Raw Water Sources

Process Description

Sources

Groundwater

- Subsurface water occupying the zone of saturation, from which springs and wells are fed.
- A ground water source includes all water obtained from drilled wells or springs.
- Groundwater is from approved sand and gravel aquifer.

Groundwater Under the Direct Influence of Surface Water

- any water beneath the surface of the ground with significant occurrence of insects or other microorganisms, algae, or large-diameter pathogens such as Giardia lamblia or Cryptosporidium, or
- significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions.

Direct influence must be determined for individual sources in accordance with criteria established by the State. The State determination of direct influence may be based on site-specific measurements of water quality and/or documentation of well construction characteristics and geology with field evaluation.

Surface Water

All water which is open to the atmosphere and subject to surface runoff. Characterized by extreme variability in:

- quantity;
- quality.

Process Control

Process control includes treatment for:

- algae control;
- tastes and odors;
- oxidation of iron and manganese; and,
- oxidation of organic compounds which can contribute to the formation of disinfection by-products.

©2004. TAUD. All rights reserved.

Algae Control

- Calculation of Copper Sulfate
- Reporting pounds of copper sulfate fed.
- Reporting calculated dose.

Feeding Chemical Oxidants

Liquid Chemical Oxidants – Potassium or Sodium Permanganate

- Prepare batches of solution (potassium permanganate).
- Determine best dose (permanganate demand test)
- Calculate feed rate.
- Set up feeder to deliver desired dose.
- Determine permanganate residual.
- Report pounds of oxidant used.
- Report oxidant calculated dose.

Dry Chemical Oxidants – Potassium Permanganate

- Determine best dose (permanganate demand test)
- Calculate feed rate.
- Set up feeder to deliver desired dose.
- Determine permanganate residual.
- Report pounds of oxidant used.
- Report oxidant calculated dose.

Feeding Activated Carbon

- Determine best dose (jar test)
- Calculate feed rate.
- Set up feeder to deliver desired dose.
- Report pounds of powdered activated carbon used.
- Report powdered activated carbon calculated dose.

 ©2004. TAUD. All Rights Reserved.

Process Evaluation and Troubleshooting

Most problems associated with surface water are beyond the control of the operator. The operator must deal with these problems as they arise. These problems include those associated with:

- algae and other aquatic plants;
- iron and manganese;
- rapid changes in physical and chemical parameters (turbidity, temperature, pH, alkalinity).

Algae

I. Operational Problems Caused by Algae

A. taste, odor, color

B. toxicity

C. clogged filters

D. slime accumulations on structures

E. corrosion of structures

F. interference with other processes

G. trihalomethane formation

II. Interference with Other Processes - Algae can change

A. pH

B. alkalinity

C. hardness

D. dissolved oxygen

E. concentration of organic materials

III. Chemical Control of Algae

A. Can use:

1. copper sulfate

2. powdered activated carbon

B. Copper sulfate

1. effectiveness depends on ability to dissolve in water

2. ability to dissolve in water depends on:

a. pH

b. alkalinity

©2004. TAUD. All rights reserved.

3. conditions for best/most lasting control
    a. total alkalinity less than or equal to 50 mg/l as $CaCO_3$
    b. pH between 8 and 9
4. Minimum copper sulfate dose depends on the alkalinity.
5. Maximum dose depends on toxic effect on fish.

Algae Control

The copper sulfate dosage is calculated using these formulas.

When the alkalinity is less than 50 mg/L as $CaCO_3$;

$$\text{Copper Sulfate Dose, lbs} = \text{Volume, ac - ft} \times 0.9 \text{ lbs/ac - ft}$$

When the total alkalinity is greater than 50 mg/L as $CaCO_3$;

$$\text{Copper Sulfate Dose, lbs} = \text{Surface Area, ac} \times 5.4 \text{ lbs/ac}$$

Additional Formulas

$$\text{Area, ac} = \frac{\text{(Length, ft) (Width, ft)}}{43{,}560 \text{ ft}^2\text{/ac}}$$

$$\text{Volume, ac - ft} = \text{(Area, ac) (Average Depth, ft)}$$

$$\text{Volume, ac - ft} = \frac{\text{(Length, ft) (Width, ft) (Average Depth, ft)}}{43{,}560 \text{ ft}^2\text{/ac}}$$

$$\text{Volume, gal} = \text{(Volume, ac - ft)} (43{,}560 \text{ ft}^2\text{/ac}) (7.48 \text{ gal/ft}^3)$$

$$\text{Volume, gal} = \text{(Area, ac) (Average Depth, ft)} (43{,}560 \text{ ft}^2\text{/ac}) (7.48 \text{ gal/ft}^3)$$

 ©2004. TAUD. All Rights Reserved.

Chemical Oxidation

Iron, manganese, and organics can be removed using chemical oxidants, such as potassium permanganate (3 percent solution) or sodium permanganate (20 percent solution).

The best dose for either permanganate can be determined by performing the permanganate demand test on a raw water sample.

Once the desired dose is determined, these formulas can be used to calculate the desired feed rate.

Solution Preparation

When preparing potassium permanganate solutions, a three percent solution is best. Potassium permanganate has a limited solubility of about five percent at normal temperatures.

$$\text{Chemical Required, lbs} = \frac{(\text{Volume of Water, gal} \times 8.34\ \text{lbs/gal}) \times \text{Desired Concentration, \%}}{100\% - \text{Desired Concentration, \%}}$$

$$\text{Volume of Water Required, gal} = \frac{\text{Chemical to be Used, lbs} \times (100\% - \text{Desired Concentration, \%})}{8.34\ \text{lbs/gal} \times \text{Desired Concentration, \%}}$$

$$\text{Specific Gravity} = \frac{\text{Weight of cylinder plus contents, g} - \text{Weight of empty cylinder, g}}{100\ g}$$

$$\text{Weight of One Gallon of Solution, lbs} = 8.34\ \text{lbs/gal} \times \text{Specific Gravity}$$

$$\text{Concentration, lbs/gal} = \frac{\text{Weight of One Gallon, lbs} \times \text{Concentration, \%}}{100\%}$$

$$\text{Concentration, mg/mL} = \frac{\text{Concentration, lbs/gal} \times 453{,}600\ \text{mg/lbs}}{3{,}785\ \text{mL/gal}}$$

Chemical Feeder Rate, mL/min

These formulas can be used to calculate the required feed rate in milliliters per minute (mL/min).

$$\text{Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(3.785\ \text{liters/gal})}{\text{Concentration, mg/mL}}$$

$$\text{Required Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(3.785\ \text{liters/gal})}{(\text{Concentration, mg/mL})\,(1{,}440\ \text{min/day})}$$

$$\text{Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(3.785\ \text{liters/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}{(\text{Concentration, mg/mL})\,(1{,}440\ \text{min/day})}$$

©2004. TAUD. All rights reserved.

Chemical Feeder Rate, gal/day

These formulas can be used to calculate the required feed rate in gallons per day (gal/day).

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(8.34\ \text{lbs/gal})\,(1{,}440\ \text{min/day})}{(\text{Concentration, lbs/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(8.34\ \text{lbs/gal})}{(\text{Concentration, lbs/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})}{\text{Concentration, lbs/gal}}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(1{,}440\ \text{min/day})}{(\text{Concentration, \%})\,(\text{Specific Gravity})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})}{(\text{Concentration, \%})\,(\text{Specific Gravity})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})}{(\text{Concentration,\%})\,(\text{Specific Gravity})}$$

 ©2004. TAUD. All Rights Reserved.

Dry Chemical Feed

Feeder Rate, grams/min

$$\text{Feed Rate, grams/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(3.785\ \text{L/gal})}{(1{,}000\ \text{mg/gram})}$$

$$\text{Feed Rate, grams/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(3.785\ \text{L/gal})}{(1{,}000\ \text{mg/gram})\,(1{,}440\ \text{min/day})}$$

$$\text{Feed Rate, grams/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(3.785\ \text{L/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}{(1{,}000\ \text{mg/gram})\,(1{,}440\ \text{min/day})}$$

Feeder Rate, lbs/day – Commercial Purity of 100%

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\ \ (8.34\ \text{lbs/gal})\,(1{,}440\ \text{min/day})}{(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(8.34\ \text{lbs/gal})}{(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, lbs/day} = (\text{Dose, mg/L})\,(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})$$

Feeder Rate, lbs/day – Commercial Purity, <100%

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(8.34\ \text{lbs/gal})}{(\text{Commercial Purity, \%})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(8.34\ \text{lbs/gal})}{(\text{Commercial Purity, \%})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})}{\text{Commercial Purity, \%}}$$

©2004. TAUD. All rights reserved.

Design Criteria

See Tab 4.

Division of Water Supply Rules

See Tab 3.

Process Monitoring and Reporting

For process control purposes, these raw water characteristics are monitored and reported on the daily operations records.

- Volume of Water Pumped
- Temperature
- Turbidity
- Total Alkalinity
- pH
- Hardness
- Free Carbon Dioxide
- Iron
- Manganese
- Fluoride

The volume of water pumped is recorded on the Daily operations records (MOR) each day the plant is in operation. The concentrations or levels of these water characteristics are to be measured at least at the frequency identified by the Division of Water Supply for that system. Daily monitoring is desirable. Monitoring more than once per day may be necessary for surface water systems and groundwater under the direct influence of surface water when water quality changes quickly, such as during heavy rains.

In addition to the daily values, these values must be determined and recorded:

total of daily values for each parameter;

- average daily value for each parameter;
- maximum daily value recorded for each parameter; and,
- minimum daily value recorded for each parameter.

All of these values are recorded on the ***Monthly Operations Report (MOR).***

Raw water pumpage data is recorded on the ***Water Pumpage Data Report Form***.

In addition, any chemicals added at the raw water intake should be reported on the MOR. These include chemical oxidants (potassium permanganate and sodium permanganate) and powdered activated carbon.

Formulas for Monitoring and Reporting

Dry Chemical Fed, lbs = Previous Scale Reading, lbs – Current Scale Reading, lbs

 ©2004. TAUD. All Rights Reserved.

Chemical Fed, lbs = (Solution Fed, gal) (Concentration, lbs/gal)

$$\text{Calculated Dosage, mg/L} = \frac{\text{Chemical Fed, lbs}}{\text{(Flow, MGD) (8.34 lbs/gal)}}$$

©2004. TAUD. All rights reserved.

Notes

 ©2004. TAUD. All Rights Reserved.

Aeration

Process Description

Aeration is the process of exposing raw water to air in order to remove certain dissolved gases and to oxidize metals.

Mechanisms

The turbulence (sweeping or scrubbing action) created as water flows over the aerator media and is broken up into small droplets.

The introduction (dissolving) of oxygen into the water, in order to oxidize metals (Iron and Manganese).

Efficiency

The efficiency of the aeration is most influenced by the amount of water surface area in contact with the air. The amount of surface area exposed to the air depends on the size of the water droplet.

The smaller the water droplet, the greater the surface area exposed to the air, the greater the efficiency.

Constituents Affected by Aeration

Aeration removes troublesome gases:

- Carbon Dioxide;
- Hydrogen Sulfide;
- Methane.

The process by which nuisance gases are removed from water is called degasification.

Aeration removes volatile materials, which can contribute to tastes and odors. Aeration cannot remove tastes and odors caused by non-volatile compounds.

Aeration increases the dissolved oxygen content of the water.

Aeration provides the oxygen needed to oxidize iron and manganese.

MCL for Iron = 0.3 mg/l

MCL for Manganese = 0.05 mg/l

©2004. TAUD. All rights reserved.

Process Control

Process control of the aeration process consists of cleaning the aerator to insure that the smallest possible water droplet is formed, and, that motors operate and belts are adjusted properly on blowers for draft aerators.

Process Evaluation and Troubleshooting

Dissolved Oxygen - too much dissolved oxygen causes the water to be corrosive.

Super-saturation of water with dissolved oxygen can cause floating floc in the sedimentation basins, and air binding of filters.

The amount of dissolved oxygen water can hold depends on water temperature, as the water temperature goes up, the amount of dissolved oxygen the water can hold goes down.

Corrosion, can be solved by:

a. coating surfaces with a protective coating;

b. operating the process to provide adequate but not excessive dissolved oxygen.

Algae - can be controlled by:

- shading the aerator from direct sunlight;
- treating the aerator periodically with copper sulfate.

Design Criteria

4.6 AERATION - Aeration treatment devices as described herein may be used for oxidation, separation of gases or for taste and odor control.

4.6.1 Natural Draft Aeration - Design should provide that:

a. water is distributed uniformly over the top tray,

b. water is discharged through a series of three or more trays with separation of trays not less than 12 inches,

c. trays are loaded at a maximum rate of 20 gpm for each square foot of the top tray area,

d. trays have heavy wire mesh or perforated bottoms,

e. perforations are 3/16 to 1/2 inches in diameter, spaced 1 to 3 inches on centers, when perforations are used,

f. 8 to 12 inches of inert media are used, such as coke or limestone, that will not disintegrate due to freezing cycles,

 ©2004. TAUD. All Rights Reserved.

g. aerated water receives disinfection treatment,

h. sufficient trays to reduce carbon dioxide to 10-15 mg/L,

i. location to take advantage of prevailing wind direction.

4.6.2 Forced or Induced Draft Aeration - Devices shall be designed to:

a. provide adequate countercurrent of air through enclosed aeration column,

b. be insect proof and lightproof,

c. be such that air introduced into column shall be screened through insect tight screen and be as free of dust as possible,

d. insure that water outlet is adequately sealed to prevent unwanted loss of air,

e. be such that sections of the aerator can be easily reached and removed for maintenance.

4.6.3 Other Methods of Aeration - Other methods of aeration may be used if applicable to the treatment needs. Such methods include but are not restricted to spraying, diffused air and mechanical aeration. The treatment processes must be designed to meet the particular needs of the water to be treated and are subject to the approval of the Department.

4.6.4 Wind Protection - Aerators that discharge through the atmosphere should be protected by being placed in a louvered enclosure so designed as to provide easy access to the interior.

4.6.5 Protection from Contamination - Aerators that are used for oxidation or removal of dissolved gases from waters that will be given no further treatment other than chlorination shall be protected from contamination from insects and birds.

4.6.6 Bypass - A bypass shall be provided for all aeration units.

4.6.7 Corrosion Control - The aggressiveness of the water after aeration should be determined and corrected by additional treatment, if necessary (See Section 4.9).

Division of Water Supply Regulations

1200-5-1-.12 Secondary Drinking Water Regulations

(1) The following maximum contaminant levels are established to provide a water that is aesthetically pleasing to the consumer. These standards will apply to all community water systems and to those non-community water systems as may be deemed necessary by the

©2004. TAUD. All rights reserved.

Department. Monitoring for these contaminants will be set in the Monitoring Program for each system, but in no event less than once every year for a surface and surface/ground supply and once every three years for a ground water supply.

Contaminant	**Maximum Contaminant Level Milligrams per Liter (unless otherwise indicated)**
(e) Iron	0.3
(f) Manganese	0.05
(g) Odor	3 (Threshold Odor Number)
(h) pH	6.5 to 8.5

Process Monitoring and Reporting

- pH
- Temperature
- Iron
- Carbon Dioxide
- Manganese

These parameters are reported on the ***Physical and Chemical Characteristics*** section of the Monthly Operations Report (MOR) .

Safety

Dangerous Gases – make certain indoor aerators are well ventilated.

Slips and Falls – Algae growing on walkways present a walking hazards. Make certain to keep algae cleaned off walls and walking surfaces. Treating the nuisance spots with a copper sulfate solution can retard re-growth.

 ©2004. TAUD. All Rights Reserved.

Coagulation and Flocculation

Process Description

Purpose to aid in the removal of nonsettleable solids from water.

Coagulation is defined as:

- the destabilization of colloidal solids;
- the water treatment process which causes very small suspended solids to attract one another and form larger particles.

Suspended particles in water resist settling for two primary reasons:

1. particle size; and,
2. natural forces between particles.

Suspended particles in water normally have a negative (-) charge. Since these particles all have the same charge, they repel each other, keeping each other from settling. This natural repelling force is called the ***zeta potential***.

Coagulation neutralizes the forces (zeta potential), which cause suspended solids in water to repel each other and resist settling.

Once the repulsive forces have been neutralized these particles can stick together (agglomerate) when they collide. The force which holds the floc together is called the van der Waals force.

Flocculation uses gentle stirring to cause the particles to collide so that they can stick together, for a particle (floc) large enough and heavy enough to settle.

Chemicals are used to neutralize the zeta potential. These chemicals are coagulants, sometimes called primary coagulants, and coagulant aids.

Since most suspended particles in water carry a negative (-) charge, coagulants consist of chemicals that provide positivley (+) charged ions. Common coagulants are:

1. Metal Salts
   a. Aluminum Salts
      i. Alum (aluminum sulfate)
      ii. PACs (polyaluminum chlorohydrate, and other variations)
   b. Iron Salts
      i. Ferric Chloride
      ii. Ferric Sulfate
      iii. Ferrous Sulfate

©2004. TAUD. All rights reserved.

2. Polymers (polyelectrolytes)

Coagulant aids are chemicals which are added to water during coagulation to improve coagulation by:

- building a stronger, more settleable floc;
- overcoming slow floc formation in cold water;
- reducing the amount of coagulant required;
- reducing the amount of sludge produced.

The key reason coagulant aids are used is to reduce the amount of alum used, which, in turn, decreases the amount of alum sludge produced. Alum sludge is difficult to dewater and to dispose of.

Types of Coagulant Aids

Activated Silica

- increases the coagulation rate;
- reduces the amount of coagulant needed;
- widens the pH range for effective coagulation;
- strengthens floc

Weighting agents provide additional particles that can enhance floc formation. They are used to treat water that is:

- high in color; or,
- low in turbidity; or,
- low in mineral content.

Forms Bentonite Clay, Powdered Limestone; Powdered Silica

Types of Polyelectrolytes

Polymers (polyelectrolytes) are extremely large molecules which produce thousands of charged ions when dissolved in water.

Cationic Polyelectrolytes - Have a positive (+) charge.

Used as either a primary coagulant or as a coagulant aid. Cationic polymers:

- allow reduced coagulant dose;
- improve floc settling;
- are less sensitive to pH;
- improve flocculation of organisms such as bacteria and algae.

Anionic Polyelectrolytes- Have a negative (-) charge.

 ©2004. TAUD. All Rights Reserved.

Used primarily as a coagulant aid. Anionic polymers are used to:

- increase floc size;
- improve settling;
- produce a stronger floc;

They are not materially affected by pH, alkalinity, hardness or turbidity.

Nonionic Polyelectrolytes- Balanced or neutral charge.

Used as a primary coagulant or coagulant aid.

Factors Which Affect How Well a Coagulant Work

(1) Mixing Conditions

(2) pH

(3) Alkalinity

(4) Water Temperature

(5) Turbidity

If the alkalinity concentration in the water is not high enough, and effective floc will not form when either alum or ferric sulfate is used. Metal salts (alum, ferric sulfate, ferric chloride) consume natural alkalinity.

- Each mg/L of alum will consume 0.5 mg/l total alkalinity (as calcium carbonate).
- Each mg/L ferric sulfate will consume 0.75 mg/L total alkalinity (as calcium carbonate).
- Each mg/L ferric chloride will consume 0.92 mg/L total alkalinity (as calcium carbonate).

It may be necessary to add alkalinity to the water (lime, soda ash, caustic soda) to the water in order for the metal salts to work properly. These doses are guidelines, and should be confirmed with jar testing.

One mg/L alum will react with:

- 0.727 mg/L sodium bicarbonate;
- 0.54 mg/L soda ash;
- 0.374 mg/L lime [as $Ca(OH)_2$];
- 0.283 mg/L caustic soda.

One mg/L ferric sulfate will react with:

- 1.08 mg/L sodium bicarbonate;
- 1.1 mg/L soda ash;
- 0.59 mg/L lime [as $Ca(OH)_2$];
- 0.426 mg/L caustic soda.

©2004. TAUD. All rights reserved.

One mg/L ferric chloride will react with:

- 0.90 mg/L sodium bicarbonate;
- 0.89 mg/L soda ash;
- 0.93 mg/L lime [as $Ca(OH)_2$];
- 035 mg/L caustic soda.

Coagulation/Flocculation Facilities

Flash Mix - purpose is to distribute the coagulant rapidly and evenly throughout the water.

Water should be stirred violently for a brief time to encourage the greatest number of collisions between particles as possible.

Types of Mixers

- Mechanical
- Pumps and Conduits
- Baffled Chambers

Detention time should be 30 seconds or less (Design Criteria).

Flocculation - provides for gentle mixing to encourage floc formation.

Detention time of at least 30 minutes, with a detention time of 45 minutes preferred.

Process Control

A. Chemical Selection - These raw water characteristics should be monitored in order to do a thorough job of chemical selection.

1. Temperature
- Low water temperatures slow chemical reactions, causing decreased efficiency and slow floc formation.
- Higher coagulant doses may be required to maintain acceptable results.

2. pH

- Extremes can interfere with the coagulation/flocculation process.
- The optimum pH depends on the specific coagulant.
- The optimum pH depends on the specific coagulant.

3. Alkalinity
- Low alkalinity causes poor coagulation.
- May be necessary to add alkalinity (lime, caustic soda, soda ash).

4. Turbidity

- Difficult to form floc with low turbidity water, may need to add weighting agents.

 ©2004. TAUD. All Rights Reserved.

- Must stay ahead of increasing turbidities. It is difficult to regain control during storm events.

5. Color - Indicates presence of organic chemicals which can react with the coagulant, and with chlorine to form disinfection byproducts.

B. Chemical Application

Solution Preparation

When preparing potassium permanganate solutions, a three percent solution is best. Potassium permanganate has a limited solubility of about five percent at normal temperatures.

$$\text{Chemical Required, lbs} = \frac{(\text{Volume of Water, gal} \times 8.34\ \text{lbs/gal}) \times \text{Desired Concentration, \%}}{100\% - \text{Desired Concentration, \%}}$$

$$\text{Volume of Water Required, gal} = \frac{\text{Chemical to be Used, lbs} \times (100\% - \text{Desired Concentration, \%})}{8.34\ \text{lbs/gal} \times \text{Desired Concentration, \%}}$$

$$\text{Specific Gravity} = \frac{\text{Weight of cylinder plus contents, g} - \text{Weight of empty cylinder, g}}{100\ g}$$

$$\text{Weight of One Gallon of Solution, lbs} = 8.34\ \text{lbs/gal} \times \text{Specific Gravity}$$

$$\text{Concentration, lbs/gal} = \frac{\text{Weight of One Gallon, lbs} \times \text{Concentration, \%}}{100\%}$$

$$\text{Concentration, mg/mL} = \frac{\text{Concentration, lbs/gal} \times 453{,}600\ \text{mg/lbs}}{3{,}785\ \text{mL/gal}}$$

Chemical Feeder Rate, mL/min

These formulas can be used to calculate the required feed rate in milliliters per minute (mL/min).

$$\text{Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(3.785\ \text{liters/gal})}{\text{Concentration, mg/mL}}$$

$$\text{Required Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(3.785\ \text{liters/gal})}{(\text{Concentration, mg/mL})\,(1{,}440\ \text{min/day})}$$

©2004. TAUD. All rights reserved.

$$\text{Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(3.785\ \text{liters/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}{(\text{Concentration, mg/mL})\,(1{,}440\ \text{min/day})}$$

Chemical Feeder Rate, gal/day

These formulas can be used to calculate the required feed rate in gallons per day (gal/day).

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(8.34\ \text{lbs/gal})\,(1{,}440\ \text{min/day})}{(\text{Concentration, lbs/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(8.34\ \text{lbs/gal})}{(\text{Concentration, lbs/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})}{\text{Concentration, lbs/gal}}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(1{,}440\ \text{min/day})}{(\text{Concentration, \%})\,(\text{Specific Gravity})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})}{(\text{Concentration, \%})\,(\text{Specific Gravity})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})}{(\text{Concentration,\%})\,(\text{Specific Gravity})}$$

Dry Chemical Feed

Feeder Rate, grams/min

$$\text{Feed Rate, grams/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(3.785\ \text{L/gal})}{(1{,}000\ \text{mg/gram})}$$

$$\text{Feed Rate, grams/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(3.785\ \text{L/gal})}{(1{,}000\ \text{mg/gram})\,(1{,}440\ \text{min/day})}$$

$$\text{Feed Rate, grams/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(3.785\ \text{L/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}{(1{,}000\ \text{mg/gram})\,(1{,}440\ \text{min/day})}$$

 ©2004. TAUD. All Rights Reserved.

Feeder Rate, lbs/day – Commercial Purity of 100%

$$\text{Feed Rate, lbs/day} = \frac{\text{(Dose, mg/L) (Flow, gal/min) (8.34 lbs/gal) (1,440 min/day)}}{\text{(1,000,000 gal/day/MGD)}}$$

$$\text{Feed Rate, lbs/day} = \frac{\text{(Dose, mg/L) (Flow, gal/day) (8.34 lbs/gal)}}{\text{(1,000,000 gal/day/MGD)}}$$

$$\text{Feed Rate, lbs/day} = \text{(Dose, mg/L) (Flow, MGD) (8.34 lbs/gal)}$$

Feeder Rate, lbs/day – Commercial Purity, <100%

$$\text{Feed Rate, lbs/day} = \frac{\text{(Dose, mg/L) (Flow, gal/day) (8.34 lbs/gal)}}{\text{(Commercial Purity, \%) (1,000,000 gal/day/MGD)}}$$

$$\text{Feed Rate, lbs/day} = \frac{\text{(Dose, mg/L) (Flow, gal/day) (8.34 lbs/gal)}}{\text{(Commercial Purity, \%) (1,000,000 gal/day/MGD)}}$$

$$\text{Feed Rate, lbs/day} = \frac{\text{(Dose, mg/L) (Flow, MGD) (8.34 lbs/gal)}}{\text{Commercial Purity, \%}}$$

C. Monitoring Process Effectiveness

(1) Jar Test

(2) pH

(3) Turbidity

(4) Temperature

(5) Alkalinity

Process Evaluation and Troubleshooting

Problems with coagulation and flocculation normally show up in subsequent processes (sedimentation and filtration).

Actual plant performance should be monitored for:

- Poor or inadequate flash mixing
- Gentle flocculation
- Adequate flocculation time

©2004. TAUD. All rights reserved.

- Settled- and filtered-water quality.

Indication of poor or inadequate flash mixing.

- Very small floc (pin floc)
- "Fish Eyes"
- High turbidity in settled water – should be less than 1.0 NTU when the raw water turbidity is less than 1 NTU 95 percent of the time; less than 2.0 NTU when the raw water turbidity is more than 1 NTU 95 percent of the time.
- Too frequent filter backwashing

If any of these symptoms occur, check:

(1) detention time and mixing energy in the flash mix (detention time should be less than 30 seconds);

(2) stirring speed in the flocculator – should have a peripheral speed of between 0.5 and 2.0 feet per second;

(3) flocculation detention time – should be at least 30 minutes, with 45 minutes being preferred.

Common Operational Problems

Low Water Temperature	Viscosity of water increases, slow rate of floc settling.
	Chemical reaction rates decrease.
	Best pH for a coagulant drops.

Floc weakened and penetrates filters.

Solutions:	Operate as close to the best pH value for the temperature as possible.
	Increase the coagulant dose.
	Add weighting agents to increase the density of the floc and/or activated silica or polymers to increase the floc strength and encourage rapid settling.
Slow Floc Formation	Low turbidity waters contribute to slow and inadequate floc formation, add weighting agents.
Low Alkalinity	Can cause slow floc formation with alum or ferric sulfate.
Solutions:	Add alkalinity (lime, caustic sods, soda ash).
Poor Mixing	Can cause slow floc formation, or pinpoint floc.

 ©2004. TAUD. All Rights Reserved.

Design Criteria

4.1 CLARIFICATION - Plants designed for processing surface waters should:

a. provide duplicate units for flocculation and sedimentation,

b. be constructed to permit units to be taken out of service without disrupting operation.

4.1.1 Pre-sedimentation - Waters containing high turbidity or silica particles may require pretreatment, usually sedimentation either with or without the addition of coagulation chemicals.

a. Basin Design - Pre-sedimentation basins should be designed to hold maximum 3-day usage.

b. Inlet - Incoming water shall be dispersed across the full width of the line of travel as quickly as possible; short-circuiting must be prevented.

c. Bypass - Provisions for bypassing pre-sedimentation basins shall be included.

4.1.2 Mixing (Flash or Quick):

a. Equipment - Basins should be equipped with mechanical mixing devices; other arrangements, such as baffling, and in-line mixers may be acceptable.

b. Mixing - The detention period shall not exceed 30 seconds. Concrete blocks may be placed in the flash mix temporarily to maintain this detention period if the plant, is expected to be expanded in the near future.

c. Velocity gradient - The minimum shall be 300 (ft/sec)/ft.

4.1.3 Flocculation (Slow Mixing):

a. Basin Design - Inlet and outlet design shall prevent short circuiting and destruction of floc. A drain shall be provided.

b. Detention - The detention time for floc formation must be at least 30 minutes, with a detention time of 45 minutes being recommended.

c. Equipment - Agitators shall be driven by variable speed drives with the peripheral speed of paddles ranging from 0.5 to 2.0 ft/sec. The speed of each successive agitator should be less than the previous one.

d. Piping - Flocculation and sedimentation basins shall be as close together as possible. The velocity of flocculated water through pipes or conduits to

©2004. TAUD. All rights reserved.

settling basins shall be not less than 0.5 nor greater than 1.5 ft./sec. Allowances must be made to minimize turbulence at bends and changes in direction.

e. Other designs - Baffling may be used to provide for flocculation in small plants only after consultation with the Department. Minimum flow-through velocity shall be not less than 0.5 nor greater than 1.5 ft./sec. with a detention as noted above.

Detention Time, secs

Flash mix basins are designed to have a detention time of 30 seconds or less.

These formulas can be used to calculate the detention time in seconds for a flash mix basin.

$$\text{Detention Time, sec} = \frac{(\text{Basin Volume, gal})\,(60\ \text{sec/min})}{\text{Flow, gal/min}}$$

$$\text{Detention Time, sec} = \frac{(\text{Basin Volume, gal})\,(86{,}400\ \text{sec/day})}{\text{Flow, gal/day}}$$

$$\text{Detention Time, sec} = \frac{(\text{Basin Volume, gal})\,(86{,}400\ \text{sec/day})}{(\text{Flow, MGD})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

Detention Time, Minutes

Flocculation basins are designed to have a detention time of at least 30 minutes, with 45 minutes being preferable.

These formulas can be used to calculate the detention in minutes for a flocculation basin.

$$\text{Detention Time, min} = \frac{\text{Basin Volume, gal}}{\text{Flow, gal/min}}$$

$$\text{Detention Time, min} = \frac{(\text{Basin Volume, gal})\,(1{,}440\ \text{min/day})}{\text{Flow, gal/day}}$$

$$\text{Detention Time, min} = \frac{(\text{Basin Volume, gal})\,(1{,}440\ \text{min})}{(\text{Flow, MGD})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

 ©2004. TAUD. All Rights Reserved.

Division of Water Supply Regulations

1200-5-1-.17(31) Each public water system must certify annually in writing to the State that when acrylamide and epichlorohydrin are used in drinking water systems, the combination (or product) of dose and monomer level does not exceed the levels specified as follows:

Acrylamide = 0.05% dosed at 1 ppm (or equivalent)

Epichlorohydrin = 0.01% dosed at 20 ppm (or equivalent)

Public water systems can rely on manufacturer's or third parties certification for complying with this requirement.

1200-5-1-.36(9) Treatment technique for control of disinfection byproduct (DBP) precursors.

(a) Applicability.

1. Subpart H systems using conventional filtration treatment (as defined in 1200-5-1-.04) must operate with enhanced coagulation or enhanced softening to achieve the TOC percent removal levels specified in subparagraph (b) of this section unless the system meets at least one of the alternative compliance criteria listed in subparagraph (a)2. or (a)3. of this section.

2. Alternative compliance criteria for enhanced coagulation and enhanced softening systems. Subpart H systems using conventional filtration treatment may use the alternative compliance criteria in subparagraphs (a)2.(i) through (vi) of this section to comply with this section in lieu of complying with subparagraph (b) of this section. Systems must still comply with monitoring requirements in 1200-5-1-.36(6)(d).

   (i) The system's source water TOC level, measured according to 1200-5-1-.36(5)(d)3., is less than 2.0 mg/L, calculated quarterly as a running annual average.

   (ii) The system's treated water TOC level, measured according to 1200-5-1-.36(5)(d)3., is less than 2.0 mg/L, calculated quarterly as a running annual average.

   (iii) The system's source water TOC level, measured according to 1200-5-1-.36(5)(d)3., is less than 4.0 mg/L, calculated quarterly as a running annual average; the source water alkalinity, measured according to 1200-5-1-.36(5)(d)1., is greater than 60 mg/L (as $CaCO_3$), calculated quarterly as a running annual average; and either the TTHM and HAA5 running annual averages are no greater than 0.040 mg/L and 0.030 mg/L, respectively; or prior to the effective date for compliance in 1200-5-1-.36(2), the system has made a clear and irrevocable financial commitment not later than the effective date for compliance in 1200-5-1-.36(2) to use of technologies that will limit the levels of TTHMs and HAA5 to no more than 0.040

©2004. TAUD. All rights reserved.

mg/L and 0.030 mg/L, respectively. Systems must submit evidence of a clear and irrevocable financial commitment, in addition to a schedule containing milestones and periodic progress reports for installation and operation of appropriate technologies, to the State for approval not later than the effective date for compliance in 1200-5-1-.36(2). These technologies must be installed and operating not later than June 16, 2005. Failure to install and operate these technologies by the date in the approved schedule will constitute a violation of National Primary Drinking Water Regulations.

(iv) The TTHM and HAA5 running annual averages are no greater than 0.040 mg/L and 0.030 mg/L, respectively, and the system uses only chlorine for primary disinfection and maintenance of a residual in the distribution system.

(v) The system's source water SUVA, prior to any treatment and measured monthly according to 1200-5-1-.36(5)(d)4., is less than or equal to 2.0 L/mg-m, calculated quarterly as a running annual average.

(vi) The system's finished water SUVA, measured monthly according to 1200-5-1-.36(5)(d)4., is less than or equal to 2.0 L/mg-m, calculated quarterly as a running annual average.

3. Additional alternative compliance criteria for softening systems. Systems practicing enhanced softening that cannot achieve the TOC removals required by paragraph (9)(b)2, of this section may use the alternative compliance criteria in paragraphs (9)(a)(3)(i) and (ii) of this section in lieu of complying with paragraph (9)(b) of this section. Systems must still comply with monitoring requirements in 1200-5-1-.36(6)(d).

(i) Softening that results in lowering the treated water alkalinity to less than 60 mg/L (as $CaCO_3$), measured monthly according to 1200-5-1-.36(5)(d)1., and calculated quarterly as a running annual average.

(ii) Softening that results in removing at least 10 mg/L of magnesium hardness (as $CaCO_3$), measured monthly and calculated quarterly as an annual running average.

(b) Enhanced coagulation and enhanced softening performance requirements.

1. Systems must achieve the percent reduction of TOC specified in paragraph (9)(b)(2) between the source water and the combined filter effluent, unless the State approves a system's request for alternate minimum TOC removal (Step 2) requirements under paragraph (9)(b)(3).

2. Required Step 1 TOC reductions, indicated in the following table, are based upon specified source water parameters measured in accordance with 1200-5-1-.36(5)(d). Systems practicing softening are required to

 ©2004. TAUD. All Rights Reserved.

meet the Step 1 TOC reductions in the far-right column (Source water alkalinity >120 mg/L) for the specified source water TOC:

Step 1 Required Removal of TOC in Percent Removal by Enhanced Coagulation and Enhanced Softening for Subpart H Systems Using Conventional Treatment[1,2]

Source Water TOC, mg/L	**Source Water Alkalinity, mg/L as $CaCO_3$**		
	0-60	**>60-120**	**>120[3]**
>2.0-4.0	35.0%	25.0%	15.0%
>4.0-8.0	45.0%	35.0%	25.0%
>8.0	50.0%	40.0%	30.0%

[1] Systems meeting at least one of the conditions in paragraph (9)(a)(2)(i)-(vi) of this section are not required to operate with enhanced coagulation.

[2] Softening systems meeting one of the alternative compliance criteria in paragraph (9)(a)(3) of this section are not required to operate with enhanced softening.

