th>Alternative filtration technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Additional Treatment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1-log treatment</td>
<td>1.5-log treatment</td>
<td>RMVL + Inactivation ≥ 4.0-log</td>
</tr>
<tr>
<td>3</td>
<td>2-log treatment</td>
<td>2.5-log treatment</td>
<td>RMVL + Inactivation ≥ 4.0-log</td>
</tr>
<tr>
<td>4</td>
<td>2.5-log treatment</td>
<td>3-log treatment</td>
<td>RMVL + Inactivation ≥ 5.0-log</td>
</tr>
</tbody>
</table>

* As determined by the State such that the total Cryptosporidium removal and inactivation is at least 4.0-log.
*0 determined by the State such that the total Cryptosporidium removal and inactivation is at least 5.0-log.
LONG-TERM 2 ESWTR (LT2)
Microbial Toolbox Treatment Options

Options can be used singly or in combination. Systems must meet specific criteria for prescribed treatment credit.

Pre-Filtration
- Pre-sedimentation
- Sedimentation Via Filter Media

Pre-Treatment Performance
- Chemical Feed
- Prechlorination
- Lime Softening
- Preoxidation

Chlorination
- Chlorine
- Chloramine
- Hypochlorite

Treatment Performance
- Membrane
- UF
- Ozone
- UV
- UV/ozone

Demonstration of Performance
- Combined Filter Performance
- Individual Filter Performance
- Demonstration of Performance

Options can be used singly or in combination. Systems must meet specific criteria for prescribed treatment credit.

Source Protection & Management
- Watershed Control Program
- Source Water Protection
- Source Water Intake Management
- Alternative Source/Intake Management

REGULATORY REQUIREMENTS – DISINFECTION

Entry Point Chlorine Residual

| Residual disinfectant concentration cannot be < 0.2 mg/l for more than 4 hours based on continuous monitoring (> 3,300 pop) or less frequent monitoring as allowed by the state. (SWTR) |
| Residual disinfectant concentration cannot be < 0.2 mg/l for more than 4 hours based on continuous monitoring (> 3,300 pop) or less frequent monitoring as allowed by the state. (SWTR) |
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No two consecutive daily samples should exceed 4.0 mg/l (DBPR)

Where chlorine is used as the disinfectant, the measurement of residual chlorine shall be by the DPD or other EPA-approved method in accordance with Standard Methods for the Examination of Water and Waste-water, and shall measure the free chlorine residual or total chlorine residual as applicable.

REGULATORY REQUIREMENTS – CL2 REPORTING

Chlorine Residual Reporting Required

| Entry Point (reported with turbidity) | Lowest daily value for each day, the date and duration when residual disinfectant was < 0.2 mg/l, and when State was notified of events where residual disinfectant was < 0.2 mg/l. |
| Distribution (reported with coliform sample results) | Number of residual disinfectant or HPC measurements taken in the month resulting in no more than 5% of the measurements as being undetectable in any 2 consecutive months. |

CLORINE ANALYZERS

- Chlorine analyzers
  - Handheld (HACH Colorimeter shown)
  - Follow manufacturer’s instructions
- Online
  - Check calibration against a handheld that has been calibrated
  - At least weekly
  - Follow manufacturer’s instructions if out of calibration
REGULATORY REQUIREMENTS – OTHER

Other SWTR/IESWTR/LT1 Requirements

Disinfection Profiling & Benchmarking
- Systems must profile inactivation levels and generate a benchmark, if required due to disinfection changes (IESWTR & LT1)

Water System Surveys (State Requirement)
- CWS: Every 3 years
- NCWS: Every 5 years (IESWTR & LT1)

Finished Water Reservoirs
- New (post-1989) reservoirs must be covered under SWTR.
- Pre-SWTR reservoirs must be covered (or have additional treatment) under LT2

Operator Certification
- Operated by Qualified Personnel as Specified by State (SWTR)