[3]Systems practicing softening must meet the TOC removal requirements in this column.

3. Subpart H conventional treatment systems that cannot achieve the Step 1 TOC removals required by paragraph (9)(b)(2) of this section due to water quality parameters or operational constraints must apply to the State, within three months of failure to achieve the TOC removals required by subparagraph (b)(2) of this section, for approval of alternative minimum TOC (Step 2) removal requirements submitted by the system. If the State approves the alternative minimum TOC removal (Step 2) requirements, the State may make those requirements retroactive for the purposes of determining compliance. Until the State approves the alternate minimum TOC removal (Step 2) requirements, the system must meet the Step 1 TOC removals contained in paragraph (b)(2) of this section.

4. Alternate minimum TOC removal (Step 2) requirements. Applications made to the State by enhanced coagulation systems for approval of alternative minimum TOC removal (Step 2) requirements under paragraph (9)(b)3., of this section must include, as a minimum, results of bench- or pilot-scale testing conducted under paragraph (9)(b)4.(i) of this section and used to determine the alternate enhanced coagulation level. The submitted bench or pilot scale testing must be used to determine the alternate enhanced coagulation level.

   (i) Alternate enhanced coagulation level is defined as coagulation at a coagulant dose and pH as determined by the method described in paragraphs (9)(b)4.(i) through (v) of this section such that an incremental addition of 10 mg/L of alum (as aluminum) (or equivalent amount of ferric salt) results in a TOC removal of $\leq$0.3

©2004. TAUD. All rights reserved.

mg/L. The percent removal of TOC at this point on the ``TOC removal versus coagulant dose'' curve is then defined as the minimum TOC removal required for the system. Once approved by the State, this minimum requirement supersedes the minimum TOC removal required by the table in subparagraph (b)(2) of this section. This requirement will be effective until such time as the State approves a new value based on the results of a new bench- and pilot-scale test. Failure to achieve State-set alternative minimum TOC removal levels is a violation of National Primary Drinking Water Regulations.

(ii) Bench- or pilot-scale testing of enhanced coagulation must be conducted by using representative water samples and adding 10 mg/L increments of alum (as aluminum) (or equivalent amounts of ferric salt) until the pH is reduced to a level less than or equal to the enhanced coagulation Step 2 target pH shown in the following table:

Enhanced Coagulation Step 2

Target pH

Alkalinity (mg/L as $CaCO_3$)	**Target pH**
0-60	5.5
>60-120	6.3
>120-240	7.0
>240	7.5

(iii) For waters with alkalinities of less than 60 mg/L for which addition of small amounts of alum or equivalent addition of iron coagulant drives the pH below 5.5 before significant TOC removal occurs, the system must add necessary chemicals to maintain the pH between 5.3 and 5.7 in samples until the TOC removal of 0.3 mg/L per 10 mg/L alum added (as aluminum) (or equivalent addition of iron coagulant) is reached.

(iv) The system may operate at any coagulant dose or pH necessary (consistent with other NPDWRs) to achieve the minimum TOC percent removal approved under paragraph (9)(b)3., of this section.

(v) If the TOC removal is consistently less than 0.3 mg/L of TOC per 10 mg/L of incremental alum dose (as aluminum) at all dosages of alum (or equivalent addition of iron coagulant), the water is deemed to contain TOC not amenable to enhanced coagulation. The system may then apply to the State for a waiver of enhanced coagulation requirements.

 ©2004. TAUD. All Rights Reserved.

(c) Compliance calculations.

1. Subpart H systems other than those identified in paragraph (9)(a)2., or (a)3., of this section must comply with requirements contained in paragraph(9) (b)2. or (b)3. of this section. Systems must calculate compliance quarterly, beginning after the system has collected 12 months of data, by determining an annual average using the following method:

(i) Determine actual monthly TOC percent removal, equal to:

(1-(treated water TOC/source water TOC)) x 100

(ii) Determine the required monthly TOC percent removal (from either the table in subparagraph (b)2. of this section or from paragraph (9)(b)3., of this section).

(iii) Divide the value in paragraph (9)(c)1.(i) of this section by the value in paragraph (9)(c)1.(ii) of this section.

(iv) Add together the results of paragraph (9)(c)1.(iii) of this section for the last 12 months and divide by 12.

(v) If the value calculated in paragraph (9)(c)1.(iv) of this section is less than 1.00, the system is not in compliance with the TOC percent removal requirements.

2. Systems may use the provisions in paragraphs (9)(c)2.(i) through (v) of this section in lieu of the calculations in paragraph (9)(c)1.(i) through (v) of this section to determine compliance with TOC percent removal requirements.

(i) In any month that the system's treated or source water TOC level, measured according to 1200-5-1-.36(5)(d)3., is less than 2.0 mg/L, the system may assign a monthly value of 1.0 (in lieu of the value calculated in paragraph (9)(c)1.(iii) of this section) when calculating compliance under the provisions of paragraph (9)(c)1. of this section.

(ii) In any month that a system practicing softening removes at least 10 mg/L of magnesium hardness (as $CaCO_3$), the system may assign a monthly value of 1.0 (in lieu of the value calculated in paragraph (9)(c)1.(iii) of this section) when calculating compliance under the provisions of paragraph (9)(c)1. of this section.

(iii) In any month that the system's source water SUVA, prior to any treatment and measured according to 1200-5-1-.36(5)(d)4., is less than or equal to 2.0 L/mg-m, the system may assign a monthly value of 1.0 (in lieu of the value calculated in paragraph (9)(c)1.(iii) of this section) when calculating compliance under the provisions of paragraph (9)(c)1. of this section.

(iv) In any month that the system's finished water SUVA, measured according to 1200-5-1-.36(5)(d)4., is less than or equal to 2.0 L/mg-m, the system may assign a monthly value of 1.0 (in lieu of the value calculated in paragraph (9)(c)1.(iii) of this section) when calculating

©2004. TAUD. All rights reserved.

compliance under the provisions of paragraph (9)(c)(1) of this section.

(v) In any month that a system practicing enhanced softening lowers alkalinity below 60 mg/L (as $CaCO_3$), the system may assign a monthly value of 1.0 (in lieu of the value calculated in paragraph (9)(c)1.(iii) of this section) when calculating compliance under the provisions of paragraph (9)(c)1. of this section.

3. Subpart H systems using conventional treatment may also comply with the requirements of this section by meeting the criteria in paragraph (9)(a)(2) or (3) of this section.

(d) Treatment technique requirements for DBP precursors. The Administrator identifies the following as treatment techniques to control the level of disinfection byproduct precursors in drinking water treatment and distribution systems: For Subpart H systems using conventional treatment, enhanced coagulation or enhanced softening.

Process Monitoring and Reporting

Monthly Operations Report (MOR)

The Operator must monitor and report the following parameters.

Physical and Chemical Characteristics

- Raw Water Pumpage
- Raw Water Temperature
- Raw Water Turbidity
- Settled Water Turbidity
- Finished Water Turbidity

Chemical Use

For each coagulant, coagulant aid, and pH adjustment chemical used, this information must be recorded and reported.

- Chemical Fed, lbs – Total Monthly
- Chemical Fed, lbs – Average Daily
- Chemical Fed, lbs – Maximum Daily
- Chemical Fed, lbs – Minimum Daily
- Chemical Cost per Pound
- Chemical Cost per Month
- Calculated Dosage, mg/L – Daily
- Calculated Dosage, mg/L – Total Monthly
- Calculated Dosage, mg/L – Average Daily
- Calculated Dosage, mg/L – Maximum Daily
- Calculated Dosage, mg/L – Minimum Daily

 ©2004. TAUD. All Rights Reserved.

Formulas for Monitoring and Reporting

Liquid Chemical Feed

$$\text{Chemical Fed, gal} = \frac{(0.785)\,(\text{Tank Diameter, in})^2\,(\text{Drop in Volume, in})}{231\,\text{in}^3/\text{gal}}$$

$$\text{Chemical Fed, lbs} = (\text{Chemical Fed, gal})\ (\text{Concentration, lbs/gal})$$

$$\text{Chemical Fed, lbs} = \frac{\text{Previous Scale Reading, lbs - Current Scale Reading, lbs}}{\text{Concentration, \%}}$$

Dry Chemical Feed

Dry Chemical Fed, lbs = Previous Scale Reading, lbs – Current Scale Reading, lbs

Monitoring and Reporting

$$\text{Average} = \frac{\text{Sum of All Daily Measuements}}{\text{Number of Daily Measurements}}$$

$$\text{Calculated Dosage, mg/L} = \frac{\text{Chemical Fed, lbs}}{(\text{Flow, MGD})\,(8.34\,\text{lbs/gal})}$$

$$\text{Cost per Pound, \$} = \frac{\text{Cost of Shipment, \$}}{\text{Weight of Shipment, lbs}}$$

$$\text{Cost per Pound, \$} = \frac{\text{Cost per CT, \$}}{100\ \text{lbs/CT}}$$

Cost per Month, $ = Total Pounds of Chemical Used X Cost per Pound, $

In addition, operators must complete and submit a copy of the ***Total Organic Carbon (TOC) and Enhanced Coagulation Report***, form CN – 1198.

©2004. TAUD. All rights reserved.

Safety

Safe Handling of Coagulation Chemicals

OSHA Standards Addressing Chemicals Used in Treatment Processes

- Personal Protective Equipment Standard
- Respiratory Protection Standard
- Right-to-Know Law Standard

 ©2004. TAUD. All Rights Reserved.

Sedimentation

Process Description

Purpose - to remove settleable solids such as grit, sand, and chemical precipitates in order to decrease the solids loading on filters and other processes: to produce settled water with the lowest possible turbidity, to reduce the concentrations of materials which can cause tastes and odors, and trihalomethanes.

Decreased solids loading can result in:

(1) longer filter runs;

(2) reduced filter maintenance.

Sedimentation Basin Zones

There are four distinct operational zones in sedimentation basins. These zones are the:

(1) Inlet Zone, which decreases the water velocity and distributes the flow evenly across the basin;

(2) Settling Zone, which provides a calm (low flow velocity) area in the basin so that suspended materials can settle out;

(3) Outlet Zone, which allows the water to flow smoothly and evenly out of the basin;

(4) Sludge Zone, which stores the settled solids until they can be disposed of.

The settling zone is directly affected by the other three zones, which can result in less efficient settling.

Sedimentation basin performance depends on the:

- settling characteristics of the floc;
- coagulant dose;
- flow rate through the basin.

Sedimentation basin efficiency depends on the flow rate through the basin

The optimum surface overflow rate depends on the settling velocity of the floc. Also referred to as the surface loading rate.

©2004. TAUD. All rights reserved.

Process Control

The turbidity of the sedimentation basin effluent should be sampled and analyzed for turbidity:

- at least once every four hours while the plant is in operation;
- more frequently when the raw water turbidity is rising, particularly during heavy rains.

Process Evaluation and Troubleshooting

It is recommended at that the treatment plant be operated to produce a sedimentation basin effluent turbidity of:

- Less than 1 NTU when the raw water turbidity is less than 10 NTU 90 percent of the time;
- Less than 2 NTU when the raw water turbidity is more than 10 NTU 90 percent of the time.

The operator should calculate the theoretical detention time for the basin in hours. In addition, if the sedimentation basin effluent does not meet the recommended limits, a tracer study should be performed on the basin to determine the actual detention time, and if short-circuiting is a problem.

Operating Problems

Most Common

(1) Poorly formed floc.

(2) Short-circuiting.

Poorly formed floc

Results of incorrect operations of the coagulation and flocculation processes. The operations of these two processes directly impacts the operations of the sedimentation and filtration processes.

(1) Inadequate Flash Mixing
   a. Mixing energy too high or too low.
   b. Detention time too long.

(2) Improper Coagulant or Coagulant Doses
   a. Wrong coagulant for raw water conditions.
   b. Coagulant does too high.
   c. Coagulant does too low.
   d. Not enough alkalinity.

(3) Improper Flocculation
   a. Mixing energy too high or too low.
   b. Detention time too long.

 ©2004. TAUD. All Rights Reserved.

Short-circuiting

(1) Poor inlet baffling (major cause)

(2) Density currents caused by high solids concentrations or cold water

(3) Wind

Short-circuiting can be identified using tracer studies, such as:

(1) dye tracing; or,

(2) tracking the fluoride concentration at various points versus time.

Algae and Slime Growth

Algae must be removed before it causes water quality, operational and safety problems. If it is too prolific, the basin should be drained and the walls treated with a strong hypochlorite solution.

Theoretical Detention Time, Hours

Detention time is defined as:

- the theoretical amount of time it takes for water to flow through a basin;
- the amount of time water remains in a basin;
- the amount of time it takes to fill a basin at a given flow rate;
- the amount of time it takes to drain a basin at a given flow rate.

Detention Times for Various Basins

Iron Removal	.....3 hours
Conventional Turbidity Removal	.....4 hours
Tube Settlers	..... 1 hour

The detention time in hours for sedimentation basins can be determined using these formulas.

$$\text{Detention Time, hr} = \frac{\text{Basin Volume, gal}}{\text{Flow, gal/min X 60 min/hr}}$$

$$\text{Detention Time, hr} = \frac{(\text{Basin Volume, gal})\,(24\ \text{hr/day})}{\text{Flow, gal/day}}$$

$$\text{Detention Time, hr} = \frac{(\text{Basin Volume, gal})\,(24\ \text{hr/day})}{(\text{Flow, MGD})\,(1{,}000{,}000\ \text{gal/MGD})}$$

©2004. TAUD. All rights reserved.

Design Criteria

4.1.4 Sedimentation - Sedimentation shall follow flocculation. The detention time for effective clarification is dependent upon a number of factors related to basin design and the nature of the raw water. The number of basins required is dependent upon the turbidity, color and colloidal matter and taste and odor causing compounds to be removed.

c. Detention Time - Plants with conventional sedimentation shall provide a minimum of 4 hours of settling time, except for iron removal plants which shall have a minimum of 3 hours.

d. Depth - Should be based on an average depth of 8 ft. However, calculations using surface area, overflow rate and detention time should be used.

e. Rectangular tanks - A length to width ratio of 4:1 should be used.

f. Tube Settlers - Detention time required for sedimentation basins may be reduced to a minimum of 1 hour if tube settlers are installed. The maximum loading rate on the tube settlers shall be no greater than 2.5 gpm/ft2. Provisions shall be made for more frequent removal of sludge from the basins than is required for conventional sedimentation.

g. Inlet Devices - Inlets shall be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports, or similar entrance arrangements are required. A baffle should be constructed across the basin close to the inlet end and should project several feet below the water surface to dissipate inlet velocities and provide uniform flows across the basin. Velocity is not to exceed 0.25 ft/sec.

h. Surface overflow Rate - Shall be between 0.25 - 0.38 gpm/sq. ft. for conventional sedimentation. When tube settlers are used design of effluent weirs or pipes shall minimize carry over of floc from the tubes.

i. Velocity - The velocity through settling basins shall not exceed 0. 5 feet per minute. The basins must be designed to minimize short circuiting. Baffles must be provided as necessary. Not applicable if tube settlers are used.

j. Drainage - Basins must be provided with a means for dewatering. Basin bottoms should slope toward the drain not less than 1 foot in 12 feet where mechanical sludge collection equipment is not required. Drain lines shall be designed to empty the basin in 4 hours or less.

k. Weir Overflow Rate - An overflow weir should be installed which will establish the maximum water level desired on top of the filters. Adjustable V-notch weirs are preferred. Weir overflow rates shall be between 8 - 10 gpm/ft. for raw water with low turbidity and 10 - 15 gpm/ft. for raw water with high turbidity. It shall discharge with

 ©2004. TAUD. All Rights Reserved.

a free fall at a location where the discharge can be observed. Other methods will be considered when presented.

l. Safety - Permanent ladders or handholds should be provided for safety on the inside walls of basins above water level. Guard rails shall be included. Flushing lines or hydrants must not include interconnection of the potable water with non-potable water.

m. Sludge Collection - Mechanical sludge collection equipment should be provided.

n. Sludge Disposal - Facilities are required by the Department for disposal of sludge. See Section 4.11. Provision shall be made for operator to observe or sample sludge being withdrawn from unit.

Detention Times for Various Basins

Iron Removal	.....3 hours
Conventional Turbidity Removal	.....4 hours
Tube Settlers	..... 1 hour

The detention time in hours for sedimentation basins can be determined using these formulas.

$$\text{Detention Time, hr} = \frac{\text{Basin Volume, gal}}{\text{Flow, gal/min X 60 min/hr}}$$

$$\text{Detention Time, hr} = \frac{(\text{Basin Volume, gal})\,(24\ \text{hr/day})}{\text{Flow, gal/day}}$$

$$\text{Detention Time, hr} = \frac{(\text{Basin Volume, gal})\,(24\ \text{hr/day})}{(\text{Flow, MGD})\,(1{,}000{,}000\ \text{gal/MGD})}$$

Surface Loading Rate, gal/min/ft^2

The surface loading rate for a sedimentation basin can be determined using this formula.

$$\text{Surface Overflow Rate, gal/min/ft}^2 = \frac{\text{flow, gal/min}}{\text{area, ft}^2}$$

$$\text{Surface Overflow Rate, gal/min/ft}^2 = \frac{\text{flow, gal/day}}{(\text{area, ft}^2)\,(1{,}440\ \text{min/day})}$$

$$\text{Surface Overflow Rate, gal/min/ft}^2 = \frac{(\text{Flow, MGD})\,(1{,}000{,}000\ \text{gal/day/MGD})}{(\text{area, ft}^2)\,(1{,}440\ \text{min/day})}$$

According Tennessee's design criteria, the surface overflow rate shall be between 0.25 - 0.38 gpm/ft^2. for conventional sedimentation. The optimum surface overflow rate depends on the settling velocity of the floc.

©2004. TAUD. All rights reserved.

Weir Overflow Rate, gal/day/ft

The weir overflow rate for a sedimentation basin can be determined using these formulas.

$$\text{Weir Overflow Rate, gal/min/lineal foot} = \frac{\text{flow, gal/min}}{\text{length of weir, ft}}$$

$$\text{Weir Overflow Rate, gal/min/lineal foot} = \frac{\text{flow, gal/day}}{\text{length of weir, ft X 1,440 min/day}}$$

$$\text{Weir Overflow Rate, gal/min/lineal foot} = \frac{\text{flow, MGD X 1,000,000 gal/MGD}}{\text{length of weir, ft X 1,440 min/day}}$$

Weir overflow rates shall be between 8 - 10 gpm/ft. for raw water with low turbidity and 10 - 15 gpm/ft. The higher the weir overflow rate, the more influence it has on the settling zone.

Division of Water Supply Rules

None.

Process Monitoring and Reporting

The turbidity of the sedimentation basin effluent should be sampled and analyzed for turbidity:

- at least once every four hours while the plant is in operation;
- more frequently when the raw water turbidity is rising, particularly during heavy rains.

The results of these analyses should be recorded on a bench sheet and saved for future reference. If the operator uses a spread sheet for keeping up the Monthly Operations Report (MOR), additional columns can be added for keeping these records.

Safety

Safety Equipment and Appurtenances

(1) Equip basins with guardrails

(2) Life jackets and poles

(3) Equipment guards

Permanent ladders or handholds should be provided for safety on the inside walls of basins above water level.

Flushing lines or hydrants must not include interconnection of the potable water with non-potable water.

 ©2004. TAUD. All Rights Reserved.

©2004. TAUD. All rights reserved.

Taste and Odor Control

Process Description

Adsorption is the process of using activated carbon to remove organic contaminants from the water.

Types of Organic Contaminants

Class I: Organic compounds causing tastes, odors, and color.

Class II: Synthetic Organic Chemicals = adverse health effects.

Class III: Disinfection by-products = precursors (primarily humic and fulvic acids.

Class IV: Disinfection by-products formed during treatment (Trihalomethanes).

Sources

Surface water

- Natural sources vegetation from runoff
- Algae
- Aquatic Plants
- Industrial waste
- Agricultural chemicals

Groundwater

- Industrial Wastes
- Agricultural Chemicals

Organic Chemical Removal

Removal at source

Surface Water

Watershed Protection

Control of Algae and Aquatic Weeds

Relocating Intake

Groundwater

Wellhead Protection

 ©2004. TAUD. All Rights Reserved.

Removal by Oxidation

Potassium permanganate

Sodium permanganate

Removal by Adsorption

Powdered Activated Carbon (PAC)
Granular Activated Carbon (GAC)

Principle

Adhesion – adhere or sticks to

Organics are attracted to and adhere to adsorbent (PAC/GAC)

Process Control

Powdered Activated Carbon

- Fed dry or as a sherry
- Wetting PAC is difficult, requires careful, through mixing
- Locate feeders in a confined room
- Add prior to coagulation/flocculation

Feed Point Recommendations

- Point of application should allow for at least 15 minutes contact time
- PAC will adsorb coagulants/coagulant aides
- PAC adsorbs chlorine
- Most advantageous point-raw water intake
- Several small doses are better than one large dose

Process Control Testing

- Determining Dosage – Jar Testing
- Threshold Odor Test

©2004. TAUD. All rights reserved.

Process Control Calculations

Dry Chemical Feed

Feeder Rate, grams/min

$$\text{Feed Rate, grams/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(3.785\ \text{L/gal})}{(1{,}000\ \text{mg/gram})}$$

$$\text{Feed Rate, grams/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(3.785\ \text{L/gal})}{(1{,}000\ \text{mg/gram})\,(1{,}440\ \text{min/day})}$$

$$\text{Feed Rate, grams/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(3.785\ \text{L/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}{(1{,}000\ \text{mg/gram})\,(1{,}440\ \text{min/day})}$$

Feeder Rate, lbs/day – Commercial Purity of 100%

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\ \ (8.34\ \text{lbs/gal})\,(1{,}440\ \text{min/day})}{(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(8.34\ \text{lbs/gal})}{(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, lbs/day} = (\text{Dose, mg/L})\,(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})$$

Feeder Rate, lbs/day – Commercial Purity, <100%

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(1{,}440\ \text{min/day})\ \ (8.34\ \text{lbs/gal})}{(\text{Commercial Purity, \%})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(8.34\ \text{lbs/gal})}{(\text{Commercial Purity, \%})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})}{\text{Commercial Purity, \%}}$$

 ©2004. TAUD. All Rights Reserved.

Process Evaluation and Troubleshooting

Common Problems (PAC)

- Dust
- "Black water"
- Persistent Taste and Odor Problems

Control

Determining Dosage – Jar Testing

Threshold Odor Test

Design Criteria

4.10 TASTE AND ODOR CONTROL

4.10.1 Chlorination - Chlorination can be used for the removal of some objectionable odors. Adequate contact time must be provided to complete the chemical reactions involved.

4.10.2 Chlorine Dioxide - Chlorine dioxide has been generally recognized as a treatment for tastes caused by industrial wastes, such as phenols; however, chlorine dioxide can be used in the treatment of any taste or odor that is treatable by an oxidizing compound. Provision shall be made for proper storing and handling of sodium chlorite, so as to eliminate any danger of explosion (See Part 5).

4.10.3 Powdered Activated Carbon

a. Powdered activated carbon may be added prior to coagulation to provide maximum contact time, although facilities to allow the addition at several points is preferred, but not near the point of chlorine application.

b. The carbon can be added as a pre-mixed slurry or by means of a dry-feed machine as long as the carbon is properly "wetted".

c. Agitation is necessary to keep the carbon from depositing in the mixing chamber.

d. Provision shall be made for adequate dust control.

e. The required dosage of carbon in a water treatment plant depends upon the tastes and/or odors involved, but provision shall be made for adding 0 mg/L to at least 40 mg/L.

©2004. TAUD. All rights reserved.

f. Powdered activated carbon shall be handled as a potentially combustible material. It should be stored in a building or compartment as nearly fireproof as possible. Other chemicals should not be stored in the same compartment. Carbon feeder rooms should be equipped with explosion-proof electrical outlets, lights and motors.

4.10.4 Granular Activated Carbon Adsorption Units - Granular activated carbon units shall not be used in place of filters described in Section 4.2. Rates of flow shall be consistent with the type and intensity of the problem. The design used must be supported by the results of pilot plant studies when granular activated carbon units are used for organic removal.

4.10.5 Copper Sulfate and Other Copper Compounds - Continuous or periodic treatment of water with copper compounds to kill algae or other growths shall be controlled to prevent copper in excess of 1.0 mg/L as copper in the plant effluent or distribution system. Care shall be taken in obtaining a uniform distribution:

a. if alkalinity is less than 50 mg/L, dose at 0.9 lb/acre foot,

b. if alkalinity is greater than 50 mg/L, dose at 5.4 lb/acre foot.

4.10.6 Aeration - See Section 4.6.

4.10.7 Potassium Permanganate - Application of potassium permanganate may be considered provided the point of application is prior to filtration.

4.10.8 Ozone - Ozonation can be used as a means of taste and odor control. Adequate contact time must be provided to complete the chemical reactions involved. Ozone is generally more desirable for treating water with high threshold odors.

4.10.9 Other Methods - The decision to use any other methods of taste and odor control should be made only after careful laboratory tests and on consultation with the Department.

4.10.10 Flexibility - Plants treating water that is known to have taste and odor problems should be provided with equipment that makes several of the control processes available so that the operator will have flexibility in operation.

Division of Water Supply Rules and Regulations

1200-5-1-.12 Secondary Drinking Water Regulations

(1) The following maximum contaminant levels are established to provide a water that is aesthetically pleasing to the consumer. These standards will apply to all community water systems and to those non-community water systems as may be deemed necessary by the Department. Monitoring for these contaminants will be set in the Monitoring Program for each

 ©2004. TAUD. All Rights Reserved.

system, but in no event less than once every year for a surface and surface/ground supply and once every three years for a ground water supply.

Contaminant	**Maximum Contaminant Level Milligrams per Liter (unless otherwise indicated)**
(g) Odor	3 (Threshold Odor Number)

Process Monitoring and Reporting

Monitor for Odor at least annually for surface water, and every three years for groundwater supplies.

For each chemical used, this information must be recorded and reported.

- Chemical Fed, lbs – Total Monthly
- Chemical Fed, lbs – Average Daily
- Chemical Fed, lbs – Maximum Daily
- Chemical Fed, lbs – Minimum Daily
- Chemical Cost per Pound
- Chemical Cost per Month
- Calculated Dosage, mg/L – Daily
- Calculated Dosage, mg/L – Total Monthly
- Calculated Dosage, mg/L – Average Daily
- Calculated Dosage, mg/L – Maximum Daily
- Calculated Dosage, mg/L – Minimum Daily

Formulas for Monitoring and Reporting

Liquid Chemical Feed

$$\text{Chemical Fed, gal} = \frac{(0.785)\,(\text{Tank Diameter, in})^2\,(\text{Drop in Volume, in})}{231\,\text{in}^3/\text{gal}}$$

$$\text{Chemical Fed, lbs} = (\text{Chemical Fed, gal})\;(\text{Concentration, lbs/gal})$$

$$\text{Chemical Fed, lbs} = \frac{\text{Previous Scale Reading, lbs} - \text{Current Scale Reading, lbs}}{\text{Concentration, \%}}$$

©2004. TAUD. All rights reserved.

Dry Chemical Feed

Dry Chemical Fed, lbs = Previous Scale Reading, lbs – Current Scale Reading, lbs

Monitoring and Reporting

$$\text{Average} = \frac{\text{Sum of All Daily Measuements}}{\text{Number of Daily Measurements}}$$

$$\text{Calculated Dosage, mg/L} = \frac{\text{Chemical Fed, lbs}}{(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})}$$

$$\text{Cost per Pound, \$} = \frac{\text{Cost of Shipment, \$}}{\text{Weight of Shipment, lbs}}$$

$$\text{Cost per Pound, \$} = \frac{\text{Cost per CT, \$}}{100\ \text{lbs/CT}}$$

Cost per Month, $ = Total Pounds of Chemical Used X Cost per Pound, $

Safety – Activated Carbon

Chemical Name:.....Carbon

Formula:.....C

Common Name:.....Carbon

CAS Number:.....7440-44-0

Carbon.....90 - 100%

Inert Ingredients.....0 - 10%

Boiling Point:.....8721° F, 4827° C (Approx.)

Solubility in Water:.....Insoluble

Specific Gravity:.....0.2 - 0.75

Appearance:.....Black, Odorless, Pelletized, Powder
Evaporation Rate: N/A

Fire and Explosion Hazard Data

Flash Point:.....N/A

 ©2004. TAUD. All Rights Reserved.

Ignition Point: .....500 - 800° F

Extinguishing Media:.....Dry Chemical, Water Fog, Foam

Special Fire Fighting Procedures:.....Wear positive pressure self-contained breathing apparatus if fire occurs in enclosed space. Oxygen starved fires may result in the release of carbon monoxide

Unusual Fires and Explosion Hazards:.....Avoid producing suspensions of dust during handling, and avoid exposure of suspensions to sources of ignition. Suspensions of -40 mesh powdered activated carbon may explode if exposed to strong sources of ignition

Health Hazard Data

Eye: Carbon particles may cause physical irritation if not removed

Skin Contact: Constant prolonged exposure may cause dryness or chapping of exposed area

Skin Adsorption: Not adsorbed by skin

Ingestion: No adverse affect unless quantity ingested causes physical discomfort

Inhalation: No toxic affect caused by dust. As with any dust, excessive exposure should be avoided. OSHA "Nuisance Dust" limitations should be observed

Systemic and Other Effects: .....None

First Aid

Eyes: Irrigate with water immediately. Repeat as needed to flush particle from eye. If irritation persists, consult medical personnel

Skin: Wash with soap and water to avoid skin drying or chapping

Ingestion: N/A

Inhalation: N/A

Reactivity Data Compatability Data

Stability: Avoid contact with strong oxidizing chemicals, such as ozone, perchloric acid, permanganate, sodium chlorite, etc. Exposure to hydrocarbons and vegetable oils may cause slow oxidation until ignition point is reached – contact should be avoided

Incompatibility: Strong oxidizing materials

Hazardous Decomposition Products: Oxygen starved combustion may yield carbon monoxide

Hazardous Polymerization: Will not occur

©2004. TAUD. All rights reserved.

Storage Handling and Use

Action to take for spills: Shovel and sweep material into appropriate container. If necessary wash area with water.

Disposal Method: Reactivation, landfill or incineration, in accordance with applicable regulations.

Personnel Protection

Ventilation: Local exhaust recommended to minimize dust exposure

Respiratory Protection: Approved "nuisance dust" dust masks should be worn in dust exposure areas

Protective Clothing: Protective gloves can be worn

Eye Protection: Safety glasses with side shields should be worn and eye wash capabilities should be available

Special Precautions and Additional Information

Precautions to be taken in handling and storage: keep dry; wet carbon will adsorb oxygen and may reduce oxygen levels in confined spaces to dangerous levels. Adequate ventilation and precautions should be employed whenever closed tanks, receptacles or other enclosed spaces containing carbon are accessed. Suspensions of dust should be avoided and exposure of suspensions of dust to sources of ignition should be avoided.

 ©2004. TAUD. All Rights Reserved.

Notes

©2004. TAUD. All rights reserved.

Corrosion Control

Process Description

Purpose To control both the corrosive and scale-forming tendencies of water. Unstable water can be either corrosive or scale-forming.

Problems Associated with Unstable Water

Public Health

(1) Toxic metals which dissolve in corrosive water

a. Lead action level is exceeded if the 90th percentile lead level is greater than 0.015 mg/l.

b. Copper action level is exceeded if the 90th percentile copper level is greater than 1.3 mg/l.

A water sample which shows an increase in iron, copper, zinc, lead, or cadmium indicates corrosion.

(2) Corrosive water can cause the formation of tubercles (iron rust deposits) which can protect bacteria and other microorganisms from residual chlorine.

a. Changes in pressure or velocity can break the tubercles open, releasing bacteria.

b. Some types of bacteria can accelerate corrosion.

Tubercles: knobs of rust formed on the interior of cast iron pipes due to corrosion.

Aesthetics Corrosive water can cause color, tastes and odors.

Red Water

- Caused by iron, dissolved by corrosive water.
- Stains plumbing and laundry yellowish- or reddish-brown.
- Makes water unappealing.
- Dissolved iron serves as a food supply for iron bacteria, which can cause serious taste and odor problems.
- Corrosion of copper causes metallic tastes and blue-green stains on laundry and plumbing.

 ©2004. TAUD. All Rights Reserved.

Stabilization Methods

(1) pH and alkalinity adjustment.

(2) Protective coatings

(3) Corrosion inhibitors and sequestering agents

1. pH and Alkalinity Adjustment

- If the pH and alkalinity levels are increased, corrosion can be prevented.
- Adjustment of the pH above the pH of saturation causes calcium carbonate to come out of solution and form a protective coating on the pipe wall.
- If the pH and alkalinity levels are decreased, scale formation can be prevented.
- Lime is used to increase both pH and alkalinity.
- Each mg/l of hydrated lime increases the alkalinity by 1.35 mg/l as calcium carbonate.
- Problems with lime feed include:

    1. lime precipitates on everything;
    2. feed equipment and piping require frequent cleaning; and,
    3. lime slurry feed lines should be as short and straight as possible to minimize maintenance problems.

- Soda ash (sodium carbonate) can be added to increase both pH and alkalinity.
- Each mg/l of soda ash increases the alkalinity by 0.94 mg/l as calcium carbonate. Soda ash (sodium carbonate) can be added to increase both pH and alkalinity.
- Caustic soda (sodium hydroxide) can be used to increase the pH and alkalinity.
- Carbon dioxide can be used to reduce the pH and scale-forming tendencies.

2. Protective Coatings

- Cement Linings
- Calcium Carbonate

3. Corrosion Inhibitors and Sequestering Agents

- Polyphosphates form protective coatings on pipe walls.
- Sequestering agents chemically tie up (sequester) the scale-forming chemicals to prevent scale and tie up iron.

©2004. TAUD. All rights reserved.

Types of Corrosion

Localized Corrosion

- attacks metal surfaces unevenly
- more serious problem than uniform corrosion
- most common types of localized corrosion are galvanic corrosion and concentration-cell corrosion

Uniform Corrosion

- metal corrodes at an even rate over the entire surface
- usually occurs in water having a very low pH and alkalinity

Factors Which Affect Corrosion Rates or Stability

Dissolved Oxygen (DO)	As the dissolved oxygen concentration in the water increases, the corrosion rate increases.
Total Dissolved Solids	As the total dissolved solids concentration in the water increases, the corrosion rate increases.
pH	As the pH increases, the corrosion rate decreases.
Alkalinity	As the alkalinity increases, the corrosion rate decreases.
Temperature	As the water temperature increases, the corrosion rate increases.
Bacteria	Certain bacteria can accelerate corrosion rates because they give off carbon dioxide and hydrogen sulfide. They also can produce slime which can increase the rate of tuberculation.
Stray Currents	Increase the corrosion rate.

 ©2004. TAUD. All Rights Reserved.

Process Control

Control Tests

- pH
- Total Alkalinity
- Pipe Coupons (specimens taking from pipes during large taps)
- Coupon Racks
- Corrosion Inhibitor Residual
- Calcium Hardness

Corrosion Indexes

Stability (Corrosive) Characteristics	*Langelier Index (LI)*	*Aggressive Index (AI)*
Highly Aggressive (Corrosive)	< -2.0	<10.0
Moderately Aggressive (Corrosive)	-2.0 to <0.0	10.0 to <12.0
Nonaggressive (non-corrosive)	>0.0	≥12.0

pHs = A + B - log Calcium Hardness - Log Total Alkalinity

Langelier Index = pH - pH_s

Aggressive Index = pH + Log Calcium Hardness + Log Total Alklinity

Process Evaluation and Troubleshooting

Common Operating Problems

Excessive Scaling

Persistence of red-water problems:

- poor flow velocities, either very high or very low;
- tuberculation (deposits of iron rust on pipe walls)
- presence of iron bacteria.

©2004. TAUD. All rights reserved.

Design Criteria

4.9 CORROSION CONTROL - corrosion is caused by a reaction between the pipe material and the water in direct contact with each other. Consequently, there are three basic approaches to corrosion control:

a. Using pipe materials and designing the system so it is not corroded by a given water,

b. Modifying the water quality so it is not corrosive to the pipe material,

c. Placing a protective barrier or lining between the water and the pipe.

4.9.1 System design

a. Choose compatible materials throughout system where possible to avoid forming galvanic cells,

b. Avoid dead ends and stagnant areas,

c. Reduce mechanical stress, sharp turns and elbows,

d. Provide adequate insulation and avoid uneven heat distribution,

e. Eliminate grounding of electrical circuits to system.