CWS: Community Water System
NCWS: Non-community Water System

Cyanotoxin Monitoring (OAR 333-061-0510 to -0580)
Healthoregon.org/dwcyanotoxins

Who does this apply to?
- Affects systems who have sources susceptible to cyanobacteria blooms (not everyone). See list systems and specific rule requirements on-line at www.healthoregon.org/dwcyanotoxins

What is required?
- Raw water (intake) sampling for total microcystin and Cylindrospermopsin toxins every 2 weeks from May 1st – October 31st each year

What happens if detected?
1. Notify your regulator
2. If any toxins are greater than or equal to 0.3 µg/L in raw water or if there is a recreational use health advisory* upstream of the intake, sample raw and entry point weekly with the first EP sample taken within 1 business day. Weekly sampling continues until non-detect at EP and less than 0.3 µg/L in raw water in two consecutive samples.
3. If above Health Advisory Level (HAL) at EP, take confirmation sample within 24 hrs & monitor EP daily.
4. If confirmation sample is above the HAL, issue Do-Not-Drink Advisory
6. If above Health Advisory Level (HAL) at EP, take confirmation sample within 24 hrs & monitor EP daily.

What are the DW Health Advisory Levels (HALs)?
- Total Microcystins: 0.3 µg/L for vulnerable people; 1.6 µg/L for all persons
- Cylindrospermopsin: 0.7 µg/L for vulnerable people; 3 µg/L for all persons

“Vulnerable people” means infants, children under the age of six, pregnant women, nursing mothers, those with pre-existing liver conditions, and those receiving dialysis treatment.

REPORTING FORMS

There are 4 forms:
- Conventional/Direct
- Slow Sand / Membrane / DE / Unfiltered
- Cartridge
- UV (if used for Giardia credit)

Must use correct form because each has questions that must be answered that are specific to the filtration type

REPORTING FORMS – CFE TURBIDITY

<table>
<thead>
<tr>
<th>System Name</th>
<th>ID #</th>
<th>Month/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Chose time closest to when daily turbidity is measured and enter result(s)
- Enter highest turbidity of all measurements for the day (e.g., online instrument or highest of multiple daily grab samples)

REPORTING FORMS – MONTHLY SUMMARY - TURBIDITY

95% of daily turbidity readings ≤ 1 NTU? Yes No
All daily turbidity readings ≤ 5 NTU? Yes No

- Based on the results entered for the month, circle "yes" or "no" to the two questions at the bottom of the form.
• Enter the peak hourly demand (PHD) flow and the time that the PHD flow occurred.
• This flow should not exceed 10% above the peak flows replicated at the time of the last tracer study.

Peak Hour Demand Flow:
• The greatest volume of water passing through the system during any one hour in a consecutive 24 hr period
• Not the same as Peak Instantaneous Flow
• Report demand flow: flow leaving the clear well, not plant flow (in most cases)

Method for determining peak hourly demand flow (flow meter w/rate):
• On a daily basis, use the best available operational data to identify the hour within the 24 hr period that had the highest demand flow.
• For the hour of highest demand flow:
  • Calculate the average flow rate within the one hour period (i.e., add the flow rates and divide by the number of data points).
  • Use as many data points as possible, preferably no less than four data points taken at 15 minute intervals

For systems that only have a flow totalizing meter:
• Spot check throughout the day to determine the time of peak demand (e.g., 8 am or 9 pm for residential or mid-day for industrial uses)
• Then record how much water is used during that hour in gallons and divide by 60 minutes to get the peak hour demand in gpm

Here is an example chart, meant to represent continuous readings that shows demand flow out of a reservoir used for contact time. What would you say the peak hourly demand flow is?

Think of it like a running hourly average of demand flow measurements.

Again, the peak hourly demand flow is the hour within the 24 hr period of the highest demand flow. The red line represents the span of 1 hour: 7:30 am to 8:30 am – the peak hour. The avg. of the 4 data points equals 4,125 gpm - the peak hourly demand flow.
The minimum chlorine residual is measured at the end of the disinfection segment.

Contact time is the time that the disinfectant is in contact with the water within the disinfection segment.

**How is contact time determined?**
- Tracer studies are used to determine contact time (T) which is used in calculating CT achieved, where:
  \[ CT = \text{chlorine Concentration} \times \text{contact Time} \]
- Contact time is the time that chlorine is in contact with the water from the point of injection to the point where it is measured (sometimes referred to as the “CT segment”)
  - May be at or before the 1st user
  - May be more than one CT segment
- Tracer studies are often conducted to simulate a worst-case scenario where peak hour demand flows are high and reservoir levels are low. This gives a conservative (i.e. lower) contact time than would normally be expected.

**What affects mixing efficiency?**
Mixing efficiency improves with high flow path length to width ratios, found in pipelines and simulated in tanks with the use of baffles (hence the term baffling efficiency or factor).

**Example: Tracer study**

1. Draw a flow diagram of the treatment plant.
2. At one of the injection points, conduct a tracer study.
3. Measure the concentration of the tracer at various points in the system.
4. Calculate the contact time using the concentration data.

**Questions:**
- If this was your treatment plant, highlight the part of the plant where you might conduct a tracer study.
- In a “worst-case scenario” tracer study, what would the flow rate be?
- In a “worst-case scenario” tracer study, what would the tracer level be?
Directions: Look at the diagram and answer the questions.

**Example: Tracer studies - Answer**

- **Smith Creek**
  - Slow sand filter #1
  - Slow sand filter #2
  - Reservoir 75,000 gal.
  - Clearwell 220,000 gal
  - Chlorine injection
  - Flow control valve: 270 gpm max

**Questions:**

- If this was your treatment plant, highlight the part of the plant where you might conduct a tracer study.

- In a “worst-case scenario” tracer study, what would the flow rate be? **270 gpm**

- In a “worst-case scenario” tracer study, what would the clearwell level be? **10.5 feet**

---

**DO I REPORT CONTACT TIME?**

- Use the time T from the tracer study on the monthly reporting form in the “Contact time (min)” column
  - Use the smallest T (highest flow) if the tracer study was done at multiple flow rates
  - This may not be your exact time, but it represents your worst case (as long as the peak flow is less and clearwell volume is more than they were at the time of the tracer study)

---

**CAN I USE A BAFFLING FACTOR?**

- As an alternative to using the tracer study contact time, you can use the results of the tracer study to determine the baffling factor of the clearwell
  - Baffling factor (%) = Time (min) x Flow During Tracer Study (gpm) / Clearwell Volume During Tracer Study (gal)
  - T can be adjusted based on flow (at flow < 110% of tracer study flow) with the following equation:
    - T = Current clearwell Volume (gal) x Baffling Factor (%) / Peak Hourly Demand Flow (gpm)
  - Contact the state for guidance on using baffling factors.

---

**REPORTING FORMS – CHLORINE & CONTACT TIME**

<table>
<thead>
<tr>
<th>System Name: OHA - Drinking Water Program</th>
<th>Source Water</th>
<th>CT in Days</th>
<th>Temp</th>
<th>pH</th>
<th>Required</th>
<th>CT achieved</th>
<th>Yes/No</th>
<th>DO (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/9 AN</td>
<td>0.6</td>
<td>100</td>
<td>60</td>
<td>1,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/</td>
<td>5/</td>
<td>7/</td>
<td>8/</td>
<td>9/</td>
<td>10/</td>
<td>1,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Enter the minimum chlorine residual at or before the first user.
- Enter the contact time (based either on the tracer study or determined from clearwell volume(s) and the peak hourly demand flow).