4.9.2 Cathodic Protection - Metal tanks and reservoirs should be considered for protection from corrosion by this method.

4.9.3 Modification of Water Quality

a. pH adjustment by addition of lime, caustic soda or soda ash, in order to stabilize the water with regard to calcium carbonate.

b. Control of oxygen. Advantages of aeration for iron, H2S Or C02 removal should be balanced against the fact that dissolved oxygen is a corrosive agent.

4.9.4 Use of inhibitors. These may be used as appropriate.

a. Addition of lime or alkalinity increases the tendency of water to deposit CaCO3 forming a protective coating inside of pipe.

b. Inorganic phosphorus. Care is needed to select a chemical which not only masks the symptoms, but also reduces corrosion. (Sodium hexametaphosphate in low dosages of 2-4 mg/L only masks the symptoms while corrosion

 ©2004. TAUD. All Rights Reserved.

continues). Recent developments indicate the addition of zinc with a phosphate is effective in both inhibiting corrosion and controlling red water.

c. Sodium silicate. Effective in water with low hardness, alkalinity and pH less than 8.4 under relatively high velocity conditions.

4.9.5 Coatings and linings - Metal distribution system components' surfaces in contact with water shall be protected by being coated or lined.

a. Pipe linings include coal tar enamels, epoxy paint, and cement mortar.

b. Storage tanks are protected by such coatings as coal tar enamels, paints, vinyls, and epoxy.

Division of Water Supply Rules

All public water systems must install and operate Optimum Corrosion Control Treatment (OCCT).

Lead action level is exceeded if the 90th percentile lead level is greater than 0.015 mg/l.

Copper action level is exceeded if the 90th percentile copper level is greater than 1.3 mg/l.

Records associated with the Lead and Copper Rule must be maintained for 12 years.

Because of the size of the Lead and Copper Rule, it is not reprinted here. See Tab 3 for the entire rule.

Monitoring and Reporting

(b) Sample collection methods.

1. All tap samples for lead and copper collected in accordance with this 1200-5-1-.33, with the exception of lead service line samples collected under paragraph (5)(c) and samples collected under subparagraph (b)5 of this paragraph, shall be first-draw samples.

2. Each first-draw tap sample for lead and copper shall be one liter in volume and have stood motionless in the plumbing system of each sampling site for at least six hours. First-draw samples from residential housing shall be collected from the cold water kitchen tap or bathroom sink tap. First-draw samples from a nonresidential building shall be one liter in volume and shall be collected at an interior tap from which water is typically drawn for consumption. Non-first-draw samples collected in lieu of first-draw samples pursuant to part (b)5 of this paragraph shall be one liter in volume and shall be collected at an interior tap from which water is typically drawn for consumption. First-draw samples may be collected by the system or the system may allow residents to collect first-draw samples after instructing the residents of the sampling procedures specified in this paragraph. To avoid problems of residents

©2004. TAUD. All rights reserved.

handling nitric acid, acidification of first-draw samples may be done up to 14 days after the sample is collected. After acidification to resolubilize the metals, the sample must stand in the original container for the time specified in the approved EPA method before the sample can be analyzed. If a system allows residents to perform sampling, the system may not challenge, based on alleged errors in sample collection, the accuracy of sampling results.

3. Each lead service line sample shall be one liter in volume and have stood motionless in the lead service line for at least six hours. Lead service line samples shall be collected in one of the following three ways:

   (i) at the tap after flushing the volume of water between the tap and the lead service line. The volume of water shall be calculated based on the interior diameter and length of the pipe between the tap and lead service line;

   (ii) tapping directly into the lead service line.

4. A water system shall collect each first draw tap sample from the same sampling site from which it collected the previous sample. If, for any reason, the water system cannot gain entry to a sampling site in order to collect a follow-up tap sample, the system may collect the follow-up tap sample from another sampling site in its sampling pool as long as the new site meets the same targeting criteria, and is within reasonable proximity of the original site.

5. A non-transient non-community water system, or a community water system that meets the criteria of paragraph (6)(c)7(i) and (ii), that does not have enough taps that can supply first-draw samples, as defined in 1200-5-1-.04, may apply to the State in writing to substitute non-first-draw samples. Such systems must collect as many first-draw samples from appropriate taps as possible and identify sampling times and locations that would likely result in the longest standing time for the remaining sites. The State has the discretion to waive the requirement for prior State approval of non-first-draw sample sites selected by the system, either through State regulation or written notification to the system.

(c) Number of samples. Water systems shall collect at least one sample during each monitoring period specified in subparagraph (d) of this paragraph from the number of sites listed in the first column (``standard monitoring'') of the table in this subparagraph. A system conducting reduced monitoring under subparagraph (d)4 of this paragraph on shall collect at least one sample from the number of sites specified in the second column (``reduced monitoring'') of the table in this paragraph during each monitoring period specified in subparagraph (d)4 of this paragraph. Such reduced monitoring sites shall be representative of the sites required for standard monitoring. States may specify sampling locations when a system is conducting reduced monitoring. The table is as follows:

 ©2004. TAUD. All Rights Reserved.

TABLE 1200-5-1-.33(7)(c)

System size (number of people served)[1]	Number of sites (standard monitoring)	Number of sites (reduced monitoring)
>100,000	100	50
10,001 to 100,000	60	30
3,301 to 10,000	40	20
501 to 3,300	20	10
101 to 500	10	5
less than or equal to 100	5	5

1 Populations shall be determined by count of the population served or by the household factor multiplied by the number of connections the system has as determined by the latest federal census.

4. Reduced Monitoring

(i) A small or medium-size water system that meets the lead and copper action levels during each of two consecutive six-month monitoring periods may reduce the number of samples in accordance with subparagraph (c) of this paragraph and reduce the frequency of sampling to once per year.

(ii) Any water system that maintains the range of values for the water quality control parameters reflecting optimal corrosion control treatment specified by the State under paragraph (3)(f) during each of two consecutive six-month monitoring periods may reduce the frequency of monitoring to once per year and reduce the number of lead and copper samples in accordance with subparagraph (c) of this paragraph if it receives written approval from the State. The State shall review monitoring, treatment, and other relevant information submitted by the water system in accordance with paragraph (11), and shall notify the system in writing when it determines the system is eligible to commence reduced monitoring pursuant to this paragraph. The State shall review, and where appropriate, revise its determination when the system submits new monitoring or treatment data, or when other data relevant to the number and frequency of tap sampling becomes available.

(iii) A small or medium-size water system that meets the lead and copper action levels during three consecutive years of monitoring may reduce the frequency of monitoring for lead and copper from annually to once every three years. Any water system that maintains the range of values for the water quality control parameters reflecting optimal corrosion control treatment specified by the State under paragraph (3)(f) during three consecutive years of monitoring may reduce the frequency of monitoring from annually to once every three years if it receives written approval

©2004. TAUD. All rights reserved.

from the State. The State shall review monitoring, treatment, and other relevant information submitted by the water system in accordance with paragraph (11), and shall notify the system in writing when it determines the system is eligible to reduce the frequency of monitoring to once every three years. The State shall review, and where appropriate, revise its determination when the system submits new monitoring or treatment data, or when other data relevant to the number and frequency of tap sampling becomes available.

(iv) A water system that reduces the number and frequency of sampling shall collect these samples from representative sites included in the pool of targeted sampling sites identified in subparagraph (a) of this paragraph. Systems sampling annually or less frequently shall conduct the lead and copper tap sampling during the months of June, July, August, or September unless the State has approved a different sampling period in accordance with item (d)4(iv)(I) of this paragraph.

(I) The State, at its discretion, may approve a different period for conducting the lead and copper tap sampling for systems collecting a reduced number of samples. Such a period shall be no longer than four consecutive months and must represent a time of normal operation where the highest levels of lead are most likely to occur. For a non-transient non-community water system that does not operate during the months of June through September, and for which the period of normal operation where the highest levels of lead are most likely to occur is not known, the State shall designate a period that represents a time of normal operation for the system.

(II) Systems monitoring annually, that have been collecting samples during the months of June through September and that receive State approval to alter their sample collection period under item (d)4(iv)(I) of this paragraph, must collect their next round of samples during a time period that ends no later than 21 months after the previous round of sampling. Systems monitoring triennially that have been collecting samples during the months of June through September, and receive State approval to alter the sampling collection period as per item (d)4(iv)(I) of this paragraph, must collect their next round of samples during a time period that ends no later than 45 months after the previous round of sampling. Subsequent rounds of sampling must be collected annually or triennially, as required by this section. Small systems with waivers, granted pursuant to subparagraph (g) of this paragraph, that have been collecting samples during the months of June through September and receive State approval to alter their sample collection period under item (d)4(iv)(I) of this paragraph must collect their next round of samples before the end of the 9-year period.

(v) Any water system that demonstrates for two consecutive 6-month monitoring periods that the tap water lead level computed under paragraph (1)(c)3 is less than or equal to 0.005 mg/L and the tap water copper level computed under paragraph (1)(c)3 is less than or equal to 0.65 mg/L may reduce the number of samples in accordance with

 ©2004. TAUD. All Rights Reserved.

subparagraph (c) of this paragraph and reduce the frequency of sampling to once every three calendar years.

(vi)

(I) A small or medium-size water system subject to reduced monitoring that exceeds the lead or copper action level shall resume sampling in accordance with subparagraph (d)3 of this paragraph and collect the number of samples specified for standard monitoring under subparagraph (c) of this paragraph. Such a system shall also conduct water quality parameter monitoring in accordance with paragraph (8)(b), (c) or (d) (as appropriate) during the monitoring period in which it exceeded the action level. Any such system may resume annual monitoring for lead and copper at the tap at the reduced number of sites specified in subparagraph (c) of this paragraph after it has completed two subsequent consecutive six-month rounds of monitoring that meet the criteria of subparagraph (d)4(i) of this paragraph and/or may resume triennial monitoring for lead and copper at the reduced number of sites after it demonstrates through subsequent rounds of monitoring that it meets the criteria of either subparagraph (d)4(iii) or (d)4(v) of this paragraph.

(II) Any water system subject to the reduced monitoring frequency that fails to operate at or above the minimum value or within the range of values for the water quality parameters specified by the State under paragraph (3)(f) for more than nine days in any six-month period specified in paragraph (8)(d) shall conduct tap water sampling for lead and copper at the frequency specified in subparagraph (d)3 of this paragraph, collect the number of samples specified for standard monitoring under subparagraph (c) of this paragraph, and shall resume monitoring for water quality parameters within the distribution system in accordance with subparagraph (8)(d). Such a system may resume reduced monitoring for lead and copper at the tap and for water quality parameters within the distribution system under the following conditions:

I. The system may resume annual monitoring for lead and copper at the tap at the reduced number of sites specified in subparagraph (c) of this paragraph after it has completed two subsequent six-month rounds of monitoring that meet the criteria of subparagraph (d)4(ii) of this paragraph and the system has received written approval from the State that it is appropriate to resume reduced monitoring on an annual frequency.

II. The system may resume triennial monitoring for lead and copper at the tap at the reduced number of sites after it demonstrates through subsequent rounds of monitoring that it meets the criteria of either subparagraph (d)4(iii) or (d)4(v) of this paragraph and the system has received written approval from the State that it is appropriate to resume triennial monitoring.

©2004. TAUD. All rights reserved.

III. The system may reduce the number of water quality parameter tap water samples required in accordance with paragraph (8)(e)1 and the frequency with which it collects such samples in accordance with part (8)(e)2. Such a system may not resume triennial monitoring for water quality parameters at the tap until it demonstrates, in accordance with the requirements of paragraph (8)(e)2, that it has re-qualified for triennial monitoring.

(vii) Any water system subject to a reduced monitoring frequency under subparagraph (d)4 of this section that either adds a new source of water or changes any water treatment shall inform the State in writing in accordance with paragraph (11)(a)3. The State may require the system to resume sampling in accordance with subparagraph (d)3 of this paragraph and collect the number of samples specified for standard monitoring under subparagraph (c) of this paragraph or take other appropriate steps such as increased water quality parameter monitoring or re-evaluation of its corrosion control treatment given the potentially different water quality considerations.

(e) Additional monitoring by systems. The results of any monitoring conducted in addition to the minimum requirements of this section shall be considered by the system and may be considered by the State in making any determinations (i.e., calculating the 90th percentile lead or copper level) under this rule.

(f) Invalidation of lead or copper tap water samples. A sample invalidated under this paragraph does not count toward determining lead or copper 90th percentile levels under paragraph (1)(c) or toward meeting the minimum monitoring requirements of subparagraph (c) of this paragraph.

1. The State may invalidate a lead or copper tap water sample at least if one of the following conditions is met.

   (i) The laboratory establishes that improper sample analysis caused erroneous results.

   (ii) The State determines that the sample was taken from a site that did not meet the site selection criteria of this paragraph.

   (iii) The sample container was damaged in transit.

   (iv) There is substantial reason to believe that the sample was subject to tampering.

2. The system must report the results of all samples to the State and all supporting documentation for samples the system believes should be invalidated.

3. To invalidate a sample under subparagraph (f)1 of this paragraph, the decision and the rationale for the decision must be documented in writing. States may not invalidate a sample solely on the grounds that a follow-up sample result is higher or lower than that of the original sample.

 ©2004. TAUD. All Rights Reserved.

4. The water system must collect replacement samples for any samples invalidated under this section if, after the invalidation of one or more samples, the system has too few samples to meet the minimum requirements of subparagraph (c) of this paragraph. Any such replacement samples must be taken as soon as possible, but no later than 20 days after the date the State invalidates the sample or by the end of the applicable monitoring period, whichever occurs later. Replacement samples taken after the end of the applicable monitoring period shall not also be used to meet the monitoring requirements of a subsequent monitoring period. The replacement samples shall be taken at the same locations as the invalidated samples or, if that is not possible, at locations other than those already used for sampling during the monitoring period.

Safety

Refer to the Material Safety Data Sheets for the specific corrosion inhibitors used.

©2004. TAUD. All rights reserved.

Chemical Oxidation

Process Description

Oxidation

The process of converting iron and manganese from soluble to insoluble forms (precipitates).

Soluble Forms of Iron and Manganese

Ferrous Iron Manganous Manganese

Insoluble Forms of Iron and Manganese

Ferric Iron Manganic Manganese

Chemical Oxidants

- Chlorine
- Potassium Permaganate
- Sodium Permanganate

Precipitation

The process of separating a substance from a solution or suspension due to a chemical reaction.

Precipitates are insoluble, finely divided substances which are a product of a chemical reaction in liquids.

Sedimentation

Minimum of 3 hours detention time

Nominal Filtration Rates

Filtration

Rapid Sand = 3 gal/min/ft^2

High Rate = 4 gal/min/ft^2

 ©2004. TAUD. All Rights Reserved.

Process Control

Process control for this process includes the following tasks.

1. Determine the required oxidant dose.
   a) Permanganate Demand Test
   b) Dry Feeders – determine the desired feed rate.
      i) grams per minute (grams/min)
      ii) pounds per day (lbs/day)
   c) Liquid Feeders
      i) Prepare a batch of chemical solution
      ii) Determine the gallons of water required to make the solution.
      iii) Determine the pounds of chemical needed to make the solution.
      iv) Determine the required solution feed rate.
         a. milliliters per minute (mL/min)
         b. ii.gallons per day (gal/day)
2. Analyze the concentrations of permanganate in the finished water.
3. Analyze the iron and manganese concentrations in the raw, finished water, and samples from the distribution system.

Iron, manganese, and organics can be removed using chemical oxidants, such as potassium permanganate (3 percent solution) or sodium permanganate (20 percent solution).

The best dose for either permanganate can be determined by performing the permanganate demand test on a raw water sample.

Once the desired dose is determined, these formulas can be used to calculate the desired feed rate.

Solution Preparation

When preparing potassium permanganate solutions, a three percent solution is best. Potassium permanganate has a limited solubility of about five percent at normal temperatures.

$$\text{Chemical Required, lbs} = \frac{(\text{Volume of Water, gal} \times 8.34\ \text{lbs/gal}) \times \text{Desired Concentration, \%}}{100\% - \text{Desired Concentration, \%}}$$

$$\text{Volume of Water Required, gal} = \frac{\text{Chemical to be Used, lbs} \times (100\% - \text{Desired Concentration, \%})}{8.34\ \text{lbs/gal} \times \text{Desired Concentration, \%}}$$

$$\text{Specific Gravity} = \frac{\text{Weight of cylinder plus contents, g} - \text{Weight of empty cylinder, g}}{100\ g}$$

©2004. TAUD. All rights reserved.

$$\text{Weight of One Gallon of Solution, lbs} = 8.34\ \text{lbs/gal} \times \text{Specific Gravity}$$

$$\text{Concentration, lbs/gal} = \frac{\text{Weight of One Gallon, lbs} \times \text{Concentration, \%}}{100\%}$$

$$\text{Concentration, mg/mL} = \frac{\text{Concentration, lbs/gal} \times 453{,}600\ \text{mg/lbs}}{3{,}785\ \text{mL/gal}}$$

Chemical Feeder Rate, mL/min

These formulas can be used to calculate the required feed rate in milliliters per minute (mL/min).

$$\text{Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(3.785\ \text{liters/gal})}{\text{Concentration, mg/mL}}$$

$$\text{Required Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(3.785\ \text{liters/gal})}{(\text{Concentration, mg/mL})\,(1{,}440\ \text{min/day})}$$

$$\text{Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(3.785\ \text{liters/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}{(\text{Concentration, mg/mL})\,(1{,}440\ \text{min/day})}$$

Chemical Feeder Rate, gal/day

These formulas can be used to calculate the required feed rate in gallons per day (gal/day).

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(8.34\ \text{lbs/gal})\,(1{,}440\ \text{min/day})}{(\text{Concentration, lbs/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(8.34\ \text{lbs/gal})}{(\text{Concentration, lbs/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})}{\text{Concentration, lbs/gal}}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(1{,}440\ \text{min/day})}{(\text{Concentration, \%})\,(\text{Specific Gravity})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})}{(\text{Concentration, \%})\,(\text{Specific Gravity})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})}{(\text{Concentration,\%})\,(\text{Specific Gravity})}$$

 ©2004. TAUD. All Rights Reserved.

Design Criteria – Iron and Manganese Control

4. 7 IRON AND MANGANESE CONTROL - Iron and manganese control, as used herein, refers solely to treatment processes designed specifically for this purpose. The treatment process used will depend upon the character of the raw water. The selection of one or more treatment processes must meet specific local conditions as determined by engineering investigations, including chemical analysis of representative samples of water to be treated, and receive the approval of the Department. It may be necessary to operate a pilot plant in order to gather all information pertinent to the design.

4.7.1 Removal by Oxidation, Detention and Filtration.

a. Oxidation - Oxidation may be by aeration, as indicated in Section 4.6, or by chemical oxidation with chlorine or potassium permanganate.

b. Detention - A minimum detention of 20 minutes shall be provided following oxidation by aeration in order to insure that the oxidation reactions are as complete as possible. The detention basin shall be designed as a holding tank with no provisions for sludge collection but with sufficient baffling to prevent short circuits. Sedimentation basins (3 hours detention time) should be provided when treating water with high iron and/or manganese content or where chemical coagulation is used to reduce the load on the filters.

c. Filtration - Filters shall conform to Section 4.2, except nominal rate shall not exceed 3 gpm/ft^2 of filter area.

4.7.2 Removal by Lime-Soda Process - See Section 4.5.1.

4.7.3 Removal by Units Using Continuous Potassium Permanganate "Regeneration" - This process, consisting of a continuous feed of potassium permanganate to the influent of a manganese green-sand filter, is more applicable to the removal of manganese than to the removal of iron, due to economic considerations. The following apply:

a. The permanganate should be applied as far ahead of the filter as practical.

b. other oxidizing agents or processes such as chlorination or aeration may be used prior to the permanganate feed to reduce the cost of the chemical.

c. Anthracite media cap of at least six inches shall be provided over manganese treated greensand.

d. Normal filtration rate is 3 gpm/ft^2.

e. Normal wash rate is 8 to 10 gpm/ft^2.

f. Air washing should be provided.

©2004. TAUD. All rights reserved.

g. Sample taps should be provided:

1. prior to application of permanganate,

2. immediately ahead of filtration,

3. at point between anthracite coal media and the manganese treated greensand,

4. halfway down the manganese treated greensand,

5. at the filter effluent.

4.7.4 Sequestration by polyphosphates - This process is generally suitable only for low contents of iron and manganese, generally 1.0 mg/L or less. The dosage should not exceed 10 mg/L. Where phosphate treatment is used, satisfactory chlorine residuals should be maintained in the distribution system.

a. Feeding equipment shall conform to requirements of Part 5.

b. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 mg/L chlorine residual.

c. The point of application should be prior to any aeration or oxidation if no iron or manganese removal treatment is provided.

d. Phosphate chemicals must be food grade and meet or exceed AWWA Specifications.

4.7.5 Sampling Equipment - Smooth-nosed sampling taps shall be provided for control purposes. Taps shall be located on each raw water source, each treatment unit influent and each treatment unit effluent.

4.7.6 Testing Equipment - Testing equipment shall be provided for all plants. The equipment should have the capacity to accurately measure the iron content to a minimum of 0.1 mg/L and the manganese content to 0.05 mg/L.

 ©2004. TAUD. All Rights Reserved.

Division of Water Supply Rules

1200-5-1-.12 Secondary Drinking Water Regulations

(1) The following maximum contaminant levels are established to provide a water that is aesthetically pleasing to the consumer. These standards will apply to all community water systems and to those non-community water systems as may be deemed necessary by the Department. Monitoring for these contaminants will be set in the Monitoring Program for each system, but in no event less than once every year for a surface and surface/ground supply and once every three years for a ground water supply.

Contaminant	Maximum Contaminant Level
(e) Iron	0.3 mg/L
(f) Manganese	0.05 mg/L

Monitoring and Reporting

The concentrations of iron and manganese

For each chemical used, this information must be recorded and reported.

- Chemical Fed, lbs – Total Monthly
- Chemical Fed, lbs – Average Daily
- Chemical Fed, lbs – Maximum Daily
- Chemical Fed, lbs – Minimum Daily
- Chemical Cost per Pound
- Chemical Cost per Month
- Calculated Dosage, mg/L – Daily
- Calculated Dosage, mg/L – Total Monthly
- Calculated Dosage, mg/L – Average Daily
- Calculated Dosage, mg/L – Maximum Daily
- Calculated Dosage, mg/L – Minimum Daily

Formulas for Monitoring and Reporting

Liquid Chemical Feed

$$\text{Chemical Fed, gal} = \frac{(0.785)\,(\text{Tank Diameter, in})^2\,(\text{Drop in Volume, in})}{231\,\text{in}^3/\text{gal}}$$

©2004. TAUD. All rights reserved.

$$\text{Chemical Fed, lbs} = (\text{Chemical Fed, gal})\ (\text{Concentration, lbs/gal})$$

$$\text{Chemical Fed, lbs} = \frac{\text{Previous Scale Reading, lbs - Current Scale Reading, lbs}}{\text{Concentration, \%}}$$

Dry Chemical Feed

Dry Chemical Fed, lbs = Previous Scale Reading, lbs – Current Scale Reading, lbs

Monitoring and Reporting

$$\text{Average} = \frac{\text{Sum of All Daily Measuements}}{\text{Number of Daily Measurements}}$$

$$\text{Calculated Dosage, mg/L} = \frac{\text{Chemical Fed, lbs}}{(\text{Flow, MGD})\ (8.34\ \text{lbs/gal})}$$

$$\text{Cost per Pound, \$} = \frac{\text{Cost of Shipment, \$}}{\text{Weight of Shipment, lbs}}$$

$$\text{Cost per Pound, \$} = \frac{\text{Cost per CT, \$}}{100\ \text{lbs/CT}}$$

Cost per Month, $ = Total Pounds of Chemical Used X Cost per Pound, $

 ©2004. TAUD. All Rights Reserved.

Potassium Permanganate Safety

Composition/Information on Ingredients

Material or component - Potassium permanganate 97% min.

CAS No. 7722-64-7

Hazards Identification

1. Eye Contact - Potassium permanganate is damaging to eye tissue on contact. It may cause severe burns that result in damage to the eye.

2. Skin Contact - Contact of solutions at room temperature may be irritating to the skin, leaving brown stains. Concentrated solutions at elevated temperature and crystals are damaging to the skin.

3. Inhalation - Acute inhalation toxicity data are not available. However, airborne concentrations of potassium permanganate in the form of dust or mist may cause damage to the respiratory tract.

4. Ingestion - Potassium permanganate, if swallowed, may cause severe burns to mucous membranes of the mouth, throat, esophagus, and stomach.

First Aid Measures

1. Eyes - Immediately flush eyes with large amounts of water for at least 15 minutes holding lids apart to ensure flushing of the entire surface. Do not attempt to neutralize chemically. Seek medical attention immediately.

Note to physician: Soluble decomposition products are alkaline. Insoluble decomposition product is brown manganese dioxide.

2. Skin - Immediately wash contaminated areas with large amounts of water. Remove contaminated clothing and footwear. Wash clothing and decontaminate footwear before reuse. Seek medical attention immediately if irritation is severe or persistent.

3. Inhalation - Remove person from contaminated area to fresh air. If breathing has stopped, resuscitate and administer oxygen if readily available. Seek medical attention immediately.

4. Ingestion - Never give anything by mouth to an unconscious or convulsing person. If person is conscious, give large quantities of water. Seek medical attention immediately.

Fire Fighting Measures

Red – Flammability – 0

Yellow – Stability - 0

Blue – Health - 1

White – Special - OX

©2004. TAUD. All rights reserved.

FIRST RESPONDERS:

Wear protective gloves, boots, goggles, and respirator. In case of fire, wear positive pressure breathing apparatus. Approach site of incident with caution. Use Emergency Response Guide NAERG 96 (RSPA P5800.7). Guide No. 140.

FLASHPOINT None

FLAMMABLE OR EXPLOSIVE LIMITS Lower: Nonflammable Upper: Nonflammable

EXTINGUISHING MEDIA Use large quantities of water. Water will turn pink to purple if in contact with potassium permanganate. Dike to contain. Do not use dry chemicals, CO2, Halon® or foams.

SPECIAL FIREFIGHTING PROCEDURES If material is involved in fire, flood with water. Cool all affected containers with large quantities of water. Apply water from as far a distance as possible. Wear self-contained breathing apparatus and full protective clothing.

Accidental Release Measures

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

Clean up spills immediately by sweeping or shoveling up the material. Do not return spilled material to the original container. Transfer to a clean metal drum. EPA banned the land disposal of D001 ignitable waste oxidizers. These wastes must be deactivated by reduction. To clean floors, flush with abundant quantities of water into sewer, if permitted by Federal, State, and Local regulations. If not permitted, collect water and treat chemically.

PERSONAL PRECAUTIONS

Personnel should wear protective clothing suitable for the task. Remove all ignition sources and incompatible materials before attempting clean-up.

Handling and Storage

WORK/HYGENIC PRACTICES

Wash hands thoroughly with soap and water after handling potassium permanganate, and before eating or smoking. Wear proper protective equipment. Remove contaminated clothing.

VENTILATION REQUIREMENTS

Provide sufficient area or local exhaust to maintain exposure below the TLV-TWA.

CONDITIONS FOR SAFE STORAGE

Store in accordance with NFPA 430 requirements for Class II oxidizers. Protect containers from physical damage. Store in a cool, dry area in closed containers. Segregate from acids, peroxides, formaldehyde, and all combustible, organic or easily oxidizable materials including anti-freeze and hydraulic fluid.

 ©2003. TAUD All rights reserved.

Exposure Controls/Personal Protection

RESPIRATORY PROTECTION **-** In the case where overexposure may exist, the use of an approved NIOSH-MSHA dust respirator or an air supplied respirator is advised. Engineering or administrative controls should be implemented to control dust.

EYE **-** Faceshield, goggles, or safety glasses with side shields should be worn. Provide eye wash in working area.

GLOVES **-** Rubber or plastic gloves should be worn.

OTHER PROTECTIVE EQUIPMENT **-** Normal work clothing covering arms and legs, and rubber or plastic apron should be worn.

Physical and Chemical Properties

APPEARANCE AND ODOR Dark purple solid with a metallic luster, odorless

SOLUBILITY IN WATER - 6% at 20^{o}C (68^{o}F), and 20% at 65^{o}C (149^{o}F)

OXIDIZING PROPERTIES - Strong oxidizer

SPECIFIC GRAVITY - 2.7 @ 20^{o}C (68^{o}F)

Stability and Reactivity

CONDITIONS TO AVOID - Contact with incompatible materials or heat (>150^{o}C/302^{o}F).

INCOMPATIBLE MATERIALS - Acids, peroxides, formaldehyde, anti-freeze, hydraulic fluids, and all combustible organic or readily oxidizable inorganic materials including metal powders. With hydrochloric acid, toxic chlorine gas is liberated.

HAZARDOUS DECOMPOSITION PRODUCTS - When involved in a fire, potassium permanganate may liberate corrosive fumes.

Toxicological Information

The fatal adult human dose by ingestion is estimated to be 10 grams. (Ref. Handbook of Poisoning: Prevention, Diagnosis & Treatment, Twelfth Edition)

EFFECTS OF OVEREXPOSURE

1. Acute Overexposure - Irritating to body tissue with which it comes into contact.

2. Chronic Overexposure - No known cases of chronic poisoning due to potassium permanganate have been reported. Prolonged exposure, usually over many years, to heavy concentrations of manganese oxides in the form of dust and fumes, may lead to chronic manganese poisoning, chiefly involving the central nervous system.

3. Carcinogenicity - Potassium permanganate has not been classified as a carcinogen by OSHA, NTP, IARC.

©2003. TAUD All rights reserved.

4. Medical Conditions Generally Aggravated by Exposure - Potassium permanganate will cause further irritation of tissue, open wounds, burns or mucous membranes.

Disposal Consideration

DEACTIVATION OF D001 IGNITABLE WASTE OXIDIZERS BY CHEMICAL REDUCTION

Reduce potassium permanganate in aqueous solutions with sodium thiosulfate (Hypo), or sodium bisulfite or ferrous salt solution. The thiosulfite or ferrous salt may require some dilute sulfuric acid to promote rapid reduction. If acid was used, neutralize with sodium bicarbonate to neutral pH. Decant or filter, and mix the sludge with sodium carbonate and deposit in an approved landfill. Where permitted, the sludge can be drained into sewer with large quantities of water. Use caution when reacting chemicals. Contact Carus Chemical Company for additional recommendations.

 ©2003. TAUD All rights reserved.

Sodium Permanganate Chemical Safety

Hazardous Ingredients

Material or Component - Sodium Permanganate, 20%

CAS No. 10101-50-5

Hazard Data

PEL/C 5 mg Mn per cubic meter of air

TLV-TWA 0.2 mg Mn per cubic meter of air

Hazards Identification

1. Eye Contact - Sodium Permanganate is damaging to eye tissue on contact. It may cause burns that result in damage to the eye.

2. Skin Contact - Momentary contact of solution at room temperature may be irritating to the skin, leaving brown stains. Prolonged contact is damaging to the skin.

3. Inhalation - Acute inhalation toxicity data are not available. However, airborne concentrations of sodium permanganate in the form of mist may cause irritation to the respiratory tract.

4. Ingestion - Sodium permanganate solution, if swallowed, may cause burns to mucous membranes of the mouth, throat, esophagus, and stomach.

First Aid Measures

1. Eyes - Immediately flush eyes with large amounts of water for at least 15 minutes holding lids apart to ensure flushing of the entire surface. Do not attempt to neutralize chemically. Seek medical attention immediately. Note to physician: Decomposition products are alkaline.

2. Skin - Immediately wash contaminated areas with water. Remove contaminated clothing and footwear. (Caution: Solution may ignite certain textiles). Wash clothing and decontaminate footwear before reuse. Seek medical attention immediately if irritation is severe and persistent.

3. Inhalation - Remove person from contaminated area to fresh air. If breathing has stopped, resuscitate and administer oxygen if readily available. Seek medical attention immediately.

4. Ingestion - Never give anything by mouth to an unconscious or convulsing person. If person is conscious, give large quantities of water or milk. Seek medical attention immediately.

Fire Fighting Measures

Health Hazard 1 = Materials which under fire conditions would give off irritating combustion products (less than 1 hour exposure). Materials which on the skin could cause irritation.

©2003. TAUD All rights reserved.

Flammability Hazard 0 = Materials that will not burn.

Reactivity Hazard 0 = Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.

Special Hazard OX = Oxidizer

Accidental Release Measures

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

- Contain spill by collecting the liquid in a pit or holding behind a dam (sand or soil).
- Dilute to approximately 6% with water, and then reduce with sodium thiosulfate, a bisulfite or ferrous salt solution. The bisulfite or ferrous salt may require some dilute sulfuric acid (10% w/w) to promote reduction.
- Neutralize with sodium carbonate to neutral pH, if acid was used. Decant or filter and deposit sludge in approved landfill.
- Where permitted, the sludge may be drained into sewer with large quantities of water. To clean contaminated floors, flush with abundant quantities of water into sewer, if permitted by federal, state, and local regulations. If not, collect water and treat as above.

PERSONAL PRECAUTIONS

Personnel should wear protective clothing suitable for the task. Remove all ignition sources and incompatible materials before attempting clean up.

Handling and Storage

WORK/HYGIENIC PRACTICES - Wash hands thoroughly with soap and water after handling permanganate solution, and before eating or smoking. Wear proper protective equipment. Remove clothing, if it becomes contaminated.

VENTILATION REQUIREMETNS - Provide sufficient mechanical and/or local exhaust to maintain exposure below the TLV/TWA.

CONDITIONS FOR SAFE STORAGE - Store in accordance with NFPA 430 requirements for Class II oxidizers. Protect containers from physical damage. Store in a cool, dry area in closed containers. Segregate from acids, peroxides, formaldehyde, and all combustible, organic, or easily oxidizable materials including antifreeze and hydraulic fluid.

Exposure Controls and Personal Protection

RESPIRATORY PROTECTION - In cases where overexposure to mist may occur, the use of an approved NIOSH-MSHA mist respirator or an air supplied respirator is advised. Engineering or administrative controls should be implemented to control mist.

EYE - Faceshield, goggles, or safety glasses with side shields should be worn. Provide eyewash in working area.

 ©2003. TAUD All rights reserved.

GLOVES - Rubber or plastic gloves should be worn.

OTHER PROTECTIVE EQUIPMENT - Normal work clothing covering arms and legs, and rubber, or plastic apron should be worn. Caution: If clothing becomes contaminated, wash off immediately. Spontaneous ignition may occur with cloth or paper.

Physical and Chemical Properties

APPEARANCE AND ODOR - Dark purple solution, odorless

PERCENT VOLATILE BY VOLUME - 80% (as water)

SPECIFIC GRAVITY - 1.16

pH - 6-9

OXIDIZING PROPERTIES - Strong oxidizer. May ignite wood and cloth.

EXPLOSIVE PROPERTIES - Explosive in contact with sulfuric acid or peroxides, or readily oxidizable substances.

Stability and Reactivity

STABILITY - Under normal conditions, the material is stable.

CONDITIONS TO AVOID - Contact with incompatible materials or heat (135° C/275ºF).

INCOMPATIBLE MATERIALS - Acids, peroxides, formaldehyde, antifreeze, hydraulic fluids, and all combustible organic or readily oxidizable materials, including metal powders. With hydrochloric acid, toxic chlorine gas is liberated.

HAZARDOUS DECOMPOSITION PRODUCTS - When involved in a fire, sodium permanganate may form corrosive fumes.

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION - Material is not known to polymerize.

Toxicological Information

1. Acute Overexposure - Irritating to body tissue with which it comes into contact.

2. Chronic Overexposure - No known cases of chronic poisoning due to permanganates have been reported. Prolonged exposure, usually over many years, to heavy concentrations of manganese oxides in the form of dust and fumes may lead to chronic manganese poisoning, chiefly involving the central nervous system.

3. Carcinogenicity - Sodium Permanganate has not been classified as a carcinogen by OSHA, NTP, IARC.

4. Medical Conditions Generally Aggravated by Exposure - Sodium permanganate solution will cause further irritation of tissue, open wounds, burns or mucous membranes.

©2003. TAUD All rights reserved.

Disposal Considerations

Waste Disposal

Liquid sodium permanganate, once it becomes a waste, is considered a D001 hazardous (ignitable) waste. For disposal of liquid permanganate solutions, follow procedures in Section 6 and deactivate the permanganate to insoluble manganese dioxide. Dispose of it in a permitted landfill. Contact supplier for additional recommendations.

 ©2003. TAUD All rights reserved.

Notes

©2003. TAUD All rights reserved.

Fluoridation

Process Description

Purpose To provide and maintain a fluoride concentration in the finished water sufficient to reduce the incidence of tooth decay (1.0 mg/l).

Fluoride's effectiveness depends on the amount of fluoride ion consumed each day, which in turn,

depends on:

(1) the fluoride concentration in the drinking water; and,

(2) the amount of water consumed.

Optimum fluoride levels must be maintained in the water in order to achieve maximum benefits from fluoride. The optimum fluoride concentration is 1.0 mg/L.

Two Problems

Dental Fluorosis

- Mildest Form - mottling (light, opaque areas, whitish in color)
- More Severe Form - teeth darken to shades of gray to black
- Most Severe Form - pitting forms in teeth, increasing the likelihood of decay.
- Occasional overfeeding does not cause dental fluorosis.
- Fluorosis results from excessive fluoride levels in drinking water when the fluoride level is greater than approximately 5 mg/l.

Skeletal Fluorosis – a crippling skeletal disorder, similar to arthritis.

Fluoride Chemicals

Sodium Fluoride

DOT Chemical Name: .....Sodium Fluoride

Synonyms:.....SF

Chemical Family:.....Inorganic Fluoride

Formula:.....NaF

Specific Gravity (H2O)=1): 2.56

Solubility in Water:.....4g/100g H_2O

Physical State:.....Solid, granular

 ©2003. TAUD All rights reserved.

Molecular Weight: 42.00

Bulk Density: .....1.44g/cm3(90 lb./ft^3)

pH (1% solution):.....Close to 7

Appearance and Odor: .....White, crystalline powder, no odor.

Fluoride concentration in a 4% solution: .....18 mg/mL

Fluoride concentration in a 4% solution: .....0.15 lbs/gal.

Hydrofluosilicic Acid

DOT Chemical Name: .....Fluorosilicic Acid

Synonyms:.....Hydrofluosilicic Acid, Fluosilicic Acid, Hexafluosilicic Acid

Chemical Family:.....Inorganic

Acid Formula: ……H2SiF6

Freezing Point:.....4°F(-15.5°C)

Specific Gravity(H2O=1): .....1.234 @ 25%

Physical State: .....Fuming Liquid

Molecular Weight: 144.08

Bulk Density: 10.29 lbs/gal @ 25% pH (1% Solution): 1.2

Appearance and Odor: .....Water white to straw yellow, burning liquid, with pungent odor.

Fluoride concentration in a 23% solution: .....227 mg/mL

Fluoride concentration in a 23% solution: .....1.89 lbs/gal.

Fluoride concentration in a 24% solution: .....237 mg/mL

Fluoride concentration in a 24% solution: .....1.98 lbs/gal.

Fluoride concentration in a 23% solution: .....247 mg/mL

Fluoride concentration in a 23% solution: .....2.06 lbs/gal.

pH.....1.0 to 1.5

Sodium Silicofluoride

DOT Chemical Name: .....Sodium Fluorosilicate

Synonyms:.....Sodium Silicofluoride, Sodium Fluosilicate, Disodium Hexafluosilicate

©2003. TAUD All rights reserved.

Specific Gravity (H2O=1): 2.679

Bulk Density: .....90 lbs/Ft^3

pH: 3.1

Solubility in Water: .....0.76 grams/100 ml of water @ 25°C; 2.45 grams/100 ml of water @ 100°C

Physical State:.....Solid, granules

Molecular Weight: 188.05

Appearance and Odor: .....White, odorless, granular, crystalline

Process Control

Process control consists of:

Determining the amount of fluoride in the raw water.

Determining the fluoride dose needed.

Setting chemical feeders to deliver the desired dose;

1. Hydrofluosilicic Acid (Fluorosilicic Acid)
   a. feeder setting in milliliters per minute;
   b. feeder setting in gallons per day.
2. Saturated Sodium Fluoride Solution
   a. feeder setting in milliliters per minute;
   b. feeder setting in gallons per day;
3. Sodium Silicofluoride
   a. feeder setting in grams per minute;
   b. feeder setting in pounds per day.

Hydrofluosilicic Acid Feed Rate, ml/min

These formulas can be used to calculate the hydrofluosilicic acid feed rate in milliliters per minute (ml/min) when flow is given in gallons per minute.

$$\text{Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(3.785\ \text{L/gal})}{227\ \text{mg/mL}}$$

$$\text{Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(3.785\ \text{L/gal})}{(227\ \text{mg/mL})\,(1{,}440\ \text{min/day})}$$

$$\text{Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(3.785\ \text{L/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}{(227\ \text{mg/mL})\,(1{,}440\text{min/day})}$$

 ©2003. TAUD All rights reserved.

There is some variability in the fluoride concentration in hydrofluosilicic acid. It ranges from 227 mg/mL (23%) to 247 mg/mL (25%).

Hydrofluosilicic Acid - Liquid Feeder Setting, gal/day

These formulas can be used to calculate feeder settings in gallons per day for hydrofluosilicic acid.

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/l})\,(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})}{\text{Concentration, lbs/gal}}$$

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/l})\,(\text{Flow, gal/day})\,(8.34\ \text{lbs/gal})}{(\text{Concentration, lbs/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/l})\,(\text{Flow, gal/min})\,(1{,}440\ \text{min/day})\ \ (8.34\ \text{lbs/gal})}{(\text{Concentration, lbs/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

These formulas can be used to calculate feeder settings in gallons per day for hydrofluosilicic acid.

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/l})\,(\text{Flow, MGD})}{(0.18216)\,(\text{Specific Gravity})}$$

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/l})\,(\text{Flow, gal/day})}{(0.18216)\,(\text{Specific Gravity})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/l})\,(\text{Flow, gal/min})\,(1{,}440\ \text{min/day})}{(0.18216)\,(\text{Specific Gravity})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

Saturated Sodium Fluoride Solution Feed Rate, mL/min

These formulas can be used to calculate the saturated sodium fluoride solution feed rate in milliliters per minute (ml/min) when flow is given in gallons per minute.

$$\text{Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(3.785\ \text{L/gal})}{18\ \text{mg/mL}}$$

$$\text{Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(3.785\ \text{L/gal})}{(18\ \text{mg/mL})\,(1{,}440\ \text{min/day})}$$

$$\text{Feed Rate, mL/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(3.785\ \text{L/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}{(18\ \text{mg/mL})\,(1{,}440\ \text{min/day})}$$

©2003. TAUD All rights reserved.

Saturated Sodium Fluoride Solution Feed Rate, gal/day

These formulas can be used to calculate feeder settings in gallons per day for saturated sodium fluoride solutions.

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/l})\,(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})}{0.15\ \text{lbs/gal}}$$

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/l})\,(\text{Flow, gal/day})\,(8.34\ \text{lbs/gal})}{(0.15\ \text{lbs/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/l})\,(\text{Flow, gal/min})\,(1{,}440\ \text{min/day})\ \ (8.34\ \text{lbs/gal})}{(0.15\ \text{lbs/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

Sodium Silicofluoride Feed Rate, grams/min

$$\text{Feed Rate, grams/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/min})\,(3.785\ \text{L/gal})}{(1{,}000\ \text{mg/gram})\,(0.598)}$$

$$\text{Feed Rate, grams/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(3.785\ \text{L/gal})}{(1{,}000\ \text{mg/gram})\,(0.598)\,(1{,}440\ \text{min/day})}$$

$$\text{Feed Rate, grams/min} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(3.785\ \text{L/gal})\,(1{,}000{,}000\ \text{gal/day/MGD})}{(1{,}000\ \text{mg/gram})\ \ (0.598)\,(1{,}440\ \text{min/day})}$$

Sodium Silicofluoride Feed Rate, lbs/day

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(8.34\ \text{lbs/gal})}{(0.598)\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, gal/day})\,(8.34\ \text{lbs/gal})}{(0.598)\,(1{,}000{,}000\ \text{gal/day/MGD})}$$

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})}{0.598}$$

 ©2003. TAUD All rights reserved.

Process Evaluation and Troubleshooting

The optimal fluoride concentration in 1.0 mg/L. Fluoride compounds should be fed so that the fluoride concentration in the water is 1.0 mg/L (including any fluoride that is naturally present.

Common Operating Problems

Variable Fluoride Readings - Causes:

- dilution of fluoridated water unfluoridated water in finished water storage tanks;
- feeders out of calibration.

Low Fluoride Readings Causes:

- Aluminum interfering with the Alizarin-Visual test;
- underdosing caused by inadequate sodium fluoride depth in a saturator;
- empty feeders;
- under dosing due to incomplete mixing in dissolving tanks;
- water which has been fluoridated mixing with water which has not been fluoridated.

High Fluoride Readings - Causes:

- Interference from polyphosphates, resulting in high fluoride readings (1.0 mg/l polyphosphates increases fluoride reading by 0.1 mg/l).
- Not accounting for natural fluoride in the water.

It is advisable to shut down fluoride feeder until the cause is identified and the problem is solved.

Design Criteria

4.8 FLUORIDATION - Commercial sodium fluoride, sodium silicofluoride and hydrofluosilicic acid shall conform to the applicable AWWA Standards. Other chemicals which may be made available must be approved by the Department.

4.8.1 Fluoride Compound Storage - Compounds shall be stored in covered or unopened shipping containers. Bulk storage units and day tanks, including carboys and drums in use for hydrofluosilicic acid, shall be vented to the atmosphere at a point outside any building.

4.8.2 Dry Conveyers - Provision must be made for the proper transfer of dry fluoride compounds from shipping containers to storage bins or hoppers, in such a way as to minimize the quantity of fluoride dust.

4.8.3 Chemical Feed Installations

a. shall conform to Part 5,

©2003. TAUD All rights reserved.

b. shall provide scales or loss-of-weight recorders for dry or acid chemical feeds. Dry volumetric feeders are to have percent-of-cycle timer or variable speed SCR drive. A minimum of 35-gallon dissolver with mechanical agitation,

c. shall have an accuracy that actual feed will be within 5% of that intended,

d. shall be such that the point of application of hydrofluosilicic acid, if into a pipe, shall be in the lower third of the pipe and project upward,

e. downflow saturators are not acceptable,

f. shall provide adequate anti-siphon devices for all fluoride feed lines,

g. piping from bulk storage to day tank should be schedule 80 PVC.

4.8.4 Protective Equipment - Suitable protective equipment shall be provided.

4.8.5 Dust Control Equipment - Suitable equipment shall be provided for wet-mopping and hosing dust that might accumulate in the plant.

4.8.6 Testing Equipment - Equipment shall be provided for measuring the quantity of fluoride ion in the water. Such equipment shall be subject to the approval of the Department.

Division of Water Supply Regulations

1200-5-1-.06 Maximum Contaminant Levels.

(1) Inorganic Chemicals

(a) The maximum contaminant level for fluoride applies to community water systems. The maximum contaminant levels for nitrate, nitrite and total nitrate and nitrite are applicable to both community water systems and non-community water systems. The maximum contaminant levels for the remaining inorganic chemicals apply only to community water systems and non-transient non-community systems. The effective date for antimony, beryllium, cyanide, nickel and thallium shall be January 1, 1993, or the effective date of this rule whichever is later.

(b) The following are the maximum contaminant levels for inorganic chemicals:

CONTAMINANT	LEVEL, MILLIGRAMS PER LITER
9. Fluoride	4.0

This limit is set to avoid crippling skeletal fluorosis.

 ©2003. TAUD All rights reserved.

1200-5-1-.12 Secondary Drinking Water Regulations

(1) The following maximum contaminant levels are established to provide a water that is aesthetically pleasing to the consumer. These standards will apply to all community water systems and to those non-community water systems as may be deemed necessary by the Department. Monitoring for these contaminants will be set in the Monitoring Program for each system, but in no event less than once every year for a surface and surface/ground supply and once every three years for a ground water supply.

Contaminant	**Maximum Contaminant Level mg/L unless otherwise indicated**
(l) Fluoride	2.0

This limit is set to avoid dental fluorosis.

1200-5-1-.17 Operations and Maintenance Requirements

(20) Public water systems which adjust the fluoride content of the water supply shall maintain the concentration of fluoride in the finished water between 0.9 mg/l and 1.3 mg/l based on the monthly average. Each water system adjusting the fluoride content to the finished water must monitor for fluoride as required by the system's individual monitoring program established by the Department.

1200-5-1-.19 Public Notice

(8) Community water systems that exceed the secondary maximum contaminant level for fluoride as determined by the last single sample taken in accordance with the requirements of 1200-5-1-.09 shall send the notice described in (9) to all billing units annually, all new billing units at the time service begins, and the Department.

(9) The notice to be used by systems which exceed the secondary MCL for fluoride shall contain the following language and no additional language except as necessary to replace the asterisks:

Public Notice

Dear User:

The Tennessee Department of Health and Environment requires that we send you this notice on the level of fluoride in your drinking water. The drinking water in your community has a fluoride concentration of * milligrams per liter (mg/l).

State regulations require that fluoride which occurs naturally in your water supply not exceed a concentration of 4.0 mg/l in drinking water. This is an enforceable standard called a Maximum Contaminant Level (MCL), and it has been established to protect the public health.

©2003. TAUD All rights reserved.

Exposure to drinking water levels above 4.0 mg/l for many years may result in some cases of crippling skeletal fluorosis, which is a serious bone disorder.

State law also requires that we notify you when monitoring indicates that the fluoride in your drinking water exceeds 2.0 mg/l. This is intended to alert families about dental problems that might affect children under nine years of age. The fluoride concentration of your water exceeds this federal guideline.

Fluoride in children's drinking water at levels of approximately 1 mg/l reduces the number of dental cavities. However, some children exposed to levels of fluoride greater than about 2.0 mg/l may develop dental fluorosis. Dental fluorosis, in its moderate and severe forms, is a brown staining and/or pitting of permanent teeth.

Because dental fluorosis occurs only when developing teeth (before they erupt from the gums) are exposed to elevated fluoride levels, households without children are not expected to be affected by this level of fluoride. Families with children under the age of nine are encouraged to seek other sources of drinking water for their children to avoid the possibility of staining and pitting.

Your water supplier can lower the concentration of fluoride to your water so that you will still receive the benefits of cavity prevention while the possibility of stained and pitted teeth is minimized. Removal of fluoride may increase your water costs. Treatment systems are also commercially available for home use. Information on such systems is available at the address given below. Low fluoride bottled drinking water that would meet all standards is also commercially available.

For further information, contact ** at your water system.

* The Public Water System shall insert the compliance result which triggered notification under this part.

** The Public Water System shall insert the name, address, and telephone number of a contact person at the Public Water System.

(10) The owner or operator shall notify persons served by the system of the availability of the results of sampling conducted under 1200-5-1-.28 by including a notice in the first set of water bills issued by the system after the receipt of the results or by written notice within three months. The notice shall identify a person and supply the telephone number to contact for information on the monitoring results.

Safety

Types of Exposure

Acute Toxic Exposure – [1]reaching a crisis rapidly; [2]a single, massive dose.

Chronic Toxic Exposure – [1]of long duration; [2]exposure to large doses fluoride over long periods of time.

 ©2003. TAUD All rights reserved.

Modes of Exposure

Inhalation – most likely mode of chronic exposure.

Ingestion

Bodily Contact

Symptoms of Exposure

Acute

Fluoride dust may cause irritation to eyes and respiratory tract.

Swallowing fluoride dust may cause nausea, vomiting, abdominal pain or burning, diarrhea, shortness of breath, difficulty in speaking, thirst, weakness of pulse, disturbed color vision, muscular weakness, convulsions, loss of consciousness and death. Kidney injury and bleeding from injury may occur.

Chronic

Repeated exposure above the PEL or TLV to fluoride dust may cause excessive calcification of ligaments of the ribs, pelvis and spinal column. Sclerosis or changes of bones and ligaments can be seen by x-ray.

Enzyme system effects and pulmonary fibrosis are reported.

Stiffness and limitation of motions may result.

Common findings are eye, skin, and mucous membrane irritation, loss of weight, anorexia, anemia, wasting, cachexia, and dental defects.

Repeated or prolonged exposure to the skin may cause skin rash.

Aggravated Medical Condition

Pre-existing respiratory diseases including asthma and emphysema.

©2003. TAUD All rights reserved.

Specific Chemical Safety Information

Hydrofluosilicic Acid

Personal Protection Information

Respiratory Protection: A NIOSH approved cartridge respirator with full-face shield. Chemical cartridge should provide protection against acid fumes (Hydrogen Fluoride). For concentrations greater than 20ppm, a NIOSH approved self-contained breathing apparatus with full-face shield should be used.

Eye and Face Protection: Use tight-fitting chemical splash goggles and a full-face shield, 8 inch minimum. Contact lenses should not be worn.

Hand, Arm and Body Protection: Prevent contact with skin by use of acid-proof clothing, gloves and shoes. Use a NIOSH approved acid proof suit and boots where liquid or high vapor concentration is possible.

Other Protective Clothing and Equipment: Eye wash and emergency shower facilities should be available in handling area.

Engineering Controls: General or local exhaust systems sufficient to maintain vapors below 2.5 mg/m^3 (as F).

Symptoms of Exposure:

Acute:

Liquid or vapors can cause severe irritation and burns which may not be apparent for hours.

Can cause severe irritation to the lungs, nose and throat if swallowed, can cause severe damage to throat and stomach.

Chronic:

Prolonged exposure could result in bone changes, corrosive effect on mucous membranes including ulceration of nose, throat and bronchial tubes, cough, shock, pulmonary edema, Fluorosis, coma and death.

Aggravated Medical Condition: Any skin condition and/or pre-existing respiratory disease including asthma and emphysema.

Toxic Data:.....LD50200 mg/kg (Oral - Guinea Pig)

Emergency and First Aid Procedures

Inhalation: Remove exposed person to an uncontaminated area immediately. If breathing has stopped, start artificial respiration at once. Oxygen should be provided for an exposed person having difficulty breathing (but only by an authorized person) until exposed person is able to breathe easily by themselves. Exposed person should be examined by a physician.

 ©2003. TAUD All rights reserved.

Eye Contact: Flush eyes for at least 15 minutes with large amounts of water. Eyelids should be held apart during the flushing to insure contact of water with all accessible tissue of the eyes and lids. Medical attention should be given as soon as possible.

Skin Contact: Exposed person should be removed to an uncontaminated area and subjected immediately to a drenching shower of water for a minimum of 15 to 20 minutes. Remove all contaminated clothing while under shower. Medical attention should be given as soon as possible for all burns, regardless of how minor they seem.

Ingestion: If conscious, give the exposed person large quantities of water immediately to dilute the acid. Do NOT induce vomiting. Milk may be given for its soothing effect. A physician should be contacted immediately.

Note to Physician: Beware of late onset of pulmonary edema for up to 48 hours. Treat severe burns similar to Hydrofluoric Acid exposure.

Storage and Special Precautions

Handling and Storing Precautions:

- Store in containers in cool, dry, well ventilated area away from sources of heat or ignition.
- Do NOT store in glass or stoneware.
- Use non-sparking tools.
- Keep separate from alkali metals, oxidizing agent, combustible solids and organic peroxides.

Ventilation:

Provide adequate general and/or local exhaust to maintain vapors below 2.5 mg/m3 (as F).

Other Precautions:

- Do not inhale fumes and prevent skin contact.
- If pungent, irritating odor can be detected, workers are being over-exposed.
- Eye wash and safety shower should be available in all acid handling areas.

Emergency Action – Spills or Leaks

Emergency Action:

1. Keep unnecessary people away.
2. Stay upwind, keep out of low areas.
3. Isolate hazard area and deny entry.
4. We recommend that the user establish a spill prevention, control and countermeasure plan. This plan should include procedures for proper storage as well as containment and clean-up of spills and leaks. The procedures should conform to safe practices and provide for proper recovery and disposal in accordance with federal, state and local regulation. Contact Chemtrec at 1-800-424-9300 for 24-hour emergency assistance.

©2003. TAUD All rights reserved.

Small Spills:

1. Any personnel in area should wear a NIOSH approved air supplied acid suit.
2. Dike area to contain material.
3. Do not allow solution to enter sewers or surface water.
4. Neutralize the spill with water and lime (hydrated lime).
5. Take up with sand or non-combustible absorbent material and place in containers for later disposal.
6. Provide ventilation and be wary of hydrogen generation upon reaction with some metals.
7. Contact Chemtrec at 1-800-424-9300 for 24-hour emergency assistance.

Large Spills:

1. Contact Chemtrec at 1-800-424-9300 for 24-hour emergency assistance.
2. Any personnel in area should wear a NIOSH approved air supplied acid suit.
3. Dike area ahead of spill to contain material.
4. Do not allow solution to enter sewers or surface water.
5. Neutralize the spill with water and lime (hydrated lime).
6. Provide ventilation and be wary of hydrogen generation upon reaction with some metals.
7. Notify the National Response Center, if required.

 ©2003. TAUD All rights reserved.

Sodium Fluorosilicate

Personal Protection Information

Respiratory Protection: A NIOSH approved respirator should be worn. Self-contained breathing apparatus may be required when chemical is heated to decomposition or in a spill area.

Eye and Face Protection: Splash-proof goggles should be worn when there is danger of splash from solution containing chemical. Protection against splash or mist from solution containing chemical with 8-inch minimum face shield is recommended. Eye protection should be worn in presence of dry chemical, or solution, containing chemical, at all times.

Hand, Arm and Body Protection: Impervious gloves should be worn. Protective, impervious clothing should be worn in presence to prevent contact with skin (coveralls, boots, etc.)

Other Protective Clothing and Equipment: Protect open wounds. Heating to decomposition requires full protective clothing and self-contained breathing apparatus.

Engineering Controls: Adequate ventilation to maintain fluoride concentrations below applicable standards.

Symptoms of Exposure:

Acute: Fluoride dust may cause irritation to eyes and respiratory tract. Swallowing fluoride dust may cause nausea, vomiting, abdominal pain or burning, diarrhea, shortness of breath, difficulty in speaking, thirst, weakness of pulse, disturbed color vision, muscular weakness, convulsions, loss of consciousness and death. Kidney injury and bleeding from injury may occur.

Chronic: Repeated exposure above the PEL or TLV to fluoride dust may cause excessive calcification of ligaments of the ribs, pelvis and spinal column. Sclerosis of changes of bones and ligaments can be seen by x-ray. Enzyme system effects and pulmonary fibrosis are reported. Stiffness and limitation of motions may result. Common findings are eye, skin, and mucous membrane irritation, loss of weight, anorexia, anemia, wasting, cachexia, and dental defects. Repeated or prolonged exposure to the skin may cause skin rash.

Aggravated Medical Condition: Pre-existing respiratory diseases including asthma and emphysema.

Emergency and First Aid Procedures

Inhalation: If a person breathes in chemical dust, remove exposed person promptly to fresh air. If breathing has stopped, perform artificial respiration. Oxygen should be provided for a person having difficulty breathing (but only administered by an authorized individual) until the person is able to breath easily by themselves. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Eye Contact: Flush eyes with large amounts of water, lifting the upper and lower lids at periodic intervals to insure contact of water with all accessible tissue of the eyes and lids. Medical attention should be given as soon as possible, preferably an eye specialist.

©2003. TAUD All rights reserved.

Skin Contact: Promptly wash the contaminated skin using soap or mild detergent and water. If chemical, or solution containing chemical, soaks through clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. Medical attention should be given as soon as possible for all burns, regardless of how minor thy seem.

Ingestion: If conscious, give the exposed person large quantities of water immediately. Do NOT induce vomiting. Several glasses of milk may be given for its soothing effect. A physician should be contacted immediately. Note to Physician: Exposed person should be observed for 48 - 72 hours for delayed onset of pulmonary edema.

Storage and Handling

Handling and Storing Precautions: Store in a cool, dry place and away from acids. Use only with adequate ventilation, dust mask or self-contained breathing apparatus. Protective clothing should always be worn. Avoid contact with eyes, skin, and clothing. Keep bag or container closed when not in use. Avoid breathing dust or mist.

Ventilation: Provide adequate general and/or local exhaust to maintain vapors below acceptable air level maximums.

Other Precautions: Do not get on skin, clothing, or in eyes. Wash off with water. Do not take internally. Do not breathe dust. Keep separated from strong acids and alkalis.

Emergency Action – Spills or Leaks

Emergency Action: Keep unnecessary people away. Stay upwind, keep out of low areas. Isolate hazard area and deny entry. Ventilate closed spaces before entering them. We recommend that the user establish a spill prevention, control and countermeasure plan. This plan should include procedures for proper storage as well as containment and clean up of spills and leaks. The procedures should conform to safe practices and provide for proper recovery and disposal in accordance with federal, state and local regulation. Contact Chemtrec at 1-800-424-9300 for 24-hour emergency assistance.

Small Spills: Employees should be trained in safety procedures for storage and handling this product. Any personnel in area should wear a NIOSH approved breathing apparatus and protective clothing. Isolate product spill area. Carefully shovel material and place in clean, dry container and cover. Remove container from spill site and dispose of in accordance with federal, state and local regulations. Contact Chemtrec at 1-800-424-9300 for 24-hour emergency assistance.

Large Spills: Contact Chemtrec at 1-800-424-9300 for 24-hour emergency assistance. Employees should be trained in safety procedures for the storage and handling of this product. Any personnel in area should wear a NIOSH approved breathing apparatus and protective clothing. Isolate product spill area. Carefully shovel material and place in clean, dry container and cover. Remove container from spill site and dispose of in accordance with federal, state and local regulations.

 ©2003. TAUD All rights reserved.

Sodium Fluoride

Personal Protection Information

Respiratory Protection: A NIOSH approved single-use dust respirator. Self-contained breathing apparatus may be required when dealing with spills or when heated to decomposition.

Eye and Face Protection: Splash-proof goggles should be worn when there is danger of splash from solution containing chemical. Protection against splash or mist from solution containing chemical with 8-inch minimum face shield is recommended. Eye protection should be worn in presence of dry chemical, or solution, containing chemical, at all times.

Hand, Arm and Body Protection: Impervious gloves should be worn. Protective, impervious clothing should be worn in presence to prevent contact with skin (coveralls, boots, etc.)

Other Protective Clothing and Equipment: Protect open wounds. Heating to decomposition requires full protective clothing and self-contained breathing apparatus.

Engineering Controls: Adequate ventilation to maintain fluoride concentrations below applicable standards.

Symptoms of Exposure:

Acute: Inhalation of dust or mist may cause severe mucous membrane irritation and burns. Effects may not be immediately apparent, especially with diluted solutions. First aid procedures should be followed even in cases of suspected contact.

Chronic: Causes severe skin irritation and burns. Ingestion or inhalation may be harmful and possibly fatal depending on severity and length of over-exposure. Chronic over-exposure may cause Fluorosis. Product may be absorbed through the skin and produce signs of fluorosis such as weight loss, brittleness of bones, anemia, weakness and stiffness of joints. Internal bleeding may develop.

Aggravated Medical Condition: Any skin, respiratory or mucous membrane conditions.

Emergency and First Aid Procedures

Inhalation: If a person breathes in chemical dust or mist, remove exposed person promptly to fresh air. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Eye Contact: Flush eyes with large amounts of water, lifting the upper and lower lids at periodic intervals to insure contact of water with all accessible tissue of the eyes and lids. Medical attention should be given as soon as possible, preferably an eye specialist.

Skin Contact: Promptly wash the contaminated skin using soap or mild detergent and water. If chemical, or solution containing chemical, soaks through clothing, remove the clothing promptly and wash the skin using soap or mild detergent and water. Medical attention should be given as soon as possible for all burns, regardless of how minor thy seem.

Ingestion: If conscious, give the exposed person large quantities of water immediately. Do NOT induce vomiting. Several glasses of milk may be given for its soothing effect. A physician should

©2003. TAUD All rights reserved.

be contacted immediately. Note to Physician: Exposed person should be observed for 48 - 72 hours for delayed onset of pulmonary edema.

Storage and Handling

Handling and Storing Precautions: Store in a cool, dry place and away from acids. Use only with adequate ventilation, dust mask or self-contained breathing apparatus. Protective clothing should always be worn. Avoid contact with eyes, skin, and clothing. Keep bag or container closed when not in use. Avoid breathing dust or mist.

Ventilation: Provide adequate general and/or local exhaust to maintain vapors below acceptable air level maximums.

Other Precautions: If chemical should become heated, as in a fire, it will decompose, releasing highly toxic hydrogen fluoride gas.

Emergency Actions – Spills or Leaks

Emergency Action:

1. Keep unnecessary people away.
2. Stay upwind, keep out of low areas.
3. Isolate hazard area and deny entry.
4. Ventilate closed spaces before entering them.
5. We recommend that the user establish a spill prevention, control and countermeasure plan. This plan should include procedures for proper storage as well as containment and clean-up of spills and leaks. The procedures should conform to safe practices and provide for proper recovery and disposal in accordance with federal, state and local regulation.
6. Contact Chemtrec at 1-800-424-9300 for 24-hour emergency assistance.

Small Spills:

1. Employees should be trained in safety procedures for storage and handling this product.
2. Any personnel in area should wear a NIOSH approved breathing apparatus and protective clothing.
3. Isolate product spill area.
4. Carefully shovel material and place in clean, dry container and cover.
5. Remove container from spill site and dispose of in accordance with federal, state and local regulations.
6. Contact Chemtrec at 1-800-424-9300 for 24-hour emergency assistance.

Large Spills:

1. Contact Chemtrec at 1-800-424-9300 for 24-hour emergency assistance.
2. Employees should be trained in safety procedures for the storage and handling of this product.

 ©2003. TAUD All rights reserved.

3. Any personnel in area should wear a NIOSH approved breathing apparatus and protective clothing.
4. Isolate product spill area.
5. Carefully shovel material and place in clean, dry container and cover.
6. Remove container from spill site and dispose of in accordance with federal, state and local regulations.

©2003. TAUD All rights reserved.

Recommend Actions for Fluoride Overfeed

If the fluoride content (mg/L) is:	***Then perform the following actions:***
0.5 to 2.0	1. Leave the fluoride feeder on. 2. Determine what has malfunctioned and repair it.
2.0 to 4.0	1. Leave the fluoride feeder on. 2. Determine what has malfunctioned and repair it. 3. Notify your supervisor: 4. Name: _____ 5. Phone: _____ 6. Notify the Division of Water Supply: Name: _____ 7. Phone: _____
4.0 to 10.0	1. Determine what has malfunctioned and try to repair it. 2. If the problem is not found and corrected quickly, turn off the fluoride feeder. 3. Notify your supervisor: 4. Name: _____ 5. Phone: _____ 6. Notify the Division of Water Supply: Name: _____ 7. Phone: _____ 8. Take water samples at several points in the distribution system and test for fluoride content. (Save the parts of the water samples not used.) 9. Determine what has malfunctioned and repair it. With supervisor's permission, restart the fluoride feeder.
> 10.0	1. Turn off the fluoride feeder **immediately**. 2. Notify your supervisor: 3. Name: _____ 4. Phone: _____ 5. Notify the Division of Water Supply: Name: _____

 ©2003. TAUD All rights reserved.

If the fluoride content (mg/L) is:	*Then perform the following actions:*
	6. Phone: _____ 7. Take water samples at several points in the distribution system and test for fluoride content. (Save the parts of the water samples not used.) 8. Determine what has malfunctioned and repair it. With supervisor's permission, restart the fluoride feeder.
Source: ***Water Fluoridation: A Manual for Water Plant Operators.*** April 1994. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention.	

©2003. TAUD All rights reserved.

Filtration

Process Description

Purpose	to remove (turbidity) suspended material from water
Turbidity	The cloudy appearance of water caused by suspended materials.
Suspended Materials	(1) Floc carryover from sedimentation basin (2) Precipitates from the softening process, primarily calcium carbonate (3) Iron and manganese (4) Microorganisms

Problems Caused by Turbidity

- Interference with disinfection - shields microorganisms from disinfectant.
- React with chlorine, leaving less for disinfection
- Forms deposits in water mains which can create tastes and odors and bacterial regrowth.

Mechanisms of Suspended Solids Removal

- Adsorption [Most Important]
- Straining [Least Important]

Driving Force Head

Efficiency of process depends on:

(1) raw water quality

(2) effectiveness of treatment processes preceding filtration

(3) filter operations.

 ©2003. TAUD All rights reserved.

Types of Filters	Gravity Filters	Pressure Filters
	(1) Slow Sand Filters	(1) Sand or Multi-Media
	(2) Rapid Sand	(2) Diatomaceous Earth
	(3) High Rate	
	(a) Dual Media	
	(b) Multi-Media	

Gravity Filters - water moves through the filter because of gravity

Pressure Filters - water is pumped through the filter

Rapid Sand Filter Components

Filter Bay Backwash Troughs	Filter Media Surface Wash
Support Gravel Control Equipment	Underdrain

Filter Media

- Single Media Filters - Sand (total of at least 30 inches)
- Dual Media - Sand and Anthracite (total of at least 30 inches)
- Multi-Media (Triple Media) - Silica Sand, Garnet Sand and Anthracite (total of at least 30 inches)

Support Gravel

(1) Keeps media out of underdrain

(2) Even distribution of backwash water

Underdrains

	Pipe-lateral	Leopold Bottom
	Wheeler Bottom	Porous Plates
	Strainer Nozzles	

Functions	(1) even distribution of backwash water
	(2) even collection of filtered water

©2003. TAUD All rights reserved.

Backwash Troughs

Must be placed to (1) prevent media loss

(2) allow for water to flow evenly out of filter during backwash

Surface Wash

(1) Provides additional cleaning [also called auxiliary scours or filter agitation]

(2) Required to provide extra agitation for cleaning filter media because normal backwash rates are insufficient to clean filters.

Filter Controls

- Rate-of-flow Controller - provides reasonably constant filtration rate

- Loss-of-head Indicator - indicates the amount of head-loss due to buildup of suspended matter in water. Used to determine when a filter is to be backwashed.

- On-line Turbidimeters - continuously records turbidity in filter effluent

Filter Operations

3 Steps Filtration Backwash Filtering-to-Waste [Rewash]

Backwashing essential to filter operation

Determining when to backwash, consider (1) headloss

(2) turbidity breakthrough

(3) duration of run

Filtering to Waste do until turbidity returns to acceptable level

Filter Aids - Polymers used to:

(1) strengthen bonds between floc particles

(2) improves adhesion to media by coating them

 ©2003. TAUD All rights reserved.

This results in: (1) the floc holding together better

(2) the flow adhering to the media more strongly

(3) increased resistance to shear forces exerted by water as it flows through the filter

Added just ahead of filters

Too much results in rapid headloss

Allowable Rates

Type of Filter	Allowable Rate, gal/min/ft2
Rapid Sand	2 gal/min/ft2
Iron Removal	3 gal/min/ft2
High Rate	4 gal/min/ft2

Backwashing the Filter

Poor backwashing can cause (1) Mudballs

(2) Filter bed shrinkage

(3) Gravel displacement

(4) Air binding

(5) Media loss

Backwash must agitate the media grains violently, causing the grains to rub together to dislodge sticky coating.

Proper backwashing essential for the production of high quality water.

Filters must be cleaned for efficient operation.

Backwashing reduces maintenance requirements.

©2003. TAUD All rights reserved.

Treated water is always used for backwashing so that the filter bed will not be contaminated.

If the filter is not backwashed soon enough the voids between the media grains will become filled with sticky solids, preventing water from flowing through the filter. This is called terminal head loss.

When a filter bed goes dry, it should be filled using the backwash valve.

During backwash, the mass of media particles is made to flow like a liquid by the backwash water. It is said that the bed has become fluidized.

Operational Control Tests

Effluent Turbidity (NTU)	Minimum of one sample per four hour period while plant is in operation.

Pressure Filters

Media should be inspected annually.

Air binding does not occur in pressure filters since they remain under pressure constantly during operation.

Major disadvantage - the filter cannot be observed during operation.

According to Design Criteria pressure filters should only be used in groundwater plants for turbidity or iron and manganese removal.

 ©2003. TAUD All rights reserved.