---

**REPORTING FORMS – ACTUAL CT**

<table>
<thead>
<tr>
<th>System Name: OHA - Drinking Water Program</th>
<th>Source Water</th>
<th>CT in Days</th>
<th>Temp</th>
<th>pH</th>
<th>Required</th>
<th>CT achieved</th>
<th>Yes/No</th>
<th>DO (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/9 AN</td>
<td>0.6</td>
<td>100</td>
<td>60</td>
<td>1,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/</td>
<td>5/</td>
<td>7/</td>
<td>8/</td>
<td>9/</td>
<td>10/</td>
<td>1,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Enter the actual CT achieved that day:
  - Actual CT = Chlorine Concentration (mg/l) x Contact Time (min)
  - Do not confuse “CT” and “Contact Time”

---

**REPORTING FORMS – TEMPERATURE & PH**

<table>
<thead>
<tr>
<th>System Name: OHA - Drinking Water Program</th>
<th>Source Water</th>
<th>CT in Days</th>
<th>Temp</th>
<th>pH</th>
<th>Required</th>
<th>CT achieved</th>
<th>Yes/No</th>
<th>DO (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/9 AN</td>
<td>0.6</td>
<td>100</td>
<td>60</td>
<td>12</td>
<td>6.8</td>
<td>1,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/</td>
<td>5/</td>
<td>7/</td>
<td>8/</td>
<td>9/</td>
<td>10/</td>
<td>1,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Enter the finished water temperature (°C) and pH measured at or prior to the first customer and after any storage (tank, reservoir, or pipeline) used for contact time.
REPORTING FORMS – REQUIRED CT

HOW IS REQUIRED CT CALCULATED?

- We use the EPA tables (or “regression equations”) to determine the CT required to inactivate *Giardia* (CT<sub>required</sub>):
  - 1-log inactivation of *Giardia* using chlorine results in at least 4.0-log inactivation of viruses.
  - To determine CT, we need to know pH, temperature, and free chlorine residual at or before the first user.
  - Then we compare the CT<sub>required</sub> with the actual CT achieved in the water system (CT<sub>actual</sub>) where:
    \[ \text{CT}_{\text{actual}} = \text{chlorine concentration (mg/l)} \times \text{contact time (min)} \]
  - Must keep CT<sub>actual</sub> ≥ CT<sub>required</sub>

HOW IS REQUIRED CT CALCULATED, CONT.

USING REGRESSION EQUATIONS TO DETERMINE REQUIRED CT

USING REGRESSION EQUATIONS to determine required CT:

1. Built into the MS Excel reporting forms on-line

   - Surface Water: monitoring and reporting forms for CT and turbidity data
   - Groundwater: monitoring and reporting forms for CT and turbidity data

   - Regression Equation (for Temp < 12.5°C)
     \[ \text{CT} = (0.353 \times L) \times (12.006 + e^{(2.46 - 0.073 \times T + 0.125 \times C + 0.389 \times \text{pH})}) \]
   - Regression Equation (for Temp > 12.5°C)
     \[ \text{CT} = (0.361 \times L) \times (-2.261 + e^{(2.69 - 0.065 \times T + 0.111 \times C + 0.361 \times \text{pH})}) \]

   - Variables:
     \[ \text{CT} = \text{Product of Free Chlorine Residual and Time required} \]
     \[ L = \text{number of log inactivation for Giardia (L = 1 for slow sand)} \]
     \[ T = \text{temperature, in Celsius} \]
     \[ C = \text{chlorine residual in mg/L} \]
     \[ \text{pH} = \text{pH of water} \]
     \[ e = 2.7183, \text{base for natural log} \]
     (Smith, Clark, Pierce and Regli, 1995, from EPA’s 1999 Guidance Manual for Disinfection Profiling and Benchmarking)

USING REGRESSION EQUATIONS, CONT.

USING EPA CT TABLES - TEMPERATURE

- There are six EPA CT tables based on temperature
- Find the correct table based on your water temperature in degrees Celsius.
  - °C = 5/9 × (°F − 32)
- If water temp is between values, then round down
  - Example: for water temp of 12°C, use the 10°C table
  - Even if the water temp is 14.9°C, round down to 10°C
- Water gets more viscous the colder it gets and chemical reactions take longer, so rounding temp down is more conservative.