Process Control

Process Evaluation and Troubleshooting

Major Operational Problems

Chemical Treatment Prior to Filtration

Short filter runs because of turbidity breakthrough	(1) more coagulation; or (2) better flash mixing (3) less filter aid
Short filter due to rapid build-up of head loss	(1) less coagulant (2) less filter aid

Sand Boils Violent, upswelling boils which indicate that the supporting gravel in a filter has been displaced.

Some gravel movement always occurs so filters should be probed at least once per year to locate the gravel bed.

©2003. TAUD All rights reserved.

Most problems are caused by ineffective backwashing. These problems include:

(1) Mud ball formation

(2) Filter bed shrinkage

(3) Gravel displacement

(4) Sand boils

Other Operational Problems

(A) Air Binding - caused by:

(1) operating filter under negative head

(2) cold water, supersaturated with air, warming up in the filter bed

(B) Media Loss

(C) Flow Rate

Fluctuations in filtration rates caused by:

(1) increase in total plant flow

(2) malfunctioning rate-of-flow controller

(3) flow increase when a filter is taken out of service for backwash

(4) operator error

 ©2003. TAUD All rights reserved.

Filtration Rate Analysis

Purpose - To determine the actual filtration rate in gallons per minute per square foot ($gal/min/ft^2$)

Equipment Required Stopwatch Hook gauge Filtration Rate Analysis Form

Procedure

1. Secure the hook gauge to the filter, ensuring it is level, with the top hook far enough below the surface of the water that all valves are fully open before water level reaches top nail.

2. Close the filter influent valve.

3. Record the effluent valve setting and flow meter reading.

4. Start timing when the top hook breaks the water surface.

5. Stop timing when the bottom hook breaks the water surface.

6. Record the time required for the water to drop 6 inches.

7. Refill the filter basin.

8. Repeat steps 3 through 8 two more times.

Calculations

Step One: Determine how many gallons of water passed through the filter during the drop (hook gauge) test.

1. Calculate the volume of water in cubic feet which passed through the filter during the test.

$$\text{Volume, ft3} = \text{Filter Bay Length, ft} \times \text{Filter Bay Width, ft} \times \text{Water Drop, ft}$$

2 Calculate the volume of water in gallons which passed through the filter during the test.

$$\text{Volume, gal} = \text{Volume, ft3} \times 7.48\ \text{gal/ft3}$$

Step Two: Determine the average time in minutes required for the water to drop 6 inches during the test.

1. Calculate the average time in seconds required for the water to drop 6 inches.

$$\text{Average Time, sec} = \frac{Time_1 + Time_2 + Time_3}{3}$$

2. Calculate the average time in minutes.

$$\text{Time, min} = \frac{\text{Average Time, sec}}{60\ \text{sec/min}}$$

©2003. TAUD All rights reserved.

Step Three: Calculate the area of the filter bed in square feet.

$$\text{Area, ft}^2 = \text{Filter Bed Length, ft} \times \text{Filter Bed Width, ft}$$

Step Four: Determine the filtration rate in gallons per minute.

$$\text{Filtration Rate, gal/min} = \frac{\text{Volume, gal}}{\text{Average Time, min}}$$

Step Five: Determine the filtration rate in gallons per minute per square foot (gal/min/ft^2).

$$\text{Filtration Rate, gal/min/ft}^2 = \frac{\text{Filtration Rate, gal/min}}{\text{Area, ft}^2}$$

Step Six: Determine the accuracy of the filter flow meter reading.

$$\text{Flow Meter Accuracy, \%} = \frac{\text{Flow Meter Rading, gal/min}}{\text{Calculated Filtration Rate, gal/min}} \text{ X } 100\%$$

Interpretation

Allowable Rates

Rapid Sand Turbidity Removal Filters ..... 2.0 gal/min/ft^2

Rapid Sand Iron Removal Filters 3.0 gal/min/ft^2

High Rate Turbidity Removal Filters 4.0 gal/min/ft^2

High Rate Iron Removal Filters 4.0 gal/min/ft^2

If the filtration rate is higher than the allowable rate, adjust the rate-of-flow controller to slow filter down.

If the flow meter accuracy is too far off, have it calibrated.

 ©2003. TAUD All rights reserved.

Backwash Bed Expansion Analysis

Purpose: To determine that filter bed expansion during backwash is adequate to clean the filter media.

Equipment: Secchi Disc Tape 5-ft Ruler

Procedure:

Step One: Determine the average depth of the media.

1. Using the 5-ft ruler, select several random spots for measuring the media depth.

2. Gently push the ruler into the media until the torpedo sand layer is found.

3. Read and record the media depth in inches.

4. Repeat steps 2 and 3 at the other spots selected for measuring the media depth.

5. Using this formula, calculate the average media depth in inches. (N = number of measurements)

$$\text{Average Media Depth, in} = \frac{\text{Measurement}_1 + \text{Measurement}_2 + \ldots + \text{Measurement}_N}{N}$$

Step Two:

Step Two: Determine the filter bed expansion in inches, during backwash.

1.Locate a place to take measurements where the Secchi disc will hang free.

2. Place a piece of tape on the handrail or walkway to establish a fixed reference point.

3. Lower the Secchi disc until it rests on the media surface.

4. Using a fixed point as a reference, mark the Secchi rope with tape.

5. Remove the Secchi disc and start the backwash procedure.

6. When the backwash water clears, lower the Secchi disc until filter media washes onto the white sections.

7. Using the same fixed reference point from step 2, mark the Secchi disc rope with tape.

8. Measure the distance between the tops of each piece of tape.

9. Record as bed expansion, inches.

Step Three: Determine the percent bed expansion.

$$\text{Bed Expansion, \%} = \frac{\text{Bed Expansion, in} \times 100\%}{\text{Average Media Depth, in}}$$

©2003. TAUD All rights reserved.

Backwash Rise Rate

Purpose To confirm the backwash flow rate and backwash flow meter accuracy.

Equipment Requirements Stop Watch Hook Gauge

Procedure

1. Measure and record the length and width of the filter bay.
2. Secure the hook gauge to the filter bay railing, making certain that it is vertical.
3. Begin the backwash.
4. Record the backwash flow rate.
5. When the rising water reaches the lower rail point, start timing the rise.
6. Record the time required to reach the 6-inch point.

Calculations

Step One: Determine how many gallons of water passed through the filter during the rise test.

1. Calculate the volume of water in cubic feet which passed through the filter during the test.

$$\text{Volume, ft}^3 = \text{Filter Bay Length, ft} \times \text{Filter Bay Width, ft} \times \text{Water Drop, ft}$$

2 Calculate the volume of water in gallons which passed through the filter during the test.

$$\text{Volume, gal} = \text{Volume, ft}^3 \times 7.48\ \text{gal/ft}^3$$

Step Two: Determine the average time in minutes required for the water to rise 6 inches during the test.

1. Calculate the average time in seconds required for the water to drop 6 inches.

$$\text{Average Time, sec} = \frac{\text{Time}_1 + \text{Time}_2 + \text{Time}_3}{3}$$

2. Calculate the average time in minutes.

$$\text{Time, min} = \frac{\text{Average Time, sec}}{60\ \text{sec/min}}$$

Step Three: Calculate the area of the filter bed in square feet.

$$\text{Area, ft}^2 = \text{Filter Bed Length, ft} \times \text{Filter Bed Width, ft}$$

 ©2003. TAUD All rights reserved.

Step Four: Determine the backwash rate in gallons per minute.

$$\text{Backwash Rate, gal/min} = \frac{\text{Volume, gal}}{\text{Average Time, min}}$$

Step Five: Determine the backwash rate in gallons per minute per square foot (gal/min/ft^2).

$$\text{Backwash Rate, gal/min/ft}^2 = \frac{\text{Backwash Rate, gal/min}}{\text{Area, ft}^2}$$

Step Six: Determine the accuracy of the backwash flow meter.

$$\text{Backwash Flow Meter Accuracy, \%} = \frac{\text{Flow Meter Rading, gal/min}}{\text{Calculated Filtration Rate, gal/min}} \text{ X } 100\%$$

Interpretation

Compare test results to reading on the backwash flow meter. If they do not agree, calibrate the flow meter.

Backwash Flow Rate	Bed Expansion, %	Interpretation
Low	<20	Increase backwash rate and re-perform bed expansion analysis.
Low	20 – 30 %	Increase backwash rate and re-perform bed expansion analysis.
Low	>30	Note 1
Correct	<20	Note 2
Correct	20 – 30 %	No action necessary
Correct	>30	Check media effective size and uniformity coefficient
High	<20	Note 2
High	20 – 30 %	Note 2
High	>30	Lower backwash rate and reperform bed expansion analysis.

Note 1 - Check water temperature; if necessary, increase backwash rate. If water temperature is not the problem, check the design parameters for the filter.

Note 2 – Evaluate media for calcium carbonate scaling or polymer build – up.

©2003. TAUD All rights reserved.

If bed expansion is too low, chance of mudballs developing is high. Check physical observations for mud on media surface. Consider mudball analysis.

If bed expansion is too high, check physical observations for presence of media in trough. Check media depth.

 ©2003. TAUD All rights reserved.

Sludge Retention Profile

In order to remove turbidity effectively and minimize turbidity spikes after backwashing, some sludge should remain in the filter. The Sludge Retention Profile is a way of determining how much sludge remains in the filter. Too much sludge or too little sludge will diminish filtration efficiency and cause other problems. The retained sludge in a properly backwashed and adequately ripened filter should be in the range of 30 – 60 NTU.

Equipment Needed:

24 to 36 one-gallon resealable plastic bags	50-ml beaker
Core sampler	Tap water
100-ml graduated cylinder	Bench-top turbidimeter
Pint Jar	1-liter Erlenmeyer Flask

Procedure

The following procedure is performed twice on a filter, once before backwashing, and once after.

Sample Collecting

1. Prepare two sets of six one-gallon resealable plastic bags, labeled “Before Backwash” and “After Backwash”, and with these media depths marked on the appropriate bag.

0-2 in	6-12 in	18-24 in	30-36 in
2-6 in	12-18 in	24-30 in	

2. Select three sampling sites on the filter.

3. Completely drain the water out of the filter media.

NOTE: Sampling should take place within one hour of draining to prevent the media from drying out.

4. Layout plywood boards to stand on. Do not stand or walk on the media.

5. Gently push the core sampler into the media to the 2-inch mark. Rotate the core sampler to widen the hole so that it won’t cave in.

6. Form an airtight seal on the top of the core sampler by placing a hand over it, and slowly pull the core sampler from the media.

7. Deposit the media into the bag marked “Before Backwash – 0 to 2 in”.

8. Repeat steps 5 thru 7 for the other depths, making certain the sample is placed in the correct bag.

9. Move to second sampling site and repeat procedure, placing sample in the appropriate bag used for the first sampling site.

10. After completing the second set of samples, move to the third sampling site and repeat sampling.

©2003. TAUD All rights reserved.

11. Backwash the filter.

12. Repeat steps 3 thru 10, using the bags marked “After Backwash”.

13. Remove all equipment and samples from the filter and take the samples to the lab for analysis.

Sample Preparation

1. Separate the before and after backwash sample bags and organize them in order of depth.

2. Thoroughly mix each sample by shaking the bag vigorously.

3. Measure out 50ml of sample from the “Before Backwash Bag” marked“0-2 in” , using the 100-ml graduated cylinder. Gently tap the graduated cylinder on the counter top to aid in settling the media.

4. Transfer the 50-ml sample to the 500-ml flask.

5. Add 100-ml of the tap water to the sample and shake vigorously for 60 seconds.

6. Pour the turbid water into the 1-liter Erlenmeyer flask.

7. Using the same media sample, repeat step 5 and 6 four more times until there is a total of 500-ml of turbid water in the beaker.

8. Stir the 500-ml sample of the turbid water.

9. Pour the required amount of turbid water into the cell and read the turbidity of the sample.

10. Multiply the turbidity reading by two and record that value on the Sludge Retention Profile Evaluation Form.

11. Repeat steps 2 thru 10 for the remaining samples.

12. Graph the results. Plot turbidity on the x-axis and media depth on the y-axis, for both the before and after backwash samples.

Interpretation of Results

Using the table, determine the condition of the filter.

Turbidity	Filter Media Condition
0 – 30 NTU	Clean-unripened filter (probable extended turbidity breakthroughs)
30 – 60 NTU	Cleaned-ripened filter (optimal filter performance)
60 – 120 NTU	Slightly dirty (adequate performance for short periods of time)
>120 NTU	Dirty (evaluate backwash procedure and/or system)
>300 NTU	Mudball problems

A turbidity range of 30-60 NTU is desirable.

 ©2004. TAUD. All Rights Reserved.

Mudball Analysis

Purpose To determine the condition of a filter as indicated by the presence or absence of mud balls.

Equipment Required No. 12 (10 mesh) sieve Mudball sampling device

1-gal resealable plastic bags 5-gal bucket

250-mL graduated cylinder

If mudballs are large, a 500-mL or 1,000-mL graduated cylinder may be needed.

Procedure

Sample Collection

Backwash the filter.

Drain the water from the filter to a point below the media surface.

Select five sampling points at random.

Beginning with the first sampling point, push the mudball sampling device into the media to a depth of six inches

Tilt the mudball sampler back until it is horizontal.

Lift the mudball sampler, keeping it horizontal.

Empty the contents of the mudball sampler into the 1-gal plastic bag.

Repeat steps 4-7 at the remaining sampling points, placing all samples in the same bag.

Mark the bag with the following information:

filter I.D.;

date;

name of person taking sampler.

Sample Preparation

Fill the 5-gal bucket half-full with water.

Lower the No. 12 sieve into the water until nearly submerged.

Put a handful of the media sample into the sieve.

Raise and lower the sieve gently in the water until the media is washed through the sieve.

Repeat steps 3-4 until all of the media sample has been sieved.

©2004. TAUD. All rights reserved.

Gently wash any mudballs to one side of the sieve.

Testing

Fill the 250 mL graduated cylinder to the to the 200-mL level with water.

Record this value on the Mudball Analysis from as the initial volume.

Gently transfer the mudballs from the sieve to the graduated cylinder.

Read the new volume in the graduated cylinder and record this value on the Mudball Analysis Form as the final volume.

Calculations.

Calculate the volume of the mudball sampler in gallons (gal).

$$\text{Media Sample Volume, gal} = \frac{0.785 \times D^2 \times H \times N}{231\ \text{in}^3/\text{gal}}$$

Where D = diameter in inches H = height of sampler in inches

N= number of samples taken

Convert the sample volume to milliliters (mL).

$$\text{Media Sample Volume, mL} = \text{Volume, gal} \times 3{,}785\ \text{mL/gal}$$

Calculate the mudball volume, in milliliters (mL).

$$\text{Mudball Volume, mL} = \text{Final Cylinder Volume, mL} - \text{Initial Cylinder Volume, mL}$$

Calculate the percent mudballs

$$\%\ \text{Mudballs} = \frac{\text{Mudball Volume, mL} \times 100\%}{\text{Media Sample Volume, mL}}$$

% Mudballs	**Filter Condition**
0.0 – 0.1	Excellent
0.1 – 0.2	Very Good
0.2 – 0.5	Good
0.5 – 1.0	Fair
1.0 – 2.5	Fairly Bad
2.5 – 5.0	Bad
>5.0	Very Bad

 ©2004. TAUD. All Rights Reserved.

Media Analysis

Purpose: To determine the effective size and uniformity coefficient of a filter's media.

Equipment Needed

Sieve Shaker (if available)	Two containers	No. 10 Sieve	No. 30 Sieve
Balance	Wire brush	No. 12 Sieve	No. 35 Sieve
Small coring device	Sieves	No. 14 Sieve	No. 40 Sieve
1-gal plastic freezer bags	No. 5 Sieve	No. 16 Sieve	No. 45 Sieve
Drying crucibles	No. 6 Sieve	No. 18 Sieve	Collection tray
	No. 7 Sieve	No. 20 Sieve	Small shovel
	No. 8 Sieve	No. 25 Sieve	

Procedure

Sample Collection

1. Backwash the filter.
2. Draw the water to the gravel layer.
3. Sampling Anthracite
    a. Push the coring tool into the anthracite to a depth of 6 inches.
    b. Tilt the coring tool to horizontal.
    c. Lift the coring tool while holding it horizontally.
    d. Place content of the coring tool into a 1-gal plastic bag.
    e. Repeat steps a through d at four more locations on the filter.
    f. Mark the bag with the filter identification, date and name of the person taking samples.
4. Sampling Sand
    a. Using a small shovel, carefully dig through the anthracite down to the sand.
    b. Push the coring tool into the sand to a depth of 6-inches.
    c. Tilt the coring tool to horizontal.
    d. Lift the coring tool while holding it horizontally.
    e. Place content of the coring tool into a 1-gal plastic bag.
    f. Repeat steps a through d at four more locations on the filter.
    g. Mark the bag with the filter identification, date and name of the person taking samples.

©2004. TAUD. All rights reserved.

Sample Preparation

1. Place anthracite sample in a one-gallon bucket.

2. Wash sample gently until free of mud and silt. (Run your hand through media to make certain it is thoroughly clean.)

3. Place the samples into drying crucibles.

4. Place the crucibles into the drying oven. Dry for at least 24 hours at 105^{o}C.

5. Leave the sample in the oven until you are ready to proceed.

Testing

1. Divide the sieves into groups (No.5 – No. 10; No.12 – No. 20; No. 25- No.45).

2. Weigh each of the sieves in the first set (No.5 – No.10).

3. Record the initial weight of each sieve on the Sieve Analysis Report Form.

4. Arrange the sieves as shown in Figure 1.

5. Remove the anthracite samples from the oven and place them in the dissicator.

6. Allow the samples to cool for no more than 30 minutes.

7. Weigh out 500 grams of media.

8. Place any remaining sample back into the oven.

9. Put the 500 grams of media into the No.5 sieve, place the top on the sieves.

10. Shake for 10 minutes. (Can be done by hand if no shaker is available.)

11. After shaking, pour any media in the collection tray into a clean container. Do not discard. You will use their media in the second set of trays.

12. Carefully weigh each of the sieves and record that weight on the Sieve Analysis Report Form.

13. Place the media retained on each sieve into a second container. It may be necessary to turn the sieve upside down and use a wire brush to gently scrape the media into the container.

14. Weigh the second set of sieves (No. 12- No.20).

15. Record the initial weight on the Sieve Analysis Report Form.

16. Place the media from the first container (media from the collection tray) into the No.25 sieve.

17. Shake for 10 minutes. (Can be done by hand if no shaker is available.)

18. After shaking, pour any media in the collection tray into a clean container. Do not discard. You will use their media in the second set of trays.

 ©2004. TAUD. All Rights Reserved.

19. Carefully weigh each of the sieves and record that weight on the Sieve Analysis Report Form.

20. Place the media retained on each sieve into a second container. It may be necessary to turn the sieve upside down and use a wire brush to gently scrape the media into the container.

21. Weigh the third set of sieves (No.25- No.45)

22. Record the initial weights of the sieves on the Sieve Analysis Report Form.

23. Place the media from the first container (media from the collection tray) into the No.25 sieve.

24. Shake for 10 minutes. (Can be done by hand if no shaker is available.)

25. After shaking, pour any media in the collection tray into a clean container. Do not discard. You will use their media in the second set of trays.

26. Carefully weigh each of the sieves and record that weight on the Sieve Analysis Report Form.

27. Place the media retained on each sieve into a second container. It may be necessary to turn the sieve upside down and use a wire brush to gently scrape the media into the container.

NOTE: If you want to remove any calcium carbonate from the media you should:

1. Acid wash the media

2. Redo the procedure

Interpretation

1. Begin with the No.5 sieve and calculate the weight of the media retained on the sieve and enter on the form.

Retained media, g = weight of sieve plus media, g-weight of sieve, g

2. Repeat the calculation for each of the sieves.

3. Add all the retained weights and enter on the form.

4. Calculate the cumulative weights for each sieve and enter on the form.

Cumulative weight, g = previous cumulative weight, g + sample weight, g

5. Calculate the cumulative % passing for each sieve and enter results on the form.

6. Plot sieve size (y-axis) versus percent passing (x-axis) on single cycle semi-log paper.

7. Draw a line from the 60% point to the point intersects the curve.

8. Draw a line from this point across to the left. The point at which this line intersects the y-axis (sieve size) is the d_{60} value.

9. Repeat steps 7 and 8 for the 10% point. This is the d_{10} value, and the effective size.

10. Calculate the uniformity coefficient.

Uniformity Coefficient = d_{60}/d_{10}

©2004. TAUD. All rights reserved.

Design Criteria

4.2 FILTRATION - Acceptable filters include, at the discretion of the Department, the following types:

a. gravity filters,

b. pressure filters.

The application of any one type must be supported by water quality data representing a reasonable period of time to characterize the variations in water quality. Experimental treatment studies may be required to demonstrate the applicability of the method of filtration proposed.

4.2.1 Gravity Filters

a. Number - At least two units shall be provided. Where declining rate filtration is provided, the variable aspect of filtration rates, and the number of filters must be considered when determining the design capacity for the filters.

b. Rate of Filtration

1. Standard Rate Filtration - The permissible rate of filtration shall be determined by the quality of the raw water, the degree of pretreatment provided, the filter media provided the quality of operation provided and other considerations required by the Department. The nominal rate shall be 2 gpm/ft2 of filter area for turbidity removal plants, and 3 gpm/ft2 of filter area for iron removal plants,

2. High Rate Filtration - Filtration rates for turbidity or iron removal plants of up to 4 gpm/ft^2 are acceptable with the following.

i. Mixing, flocculation, and sedimentation must meet the requirements of section 4.1.

ii. Dual or mixed filter media must be used.

iii. Additional instrumentation for coagulation control may be required for those plants with filter rates greater than 3 gpm/ft2. (Examples: raw and settled water continuous monitoring turbidimeters, pilot filter or zetameter.)

iiii. Filtration rates above 4 gpm/ft2 will be considered on a case by case basis with a trial period to demonstrate effective treatment at the increased rate.

 ©2004. TAUD. All Rights Reserved.

c. Declining Rate Filtration - This is a design where no rate-of-flow controllers are installed. The rate of flow through the filter media is greatest when the media has just been back washed and gradually declines as the media becomes filled with contaminants.

1. The design must include means to insure that the water level during operation will not fall below the level of the top of the media.

2. The filtration rate must not exceed 6 gpm/ft2 when the filter is clean (immediately following back wash) and uses dual or mixed media.

3. This design is normally appropriate only when four or more filters are used in the plant.

d. Direct Filtration - will be considered on a case-by-case basis. However all filters shall have dual or mixed media and be operated at no greater than 2 gpm/ft2. A flash mix shall be provided and flocculation basins may also be required.

e. Structural Details and Hydraulics - The filter structure shall be so designed as to provide for:

1. vertical walls within the filter, unless otherwise approved,

2. no protrusion of the filter walls into the filter media,

3. enclosure in a building,

4. head room to permit normal inspection and operation,

5. minimum depth of filter of 8-1/2 feet,

6. minimum water depth over the surface of the sand of 3 feet,

7. trapped effluent to prevent backflow of air to the bottom of the filters,

8. prevention of floor drainage to the filter with a minimum 4-inch curb around the filters,

9. prevention of flooding by providing overflow,

10. maximum velocity of treated water in pipe and conduits to filters of 2 fps,

11. minimal disturbance of the media from incoming water,

12. washwater drain capacity to carry maximum flow,

13. walkways around filters, to be not less than 24 inches wide,

©2004. TAUD. All rights reserved.

14. no common wall between settling basins and filters.

f. Washwater Troughs - Washwater troughs shall be so designed to provide:

1. the bottom elevation above the maximum level of expanded media during washing,

2. the top elevation above the filter surface not to exceed 30 inches,

3. a 2-inch freeboard at the maximum rate of wash,

4. the top or edge to be level,

5. spacing so that each trough serves the same number of square feet of filter area,

6. maximum horizontal travel of suspended particles to reach trough not to exceed 3 feet.

g. Filter Material - installation of media shall be in accordance with current AWWA standards.

1. Sand - The media shall be clean silica sand having:

i. a depth of 30 inches,

ii. an effective size of from 0.35 mm to 0.55 mm, depending upon the quality of the raw water, and

iii. a uniformity coefficient not greater than 1.70.

2. Anthracite - a combination of sand and clean crushed anthracite may be used. The anthracite shall have:

i. an effective size of 0.8 mm - 1.2 mm, and

ii. a uniformity coefficient not greater than 1.85.

iii. anthracite layer shall not exceed 20 inches in 30-inch bed.

3. Mixed Media - To be approved by the Department.

4. A 3-inch layer of torpedo sand may be used as a supporting media for the filter sand; such torpedo sand shall have:

i. an effective size of 0.8 mm to 2.0 mm, and,

ii. a uniformity coefficient not greater than 1.7.

 ©2004. TAUD. All Rights Reserved.

5. Gravel - Gravel, when used as the supporting media, shall consist of hard, rounded particles.

i. The minimum gravel size of the bottom layer should be 3/4 inch or larger.

ii. For proper grading of intermediate layers:

(1) the minimum particle size of any layer should be as large as the maximum particle size in the layer next above and

(2) within any layer the maximum particle size should not be more than twice the minimum particle size.

iii. The depth of any gravel layer should not be less than 2 inches or less than twice the largest gravel size for that layer, whichever is greater. The bottom layer should be thick enough to cover underdrain laterals, strainers, or other irregularities in the filter bottom.

iv. The total depth of gravel above the underdrains should not be less than 10 inches.

6. Reduction of gravel depths may be considered upon justification to the Department when proprietary filter bottoms are installed.

h. Filter Bottoms and Strainer Systems - Departures from these standards may be acceptable for high rate filters and for proprietary bottoms. Porous plate bottoms shall not be used. The design of manifold type collection systems shall be such as to:

1. minimize loss of head in the manifold and laterals,

2. assure even distribution of washwater and even rate of filtration over the entire area of the filter,

3. provide the ratio of the area of the final openings of the strainer systems to the area of the filter at about 0.003,

4. provide the total cross-sectional area of the laterals at about twice the total area of the final openings,

5. provide the cross-sectional area of the manifold at l-1/2 to 2 times the total area of the laterals.

i. Surface Wash - Surface or subsurface wash facilities are required except for filters used exclusively for iron or manganese removal, and may be accomplished by a system of fixed nozzles or a revolving-type apparatus.

©2004. TAUD. All rights reserved.

1. All surface wash devices shall be designed with:

    i. provisions for water pressures of 45 to 75 psi,

    ii. air vacuum relief valve or a reduced pressure backflow preventer if the surface wash supply is provided through a separate line from the high service line,

    iii. air wash can be considered based on experimental data and operating experiences.

j. Appurtenances - The following shall be provided for every filter:

    1. sampling tap on the effluent line,

    2. indicating loss-of-head gauge,

    3. indicating flow-rate control; a modified rate controller which limits the rate of filtration to a maximum rate may be used,

    4. provisions for draining the filter to waste with appropriate measures for backflow prevention (see Section 4.11.),

    5. turbidimeter with recorder reading in NTU's on effluent line of each filter when raw water is from a surface source or ground source is in an area where turbidity may be a problem.

    6. a 1 to l½ inch pressure hose and storage rack on the operating floor for washing filter walls. The hose connection shall be protected with a vacuum breaker.

k. Backwash - Provisions shall be made for washing filters as follows:

    1. a rate to provide for a 50 percent expansion of the media is recommended; for a sand filter, a minimum rate of 18.75 gpm/ft2 is required, consistent with water temperatures and specific gravity of the filter media;

    2. filtered water provided at the required backwash rate by washwater tanks, a washwater pump, from the high service main, or a combination of these;

    3. washwater pumps in duplicate unless an alternate means of obtaining washwater is available,

    4. water supply to back wash one filter for at least 15 minutes at the design rate of wash,

 ©2004. TAUD. All Rights Reserved.

5. washwater regulator or valve on the main washwater line to obtain the desired rate of filter wash with the washwater valves on the individual filters open wide,

6. rate-of-flow indicator on the main washwater line, located so that it can be easily read by the operator during the washing process,

7. after washwater pumps are turned off and influent line is opened, a rewash cycle shall be performed for about 5 minutes during which water is filtered to the drain; piping must be provided for this purpose.

8. upon written request to this Department, if filter operation is automatic, the maximum permissible filter rate may be exceeded through remaining filters when one is being backwashed such that the plant flow would remain the same.

1. Miscellaneous - Roof drains shall not discharge into the filters or basins and conduits preceding the filters. All filters must be enclosed.

4.2.2 Pressure Filters - The use of these filters may be considered for iron and manganese removal and for turbidity removal from ground water sources. Pressure filters shall not be used in the filtration of surface waters or following lime soda softening.

a. General - Minimum criteria relative to number, rate of filtration, structural details and hydraulics, filter media, etc., provided for gravity filters also apply to pressure filters where appropriate.

b. Details of Design - The filters shall be designed to provide for:

1. head gauges on the inlet and outlet pipes of each filter,

2. an easily readable meter or flow indicator on each battery of filters; a flow indicator is recommended for each filtering unit,

3. filtration and backwashing of each filter individually with an arrangement of piping as simple as possible to accomplish these purposes,

4. minimum side wall shell height of 5 feet; a corresponding reduction in side wall height is acceptable where proprietary bottoms permit reduction of the gravel depth,

5. the top of the washwater collection trough to be at least 18 inches above the surface of media,

6. the underdrain system to collect efficiently the filtered water and to distribute the backwash water at a rate not less than 15 gpm/ft2 of filter area,

©2004. TAUD. All rights reserved.

7. backwash flow indicators and controls that are easily readable while operating the control valves,

8. air release valve on the highest point of each filter,

9. accessible manhole to facilitate inspections and repairs,

10. means to observe the wastewater during backwashing,

11. construction to prevent cross-connection,

12. depth of filter media shall be the same as for gravity filters.

Division of Water Supply Regulations

1200-5-1-.17 Operations and Maintenance

(8) Newly constructed or repaired water distribution lines, finished water storage facilities, filters, and wells shall be flushed and disinfected in accordance with American Water Works Association (AWWA) Standards. The appropriate standards are C651-86, C652-86, C653-87, and C654-87 or later versions of these standards. Bacteriological results indicating adequacy of disinfection procedures must be maintained on file for a period of five (5) years.

(12) All public water systems which utilize a filtration system shall use the following bed specifications and not exceed the following rates of filtration.

(a) Rapid Sand Filtration - 2.0 gallons per minute per square foot for turbidity removal, 3.0 gallons per minute per square foot for iron removal.

There must be 30 inches of sand media with an effective size of 0.35 mm to 0.55 mm and a uniformity coefficient not greater than 1.70

(b) High Rate Filtration - 4.0 gallons per minute per square foot for turbidity removal, 4.0 gallons per minute per square foot for iron removal.

There must be 30 inches of dual media with 10 to 12 inches of sand and 18 to 20 inches of anthracite. The sand shall have an effective size of 0.35 mm to 0.55 mm and a uniformity coefficient not greater than 1.70. The anthracite shall have an effective size of 0.8 mm to 1.2 mm with a uniformity coefficient not greater than 1.85.

(c) Existing water systems with rapid sand filters and approved for higher rates of filtration by the Department will be allowed to continue at that rate provided the drinking water standards are met. The water supplier must be able to document that the Department approved the system for the higher rate.

 ©2004. TAUD. All Rights Reserved.

(d) All mixed media filter beds will be at least 30 inches in depth and approved by the Department.

(e) Filtration rates above 4.0 gallons per minute per square foot will be considered on an individual basis. The Department will take into account the raw water characteristics, the treatment units, operational history, and operating personnel.

(21) New or modified turbidity removal facilities may not be placed into operation until the facility and the operator have been approved by the Department for the turbidity analysis.

(26) Those public water systems required to monitor for turbidity and chlorine residual must have the laboratory approved by the Department before the results of these analyses can be accepted for compliance purposes.

(27) By December 30, 1991, or 18 months after the determination that a ground water system is influenced by surface water, all public water systems classified as a ground water system impacted by surface water shall utilize treatment techniques which achieve:

(a) At least 99.9 percent (3 log) removal and/or inactivation of Giardia lamblia cysts between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer.

(b) At least 99.99 percent (4 log) removal and/or inactivation of viruses between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer.

(30) Any surface supplied public water system or ground water systems under the direct influence of surface water required to filter shall employ filtration in combination with disinfection that will achieve 99.9% (3 log) and 99.99% (4 log) inactivation of Giardia lamblia and viruses respectively between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer. For the purposes of determining removal or inactivation efficiencies for Giardia lamblia and viruses Table 1200-5-1-.17(30)1 and 1200-5-1-.17(30)2 shall apply. The free residual disinfectant concentration in the water entering the distribution system cannot be less than 0.2 mg/l for more than four hours.

©2004. TAUD. All rights reserved.

TABLE 1200-5-1-.17(30)1 - ASSUMED LOG REMOVALS BY FILTRATION METHOD AND REQUIRED LEVELS OF DISINFECTION

Treatment	Assumed Log Removals		Required minimum level of disinfection	
	Giardia	Viruses	Giardia	Viruses
Conventional filtration	2.5	2.0	0.5	2.0
Direct filtration	2.0	1.0	1.0	3.0
Slow Sand filtration	2.0	2.0	1.0	2.0
Diatomaceous Earth filtration	2.0	1.0	1.0	3.0

TABLE 1200-5-1-.17(30)2 - CT VALUES FOR ACHIEVING 1-LOG INACTIVATION OF GIARDIA CYSTS[1]

	pH	Temperature			
		0.5°C	5°C	10°C	15°C
Free Chlorine [2,3]	6	55	39	29	19
	7	79	55	41	26
	8	115	81	61	41
	9	167	118	88	59
Ozone		0.97	0.63	0.48	0.32
Chlorine dioxide		1270	735	615	500

[1]Values to achieve 0.5 log inactivation are one half those shown in the table.

[2]CT values are for 2.0 mg/l free chlorine.

[3]CT values for other concentrations of free chlorine may be taken from Appendix E of the guidance manual for Compliance with the "Filtration and Disinfection Requirements For Public Water Systems Using Surface Water Sources," October, 1989, Edition, Science and Technology Branch Criteria and Standards Division, Office of Drinking Water, USEPA, Washington, D.C.

(35) By January 1, 1996, public water systems using surface water and ground water systems under the direct influence of surface water that filter shall have rewash

 ©2004. TAUD. All Rights Reserved.

capability. Such systems shall perform a rewash cycle, or filter to waste each time a filter is backwashed. The rewash cycle shall be conducted in a way and manner necessary to prevent the introduction of contaminants such as pathogens and turbidity trapped in the filter into the clear well or distribution system.

Existing filter plants may be approved to operate without rewash (filter-to-waste provisions) if existing operational and backwash practices prevent water of unacceptable quality from entering the clearwell or distribution system. To operate without rewash the water system must demonstrate to the Department that filtered water turbidity after backwashing is reliably and consistently below 0.5 NTU immediately after backwashing each filter. Approval to operate without rewash must be approved in writing and approval must be renewed if any modifications are made to the operation or design of the plant. Each filter that operates without rewash must have a continuous recording turbidimeter and retain the records for a period of five years.

1200-5-1-.31 Filtration and Disinfection

(1) General Requirements

(a) The requirements of Rule 1200-5-1-.31 constitute primary drinking water regulations. These regulations establish criteria under which filtration is required as a treatment technique for public water systems supplied by a surface water source or a ground water source under the direct influence of surface water. Each public water system with a surface water source or a ground water source under the direct influence of surface water must provide treatment of that source water that complies with these treatment technique requirements. These regulations establish treatment technique requirements in lieu of maximum contaminant levels for Giardia lamblia, cryptosporidium, viruses, heterotrophic plate count bacteria, Legionella, and turbidity. The treatment technique requirements consist of installing and properly operating water treatment processes which reliably achieve removal of Giardia lamblia cysts, cryptosporidium and viruses as set forth herein.

(b) A public water system using a ground water source under the direct influence of surface water shall:

1. Meet the requirements for avoiding filtration in 1200-5-1-.31(2) and meet the disinfection requirements in 1200-5-1-.31(3)(a) or

2. Meet the filtration requirements in 1200-5-1-.31(4) and the disinfection requirements in 1200-5-1-.17(30).

(c) A public water supply using surface water shall meet disinfection requirements in 1200-5-1-.17(30) and filtration requirements in 1200-5-1-.31(4) to be in compliance with paragraph (a).

©2004. TAUD. All rights reserved.

(d) Each public water system using a surface water source or a ground water source under the direct influence of surface water must be operated by certified personnel who meet the requirements of the Tennessee Water Environmental Health Act T.C.A. 68-13-901 et. seq. and Certification Board Regulations contained in Chapter 1200-5-3.