USING EPA CT TABLES - TEMP = 12 °C

- Use 10°C table for T = 10 – 14.9°C (round down for temp)

USING EPA CT TABLES - TEMPERATURE

- There are six EPA CT tables based on temperature
- Find the correct table based on your water temperature in degrees Celsius.
  - °C = 5/9 × (°F − 32)
- If water temp is between values, then round down
  - Example: for water temp of 12°C, use the 10°C table
  - Even if the water temp is 14.9°C, round down to 10°C
- Water gets more viscous the colder it gets and chemical reactions take longer, so rounding temp down is more conservative.
USING EPA CT TABLES - PH

- There are 7 sections for pH on each table
- Find the section that corresponds to your water’s pH level
- If your pH is between the choices, then round up to the higher pH
  - Example: if pH of water is 6.8, use the pH 7.0 section

USING EPA CT TABLES - 1-LOG

- Use the 1-log inactivation column
  (slow sand is granted 2.0-log removal credit for Giardia, which requires that 1.0-log Giardia inactivation is needed through disinfection)

USING EPA CT TABLES - CHLORINE

- Match your free chlorine residual on the far left column
- If in between column values, round up
  - Rounding chlorine residual up is more conservative because as chlorine residual increases at a given pH, more CT is required
- The point where it intersects with the log inactivation column is the CT required
  - Example: free chlorine residual is 0.6 ppm
If you get confused on which way to round, think about how you want to set the bar (CT required) as high as possible to be the most conservative and most protective of public health.

For example, if you rounded down for pH instead of up, you would get a CT required of only 30 as opposed to 36.

If you rounded down for chlorine residual, you would get a CT required of only 35 as opposed to 36.

REPORTING FORMS – REQUIRED CT

1. Enter Required CT (CT tables or Regression Equations)
2. Was CT Met? Yes if Actual CT > Required CT
3. Actual CT must be > Required CT

REPORTING FORMS – MONTHLY SUMMARY – CT & CL2

Everyone needs to fill out the CT section of the Monthly Summary

REPORTING FORMS – MONTHLY SUMMARY – CT & CL2

12 AM 0.6 100 60 12 6.8 36 Yes 1,000
FILLING OUT THE MONTHLY REPORT – COMMON MISTAKES

- Not calculating CT's daily
  - Don't wait until the end of the month to do the calculations because if you discover you didn't meet CT's, it's too late!
- If adjusting contact time according to flow rate, use the demand flow, not the plant flow.
- Failure to answer questions at bottom of form correctly (or at all)
- Always answering “Yes” to the questions at the bottom of the form without actually looking at the numbers

FILLING OUT THE MONTHLY REPORT – COMMON MISTAKES

- Rounding errors when using EPA tables to determine CT_{required}
  - Must round down for temperature
  - Must round up for pH
  - Must round up for free chlorine residual
- Bad CT formulas in excel spreadsheets:
  - Make sure you understand your formula
  - Wilkes Equation not allowed, must use Regression Equation

FILLING OUT THE MONTHLY REPORT – AVOIDING MISTAKES

- Check how T is calculated at your plant
- Do all treatment plant operators understand it?
- Review spreadsheet equation for CTs (if applicable)
- Write an SOP for CT determination
- Arrange for a tracer study if necessary
- Calculate CT and fill out monthly report daily
- Know what to do and who to call when things go wrong (contact State regulator & refer to Emergency Response Plan)

STRIVE TO IMPROVE DATA QUALITY

- Make data reliability a plant goal
- Only collect data used for process control or compliance reporting
- Establish protocols for collection and recording of data
- Establish a data verification process that can be routinely used to confirm data integrity
- Turn data into information (e.g., draw the graph).