(e) Beginning December 31, 2001, subpart H systems serving 10,000 or more persons shall install treatment which achieve at least 99 percent (2-log) removal of cryptosporidium between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer for filtered systems, and ground water systems under the direct influence of surface water and serving 10,000 or more persons must have a watershed control plan which controls cryptosporidium. Subpart H systems shall conduct filter and disinfection profiling and benchmarking as required by this rule. Subpart H systems serving 10,000 or more persons shall also comply with the turbidity criteria in 1200-5-1-.31(4)(c).

(c) Treatment Technique Violations.

1. A system is in violation of a treatment technique requirement if it:

   (i) fails to meet any one of the criteria in paragraphs (a) and (b) of this section; or

   (ii) is required to have filtration, by written directive of the state; and

   (iii) fails to install filtration by the date specified in the introductory paragraph of this section.

2. A system that has not installed filtration is in violation of a treatment technique requirement if:

   (i) The turbidity level (measured as specified in 1200-5-1-.31(5)(a)4. and (b)2.) in a representative sample of the source water immediately prior to the first or only point of disinfection application exceeds 5 NTU; or

   (ii) The system is identified as a source of a waterborne disease outbreak.

(4) Filtration.

(c) Subpart H systems that use conventional or direct filtration shall employ filtration treatment that: 1. For systems using conventional filtration or direct filtration, the turbidity level of representative samples of a system's filtered water must be less than or equal to 0.3 NTU in at least 95 percent of the measurements taken each month, measured as specified in 1200-5-1-.31(5)(a) and (c).

2. The turbidity level of representative samples of a system's filtered water must at no time exceed 1 NTU, measured as specified in 1200-5-1-.31(5)(a) and (c).

 ©2004. TAUD. All Rights Reserved.

3. A system that uses lime softening may acidify representative samples prior to analysis using a protocol approved by the State.

(d) A public water system may use a filtration technology not listed in subparagraph (c) or in 1200-5-1-.31(4)(b) if it demonstrates to the State, using pilot plant studies or other means, that the alternative filtration technology, in combination with disinfection treatment that meets the requirements of 1200-5-1-..17(30), consistently achieves 99.9 percent removal and/or inactivation of Giardia lamblia cysts and 99.99 percent removal and/or inactivation of viruses, and 99 percent removal of Cryptosporidium oocysts, and the Department approves the use of the filtration technology. For each approval, the Department will set turbidity performance requirements that the system must meet at least 95 percent of the time and that the system may not exceed at any time at a level that consistently achieves 99.9 percent removal and/or inactivation of Giardia lamblia cysts, 99.99 percent removal and/or inactivation of viruses, and 99 percent removal of Cryptosporidium oocysts.

(5) Analytical and Monitoring Requirements

(a) Analytical Requirements. Only the analytical method(s) approved by the Department may be used to demonstrate compliance with the requirements of 1200-5-1-.31(2), (3) and (4). Measurements for pH, temperature, turbidity, and residual disinfectant concentrations must be conducted by a party approved by the State. Measurements for total coliform, and fecal coliforms, must be conducted by a laboratory certified by the State or EPA to do such analysis. Listed below are the analytic methods approved by the Department.

4. Turbidity - Method 214A (Nephelometric Method - Nephelometric Turbidity Units), pp. 134-136, as set forth in Standard Methods for the Examination of Water and Wastewater, 1985, American Public Health Association et al., 16th edition.

2. Turbidity measurements must be performed on representative grab samples of source water immediately prior to the first or only point of disinfectant application every four hours (or more frequently) that the system serves water to the public. A public water system may substitute continuous turbidity monitoring for grab sample monitoring if it validates the continuous measurement for accuracy on a regular basis using a protocol approved by the State. Turbidity must comply with the limits specified in 1200-5-1-.31(2)(a)2.

(c) Monitoring requirements for systems using filtration treatment. A public water system that uses a surface water source or a ground water source under the influence of surface water and provides filtration treatment must monitor in accordance with this paragraph (c) beginning June 29, 1993, or when filtration is installed, whichever is later.

1. Turbidity measurements as required by 1200-5-1-.31(4) must be performed on representative samples of the system's filtered water every four hours (or more

©2004. TAUD. All rights reserved.

frequently) that the system serves water to the public. A public water system may substitute continuous turbidity monitoring for grab sample monitoring if it validates the continuous measurement for accuracy on a regular basis using a protocol approved by the State. For any system using slow sand filtration or filtration treatment other than conventional treatment, direct filtration, or diatomaceous earth filtration, the State may reduce the sampling frequency to once per day if it determines that less frequent monitoring is sufficient to indicate effective filtration performance. For systems serving 500 or fewer persons, the State may reduce the turbidity sampling frequency to once per day, regardless of the type of filtration treatment used, if the State determines that less frequent monitoring is sufficient to indicate effective filtration performance.

4. In addition to monitoring required by parts 1., 2., and 3. of this subparagraph, a public water system using surface water and serving 10,000 or more persons using conventional filtration treatment or direct filtration must conduct continuous monitoring of turbidity for each individual filter using an approved method in 1200-5-1-.31(5)(a) and must calibrate turbidimeters using the procedure specified by the manufacturer. Systems must record the results of individual filter monitoring every 15 minutes.

5. If there is a failure in the continuous turbidity monitoring equipment, the system must conduct grab sampling every four hours in lieu of continuous monitoring until the turbidimeter is repaired and back on-line .A system has a maximum of five working days after failure to repair the equipment or it is in violation.

(6) Reporting and recordkeeping requirements.

(a) A public water system that uses a ground water source under the direct influence of surface water and does not provide filtration treatment must report monthly to the State the information specified in this paragraph (a) beginning December 31, 1990, or 6 months after the determination that the ground water source is under the direct influence of surface water, whichever is later, unless the State has determined in writing that filtration is required, in which case the State may specify alternative reporting requirements, as appropriate, until filtration is in place.

1. Source water quality information must be reported to the State within 10 days after the end of each month the system serves water to the public. Information that must be reported includes but is not limited to:

(i) The cumulative number of months for which results are reported.

(ii) The number of fecal and/or total coliform samples, whichever are analyzed during the month (if a system monitors for both, only fecal

 ©2004. TAUD. All Rights Reserved.

coliforms must be reported), the dates of sample collection, and the dates when the turbidity level exceeded 1 NTU.

(iii) The number of samples during the month that had equal to or less than 20/100 ml fecal coliforms and/or equal to or less than 100/100 ml total coliforms, whichever are analyzed.

(iv) The cumulative number of fecal or total coliform samples, whichever are analyzed, during the previous six months the system served water to the public.

(v) The cumulative number of samples that had equal to or less than 20/100 ml fecal coliforms or equal to or less than 100/100 ml total coliforms, whichever are analyzed, during the previous six months the system served water to the public.

(vi) The percentage of samples that had equal to or less than 20/100 ml fecal coliforms or equal to or less than 100/100 ml total coliforms, whichever are analyzed, during the previous six months the system served water to the public.

(vii) The maximum turbidity level measured during the month, the date(s) of occurrence for any measurement(s) which exceeded 5 NTU, and the date(s) the occurrence(s) was reported to the State.

(viii) For the first 12 months of recordkeeping, the dates and cumulative number of events during which the turbidity exceeded 5 NTU, and after one year of recordkeeping for turbidity measurements, the dates and cumulative number of events during which the turbidity exceeded 5 NTU in the previous 12 months the system served water to the public.

(ix) For the first 120 months of recordkeeping, the dates and cumulative number of events during which the turbidity exceeded 5 NTU, and after 10 years of recordkeeping for turbidity measurements, the dates and cumulative number of events during which the turbidity exceeded 5 NTU in the previous 120 months the system served water to the public.

2. Disinfection information specified in 1200-5-1-.31(5)(b) must be reported to the State within 10 days after the end of each month the system serves water to the public. Information that must be reported includes but is not limited to:

(i) For each day, the lowest measurement of residual disinfectant concentration in mg/l in water entering the distribution system.

(ii) The date and duration of each period when the residual disinfectant concentration in water entering the distribution system fell below 0.2 mg/l and when the State was notified of the occurrence.

©2004. TAUD. All rights reserved.

(iii) The daily residual disinfectant concentration(s) (in mg/l) and disinfectant contact time(s) (in minutes) used for calculating the CT value(s).

(iv) If chlorine is used, the daily measurement(s) of pH of disinfected water following each point of chlorine disinfection.

(v) The daily measurement(s) of water temperature in oC following each point of disinfection.

(vi) The daily CTcalc and CTcalc/CT99.9 values for each disinfectant measurement or sequence and the sum of all CTcalc/CT99.9 values before or at the first customer.

(vii) The daily determination of whether disinfection achieves adequate Giardia cyst and virus inactivation, i.e., whether (CTcalc/CT99.9) is at least 1.0 or, where disinfectants other than chlorine are used, other indicator conditions that the State determines are appropriate, are met.

(viii) The following information on the samples taken in the distribution system in conjunction with total coliform monitoring pursuant to 1200-5-1-.31(3) [Disinfection].

(I) Number of instances where the free residual disinfectant concentration is measured and the number of instances where the free residual is below 0.2 mg/l.

3. No later than ten days after the end of each Federal fiscal year (September 30), each system must provide to the State a report which summarizes its compliance with all watershed control program requirements specified in 1200-5-1-.31(2)(b)2.

4. No later than ten days after the end of each Federal fiscal year (September 30), each system must provide to the State a report which describes the on-site inspection conducted during that year pursuant to 1200-5-1-.31(2)(b)3. unless the on-site inspection was conducted by the State. If the inspection was conducted by the State, the State must provide a copy of its report to the public water system.

5.

(i) Each system, upon discovering that a waterborne disease outbreak potentially attributable to that water system has occurred, must report that occurrence to the State as soon as possible, but no later than by the close of the following business day.

(ii) If at any time the turbidity exceeds 5 NTU, the system must consult with the department as soon as practical, but no later than 24 hours after the exceedance is known, in accordance with the requirements of the Notification of Customers Rule.

 ©2004. TAUD. All Rights Reserved.

(iii) If at any time the disinfectant residual falls below 0.2 mg/l in the water entering the distribution system, the system must notify the State as soon as possible, but no later than by the end of the next business day. The system also must notify the State by the end of the next business day whether or not the residual was restored to at least 0.2 mg/l within 4 hours.

(b) A public water system that uses a surface water source or a ground water source under the direct influence of surface water and provides filtration treatment must report monthly to the State the information specified in this paragraph (b) beginning June 29, 1993, or when filtration is installed, whichever is later.

1. Turbidity measurements as required by 1200-5-1-.31(5)(c)1. must be reported within 10 days after the end of each month the system serves water to the public. Information that must be reported includes but is not limited to:

   (i) The total number of filtered water turbidity measurements taken during the month.

   (ii) The number and percentage of filtered water turbidity measurements taken during the month which are less than or equal to the applicable limits specified in 1200-5-1-.31(4).

   (iii) The date and value of any turbidity measurements taken during the month which exceed 5 NTU.

2. Disinfection information specified in 1200-5-1-.31(5)(c) must be reported to the State within 10 days after the end of each month the system serves water to the public. Information that must be reported includes:

   (i) For each day, the lowest measurement of residual disinfectant concentration in mg/l in water entering the distribution system.

   (ii) The date and duration of each period when the residual disinfectant concentration in water entering the distribution system fell below 0.2 mg/l and when the State was notified of the occurrence.

   (iii) The following information on the samples taken in the distribution system in conjunction with total monitoring pursuant to 1200-5-1-.07;

      (I) Number of instances where the free residual disinfectant concentration is measured.

      (II) The number of instances where the free residual is below 0.2 mg/l.

3.

©2004. TAUD. All rights reserved.

(i) Each system, upon discovering that a waterborne disease outbreak potentially attributable to that water system has occurred, must report that occurrence to the State as soon as possible, but no later than by the close of the following business day.

(ii) If at any time the turbidity exceeds 1 NTU in representative samples of filtered water in a system using conventional filtration treatment or direct filtration, the system must consult with the department as soon as practical, but no later than 24 hours after the exceedance is known, in accordance with the requirements of the Notification of Customers Rule. If at any time the turbidity in representative samples of filtered water exceed the maximum level set by the department for filtration technologies other than conventional and direct filtration treatment, the system must consult with the department as soon as practical, but not later than 24 hours after the exceedance is known, in accordance with the Notification of Customers Rule.

(iii) If at any time the disinfectant residual falls below 0.2 mg/l in the water entering the distribution system, the system must notify the State as soon as possible, but no later than by the end of the next business day. The system also must notify the State by the end of the next business day whether or not the residual was restored to at least 0.2 mg/l within 4 hours.

4. In addition to the reporting and recordkeeping requirements in 1200-5-1-.31(6)(b) 1.,2.,and 3., a public water system serving 10,000 or more persons that provides conventional filtration treatment or direct filtration must report monthly to the State the information specified in part 4. beginning January 1, 2002. In addition to the reporting and recordkeeping requirements in 1200-5-1-.31(6), a public water system subject to the requirements of this subpart that provides filtration approved under 1200-5-1-.31(4)(d) must report monthly to the State the information specified in subpart (i) beginning January 1, 2002. The reporting in subpart (i) of this section is in lieu of the reporting specified in 1200-5-1-.31(6)(b)1.

(i) Turbidity measurements as required by 1200-5-1-.31 must be reported within 10 days after the end of each month the system serves water to the public. Information that must be reported includes:

(I) The total number of filtered water turbidity measurements taken during the month.

(II) The number and percentage of filtered water turbidity measurements taken during the month which are less than or equal to the turbidity limits specified in paragraph (4)(c) or (d).

 ©2004. TAUD. All Rights Reserved.

(IV) The date and value of any turbidity measurements taken during the month which exceed 1 NTU for systems using conventional filtration treatment or direct filtration, or which exceed the maximum level set by the State under paragraph (4)(d).

(ii) Systems must maintain the results of individual filter monitoring taken for at least three years. Systems must report that they have conducted individual filter turbidity monitoring within 10 days after the end of each month the system serves water to the public. Systems must report individual filter turbidity measurement results taken within 10 days after the end of each month the system serves water to the public only if measurements demonstrate one or more of the conditions in items (I) through (IV) of this section. Systems that use lime softening may apply to the State for alternative exceedance levels for the levels specified in items (I) through (IV) of this section if they can demonstrate that higher turbidity levels in individual filters are due to lime carryover only and not due to degraded filter performance.

(I) For any individual filter that has a measured turbidity level of greater than 1.0 NTU in two consecutive measurements taken 15 minutes apart, the system must report the filter number, the turbidity measurement, and the date(s) on which the exceedance occurred. In addition, the system must either produce a filter profile for the filter within 7 days of the exceedance (if the system is not able to identify an obvious reason for the abnormal filter performance) and report that the profile has been produced or report the obvious reason for the exceedance.

(II) For any individual filter that has a measured turbidity level of greater than 0.5 NTU in two consecutive measurements taken 15 minutes apart at the end of the first four hours of continuous filter operation after the filter has been backwashed or otherwise taken offline, the system must report the filter number, the turbidity, and the date(s) on which the exceedance occurred. In addition, the system must either produce a filter profile for the filter within 7 days of the exceedance (if the system is not able to identify an obvious reason for the abnormal filter performance) and report that the profile has been produced or report the obvious reason for the exceedance.

(III) For any individual filter that has a measured turbidity level of greater than 1.0 NTU in two consecutive measurements taken 15 minutes apart at any time in each of three consecutive months, the system must report the filter number, the turbidity measurement, and the date(s) on which the exceedance occurred. In addition, the system must conduct a self-assessment of the filter within 14 days

©2004. TAUD. All rights reserved.

of the exceedance and report that the self-assessment was conducted. The self assessment must consist of at least the following components: assessment of filter performance; development of a filter profile; identification and prioritization of factors limiting filter performance; assessment of the applicability of corrections; and preparation of a filter self-assessment report.

(IV) For any individual filter that has a measured turbidity level of greater than 2.0 NTU in two consecutive measurements taken 15 minutes apart at any time in each of two consecutive months, the system must report the filter number, the turbidity measurement, and the date(s) on which the exceedance occurred. In addition, the system must arrange for the conduct of a comprehensive performance evaluation by the State or a third party approved by the State no later than 30 days following the exceedance and have the evaluation completed and submitted to the State no later than 90 days following the exceedance.

7) Variances and Exemptions from the Requirements of Filtration and Disinfection

(a) No variance from the requirements in 1200-5-1-.31 are permitted. No exemptions from the requirements in 1200-5-1-.31(3)(a) 3. and 1200-5-1-.17(30) to provide disinfection are permitted.

Monitoring and Reporting

4. Turbidity - Method 214A (Nephelometric Method - Nephelometric Turbidity Units), pp. 134-136, as set forth in Standard Methods for the Examination of Water and Wastewater, 1985, American Public Health Association et al., 16th edition.

2. Turbidity measurements must be performed on representative grab samples of source water immediately prior to the first or only point of disinfectant application every four hours (or more frequently) that the system serves water to the public. A public water system may substitute continuous turbidity monitoring for grab sample monitoring if it validates the continuous measurement for accuracy on a regular basis using a protocol approved by the State. Turbidity must comply with the limits specified in 1200-5-1-.31(2)(a)2.

(c) Monitoring requirements for systems using filtration treatment. A public water system that uses a surface water source or a ground water source under the influence of surface water and provides filtration treatment must monitor in accordance with this paragraph (c) beginning June 29, 1993, or when filtration is installed, whichever is later.

 ©2004. TAUD. All Rights Reserved.

1. Turbidity measurements as required by 1200-5-1-.31(4) must be performed on representative samples of the system's filtered water every four hours (or more frequently) that the system serves water to the public. A public water system may substitute continuous turbidity monitoring for grab sample monitoring if it validates the continuous measurement for accuracy on a regular basis using a protocol approved by the State. For any system using slow sand filtration or filtration treatment other than conventional treatment, direct filtration, or diatomaceous earth filtration, the State may reduce the sampling frequency to once per day if it determines that less frequent monitoring is sufficient to indicate effective filtration performance. For systems serving 500 or fewer persons, the State may reduce the turbidity sampling frequency to once per day, regardless of the type of filtration treatment used, if the State determines that less frequent monitoring is sufficient to indicate effective filtration performance.

4. In addition to monitoring required by parts 1., 2., and 3. of this subparagraph, a public water system using surface water and serving 10,000 or more persons using conventional filtration treatment or direct filtration must conduct continuous monitoring of turbidity for each individual filter using an approved method in 1200-5-1-.31(5)(a) and must calibrate turbidimeters using the procedure specified by the manufacturer. Systems must record the results of individual filter monitoring every 15 minutes.

5. If there is a failure in the continuous turbidity monitoring equipment, the system must conduct grab sampling every four hours in lieu of continuous monitoring until the turbidimeter is repaired and back on-line .A system has a maximum of five working days after failure to repair the equipment or it is in violation.

(6) Reporting and recordkeeping requirements.

(a) A public water system that uses a ground water source under the direct influence of surface water and does not provide filtration treatment must report monthly to the State the information specified in this paragraph (a) beginning December 31, 1990, or 6 months after the determination that the ground water source is under the direct influence of surface water, whichever is later, unless the State has determined in writing that filtration is required, in which case the State may specify alternative reporting requirements, as appropriate, until filtration is in place.

1. Source water quality information must be reported to the State within 10 days after the end of each month the system serves water to the public. Information that must be reported includes but is not limited to:

(i) The cumulative number of months for which results are reported.

©2004. TAUD. All rights reserved.

(ii) The number of fecal and/or total coliform samples, whichever are analyzed during the month (if a system monitors for both, only fecal coliforms must be reported), the dates of sample collection, and the dates when the turbidity level exceeded 1 NTU.

(iii) The number of samples during the month that had equal to or less than 20/100 ml fecal coliforms and/or equal to or less than 100/100 ml total coliforms, whichever are analyzed.

(iv) The cumulative number of fecal or total coliform samples, whichever are analyzed, during the previous six months the system served water to the public.

(v) The cumulative number of samples that had equal to or less than 20/100 ml fecal coliforms or equal to or less than 100/100 ml total coliforms, whichever are analyzed, during the previous six months the system served water to the public.

(vi) The percentage of samples that had equal to or less than 20/100 ml fecal coliforms or equal to or less than 100/100 ml total coliforms, whichever are analyzed, during the previous six months the system served water to the public.

(vii) The maximum turbidity level measured during the month, the date(s) of occurrence for any measurement(s) which exceeded 5 NTU, and the date(s) the occurrence(s) was reported to the State.

(viii) For the first 12 months of recordkeeping, the dates and cumulative number of events during which the turbidity exceeded 5 NTU, and after one year of recordkeeping for turbidity measurements, the dates and cumulative number of events during which the turbidity exceeded 5 NTU in the previous 12 months the system served water to the public.

(ix) For the first 120 months of recordkeeping, the dates and cumulative number of events during which the turbidity exceeded 5 NTU, and after 10 years of recordkeeping for turbidity measurements, the dates and cumulative number of events during which the turbidity exceeded 5 NTU in the previous 120 months the system served water to the public.

2. Disinfection information specified in 1200-5-1-.31(5)(b) must be reported to the State within 10 days after the end of each month the system serves water to the public. Information that must be reported includes but is not limited to:

(i) For each day, the lowest measurement of residual disinfectant concentration in mg/l in water entering the distribution system.

 ©2004. TAUD. All Rights Reserved.

(ii) The date and duration of each period when the residual disinfectant concentration in water entering the distribution system fell below 0.2 mg/l and when the State was notified of the occurrence.

(iii) The daily residual disinfectant concentration(s) (in mg/l) and disinfectant contact time(s) (in minutes) used for calculating the CT value(s).

(iv) If chlorine is used, the daily measurement(s) of pH of disinfected water following each point of chlorine disinfection.

(v) The daily measurement(s) of water temperature in oC following each point of disinfection.

(vi) The daily CTcalc and CTcalc/CT99.9 values for each disinfectant measurement or sequence and the sum of all CTcalc/CT99.9 values before or at the first customer.

(vii) The daily determination of whether disinfection achieves adequate Giardia cyst and virus inactivation, i.e., whether (CTcalc/CT99.9) is at least 1.0 or, where disinfectants other than chlorine are used, other indicator conditions that the State determines are appropriate, are met.

(viii) The following information on the samples taken in the distribution system in conjunction with total coliform monitoring pursuant to 1200-5-1-.31(3) [Disinfection].

(I) Number of instances where the free residual disinfectant concentration is measured and the number of instances where the free residual is below 0.2 mg/l.

3. No later than ten days after the end of each Federal fiscal year (September 30), each system must provide to the State a report which summarizes its compliance with all watershed control program requirements specified in 1200-5-1-.31(2)(b)2.

4. No later than ten days after the end of each Federal fiscal year (September 30), each system must provide to the State a report which describes the on-site inspection conducted during that year pursuant to 1200-5-1-.31(2)(b)3. unless the on-site inspection was conducted by the State. If the inspection was conducted by the State, the State must provide a copy of its report to the public water system.

5.

(i) Each system, upon discovering that a waterborne disease outbreak potentially attributable to that water system has occurred, must report that occurrence to the State as soon as possible, but no later than by the close of the following business day.

©2004. TAUD. All rights reserved.

(ii) If at any time the turbidity exceeds 5 NTU, the system must consult with the department as soon as practical, but no later than 24 hours after the exceedance is known, in accordance with the requirements of the Notification of Customers Rule.

(iii) If at any time the disinfectant residual falls below 0.2 mg/l in the water entering the distribution system, the system must notify the State as soon as possible, but no later than by the end of the next business day. The system also must notify the State by the end of the next business day whether or not the residual was restored to at least 0.2 mg/l within 4 hours.

(b) A public water system that uses a surface water source or a ground water source under the direct influence of surface water and provides filtration treatment must report monthly to the State the information specified in this paragraph (b) beginning June 29, 1993, or when filtration is installed, whichever is later.

1. Turbidity measurements as required by 1200-5-1-.31(5)(c)1. must be reported within 10 days after the end of each month the system serves water to the public. Information that must be reported includes but is not limited to:

(i) The total number of filtered water turbidity measurements taken during the month.

(ii) The number and percentage of filtered water turbidity measurements taken during the month which are less than or equal to the applicable limits specified in 1200-5-1-.31(4).

(iii) The date and value of any turbidity measurements taken during the month which exceed 5 NTU.

2. Disinfection information specified in 1200-5-1-.31(5)(c) must be reported to the State within 10 days after the end of each month the system serves water to the public. Information that must be reported includes:

(i) For each day, the lowest measurement of residual disinfectant concentration in mg/l in water entering the distribution system.

(ii) The date and duration of each period when the residual disinfectant concentration in water entering the distribution system fell below 0.2 mg/l and when the State was notified of the occurrence.

(iii) The following information on the samples taken in the distribution system in conjunction with total monitoring pursuant to 1200-5-1-.07;

(I) Number of instances where the free residual disinfectant concentration is measured.

 ©2004. TAUD. All Rights Reserved.

(II) The number of instances where the free residual is below 0.2 mg/l.

3.

(i) Each system, upon discovering that a waterborne disease outbreak potentially attributable to that water system has occurred, must report that occurrence to the State as soon as possible, but no later than by the close of the following business day.

(ii) If at any time the turbidity exceeds 1 NTU in representative samples of filtered water in a system using conventional filtration treatment or direct filtration, the system must consult with the department as soon as practical, but no later than 24 hours after the exceedance is known, in accordance with the requirements of the Notification of Customers Rule. If at any time the turbidity in representative samples of filtered water exceed the maximum level set by the department for filtration technologies other than conventional and direct filtration treatment, the system must consult with the department as soon as practical, but not later than 24 hours after the exceedance is known, in accordance with the Notification of Customers Rule.

(iii) If at any time the disinfectant residual falls below 0.2 mg/l in the water entering the distribution system, the system must notify the State as soon as possible, but no later than by the end of the next business day. The system also must notify the State by the end of the next business day whether or not the residual was restored to at least 0.2 mg/l within 4 hours.

4. In addition to the reporting and recordkeeping requirements in 1200-5-1-.31(6)(b) 1.,2.,and 3., a public water system serving 10,000 or more persons that provides conventional filtration treatment or direct filtration must report monthly to the State the information specified in part 4. beginning January 1, 2002. In addition to the reporting and recordkeeping requirements in 1200-5-1-.31(6), a public water system subject to the requirements of this subpart that provides filtration approved under 1200-5-1-.31(4)(d) must report monthly to the State the information specified in subpart (i) beginning January 1, 2002. The reporting in subpart (i) of this section is in lieu of the reporting specified in 1200-5-1-.31(6)(b)1.

(i) Turbidity measurements as required by 1200-5-1-.31 must be reported within 10 days after the end of each month the system serves water to the public. Information that must be reported includes:

(I) The total number of filtered water turbidity measurements taken during the month.

©2004. TAUD. All rights reserved.

(II) The number and percentage of filtered water turbidity measurements taken during the month which are less than or equal to the turbidity limits specified in paragraph (4)(c) or (d).

(IV) The date and value of any turbidity measurements taken during the month which exceed 1 NTU for systems using conventional filtration treatment or direct filtration, or which exceed the maximum level set by the State under paragraph (4)(d).

(ii) Systems must maintain the results of individual filter monitoring taken for at least three years. Systems must report that they have conducted individual filter turbidity monitoring within 10 days after the end of each month the system serves water to the public. Systems must report individual filter turbidity measurement results taken within 10 days after the end of each month the system serves water to the public only if measurements demonstrate one or more of the conditions in items (I) through (IV) of this section. Systems that use lime softening may apply to the State for alternative exceedance levels for the levels specified in items (I) through (IV) of this section if they can demonstrate that higher turbidity levels in individual filters are due to lime carryover only and not due to degraded filter performance.

(I) For any individual filter that has a measured turbidity level of greater than 1.0 NTU in two consecutive measurements taken 15 minutes apart, the system must report the filter number, the turbidity measurement, and the date(s) on which the exceedance occurred. In addition, the system must either produce a filter profile for the filter within 7 days of the exceedance (if the system is not able to identify an obvious reason for the abnormal filter performance) and report that the profile has been produced or report the obvious reason for the exceedance.

(II) For any individual filter that has a measured turbidity level of greater than 0.5 NTU in two consecutive measurements taken 15 minutes apart at the end of the first four hours of continuous filter operation after the filter has been backwashed or otherwise taken offline, the system must report the filter number, the turbidity, and the date(s) on which the exceedance occurred. In addition, the system must either produce a filter profile for the filter within 7 days of the exceedance (if the system is not able to identify an obvious reason for the abnormal filter performance) and report that the profile has been produced or report the obvious reason for the exceedance.

(III) For any individual filter that has a measured turbidity level of greater than 1.0 NTU in two consecutive measurements taken 15

 ©2004. TAUD. All Rights Reserved.

minutes apart at any time in each of three consecutive months, the system must report the filter number, the turbidity measurement, and the date(s) on which the exceedance occurred. In addition, the system must conduct a self-assessment of the filter within 14 days of the exceedance and report that the self-assessment was conducted. The self assessment must consist of at least the following components: assessment of filter performance; development of a filter profile; identification and prioritization of factors limiting filter performance; assessment of the applicability of corrections; and preparation of a filter self-assessment report.

(IV) For any individual filter that has a measured turbidity level of greater than 2.0 NTU in two consecutive measurements taken 15 minutes apart at any time in each of two consecutive months, the system must report the filter number, the turbidity measurement, and the date(s) on which the exceedance occurred. In addition, the system must arrange for the conduct of a comprehensive performance evaluation by the State or a third party approved by the State no later than 30 days following the exceedance and have the evaluation completed and submitted to the State no later than 90 days following the exceedance.

Safety

Safety issues included ladders, slips and falls, confined space work, and filter contamination.

©2004. TAUD. All rights reserved.

Disinfection

Process Description

Disinfection is the destruction of pathogenic organisms. It is accomplished by the addition of a strong oxidant, usually some form of chlorine.

A pathogenic organism is disease-producing organism.

Partial List Causative Organisms

Water-borne diseases caused by bacteria

a. gastroenteritis

b. typhoid

c. dysentery

d. cholera

Water-borne diseases caused by viruses

a. polio

b. hepatitis

Water-borne diseases caused by protozoans

a. amebic dysentery

b. cryptospirodosis

c. giardiasis

Sterilization is the destruction of of all living microorganisms. Sterilization is not required and not practiced on treatment plant scale.

Disinfection Methods

Heat Treatment	Good emergency procedure for small quantities of water
	Major disadvantages - No residual prtection/high energy costs
Radiation Treatment	Ultrviolet Radiation (UV)
	Major disadvantage- No residual disinfectant/requires close contact between UV source and water
Chemical Treatment	Use of chemical oxidants
	Chlorine
	Chlorine Dioxide

 ©2004. TAUD. All Rights Reserved.

Chlorine Compounds - hypochlorites such as bleach and HTH; combined residuals such as monochloramines and dichloramines.

Ozone

Chlorine/Sodium Hupochlorite Properties

Chlorine Liquid/Gas

Product Use:.....Water Purification, Chemical Processes, Plastic Manufacture

Chemical Name:.....Chlorine

Chemical Formula:.....Cl_2

Common Names: .....Chlorine

CAS Number:.....7782-50-5

Molecular Weight: 70.91

Percent Purity:.....99.5-100

Appearance and Odor: .....Amber color liquid. Greenish-yellow gas. Pungent irritating odor.

Lethal Concentration.....0.1% or 1,000 mg/L by volume

Odor Threshold: .....Approximately 2 ppm

Specific Gravity (Water=1): .....1.4 @ 15.4°C

Vapor Pressure:.....2748mm Hg @ 0°C

Vapor Density (Air=1):.....2.5

Density:.....11.7 lbs./gallon @15.6°C

Evaporation Rate:.....Not applicable

% Volatiles by Wt:.....100%

Boiling Point:.....-34°C (-29.3°F)

Freezing Point:.....-101°C (-150°F)

Melting Point: .....Not available

Solubility in Water (% by wt.):.....0.7% @ 20°C

pH:.....0.7% solution has pH 5.5

Sodium Hypochlorite

Product Use:.....Bleach, Water Treatment

Chemical Name:.....Hypochlorous Acid, Sodium Salt

©2004. TAUD. All rights reserved.

Chemical Formula:	NaOCl
Common Names:	Chlorine bleach, Soda bleach
Appearance and Odor:	Water clear to slight yellow color with distinctive chorine odor
Odor Threshold:	Approximately 2 ppm
Specific Gravity (Water=1):	1.27
Boiling Point:	110°C (230°F)
Solubility in Water (% by wt.):	100%
pH:	12
Other:	Available chlorine, approximately 13%

COMPOSITION/INFORMATION ON INGREDIENTS

7732-18-5	Water (MW 18.02)
7681-52-9	Hypochlorous acid, sodium salt
Common Names:	Sodium hypochlorite
Molecular Weight	74.44
1310-73-2	Sodium hydroxide (Na(OH))
Common Names:	Caustic Soda
Molecular Weight	40.00

Free chlorine residual - the chlorine residual formed once all the chlorine demand has been satisfied.

Combined chlorine residual - the residual produced by the reaction of chlorine with substances in the water, usually ammonia.

Chlorine Chemistry

Chlorine is an extremely reactive chemical. When added to water it will first react with certain material (reducing agents) before forming any residual that is useful for disinfection. These materials include:

- Iron;
- Manganese;

 ©2004. TAUD. All Rights Reserved.

- Ammonia;
- Nitirites;
- Organic Compounds.

When chlorine reacts with organic compounds and ammonia, it forms combined chlorine residuals. These combined forms of chlorine residual are:

- Chloro-organic Compounds – THMs and HAA_5s;
- Monochloramine (NH_2Cl) – $1/150^{th}$ as effective as a hypochlorous acid residual, creates taste and odor problems at about 5 mg/L;
- Dichloramine ($NHCl_2$) - $1/80^{th}$ as effective as a hypochlorous acid residual, creates taste and odor problems at about 0.8 mg/L;
- Trichloramine (NCl_3) – comparison to hypochlorous acid residual unknown, creates taste and odor problems at about 0.02 mg/L.

Once all the ammonia and organic compounds are oxidized, the chlorine will form free (unreacted) chlorine residuals. There are two forms of free chlorine residual:

Hypochlorite Ion (OCl^-) - $1/100^{th}$ as effective as a hypochlorous acid residual;

Hypochlorous Acid (HOCl) – the most effective form of chlorine residual for disinfection, creates taste and odor problems at about 20 mg/L.

Factors Affecting Sucess of Chlorination

Primary Factors - Effectiveness of chlorination depends primarily on Contact Time and Concentration (C X T).

Chlorine concentration	the amount of free chlorine residual is directly related to the amount of chlorine added.
Contact time between the water and the chlorine	

Secondary Factors

Temperature of the water	Generally, as the temperature goes up, effectiveness goes up. The effects of low temperature offset by increased stability of residual
pH of the water	pH determines the distribution of hypochlorous acid and hypochlorite ion. Hypochlorous acid is the most effective form of free residual. It predominates at pH<7.
Foreign subtances in the water	Reducing agents - Iron, Manganese, Nitrites, Ammonia, Organic Compounds. No chlorine residual can be formed until all the reducing agents have been oxidized.

©2004. TAUD. All rights reserved.

Turbidity	prevents good contact between the chlorine and pathogens by shielding the pathogens from the chlorine.

Uses of Chlorine

- Disinfection of drinking water.
- Disinfection of water mains, storage tanks, filters, wells and other treatment facilities.
- Oxidizing iron, manganese, and hydrogen sulfide.
- Controlling tastes, odors, algae and slime.

Process Control

Chlorinate to maintain a free chlorine residual of 0.2 mg/l in all parts of the distribution system.

The free chlorine residual shall not be less than 0.2 mg/l in more than 5 percent of the samples each month, for any two consecutive months.

Lowest chlorine residual for the day must be recorded

If the free chlorine residual falls below 0.2 mg/l, a sample must be taken every four hours until the residual is restored to at least 0.2 mg/l.

Maximum Residual Disinfectant Level (MRDL) for chlorine is 4.0 mg/L

Feed Rate Limitations

The chlorine withdrawal rate from a 150-lbs cylinder or ton container depends on:

(1) the temperature of the chlorine room;

(2) the threshold temperature; and,

(3) the withdrawal factor for the type of container.

If the withdrawal rate is too high, ice will form on the cylinder, reducing the withdrawal rate.