O&M MANUALS

Keep written procedures on:
- Instrument calibration methods and frequency
- Data handling/reporting
- Chemical dosage determinations
- Filter operation and cleaning
- CT determinations
- Responding to abnormal conditions (emergency response plan)

DISINFECTION

- Types of disinfectants
  - Radiation (UV)
  - Chemical (chlorine, chloramines, chlorine dioxide, ozone)
- Forms of chlorine
- NSF/ANSI Standard 60
TYPES OF DISINFECTANTS - UV

- Works by subjecting water to ultraviolet (UV) light rays as water passes through a tube
- Drawbacks:
  - Interfering agents such as turbidity can screen pathogens from the UV light
  - Effective against *Giardia* and *Cryptosporidium* but not viruses at normal doses
  - No residual is present throughout the distribution system
  - For this reason, chlorination for residual maintenance is required when UV is used

TYPES OF DISINFECTANTS - CHEMICAL

1. Chlorine
2. Chloramines
3. Chlorine dioxide
4. Ozone

TYPES OF DISINFECTANTS - CHLORINE

- The most widely used form of disinfection
- Also used as an oxidizing agent for iron, manganese and hydrogen sulfide and for controlling taste and odors
- Effectiveness as a disinfecting agent depends on factors such as pH, temperature, free chlorine residual, contact time and other interfering agents

FORMS OF CHLORINE

- Sodium Hypochlorite
- Onsite generated sodium hypochlorite
- Calcium Hypochlorite
- Chlorine Gas

FORMS OF CHLORINE - SODIUM HYPOCHLORITE

- The liquid form of chlorine
- Clear and has a slight yellow color
- Ordinary household bleach (~5% chlorine by solution) is the most common form
- Industrial strength: 12% and 15% solutions
- Can lose up to 4% of its available chlorine content per month; should not be stored for more than 60 to 90 days
- Very corrosive; should be stored and mixed away from equipment that can be damaged by corrosion

FORMS OF CHLORINE - SODIUM HYPOCHLORITE

Diaphragm pump with chlorine solution tank
ON-SITE GENERATED SODIUM HYPOCHLORITE

- 0.8% sodium hypochlorite is produced on demand by combining salt, water & electricity
- Electrolysis of brine solution produces sodium hydroxide and chlorine gas, which then mix to form sodium hypochlorite
- Hydrogen gas byproduct; vented to atmosphere
- Alleviates safety concerns associated w/ hauling and storing bulk chlorine
- Higher initial cost, high power cost
- Mixed oxidants (proprietary)

FORMS OF CHLORINE - CALCIUM HYPOCHLORITE

- The solid form of chlorine
- Usually tablet or powder form (see photo below)
- Contains ~65% chlorine by weight
- White or yellowish-white granular material and is fairly soluble in water
- Important to keep in a dry, cool place
- More stable than liquid
- Common in small systems w/ low flows or no power

FORMS OF CHLORINE – CHLORINE GAS

- 99.5% pure chlorine
- yellow-green color 2.5x heavier than air
- Liquefied at room temperature at ~107 psi – hence the pressurized cylinders actually contain liquefied chlorine gas.
- Liquefied Cl₂ is released from tanks as chlorine gas, which is then injected into the water stream.
- usually used only by large water systems
- Smaller systems may find initial cost of operation prohibitive

Below: 1 ton cylinders. Note scale used to monitor product use.

ON-SITE GENERATED SODIUM HYPOCHLORITE

Erosion chlorinator

Inside Hopper =>

FORMS OF CHLORINE – CHLORINE GAS

- 150-lb cylinders
- Note security chain spare tank & labeling.
FORMS OF CHLORINE – CHLORAMINES

- Chlorine + ammonia = chloramination
- Two advantages to regular chlorination:
  1. Produce a longer lasting chlorine residual (helpful to systems with extensive distribution systems)
  2. May produce fewer by-products depending on the application
- Disadvantage:
  1. Need a lot of contact time to achieve CTs compared to free chlorine (300 times more) which is why not used for primary disinfection
  2. Requires specific ratio of chlorine to ammonia or else potential water quality problems