A new lead washer should be used each time a cylinder is connected.

Use only the wrench provided by the manufacturer.

Process Evaluation and Troubleshooting

Problems which make maintaining a chlorine residual in the distribution system difficult include:

- stagnant water in dead ends
- biological growth
- contamination during break repairs
- contamination from cross-connections

 ©2004. TAUD. All Rights Reserved.

- inadequate treatment

Low chlorine readings are caused by:

- agitation of the sample
- aeration of the sample
- exposure to sunlight
- holding the sample too long before analysis
- using the same bottle to collect chlorine samples and bacteriological samples.

Common Operating Problems

Leaks Detect with ammonia

Leak detector for small leaks

Prevention:

(1) replace lead washer every time the container is changed;

(2) clean valve threads with wire brush and wrap threads with teflon tape;

(3) Replace all chlorine supply line valves annually.

Stiff Container Valves

Use only the wrench provided by the manufacturer.

If the wrench won't open the valve, hit wrench once with a small blok of wood held in plam of hand.

If this doesn't work, have supplier replace the cylinder.

Sudden Drop in Residual

Warning of potential danger!

Corrective measures

- increase chlorine levels immediately;
- identify contaminants;
- locate contaminant source or other causes for drop in residual.

Trihalomethane Formation

Caused by the reaction of chlorine with organic (humic and fulvic acids) compounds in water. These organic compounds come from decaying vegetation.

©2004. TAUD. All rights reserved.

Do not prechlorinate.

Remove organics by oxidizing with permanganates, practicing enhanced coagulation, or adsorbing with activated carbon.

Flush mains diligently.

Hypochlorinator Problems

(1) clogged equipment - occurs primarily at the pump head and suction and discharge lines.

(2) broken diaphragms

Design Criteria

4.4 DISINFECTION - Chlorine is the preferred disinfecting agent. Other agents will be considered by the Department, provided reliable feeding equipment is available and testing procedures for a residual are recognized in "Standard Methods for the Examination of Water and Wastewater," latest edition. Continuous disinfection is recommended for all water supplies and is required at all community public water systems serving more than 50 connections or 150 persons.

4.4.1 Equipment

a. Type - Solution feed gas type chlorinator and hypochlorite feeders of the positive displacement type are acceptable (see Part 5). Alternative chlorine feeders such as tablet chlorinators may be considered for some applications.

b. Capacity - The chlorinator capacity shall be such that a free chlorine residual of at least 2 mg/L can be attained in the water after a contact time of at least 30 minutes when maximum flow rates coincide with anticipated maximum chlorine demands. The equipment shall be of such design that it will operate accurately over the desired feeding range.

c. Dual Chlorination - Two chlorinator shall be provided and operated simultaneously such that each feeds approximately half the chlorine requirement.

d. Spare Parts - Spare parts shall be provided so that either unit could be equipped to supply the entire chlorine requirement.

e. Automatic Switchover - Automatic switchover of chlorine cylinders should be provided where necessary to assure continuous disinfection. This does not take the place of having dual chlorination.

 ©2004. TAUD. All Rights Reserved.

f. Automatic Proportioning - Automatic proportioning chlorinator will be required where the rate of flow either is not reasonably constant or where the quality of the water is subject to rapid changes.

4.4.2 Contact Time and Point of Application

a. Due consideration shall be given to the contact time of the chlorine in water with relation to pH, ammonia, taste producing substances, temperature, bacterial quality, trihalomethanes formation potential and other pertinent factors. Chlorine should be applied at a point which will provide adequate contact time. All basins used for disinfection must be designed to minimize short-circuiting.

b. At plants treating surface water, provisions should be made for applying chlorine to the raw water, top of filters, and filtered water.

c. At plants treating groundwater, provision should be made for applying chlorine to the clearwell inlet and the high lift pump suction.

d. Free residual (breakpoint) chlorination is required; 30 minutes contact time should be provided for ground waters and 2 hours for surface waters.

4.4.3 Chlorinator Piping

a. The water supply piping shall be designed to prevent contamination of the treated water supply by source of questionable quality.

b. Pipe material - The pipes carrying elemental liquid or dry gaseous chlorine under pressure and liquid chlorine must be schedule 80 seamless steel tubing or other materials recommended by the Chlorine Institute (never use PVC). Rubber, PVC, polyethylene, or other materials recommended by the Chlorine Institute must be used for chlorine solution piping and fittings. Nylon products are not acceptable for any part of the chlorine solution piping system.

c. Backflow Protection - All chlorine solution lines feeding into water having less than a full cycle of treatment (ahead of filters) shall be vented to the outside atmosphere. This venting shall be provided in such a manner that backflow into treated waters is prevented. Vacuum breakers and other mechanical devices shall not be substituted for a vent. Vents for chlorine lines shall:

1. be the same size as the solution line piping,

2. be connected to the solution line at a point where it is elevated a minimum of 6 feet above the maximum water level in the receiving basin,

3. have no shut off valves,

©2004. TAUD. All rights reserved.

4. be extended to a high enough elevation outside the building that overflow from the vent tube during surges is prevented,

5. have a nylon or other suitable insert screen covering the vent which has been turned downward near its end,

6. not be subject to back pressures.

d. Distribution Panels - The Department recommends the use of chlorine solution distribution panels to ease the change of chlorine solution application points or the change of chlorine feed equipment. If a distribution panel is installed all chlorine solution lines except those feeding into the clear well or filter effluent must be vented as specified in section 4.4.3c. This venting is to be located between the distribution panel discharge and the point of application. Where chlorine solution from one chlorine feed unit is to be split to feed at more than one application point, a suitable rotameter shall be installed to allow accurate proportioning of the total flow among the application points.

4.4.4 Housing - Adequate housing must be provided for the chlorination equipment and for storing the chlorine supply (See Section 5.3).

Division of Water Supply Rules

1200-5-1-.17 Operations and Maintenance

(4) Chlorine is the recommended disinfection agent. Other agents will be considered by the Department provided they are effective and testing procedures for their effectiveness are recognized in the latest edition of "Standard Methods for the Examination of Water and Wastewater". All community water systems, using ground water as a raw water source and serving more than 50 connections or 150 persons shall continuously chlorinate (unless other disinfection methods are approved) and shall maintain a free chlorine residual in all parts of the distribution system in the amount of not less than 0.2 mg/l. Public Water Systems using surface water shall continuously chlorinate and maintain a free chlorine residual of 0.2 mg/l in all parts of the distribution system. The residual disinfectant concentration specified by this rule shall not be less than 0.2 mg/l in more than 5 percent of the samples each month, for any two consecutive months the system serves water to the public. All public water systems serving 50 or fewer connections that do not disinfect shall install continuous disinfection if the system fails to comply with the maximum contaminant level for coliform, experiences a disease outbreak or is directed to install disinfection by the department. All public water systems serving 50 or fewer connections that do not disinfect shall install continuous disinfection if the system fails to comply with the maximum contaminant level for coliform, experiences a disease outbreak or is directed to install disinfection by the department.

(5) All systems required to submit samples for microbiological examination to the State laboratory must submit said sample in the bottle(s) provided by the Department and sent to

 ©2004. TAUD. All Rights Reserved.

the proper State laboratory in the shipping carton provided by the State. The cost of postage for shipping the sample to the proper State laboratory shall be paid by the supplier of water. All samples submitted for microbiological examination must be collected and mailed to arrive at the proper State laboratory not later than Thursday noon of any week. Thirty hours is the limit allowed from the time of collection to the time of examination at the proper State laboratory.

(10) All community water systems having more than 50 service connections shall establish and maintain an adequate flushing program. The flushing program established shall help ensure that dead end and low usage mains are flushed periodically, drinking water standards are met, sediment and air removal and the free chlorine residual specified under Rule 1200-5-1.17(4) is maintained. Records of each flushing are to be maintained by the water system. These records shall include date, time, location, persons responsible and length of flushing. In addition to the above information, the free chlorine residual will have to be measured and recorded on the end of dead end mains after being flushed.

(11) All community public water systems serving more than 50 service connections and which have their own source of water shall be required to install, operate, and maintain duplicate disinfection equipment. Duplicate disinfection equipment means at least two chlorine cylinder(s) connected to at least two chlorinators. Each set of chlorine cylinders consists of one or more cylinders which may be connected together by an automatic switchover valve. The two sets of chlorine cylinders may tee in to a common feed line leading to the chlorinators, but may not be connected together by an automatic switchover valve. The two sets of chlorine cylinders must be weighed independently and operated simultaneously. At least two chlorinators must be operated at all times with each feeding a portion of the required dosage. The chlorinators may discharge to a common manifold piping network to allow multiple injection points. Facilities may be exempt from simultaneously operating duplicate disinfection equipment if the facility has a reliable chlorine residual analyzer with an alarm notifying a manned control center capable of immediately shutting down the treatment facility.

Facilities, which are staffed during the time water is treated, can use one set of chlorine cylinders with the automatic switchover device provided the free chlorine residual is checked at the facility every two hours. A reliable free chlorine residual analyzer with an alarm system to a manned control center may be used for unmanned facilities that desire to use one set of chlorine cylinders with the automatic switchover device.

Systems which use a hypochlorinator shall be required to have two solution pumps, two tanks for bleach solution and operate both units at the same time.

(26) Those public water systems required to monitor for turbidity and chlorine residual must have the laboratory approved by the Department before the results of these analyses can be accepted for compliance purposes.

©2004. TAUD. All rights reserved.

(27) By December 30, 1991, or 18 months after the determination that a ground water system is influenced by surface water, all public water systems classified as a ground water system impacted by surface water shall utilize treatment techniques which achieve:

(a) At least 99.9 percent (3 log) removal and/or inactivation of Giardia lamblia cysts between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer.

(b) At least 99.99 percent (4 log) removal and/or inactivation of viruses between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer.

(28) All public water systems using surface water shall provide disinfection to control the biological quality of the water. Due consideration shall be given to the contact time of the disinfectant in the water with relation to pH, ammonia, taste producing substances, temperature, presence and type of pathogens, and trihalomethane formation potential. All disinfection basins must be designed to prevent water short-circuiting the system. The disinfectant will be applied in the manner needed to provide adequate contact time.

(29) All community water systems using ground water as the raw water source serving water to more than 50 connections or 150 people will apply the disinfectant in the manner needed for adequate contact time. Contact time for ground water systems shall not be less than 15 minutes prior to the first customer.

(30) Any surface supplied public water system or ground water systems under the direct influence of surface water required to filter shall employ filtration in combination with disinfection that will achieve 99.9% (3 log) and 99.99% (4 log) inactivation of Giardia lamblia and viruses respectively between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer. For the purposes of determining removal or inactivation efficiencies for Giardia lamblia and viruses Table 1200-5-1-.17(30)1 and 1200-5-1-.17(30)2 shall apply. The free residual disinfectant concentration in the water entering the distribution system cannot be less than 0.2 mg/l for more than four hours.

TABLE 1200-5-1-.17(30)1 - ASSUMED LOG REMOVALS BY FILTRATION METHOD AND REQUIRED LEVELS OF DISINFECTION

Treatment	Assumed Log Removals		Required minimum level of disinfection	
	Giardia	Viruses	Giardia	Viruses
Conventional filtration	2.5	2.0	0.5	2.0
Direct filtration	2.0	1.0	1.0	3.0
Slow Sand filtration	2.0	2.0	1.0	2.0
Diatomaceous Earth filtration	2.0	1.0	1.0	3.0

 ©2004. TAUD. All Rights Reserved.

TABLE 1200-5-1-.17(30)2 - CT VALUES FOR ACHIEVING 1-LOG INACTIVATION OF GIARDIA CYSTS[1]

	pH	Temperature			
		0.5°C	5°C	10°C	15°C
Free Chlorine [2,3]	6	55	39	29	19
	7	79	55	41	26
	8	115	81	61	41
	9	167	118	88	59
Ozone		0.97	0.63	0.48	0.32
Chlorine dioxide		1270	735	615	500

[1] Values to achieve 0.5 log inactivation are one half those shown in the table.

[2] CT values are for 2.0 mg/l free chlorine.

[3] CT values for other concentrations of free chlorine may be taken from Appendix E of the guidance manual for Compliance with the "Filtration and Disinfection Requirements For Public Water Systems Using Surface Water Sources," October, 1989, Edition, Science and Technology Branch Criteria and Standards Division, Office of Drinking Water, USEPA, Washington, D.C.

1200-5-1-.31 Filtration and Disinfection

(1) General Requirements

(a) The requirements of Rule 1200-5-1-.31 constitute primary drinking water regulations. These regulations establish criteria under which filtration is required as a treatment technique for public water systems supplied by a surface water source or a ground water source under the direct influence of surface water. Each public water system with a surface water source or a ground water source under the direct influence of surface water must provide treatment of that source water that complies with these treatment technique requirements. These regulations establish treatment technique requirements in lieu of maximum contaminant levels for Giardia lamblia, cryptosporidium, viruses, heterotrophic plate count bacteria, Legionella, and turbidity. The treatment technique requirements consist of installing and properly operating water treatment processes which reliably achieve removal of Giardia lamblia cysts, cryptosporidium and viruses as set forth herein.

©2004. TAUD. All rights reserved.

(b) A public water system using a ground water source under the direct influence of surface water shall:

1. Meet the requirements for avoiding filtration in 1200-5-1-.31(2) and meet the disinfection requirements in 1200-5-1-.31(3)(a) or

2. Meet the filtration requirements in 1200-5-1-.31(4) and the disinfection requirements in 1200-5-1-.17(30).

(c) A public water supply using surface water shall meet disinfection requirements in 1200-5-1-.17(30) and filtration requirements in 1200-5-1-.31(4) to be in compliance with paragraph (a).

(d) Each public water system using a surface water source or a ground water source under the direct influence of surface water must be operated by certified personnel who meet the requirements of the Tennessee Water Environmental Health Act T.C.A. 68-13-901 et. seq. and Certification Board Regulations contained in Chapter 1200-5-3.

(e) Beginning December 31, 2001, subpart H systems serving 10,000 or more persons shall install treatment which achieve at least 99 percent (2-log) removal of cryptosporidium between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer for filtered systems, and ground water systems under the direct influence of surface water and serving 10,000 or more persons must have a watershed control plan which controls cryptosporidium. Subpart H systems shall conduct filter and disinfection profiling and benchmarking as required by this rule. Subpart H systems serving 10,000 or more persons shall also comply with the turbidity criteria in 1200-5-1-.31(4)(c).

(c) Treatment Technique Violations.

1. A system is in violation of a treatment technique requirement if it:

(i) fails to meet any one of the criteria in paragraphs (a) and (b) of this section; or

(ii) is required to have filtration, by written directive of the state; and

(iii) fails to install filtration by the date specified in the introductory paragraph of this section.

(3) Disinfection.

A public water system that uses a ground water source under the direct influence of surface water and does not provide filtration treatment must provide disinfection treatment within 6 months of being notified by the State. Failure to meet any requirement of this section

 ©2004. TAUD. All Rights Reserved.

after the applicable date specified in this introductory paragraph is a treatment technique violation.

(a) Each public water system using ground water impacted by surface water that does not provide filtration treatment must provide disinfection treatment beginning December 30, 1991 or 6 months following a determination that the system is under the direct influence of surface water whichever is later. The disinfection treatment shall comply with the following:

1. The disinfection treatment must be sufficient to ensure at least 99.9 percent (3-log) inactivation of Giardia lamblia cysts and 99.99 percent (4-log) inactivation of viruses between a point where the raw water is not subject to recontamination by surface water runoff and a point downstream before or at the first customer, every day the system serves water to the public, except any one day each month. Each day a system serves water to the public, the public water system must calculate the CT value(s) from the system's treatment parameters, using the procedure specified in 1200-5-1-.31(5)(b)3. It must also determine whether this value(s) is sufficient to achieve the specified inactivation rates for Giardia lamblia cysts and viruses. If a system uses a disinfectant other than chlorine, the system may demonstrate to the State, through the use of a State-approved protocol for on-site disinfection challenge studies or other information satisfactory to the State, that CT99.9 values other than those specified in Tables 2.1 and 3.1 in 1200-5-1-.31(5)(b)3. or other operational parameters are adequate to demonstrate that the system is achieving minimum inactivation rates required by paragraph (a)1. of this section.

2. The disinfection system must have either (i) redundant components, including an auxiliary power supply with automatic start-up and alarm to ensure that disinfectant application is maintained continuously while water is being delivered to the distribution system, or (ii) automatic shut-off of delivery of water to the distribution system whenever there is less than 0.2 mg/l of residual is infectant concentration in the water.

3. The free chlorine residual concentration in the water entering the distribution system, measured as specified in 1200-5-1-.31(5)(a)5. and (b)5. cannot be less than 0.2 mg/l for more than 4 hours.

4. The residual disinfectant concentration in the distribution system, measured as free chlorine shall not be less than 0.2 mg/l in more than 5 percent of the samples each month, for any two consecutive months the system serves water to the public.

(5) Analytical and Monitoring Requirements

©2004. TAUD. All rights reserved.

(a) Analytical Requirements. Only the analytical method(s) approved by the Department may be used to demonstrate compliance with the requirements of 1200-5-1-.31(2), (3) and (4). Measurements for pH, temperature, turbidity, and residual disinfectant concentrations must be conducted by a party approved by the State. Measurements for total coliform, and fecal coliforms, must be conducted by a laboratory certified by the State or EPA to do such analysis. Listed below are the analytic methods approved by the Department.

1. Fecal coliform concentration - Method 908C (Fecal Coliform MPN Procedures), pp. 878-880, Method 908D (Estimation of Bacterial Density), pp. 880-882, or Method 909C (Fecal Coliform Membrane Filter Procedure), pp. 896-898, as set forth in Standard Methods for the Examination of Water and Wastewater, 1985, American Public Health Association et al., 16th Edition.

2. Total coliform concentration - Method 908A (Standard Total Coliform Multiple - Tube (MPN) Tests), pp. 872-876, Method 908B (Application of Tests to Routine Examinations), pp. 876-878, Method 908D (Estimation of Bacterial Density), pp. 880-882, Method 909A (Standard Total Coliform Membrane Filter Procedure), pp. 887-894, or Method 909B (Delayed - Incubation Total Coliform Procedure), pp. 894-896, as set forth in Standard Methods for the Examination of Water and Wastewater, 1985, American Public Health Association et al., 16th edition; Minimal Medium ONPG-MUG Test, as set forth in the article "National Field Evaluation of a Defined Substrate Method for the Simultaneous Enumeration of Total Coliforms and Escherichia coli from Drinking Water: Comparison with the Standard Multiple Tube Fermentation Method" (Edberg et al.), Applied and Environmental Microbiology, Volume 54, pp. 1595-1601, June, 1988 (as amended under Erratum, Volume 54, p. 3197, December, 1988).

(Note: The Minimal Medium ONPG-MUG Test is sometimes referred to as the Autoanalysis Colilert System). Systems may use a five-tube test or a ten-tube test.

3. Heterotrophic Plate Count - Method 907A (Pour Plate Method), pp. 864-866, as set forth in Standard Methods for the Examination of Water and Wastewater, 1985, American Public Health Association et al., 16th edition.

5. Free Residual disinfectant concentration - Residual disinfectant concentrations for free chlorine must be measured by Method 408C (Amperometric Titration Method), pp. 303-306, Method 408D (DPD Ferrous Titrimetric Method), pp. 306-309, Method 408E (DPD Colorimetric Method), pp. 309-310, or Method 408F (Leuco Crystal Violet Method), pp. 310-313, as set forth in Standard Methods for the Examination of Water and Wastewater, 1985, American Public Health Association et al., 16th edition. Residual disinfectant concentrations for free chlorine may also be measured by using DPD colorimetric test kit if approved by the State. Residual disinfectant

 ©2004. TAUD. All Rights Reserved.

concentrations for ozone must be measured by the Indigo Method as set forth in Bader, H., Hoigne, J., "Determination of Ozone in Water by the Indigo Method; A Submitted Standard Method"; Ozone Science and Engineering, Vol. 4, pp. 169-176, Pergamon Press Ltd., 1982, or automated methods which are calibrated in reference to the results obtained by the Indigo Method on a regular basis, if approved by the State.

6. Temperature - Method 212 (Temperature), pp. 126-127, as set forth in Standard Methods for the Examination of Water and Wastewater, 1985, American Public Health Association et al., 16th edition.

7. pH - Method 423 (pH Value), pp. 429-437, as set forth in Standard Methods for the Examination of Water and Wastewater, 1985, American Public Health Association, 16th edition.

(b) A public water system that uses a ground water source under the direct influence of surface water and does not provide filtration treatment must begin monitoring as specified in this paragraph (b), beginning December 31, 1990, or 6 months following the determination that the ground water source is under the direct influence of surface water, whichever is later, unless the State has determined in writing that filtration is required, in which case the State may specify alternative monitoring requirements, as appropriate, until filtration is in place.

1. Fecal coliform or total coliform density measurements as required by 1200-5-1-.31(2)(a)1. must be performed on representative source water samples immediately prior to the first or only point of disinfectant application. The system must sample for fecal or total coliforms at the following minimum frequency each week the system serves water to the public. Fecal coliform or total coliform densities must meet the limits specified in 1200-5-1-.31(2)(a)1.

System size (persons served)	Samples/week[1]
≤500	1
501 to 3,300	2
3,301 to 10,000	3
10,001 to 25,000	4
>25,000	5

[1] Must be taken on separate days.

Also one fecal or total coliform density measurement must be made every day the system serves water to the public and the turbidity of the source water exceeds 1 NTU (these samples count toward the weekly coliform sampling requirement) unless the State determines that the system, for reasons outside the system's control, cannot have the sample analyzed within 30 hours of collection.

©2004. TAUD. All rights reserved.

3. The total inactivation ratio for each day that the system is in operation must be determined based on the CT99.9 values in Tables 1.1-1.6, 2.1 and 3.1 of this section, as appropriate. The parameters necessary to determine the total inactivation ratio must be monitored as follows:

   (i) The temperature of the disinfected water must be measured at least once per day at each chlorine residual disinfectant concentration sampling point.

   (ii) If the system uses chlorine, the pH of the disinfected water must be measured at least once per day at each chlorine residual disinfectant concentration sampling point.

   (iii) The disinfectant contact time(s) ("T") must be determined for each day during peak hourly flow.

   (iv) The residual disinfectant concentration(s) ("C") of the water before or at the first customer must be measured each day during peak hourly flow.

   (v) If a system uses a disinfectant other than chlorine, the system may demonstrate to the State, through the use of a State-approved protocol for on-site disinfection challenge studies or other information satisfactory to the State, that CT99.9 values other than those specified in Tables 2.1 and 3.1 in this section or other operational parameters are adequate to demonstrate that the system is achieving the minimum inactivation rates required by 1200-5-1-.31(3)(a)1.

 ©2004. TAUD. All Rights Reserved.

Table 1.1 - CT Values ($CT_{99.9}$) for 99.9 Percent Inactivation of Giardia lamblia Cysts by Free Chlorine at 0.5°C or Lower [1]

Free Residual (mg/L) Disinfectant Concentration	pH						
	≤6.0	6.5	7.0	7.5	8.0	8.5	9.0
≤0.4	137	163	195	237	277	329	390
0.6	141	168	200	239	286	342	407
0.8	145	172	205	246	295	354	422
1.0	148	176	210	253	304	365	437
1.2	152	180	215	259	313	376	451
1.4	155	184	221	266	321	387	464
1.6	157	189	226	273	329	397	477
1.8	162	193	231	279	338	407	489
2.0	165	197	236	286	346	417	500
2.2	169	201	242	297	353	426	511
2.4	172	205	247	298	361	435	522
2.6	175	209	252	304	368	444	533
2.8	178	213	257	310	375	452	543
3.0	181	217	261	316	382	460	552

[1]These CT values achieve greater than 99.99 percent inactivation of viruses. CT values between the indicated pH values may be determined by linear interpolation. CT values between the indicated temperature of different tables may be determined by linear interpolation. If no interpolation is used, use the $CT_{99.9}$ value at the lower temperature, and at the higher pH.

©2004. TAUD. All rights reserved.

Table 1.2 - CT Values ($CT_{99.9}$) for 99.9 Percent Inactivation of Giardia lamblia Cysts by Free Chlorine at 5.0°C[1]

Free Residual (mg/L) Disinfectant Concentration	pH						
	≤6.0	6.5	7.0	7.5	8.0	8.5	9.0
≤0.4	97	117	139	166	198	236	279
0.6	100	120	143	171	204	244	291
0.8	103	122	146	175	210	252	301
1.0	105	125	149	179	216	260	312
1.2	107	127	152	183	221	267	320
1.4	109	130	155	187	227	274	329
1.6	111	132	158	192	232	281	337
1.8	114	135	162	196	238	287	345
2.0	116	138	165	200	243	294	353
2.2	118	140	169	204	248	300	361
2.4	120	143	172	209	253	306	368
2.6	122	146	175	213	258	312	375
2.8	124	148	178	217	263	318	382
3.0	126	151	182	221	268	324	389

[1]These CT values achieve greater than a 99.99 percent inactivation of viruses. CT values between the indicated pH values may be determined by linear interpolation. CT values between the indicated temperatures of different tables may be determined by linear interpolation. If no interpolation is used, use the $CT_{99.9}$ value at the lower temperature, and at the higher pH.

 ©2004. TAUD. All Rights Reserved.

Table 1.3 - CT Values ($CT_{99.9}$) for 99.9 Percent Inactivation of Giardia lamblia Cysts by Free Chlorine at 10.0°C[1]

Free Residual (mg/L) Disinfectant Concentration	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	166	200	240
1.4	82	98	116	140	170	206	247
1.6	83	99	119	144	174	211	253
1.8	86	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

[1]These CT values achieve greater than a 99.99 percent inactivation of viruses. CT values between the indicated pH values may be determined by linear interpolation. CT values between the indicated temperatures of different tables may be determined by linear interpolation. If no interpolation is used, use the $CT_{99.9}$ value at the lower temperature, and at the higher pH.

©2004. TAUD. All rights reserved.

Table 1.4 - CT Values ($CT_{99.9}$) for 99.9 Percent Inactivation of Giardia lamblia Cysts by Free Chlorine at 15.0°C[1]

Free Residual (mg/L) Disinfectant Concentration	pH						
	≤6.0	6.5	7.0	7.5	8.0	8.5	9.0
≤0.4	49	59	70	83	99	118	140
0.6	50	60	72	86	102	122	146
0.8	52	61	73	88	105	126	151
1.0	53	63	75	90	108	130	156
1.2	54	64	76	92	111	134	160
1.4	55	65	78	94	114	137	165
1.6	56	66	79	96	116	141	169
1.8	57	68	81	98	116	144	173
2.0	58	69	83	100	122	147	177
2.2	59	70	85	102	124	150	181
2.4	60	72	86	105	127	153	184
2.6	61	73	88	107	129	156	188
2.8	62	74	89	109	132	159	191
3.0	63	76	91	111	134	162	195

[1]These CT values achieve greater than a 99.99 percent inactivation of viruses. CT values between the indicated pH values may be determined by linear interpolation. CT values between the indicated temperatures of different tables may be determined by linear interpolation. If no interpolation is used, use the $CT_{99.9}$ value at the lower temperature, and at the higher pH.

 ©2004. TAUD. All Rights Reserved.

Table 1.5 - CT Values ($CT_{99.9}$) for 99.9 Percent Inactivation of Giardia lamblia Cysts by Free Chlorine at 20.0°C[1]

Free Residual (mg/L) Disinfectant Concentration	pH						
	≤6.0	6.5	7.0	7.5	8.0	8.5	9.0
≤0.4	36	44	52	62	74	89	105
0.6	38	45	54	64	77	92	109
0.8	39	46	55	66	79	95	113
1.0	39	47	56	67	81	98	117
1.2	40	48	57	69	83	100	120
1.4	41	49	58	70	85	103	123
1.6	42	50	59	72	87	105	126
1.8	43	51	61	74	89	108	129
2.0	44	52	62	75	91	110	132
2.2	44	53	63	77	93	113	135
2.4	45	54	65	78	95	115	138
2.6	46	55	66	80	97	117	141
2.8	47	56	67	81	99	119	143
3.0	47	57	68	83	101	122	146

[1]These CT values achieve greater than a 99.99 percent inactivation of viruses. CT values between the indicated pH values may be determined by linear interpolation. CT values between the indicated temperatures of different tables may be determined by linear interpolation. If no interpolation is used, use the $CT_{99.9}$ value at the lower temperature, and at the higher pH.

©2004. TAUD. All rights reserved.

Table 1.5 - CT Values ($CT_{99.9}$) for 99.9 Percent Inactivation of Giardia lamblia Cysts by Free Chlorine at 25.0°C[1]

Free Residual (mg/L) Disinfectant Concentration	pH						
	≤6.0	6.5	7.0	7.5	8.0	8.5	9.0
≤0.4	24	29	35	42	50	59	70
0.6	25	30	36	43	51	61	73
0.8	26	31	37	44	53	63	75
1.0	26	31	37	45	54	65	78
1.2	27	32	38	46	55	67	80
1.4	27	33	39	47	57	69	82
1.6	28	33	40	48	58	70	84
1.8	29	34	41	49	60	72	86
2.0	29	35	41	50	61	74	88
2.2	30	35	42	51	62	75	90
2.4	30	36	43	52	63	77	92
2.6	31	37	44	53	65	78	94
2.8	31	37	45	54	66	80	96
3.0	32	38	46	55	67	81	97

[1]These CT values achieve greater than a 99.99 percent inactivation of viruses. CT values between the indicated pH values may be determined by linear interpolation. CT values between the indicated temperatures of different tables may be determined by linear interpolation. If no interpolation is used, use the $CT_{99.9}$ value at the lower temperature, and at the higher pH.

 ©2004. TAUD. All Rights Reserved.

Table 2.1 - CT Values ($CT_{99.9}$) for 99.9 Percent Inactivation of Giardia lamblia Cysts by Chlorine Dioxide and Ozone[1]

Disinfectant	Temperature					
	≤1°C	5°C	10°C	15°C	20°C	25°C
Chlorine Dioxide	63	26	23	19	15	11
Ozone	2.9	1.9	1.4	0.95	0.72	0.48

1 These CT values achieve greater than 99.99 percent inactivation of viruses. CT values between the indicated temperatures may be determined by linear interpolation. If no interpolation is used, use the $CT_{99.9}$ values at the lower temperature for determining $CT_{99.9}$ values between indicated temperatures.

Table 3.1 - CT Values ($CT_{99.9}$) for 99.9 Percent Inactivation of Giardia lamblia Cysts by Chloramines[1]

	Temperature				
≤1°C	5°C	10°C	15°C	20°C	25°C
3,800	2,200	1,850	1,500	1,100	750

1These values are for pH values of 6 to 9. These CT values may be assumed to achieve greater than 99.99 percent inactivation of viruses only if chlorine is added and mixed in the water prior to the addition of ammonia. If this condition is not met, the system must demonstrate, based upon on-site studies or other information, as approved by the State, that the system is achieving at least 99.99 percent inactivation of viruses. CT values between the indicated temperatures may be determined by linear interpolation. If no interpolation is used, use the $CT_{99.9}$ value at the lower temperature for determining $CT_{99.9}$ values between indicated temperatures.

©2004. TAUD. All rights reserved.

4. The total inactivation ratio must be calculated as follows:

(i) If the system uses only one point of disinfectant application, the system may determine the total inactivation ratio based on either of the following two methods:

(I) One inactivation ratio (CTcalc/CT99.9) is determined before or at the first customer during peak hourly flow and if the CTcalc/CT99.9>1.0, the 99.9 percent Giardia lamblia inactivation requirement has been achieved; or

(II) Successive CTcalc/CT99.9 values, representing sequential inactivation ratios, are determined between the point of disinfectant application and a point before or at the first customer during peak hourly flow. Under this alternative, the following method must be used to calculate the total inactivation ratio:

I. Determine for $\frac{CT_{calc}}{CT_{99.9}}$ each sequence.

II. Add the values $\frac{CT_{calc}}{CT_{99.9}}$ together

III. If the sum is $\frac{CT_{calc}}{CT_{99.9}}$ greater than or equal

to 1.0 the 99.9 percent Giardia lamblia inactivation requirement has been achieved.

(ii) If the system uses more than one point of disinfectant application before or at the first customer, the system must determine the CT value of each disinfection sequence immediately prior to the next point of disinfectant application during peak hourly flow. The CTcalc/$CT_{99.9}$ value of each sequence and the sum of

$$\sum \frac{CT_{calc}}{CT_{99.9}}$$

must be calculated using the method in paragraph (b)4.(i)(B) of this section to determine if the system is in compliance with disinfection requirements.

 ©2004. TAUD. All Rights Reserved.

5. The residual disinfectant concentration of the water entering the distribution system must be monitored continuously, and the lowest value must be recorded each day. If there is a failure in the continuous monitoring equipment, grab sampling every 4 hours may be conducted in lieu of continuous monitoring, but for no more than 5 working days following the failure of the equipment. Systems serving 3,300 or fewer persons may take grab samples in lieu of providing continuous monitoring on an ongoing basis at the frequencies prescribed below

System Size by Population	Samples/ day [1]
≤500	1
501 to 1,000	2
1,001 to 2,500	3
2,501 to 3,300	4

[1] The day's samples cannot be taken at the same time. The sampling intervals are subject to State review and approval.

If at any time the free chlorine concentration falls below 0.2 mg/l in a system using grab sampling in lieu of continuous monitoring, the system must take a grab sample every 4 hours until the free residual concentration is equal to or greater than 0.2 mg/l.

6. The residual disinfectant concentration must be measured at least at the same points in the distribution system and at the same time as total coliforms are sampled, as specified in 1200-5-1-.07(1), except that the State may allow a public water system which uses a ground water source, to take disinfectant residual samples at points other than the total coliform sampling points if the State determines that such points are more representative of treated (disinfected) water quality within the distribution system.

(c) Monitoring requirements for systems using filtration treatment. A public water system that uses a surface water source or a ground water source under the influence of surface water and provides filtration treatment must monitor in accordance with this paragraph (c) beginning June 29, 1993, or when filtration is installed, whichever is later.

1. Turbidity measurements as required by 1200-5-1-.31(4) must be performed on representative samples of the system's filtered water every four hours (or more frequently) that the system serves water to the public. A public water system may substitute continuous turbidity monitoring for grab sample monitoring if it validates the continuous measurement for accuracy on a regular basis using a protocol approved by the State. For any system using slow sand filtration or filtration treatment other than conventional treatment, direct filtration, or diatomaceous earth filtration, the State may reduce the sampling frequency to once per day if it determines that less frequent monitoring is sufficient to indicate effective filtration performance. For systems serving 500 or fewer persons, the State may reduce the turbidity sampling frequency to once per day, regardless of the type of filtration

©2004. TAUD. All rights reserved.

treatment used, if the State determines that less frequent monitoring is sufficient to indicate effective filtration performance.

2. The residual disinfectant concentration of the water entering the distribution system must be monitored continuously, and the lowest value must be recorded each day. If there is a failure in the continuous monitoring equipment, grab sampling every 4 hours may be conducted in lieu of continuous monitoring, but for no more than 5 working days following the failure of the equipment. Systems serving 3,300 or fewer persons may take grab samples each day in lieu of providing continuous monitoring on an ongoing basis at the frequencies prescribed below:

System Size by Population	Samples/ day [1]
≤500	1
501 to 1,000	2
1,001 to 2,500	3
2,501 to 3,300	4

[1] The day's samples cannot be taken at the same time. The sampling intervals are subject to State review and approval.

If at any time the free residual disinfectant concentration falls below 0.2 mg/l in a system using grab sampling in lieu of continuous monitoring, the system must take a grab sample every 4 hours until the free residual disinfectant concentration is equal to or greater than 0.2 mg/l.

3. The residual disinfectant concentration must be measured at least at the same points in the distribution system and at the same time as total coliforms are sampled, as specified in 1200-5-1-.07(1). The State may allow a public water system which uses both a surface water source or a ground water source under direct influence of surface water, and a ground water source to take disinfectant residual samples at points other than the total coliform sampling points if the State determines that such points are more representative of treated (disinfected) water quality within the distribution system.

4. In addition to monitoring required by parts 1., 2., and 3. of this subparagraph, a public water system using surface water using conventional filtration treatment or direct filtration must conduct continuous monitoring of turbidity for each individual filter using an approved method in 1200-5-1-.31(5)(a) and must calibrate turbidimeters using the procedure specified by the manufacturer. Systems must record the results of individual filter monitoring every 15 minutes.