CHLORINE DIOXIDE - ADVANTAGES

Advantages:
1. More effective than chlorine and chloramines for inactivation of viruses, Cryptosporidium, and Giardia
2. Oxidizes iron, manganese, and sulfides
3. May enhance the clarification process
4. Controls T&O resulting from algae and decaying vegetation, as well as phenolic compounds
5. Under proper generation conditions halogen-substituted DBPs are not formed
6. Easy to generate
7. Provides residual

CHLORINE DIOXIDE - DISADVANTAGES

Disadvantages
1. Forms the DBP chlorite
2. Costs associated with training, sampling, and laboratory testing for chlorite and chlorate are high
3. Equipment is typically rented, and the cost of the sodium chlorite is high
4. Explosive, so it must be generated on-site
5. Decomposes in sunlight
6. Can lead to production noxious odors in some systems

OZONE

- Colorless gas (O\textsubscript{3})
- Strongest of the common disinfecting agents
- Also used for control of taste and odor
- Extremely Unstable; Must be generated on-site
- Manufactured by passing air or oxygen through two electrodes with high, alternating potential difference

OZONE - ADVANTAGES

Advantages:
1. Short reaction time enables microbes (including viruses) to be killed within a few seconds
2. Removes color, taste, and odor causing compounds
3. Oxidizes iron and manganese
4. Destroys some algal toxins
5. Does not produce halogenated DBPs

OZONE - DISADVANTAGES

Disadvantages:
1. Overfeed or leak can be dangerous
2. Cost is high compared with chlorination
3. Installation can be complicated
4. May produce undesirable brominated byproducts in source waters containing bromide
5. No residual effect is present in the distribution system, thus post-chlorination is required
6. Much less soluble in water than chlorine; thus special mixing devices are necessary
NSF/ANSI STANDARD 60 - CHEMICALS

- Addresses the health effects implications of treatment chemicals and related impurities.
- The two principal questions addressed are:
  1. Is the chemical safe at the maximum dose, and
  2. Are impurities below the maximum acceptable levels?

NSF/ANSI STANDARD 61 - COMPONENTS & MEDIA

http://info.nsf.org/Certified/PwsChemicals/

RESOURCES FOR OPERATORS

- For surface water systems:
  www.healthoregon.gov/dwp
  Click on “Water System Operations” on left-side menu list, then “Surface Water Treatment”
    - Monthly Surface Water Quality Report form template
    - Tracer Study form
  - Surface Water Treatment Rule guidance manual, Appendix C: Determination of Disinfectant Contact Time

RESOURCES FOR OPERATORS

- EPA Rules
  http://water.epa.gov/lawsregs/rulesregs/sdwa/currentregulations.cfm
- AWWA http://www.pnws-awwa.org/Index.asp
- OAWU http://www.oawu.net/
- Circuit Rider
### RESOURCES FOR OPERATORS

**Drinking Water Data Online**

Data specific to each water system

www.healthoregon.gov/dwp

### DATA FOR EACH SYSTEM ON-LINE

Many data search options are available

1. Select WS Name Look Up
2. Enter water system name (e.g., "Salem")
3. Click Submit Query

*Note: You also could have used WS ID Look Up and entered the ID# for Salem (00731)*

### DATA FOR EACH SYSTEM ON-LINE

Select the Water System by Clicking on the PWS ID#

<table>
<thead>
<tr>
<th>PWS ID #</th>
<th>Name</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>0556</td>
<td>BPA- SALEM SUBSTATION</td>
<td>General</td>
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<tr>
<td>0792</td>
<td>SALEM MOBILE RESIDENTS</td>
<td>Sources</td>
</tr>
<tr>
<td>0495</td>
<td>MAHANA PUBLIC WATER</td>
<td>Treatment</td>
</tr>
<tr>
<td>0493</td>
<td>SUBURBAN EAST SALEM WD</td>
<td></td>
</tr>
</tbody>
</table>
View a list of Certified Operators

MORE QUESTIONS?
- Call your technical services contact at the State.
  State Drinking Water Services
  - General Info: (971) 673-0405

Astoria, OR - 1MGD plant (photo taken by Frank Wolf)