5. If there is a failure in the continuous turbidity monitoring equipment, the system must conduct grab sampling every four hours in lieu of continuous monitoring until

 ©2004. TAUD. All Rights Reserved.

the turbidimeter is repaired and back on-line .A system has a maximum of five working days after failure to repair the equipment or it is in violation.

(6) Reporting and recordkeeping requirements.

(a) A public water system that uses a ground water source under the direct influence of surface water and does not provide filtration treatment must report monthly to the State the information specified in this paragraph (a) beginning December 31, 1990, or 6 months after the determination that the ground water source is under the direct influence of surface water, whichever is later, unless the State has determined in writing that filtration is required, in which case the State may specify alternative reporting requirements, as appropriate, until filtration is in place.

1. Source water quality information must be reported to the State within 10 days after the end of each month the system serves water to the public. Information that must be reported includes but is not limited to:

(i) The cumulative number of months for which results are reported.

(ii) The number of fecal and/or total coliform samples, whichever are analyzed during the month (if a system monitors for both, only fecal coliforms must be reported), the dates of sample collection, and the dates when the turbidity level exceeded 1 NTU.

(iii) The number of samples during the month that had equal to or less than 20/100 ml fecal coliforms and/or equal to or less than 100/100 ml total coliforms, whichever are analyzed.

(iv) The cumulative number of fecal or total coliform samples, whichever are analyzed, during the previous six months the system served water to the public.

(v) The cumulative number of samples that had equal to or less than 20/100 ml fecal coliforms or equal to or less than 100/100 ml total coliforms, whichever are analyzed, during the previous six months the system served water to the public.

(vi) The percentage of samples that had equal to or less than 20/100 ml fecal coliforms or equal to or less than 100/100 ml total coliforms, whichever are analyzed, during the previous six months the system served water to the public.

(vii) The maximum turbidity level measured during the month, the date(s) of occurrence for any measurement(s) which exceeded 5 NTU, and the date(s) the occurrence(s) was reported to the State.

©2004. TAUD. All rights reserved.

(viii) For the first 12 months of recordkeeping, the dates and cumulative number of events during which the turbidity exceeded 5 NTU, and after one year of recordkeeping for turbidity measurements, the dates and cumulative number of events during which the turbidity exceeded 5 NTU in the previous 12 months the system served water to the public.

(ix) For the first 120 months of recordkeeping, the dates and cumulative number of events during which the turbidity exceeded 5 NTU, and after 10 years of recordkeeping for turbidity measurements, the dates and cumulative number of events during which the turbidity exceeded 5 NTU in the previous 120 months the system served water to the public.

2. Disinfection information specified in 1200-5-1-.31(5)(b) must be reported to the State within 10 days after the end of each month the system serves water to the public. Information that must be reported includes but is not limited to:

(i) For each day, the lowest measurement of residual disinfectant concentration in mg/l in water entering the distribution system.

(ii) The date and duration of each period when the residual disinfectant concentration in water entering the distribution system fell below 0.2 mg/l and when the State was notified of the occurrence.

(iii) The daily residual disinfectant concentration(s) (in mg/l) and disinfectant contact time(s) (in minutes) used for calculating the CT value(s).

(iv) If chlorine is used, the daily measurement(s) of pH of disinfected water following each point of chlorine disinfection.

(v) The daily measurement(s) of water temperature in ^{o}C following each point of disinfection.

(vi) The daily CTcalc and CTcalc/$CT_{99.9}$ values for each disinfectant measurement or sequence and the sum of all CTcalc/$CT_{99.9}$ values before or at the first customer.

(vii) The daily determination of whether disinfection achieves adequate Giardia cyst and virus inactivation, i.e., whether (CTcalc/$CT_{99.9}$) is at least 1.0 or, where disinfectants other than chlorine are used, other indicator conditions that the State determines are appropriate, are met.

(viii) The following information on the samples taken in the distribution system in conjunction with total coliform monitoring pursuant to 1200-5-1-.31(3) [Disinfection].

 ©2004. TAUD. All Rights Reserved.

(I) Number of instances where the free residual disinfectant concentration is measured and the number of instances where the free residual is below 0.2 mg/l.

3. No later than ten days after the end of each Federal fiscal year (September 30), each system must provide to the State a report which summarizes its compliance with all watershed control program requirements specified in 1200-5-1-.31(2)(b)2.

4. No later than ten days after the end of each Federal fiscal year (September 30), each system must provide to the State a report which describes the on-site inspection conducted during that year pursuant to 1200-5-1-.31(2)(b)3. unless the on-site inspection was conducted by the State. If the inspection was conducted by the State, the State must provide a copy of its report to the public water system.

5.

(i) Each system, upon discovering that a waterborne disease outbreak potentially attributable to that water system has occurred, must report that occurrence to the State as soon as possible, but no later than by the close of the following business day.

(ii) If at any time the turbidity exceeds 5 NTU, the system must consult with the department as soon as practical, but no later than 24 hours after the exceedance is known, in accordance with the requirements of the Notification of Customers Rule.

(iii) If at any time the disinfectant residual falls below 0.2 mg/l in the water entering the distribution system, the system must notify the State as soon as possible, but no later than by the end of the next business day. The system also must notify the State by the end of the next business day whether or not the residual was restored to at least 0.2 mg/l within 4 hours.

(b) A public water system that uses a surface water source or a ground water source under the direct influence of surface water and provides filtration treatment must report monthly to the State the information specified in this paragraph (b) beginning June 29, 1993, or when filtration is installed, whichever is later.

1. Turbidity measurements as required by 1200-5-1-.31(5)(c)1. must be reported within 10 days after the end of each month the system serves water to the public. Information that must be reported includes but is not limited to:

(i) The total number of filtered water turbidity measurements taken during the month.

(ii) The number and percentage of filtered water turbidity measurements taken during the month which are less than or equal to the applicable limits specified in 1200-5-1-.31(4).

©2004. TAUD. All rights reserved.

(iii) The date and value of any turbidity measurements taken during the month which exceed 5 NTU.

2. Disinfection information specified in 1200-5-1-.31(5)(c) must be reported to the State within 10 days after the end of each month the system serves water to the public. Information that must be reported includes:

(i) For each day, the lowest measurement of residual disinfectant concentration in mg/l in water entering the distribution system.

(ii) The date and duration of each period when the residual disinfectant concentration in water entering the distribution system fell below 0.2 mg/l and when the State was notified of the occurrence.

(iii) The following information on the samples taken in the distribution system in conjunction with total monitoring pursuant to 1200-5-1-.07;

(I) Number of instances where the free residual disinfectant concentration is measured.

(II) The number of instances where the free residual is below 0.2 mg/l.

3.

(i) Each system, upon discovering that a waterborne disease outbreak potentially attributable to that water system has occurred, must report that occurrence to the State as soon as possible, but no later than by the close of the following business day.

(ii) If at any time the turbidity exceeds 1 NTU in representative samples of filtered water in a system using conventional filtration treatment or direct filtration, the system must consult with the department as soon as practical, but no later than 24 hours after the exceedance is known, in accordance with the requirements of the Notification of Customers Rule. If at any time the turbidity in representative samples of filtered water exceed the maximum level set by the department for filtration technologies other than conventional and direct filtration treatment, the system must consult with the department as soon as practical, but not later than 24 hours after the exceedance is known, in accordance with the Notification of Customers Rule.

(iii) If at any time the disinfectant residual falls below 0.2 mg/l in the water entering the distribution system, the system must notify the State as soon as possible, but no later than by the end of the next business day. The system also must notify the State by the end of the next business day whether or not the residual was restored to at least 0.2 mg/l within 4 hours.

 ©2004. TAUD. All Rights Reserved.

4. In addition to the reporting and recordkeeping requirements in 1200-5-1-.31(6)(b) 1.,2.,and 3., a public water system serving 10,000 or more persons that provides conventional filtration treatment or direct filtration must report monthly to the State the information specified in part 4. beginning January 1, 2002. In addition to the reporting and recordkeeping requirements in 1200-5-1-.31(6), a public water system subject to the requirements of this subpart that provides filtration approved under 1200-5-1-.31(4)(d) must report monthly to the State the information specified in subpart (i) beginning January 1, 2002. The reporting in subpart (i) of this section is in lieu of the reporting specified in 1200-5-1-.31(6)(b)1.

    (i) Turbidity measurements as required by 1200-5-1-.31 must be reported within 10 days after the end of each month the system serves water to the public. Information that must be reported includes:

        (I) The total number of filtered water turbidity measurements taken during the month.

        (II) The number and percentage of filtered water turbidity measurements taken during the month which are less than or equal to the turbidity limits specified in paragraph (4)(c) or (d).

        (IV) The date and value of any turbidity measurements taken during the month which exceed 1 NTU for systems using conventional filtration treatment or direct filtration, or which exceed the maximum level set by the State under paragraph (4)(d).

(8) Disinfection Profiling and Benchmarking

(a) Subpart H public water systems serving 10,000 or more persons must conduct monitoring for haloacetic acids and trihalomethanes or conduct disinfection profiling beginning with the effective date of this rule. Those systems that exceed 0.064 mg/L of total trihalomethanes or 0.048 mg/L of total haloacetic acids annual arithmetic average based on four quarters of data must calculate disinfection profiles. Systems that must calculate profiles and that are planning changes to the disinfection process must also calculate disinfection benchmarks and submit the benchmark calculations with engineering plans for departmental approval prior to making any process changes. Sampling, analytical methods, frequency of sampling, and sample locations must be in accordance with procedures described in 1200-5-1-.36. Disinfection profiles and benchmarks must be determined by calculating daily inactivation ratios in accordance with departmental and EPA rules. Systems may elect to calculate profiles in lieu of conducting trihalomethane and haloacetic acid monitoring for the purpose of complying with the disinfection and filtration rule.

(b) The department may approve the use of a more representative set of annual data for disinfection profiling. Systems that elect to conduct disinfection profiling rather than monitoring must notify the department within 30 days of the effective date of these

©2004. TAUD. All rights reserved.

rules. Systems may use existing data if approved by the department to comply with the disinfection byproduct monitoring or profiling required by this rule.

(c) A system that uses either chloramines or ozone for a primary disinfectant must calculate the logs of inactivation for viruses using a method approved by the department.

(d) The system subject to the profiling requirements must retain disinfection profiles data in graphic form, such as a spreadsheet, or in some other format acceptable to the department for review during sanitary surveys.

(e) Any system that decides to change its disinfection practices must submit plans to the department for approval prior to making any changes. Changes to disinfection practices include but are not limited to:

1. Changes to the point of disinfection application;
2. Change in the disinfectant used;
3. Change in the disinfectant process, and
4. Any other modification identified by the department.

(f) Any system subject to the profiling requirements of this rule shall calculate its disinfection benchmark using methods approved by the department. A disinfection benchmark is the lowest monthly average value of the monthly logs of *Garidia Lamblia* inactivation. A system using ozone or chloramines must also calculate the disinfection benchmark for viruses using methods approved by the department.

Monitoring and Reporting

In addition to the ***Monthly Operations Report (MOR)***, the operator must submit the ***Monthly Disinfection Monitoring Report (CN-1201)***, and the ***Disinfection Byproducts Quarterly Report (CN-1197).***

Formulas for Monitoring and Reporting

Chlorine Feed

Pre-Chlorine Fed, lbs = Previous Scale Reading, lbs – Current Scale Reading, lbs

Post-Chlorine Fed, lbs = Previous Scale Reading, lbs – Current Scale Reading, lbs

 ©2004. TAUD. All Rights Reserved.

$$\text{Average} = \frac{\text{Sum of All Daily Measuements}}{\text{Number of Daily Measurements}}$$

$$\text{Calculated Dosage, mg/L} = \frac{\text{Pre - Chlorine Fed, lbs} + \text{Post - Chlorine Fed, lbs}}{\text{(Flow, MGD) (8.34 lbs/gal)}}$$

$$\text{Cost per Pound, \$} = \frac{\text{Cost of Shipment, \$}}{\text{Weight of Shipment, lbs}}$$

$$\text{Cost per Pound, \$} = \frac{\text{Cost per CT, \$}}{\text{100 lbs/CT}}$$

Cost per Month, $ = Total Pounds of Chemical Used X Cost per Pound, $

Safety

Safety equipment required to handle chlorine.

(1) Self-Contained Breathing Apparatus - One for each entrant. For each entrant, an attendant must be present and equipped with an SCBA. With catastrophic releases at least two entrants and two attendants, trained in HAZMAT operations, deal with the release. All others must leave plant and go to safe site.

(2) Adequate ventilation system.

(3) Appropriate emergency repair kit.

©2004. TAUD. All rights reserved.

Safety Information – Chlorine

PRODUCT NAME: CHLORINE (LIQUID OR GAS)

PRODUCT USE: .....Water Purification, Chemical Processes, Plastic Manufacture

CHEMICAL NAME:.....Chlorine

CHEMICAL FORMULA:.....Cl_2

SYNONYMS/COMMON NAMES: .....Chlorine

COMPOSITION/INFORMATION ON INGREDIENTS

CAS NUMBER.....NAME

7782-50-5.....Chlorine (MW 70.91)

PERCENTAGE.....99.5-100

HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

STRONG OXIDIZING AGENT. POISON. HAZARDOUS LIQUID AND GAS UNDER* PRESSURE. MAY CAUSE CHEMICAL PNEUMONIA AND EVEN DEATH IN HIGH* CONCENTRATIONS. MAY CAUSE SEVERE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT. LIQUID MAY BURN EYES AND SKIN. CAN REACT EXPLOSIVELY WITH ORGANIC PRODUCTS.

Amber color liquid. Greenish-yellow gas. Pungent irritating odor.

POTENTIAL HEALTH EFFECTS

ROUTES OF ENTRY: .....Eyes, Inhalation, Skin.

TARGET ORGANS: .....Eyes, Skin, Lungs, Respiratory Tract.

IRRITANCY:.....Eyes, Skin, Respiratory Tract, Severe.

SENSITIZING CAPABILITY: .....None known.

REPRODUCTIVE EFFECTS: .....None known.

CANCER INFORMATION: .....Not known to be carcinogenic.

 ©2004. TAUD. All Rights Reserved.

SHORT-TERM EXPOSURE (ACUTE)

INHALATION: Coughing, burning, chest pain, vomiting, headache, anxiety and feeling of suffocation. Severe exposure may cause pneumonitis and pulmonary edema. See Toxicology Section.

EYES: High concentrations or contact can cause burns.

SKIN: Contact may cause burns and tissue destruction. Contact with cold liquid or gas can produce freeze burns.

INGESTION: Not a likely route of exposure. Above established exposure limits may result in reduced breathing capacity.

REPEATED EXPOSURE (CHRONIC)

Above established exposure limits may result in reduced breathing capacity.

SYNERGISTIC MATERIALS:.....None known.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Pre-existing respiratory disorders.

FIRST AID MEASURES

EYES: IMMEDIATELY FLUSH EYES WITH A DIRECTED STREAM OF WATER for at least 15 minutes, forcibly holding eyelids apart to ensure complete irrigation of all eye and lid tissue. Washing eyes within several seconds is essential to achieve maximum effectiveness. GET MEDICAL ATTENTION IMMEDIATELY.

SKIN: Look for inhalation effects first. Keep airway open if consciousness impaired. Remove contaminated clothing under safety shower. Flush exposed skin with water. Wash with soap and water. If irritation is present after washing, GET MEDICAL ATTENTION.

INHALATION: Remove to fresh air. If breathing is difficult, have trained person administer oxygen. If respiration stops, have a trained person administer artificial respiration. GET MEDICAL ATTENTION IMMEDIATELY. In case of excessive inhalation, maintain under observation for 48 hours due to risk of pulmonary edema.

INGESTION: NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. (If available, give several glasses of milk.) If vomiting occurs spontaneously, keep airway clear and give more water. GET MEDICAL ATTENTION IMMEDIATELY.

NOTES TO PHYSICIAN: Treatment is symptomatic. Because there is no known antidote for chlorine gas inhalation, effective and immediate relief of symptoms is the primary goal. Steroid therapy, if given early, has been reportedeffective in preventing pulmonary edema.

FIRE FIGHTING MEASURES

Flash Point: .....Not Applicable

Method: .....Not Applicable

©2004. TAUD. All rights reserved.

Autoignition Temperature:.....Not Applicable

FLAMMABLE LIMITS IN AIR, BY % VOLUME.....Upper: Non-flammable
Lower: Non-flammable

EXTINGUISHING MEDIA: .....Cool fire exposed containers with water spray. Use agents appropriate for surrounding fire.

FIRE FIGHTING PROCEDURES: Chlorine containers should be removed from fire zone immediately. Tank cars or barges should be disconnected and pulled out of the danger area. If no chlorine is escaping, water should be applied to cool containers that cannot be moved. If it is necessary to stop the flow of gas, use water spray to direct escaping gas away from persons effecting the shut-off. Keep unauthorized personnel removed and upwind. Wear NIOSH/MSHA approved positive pressure self-contained breathing apparatus and full protective clothing.

FIRE AND EXPLOSION HAZARD: Chlorine gas or liquid, is nonexplosive and nonflammable. However, like oxygen, it is capable of supporting combustion of certain substances. Reacts explosively, or forms explosive compounds, with many chemicals, such as acetylene, turpentine, ether, ammonia gas, hydrogen, and finely divided metals.

SENSITIVITY TO MECHANICAL IMPACT:.....Not sensitive.

SENSITIVITY TO STATIC DISCHARGE:.....Not sensitive.

ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS: Evacuate unnecessary personnel. Keep unprotected personnel upwind of the spill area. Follow protective measures provided under Personal Protection.

ENVIRONMENTAL PRECAUTIONS: Contain liquids and prevent discharges to streams or sewers, control or stop the loss of volatile materials to the atmosphere. Large leaks may require environmental consideration and possible evacuation. Do not apply water to the leak. Spills or releases should be reported, if required, to the appropriate local, state and federal agencies.

Spills of chlorine of 10 or more pounds must be reported to the National Response Center, 1-800-424-8802.

METHODS FOR CLEANING UP: Move leaking container to an isolated area. Position to release gas, NOT LIQUID. Chlorine can be absorbed into an alkaline solution such as caustic soda, soda ash or hydrated lime.

HANDLING AND STORAGE

HANDLING: Follow safety procedures for containers of compressed gases. Provide special training to workers handling chlorine. Avoid breathing vapor or gas. Do not get in eyes, on skin, on clothing. Do not heat container. Wear all protective equipment as described in Section 8.

SPECIAL MIXING AND HANDLING INSTRUCTIONS: Do not allow contact with materials as noted in Section 10.

STORAGE: Store containers in a well ventilated area of low fire potential and away from incompatible materials. Keep away from heat and sources of ignition. Protect container from

 ©2004. TAUD. All Rights Reserved.

weather and physical damage. Regularly test and inspect piping and containment used for chlorine service. Liquid levels should be less than 85% of tank or cylinder capacity.

EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS

General room ventilation plus local exhaust at points of emission to maintain levels of airborne contaminants below exposure limits. Odor may indicate concentrations above exposure limits. Provide venting for low-lying areas. Use closed systems when possible. Maintain concentrations below all applicable exposure limits.

PERSONAL PROTECTION

RESPIRATORY: Use NIOSH/MSHA supplied air respirator in positive pressure mode for tank and confined space entry (ANSI Z117.1). Wear a NIOSH/MSHA approved organic vapor acid-gas respirator following manufacturer's recommendations.

EYE/FACE: Wear chemical safety goggles plus full face shield to protect against splashing when appropriate (ANSI Z87.1).

SKIN: Wear chemical resistant gloves such as rubber, neoprene or vinyl. Wash contaminated clothing and dry before reuse. Wear protective clothing to minimize skin contact. Whenever there is a possibility of splash or contact wear a chemical resistant full body suit and boots.

OTHER: Emergency shower and eyewash facility should be in close proximity (ANSI Z358.1).

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Amber color liquid. Greenish-yellow gas. Pungent irritating odor.

Odor Threshold: .....Approximately 2 ppm

Specific Gravity (Water=1): .....1.4 @ 15.4°C

Vapor Pressure: .....2748mm Hg @ 0°C

Vapor Density (Air=1): 2.5

Density: .....11.7 lbs./gallon @15.6°C

Evaporation Rate: .....Not applicable

% Volatiles by Wt: 100%

Boiling Point: .....-34°C (-29.3°F)

Freezing Point: .....-101°C (-150°F)

Melting Point: .....Not available

Solubility in Water (% by wt.): .....0.7% @ 20°C

pH: .....0.7% solution has pH 5.5

©2004. TAUD. All rights reserved.

STABILITY AND REACTIVITY

CHEMICAL STABILITY:	☒ STABLE	☐ UNSTABLE	
REACTS WITH:	☐ AIR	☐ OXIDIZERS	☒ METALS
	☒ WATER	☐ ACIDS	☒ OTHER
	☐ HEAT	☒ ALKALIS	☐ NONE

HAZARDOUS POLYMERIZATION: ☐ OCCURS ☒ WILL NOT OCCUR

COMMENTS: Strong oxidizer. Avoid contact with reducing agents, combustible materials. Keep away from materials such as acetylene, turpentine and other hydrocarbons, ammonia, hydrogen, ether, powdered metals, sulfur and aluminum. Reacts with hydrogen sulfide and water forming hydrochloric acid. Combines with carbon monoxide and sulfur dioxide forming phosgene and sulfuryl chloride. Moist chlorine is highly corrosive to most metals. Chlorine reaction to some organic compounds can be explosive.

HAZARDOUS DECOMPOSITION PRODUCTS: .....None.

TOXICOLOGICAL INFORMATION

7782-50-5 Chlorine

Chlorine gas is a primary irritant of the respiratory tract. Severe exposure to vapor can be fatal. Exposure to liquid can cause severe burns on contact. Prompt treatment is important to minimize effects. The hazard at different concentrations is reported to be as follows:

0.2-0.5 ppm	No toxic long term effect
1 - 3 ppm	Definite odor; irritation of eyes and nose
5 - 8 ppm	Throat, eye and mucous membrane irritation
30 ppm	Intense coughing fits
34 - 51 ppm	Lethal in 1 to 1.5 hours exposure
40 - 60 ppm	Exposure for 30-60 minutes without effective respiration may cause bronchitis, pulmonary edema or bronchopneumonia
100 ppm	May be lethal after 50 minutes exposure (estimated)
430 ppm	Lowest concentration known to cause lethality after 30 minutes of exposure
1000 ppm	May be fatal with a few deep breaths

DISPOSAL CONSIDERATIONS

Dispose of in accordance with all applicable federal, state and local regulations. Depending on the particular situation involved, special equipment may be required; consult with your chlorine supplier.

 ©2004. TAUD. All Rights Reserved.

REGULATORY INFORMATION

U.S. FEDERAL REGULATIONS: Chlorine is contained on a list as required under Sec 101(14) of CERCLA, which includes substances designated persuant to Sec 311 of the Clean Water Act, Hazardous Wastes under Sec 3001 of RCRA, Toxic Pollutants under Sec 307 of the Clean Water Act, Imminently Hazardous Chemicals under Sec 7 of TSCA. Chlorine is designated a hazardous substance by 29 CFR Sec 1910, Subpart Z. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is applicable if chlorine is used as a pesticide or in water or sewer treatment applications.

This product contains a toxic chemical or chemicals subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR 372. See Section 2, List Legend 02.

OSHA Standard 29 CFR 1910.1200 requires that information be provided to employees regarding the hazards of chemicals by means of a hazard communication program including labeling, material safety data sheets, training and access to written records. We request that you, and it is your legal duty to, make all information in this Material Safety Data Sheet available to your employees.

TSCA: All components of this product that are required to be on the TSCA inventory are listed on the inventory.

HMIS HAZARD RATINGS:

HEALTH HAZARD:	3
FIRE HAZARD:	0
REACTIVITY:	1

PRECAUTIONS:

- Strong oxidizer.
- Avoid contact with reducing agents, combustible materials, acetylene, turpentine and other hydrocarbons, ammonia, powdered metals,sulfur and aluminum. Moist chlorine is highly corrosive to most metals.
- Before using, read Material Safety Data Sheet (MSDS) for this material.
- Avoid contact with organic products to prevent explosive reaction.
- Wear a NIOSH/MSHA approved respirator and use local exhaust ventilation where vapors may be generated.
- Wash thoroughly after handling.

FIRST AID

EYES: IMMEDIATELY FLUSH EYES WITH A DIRECTED STREAM OF WATER for at least 15 minutes, forcibly holding eyelids apart to ensure complete irrigation of all eye and lid tissue. Washing eyes within several seconds is essential to achieve maximum effectiveness. GET MEDICAL ATTENTION IMMEDIATELY.

©2004. TAUD. All rights reserved.

SKIN: Look for inhalation effects first. Keep airway open if consciousness impaired. Remove contaminated clothing under safety shower. Flush exposed skin with water. Wash with soap and water. If irritation is present after washing, GET MEDICAL ATTENTION.

INHALATION: Remove to fresh air. If breathing is difficult, have trained person administer oxygen. If respiration stops, have a trained person administer artificial respiration. GET MEDICAL ATTENTION IMMEDIATELY. In case of excessive inhalation, maintain under observation for 48 hours due to risk of pulmonary edema.

INGESTION: NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. (If available, give several glasses of milk.) If vomiting occurs spontaneously, keep airway clear and give more water. GET MEDICAL ATTENTION IMMEDIATELY.

IN CASE OF SPILL OR LEAK:

- If this material is spilled or released to the atmosphere, keep upwind, provide ventilation, wear full protective equipment and shut off supply at source.
- Exclude non-essential personnel.
- Contain liquids and prevent discharges to streams or sewers system.
- Control loss of volatile materials to the atmosphere.
- Large leaks may require environmental consideration and possible evacuation.
- Do not apply water to leak.
- Chlorine can be absorbed into an alkaline solution, ie. Caustic soda,caustic potash, lime etc.

FIRE:

- Use water to keep fire-exposed containers cool.
- If it is necessary to stop the flow of gas, use water spray to direct escaping gas away from persons effecting the shut-off.
- Wear full protective clothing

HANDLING AND STORAGE:

- Store chlorine containers in a well ventilated area of low fire potential and away from incompatible materials (acetylene, turpentine, other hydrocarbons, ammonia, hydrogen, ether, powdered metals, sulfur, aluminium, reducing agents and combustible materials).
- Keep away from heat and sources of ignition.
- Protect container from weather and physical damage.
- Follow safety procedures for containers of compressed gases.
- Provide special training to workers handling chlorine.
- Regularly test and inspect piping and containment used for chlorine service.
- Liquid levels should be less than 85% of tank or cylinder capacity.

 ©2004. TAUD. All Rights Reserved.

DISPOSAL:

- Vent waste chlorine gas into scrubber using dilute alkali solution.
- Dispose of resultant hypochlorite in accordance with local, state, and federal regulations. Return empty chlorine tank cars and tank trucks containing residual gas and/or liquid to supplier in compliance with applicable DOT regulations.
- Spills of 10 pounds or more must be reported to the NATIONAL RESPONSE CENTER 1-800-424-8802.

©2004. TAUD. All rights reserved.

Safety Information – Sodium Hypochlorite

PRODUCT NAME : SODIUM HYPOCHLORITE (EPA)

PRODUCT USE: .....Bleach

CHEMICAL NAME:.....Hypochlorous Acid, Sodium Salt

CHEMICAL FORMULA:.....NaOCl

SYNONYMS/COMMON NAMES: .....Chlorine bleach, Soda bleach

COMPOSITION/INFORMATION ON INGREDIENTS

7732-18-5 .....Water (MW 18.02)

7681-52-9.....Hypochlorous acid, sodium salt

COMMON NAMES: Sodium hypochlorite (MW 74.44)

1310-73-2 .....Sodium hydroxide (Na(OH))

COMMON NAMES: CAUSTIC SODA (MW 40.00)

HAZARDS IDENTIFICATION

STRONG OXIDIZING AGENT. - MAY CAUSE BURNS TO THE EYES, SKIN, AND MUCOUS MEMBRANES.

Water clear to slight yellow color with distinctive chorine odor.

POTENTIAL HEALTH EFFECTS

ROUTES OF ENTRY: .....Inhalation, Ingestion.

TARGET ORGANS: .....Eyes, Skin, Respiratory Tract, Gastrointestinal Tract.

IRRITANCY:.....Irritating to eyes, skin, respiratory tract and gastrointestinal tract. May cause chemical burns to these tissues.

SENSITIZING CAPABILITY: .....No relevant data found.

REPRODUCTIVE EFFECTS: .....No relevant data found.

CANCER INFORMATION: .....Not classified as carcinogenic by NTP, IARC, OSHA, ACGIH, or NIOSH.

 ©2004. TAUD. All Rights Reserved.

SHORT-TERM EXPOSURE (ACUTE)

INHALATION: May cause coughing, sneezing or other symptoms of upper respiratory tract irritation. Exposure may result in lung tissue damage due to corrosive effects. Severe exposures could result in chemical pneumonia.

EYES: Strongly irritating to eyes. Exposure to vapor can cause tearing, conjunctivitis and burning of the eyes. Eye contact may cause corneal injury. The severity of the effects depend on concentration and how soon after exposure the eyes are washed.

SKIN: Contact may cause burns and tissue destruction.

INGESTION: Can produce severe burns of the mouth, throat, esophagus and gastrointestinal tract with nausea, vomiting, abdominal pain and diarrhea.

REPEATED EXPOSURE (CHRONIC)

Prolonged or repeated contact with skin may result in moderate to severe skin irritation. Prolonged or repeated exposure may result in lung damage.

SYNERGISTIC MATERIALS: None known.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: Pre-existing disorders affecting target organs.

FIRST AID MEASURES

EYES: Immediately flush eyes with a directed stream of water for at least 15 minutes, forcibly holding eyelids apart to ensure complete irrigation of all eye and lid tissues. Washing eyes within several seconds is essential to achieve maximum effectiveness. GET MEDICAL ATTENTION IMMEDIATELY.

SKIN: Immediately flush contaminated areas with water. Remove contaminated clothing and footwear. Wash contaminated areas with plenty of soap and water. Wash clothing before reuse. Discard footwear which cannot be decontaminated. GET MEDICAL ATTENTION IMMEDIATELY.

INHALATION: Remove to fresh air if safe to transport. Otherwise attempt to provide fresh air by ventilation. If breathing is difficult, have a trained person administer oxygen. If respiration or pulse has stopped, have a trained person administer Basic Life Support (Cardio-Pulmonary Resuscitation/Automatic External Defibrillator) and CALL FOR EMERGENCY SERVICES IMMEDIATELY (911 or emergency transport services).

INGESTION: Sodium hypochlorite is an alkaline corrosive. For exposure by ingestion do not use vomiting, lavage or acidic antidotes. Dilute immediately by giving milk, melted ice cream, beaten egg white, starch paste or antacids such as milk of magnesia, aluminum hydroxide gel, or magnesium trisilicate gel. Avoid sodium bicarbonate because of carbon dioxide release. Sodium thiosulfate solution may prove beneficial by reducing unreacted material.

NOTES TO PHYSICIAN: In addition to the alkalinity of the product, the continued generation of chlorine gas after ingestion can damage further the stomach mucous, depending on the amount ingested. Consideration may be given to removal of the product from the stomach, taking care to

©2004. TAUD. All rights reserved.

avoid perforation of esophagus or stomach. An ounce of 1% sodium thiosulfate or milk of magnesia may be helpful.

FIRE FIGHTING MEASURES

Flash Point: .....Not applicable

Method: .....Not applicable

Autoignition Temperature:.....Not applicable

FLAMMABLE LIMITS IN AIR, BY % VOLUME

Upper: .....Not applicable

Lower: .....Not applicable

EXTINGUISHING MEDIA: Non-flammable / Non-combustible. Use water spray, foam, dry chemicals, carbon dioxide, or other extinguishing medium as appropriate for surrounding fire.

FIRE FIGHTING PROCEDURES: .....Wear NIOSH approved positive pressure self-contained breathing apparatus and full protective clothing.

FIRE AND EXPLOSION HAZARD: .....Material does not sustain combustion. This product is non-flammable and non-explosive under normal conditions of use. At high temperatures this product can decompose to give off hydrogen chloride and chlorine gas.

SENSITIVITY TO MECHANICAL IMPACT: .....Not sensitive.

SENSITIVITY TO STATIC DISCHARGE: .....Not sensitive.

ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS: .....Follow protective measures provided under Personal Protection in Section 8.

ENVIRONMENTAL PRECAUTIONS: .....Do not allow entry into sewers and waterways.

METHODS FOR CLEANING UP:.....For small spills, soak up with absorbent material and place in properly labeled containers for disposal. For large spills, dike and pump into properly labeled containers for reclamation or disposal.

 ©2004. TAUD. All Rights Reserved.

HANDLING AND STORAGE

HANDLING: .....Do not eat, drink or smoke in areas where this material is used. Wash thoroughly with soap and water after handling.

CONTAINERS: .....Containers, even those that have been emptied, will retain product residue and vapor and should be handled as if they were full. Do not reuse containers.

SPECIAL MIXING AND HANDLING INSTRUCTIONS:.Do not allow contact with materials as noted in Section 10.

STORAGE:.....Store in a cool, ventilated area away from incompatible materials (see Section 10). Keep container tightly closed and properly labeled.

EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS: Handle product in a well ventilated area. If product is handled in an open system, the use of process enclosures, local exhaust ventilation, and/or other engineering controls should be considered to control airborne levels to below recommended exposure limits, or below acceptable levels where there are no limits. The AIHA WEEL (Worplace Environmental Exposure Level) for sodium hypochlorite (CAS 7681-52-9) is 2 mg/m^3 for a 15-minute STEL.

PERSONAL PROTECTION

RESPIRATORY: A NIOSH approved respirator with N95 (dust, fume, mist) filter(s) may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits, or when symptoms have been observed that are indicative of overexposure. Where the possibility exists for decomposition, a NIOSH approved respirator with acid gas cartridge(s) and N95 filter(s) may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits, or when symptoms have been observed that are indicative of overexposure. A half facepiece air-purifying respirator can be used in concentrations up to 10X the acceptable exposure level and a full facepiece air-purifying respirator can be used in concentrations up to 50X the acceptable exposure level. Supplied air should be used when the level is expected to be above 50X the acceptable level, or when there is a potential for uncontrolled release. A respiratory protection program that meets 29 CFR 1910.134 and ANSI Z88.2 requirements must be followed whenever workplace conditions warrant use of a respirator.

EYE/FACE: Wear chemical safety goggles plus full face shield to protect against contact when appropriate (ANSI Z87.1).

©2004. TAUD. All rights reserved.

SKIN: Wear chemical resistant gloves such as butyl rubber, natural rubber, neoprene or nitrile. Wear chemical resistant clothing and boots when potential for contact with the material exists.

OTHER: Emergency shower and eyewash facility should be in close proximity (ANSI Z358.1).

PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: .....Water clear to slight yellow color with distinctive chorine odor

Odor Threshold: .....Approximately 2ppm

Specific Gravity (Water=1): 1.27

Vapor Pressure: .....Not applicable

Vapor Density (Air=1): .....Not applicable

Density: .....Not applicable

Evaporation Rate: .....Not available

% Volatiles by Wt: .....Not applicable

Boiling Point: .....110°C (230°F)

Freezing Point: .....Not available

Melting Point: .....Not applicable

Solubility in Water (% by wt.): 100%

pH: 12

Other: .....Available chlorine, approximately 13%

VOC (% by wt;g/l): .....Not applicable

STABILITY AND REACTIVITY

CHEMICAL STABILITY: ☒ STABLE ☐ UNSTABLE

REACTS WITH: ☐ AIR ☐ OXIDIZERS ☒ METALS

☐ WATER ☒ ACIDS ☒ OTHER

☒ HEAT ☐ ALKALIS ☐ NONE

HAZARDOUS POLYMERIZATION: ☐ OCCURS ☒ WILL NOT OCCUR

COMMENTS: Avoid contact with heavy metals, reducing agents,organics, ether, ammonia and acids. STRONG OXIDIZING AGENT.

HAZARDOUS DECOMPOSITION PRODUCTS: Chlorine containing gases can be produced.

 ©2004. TAUD. All Rights Reserved.

TOXICOLOGICAL INFORMATION

7681-52-9 Hypochlorous acid, sodium salt

This substance may be moderately toxic by the oral route at low concentrations. It is slightly toxic by the dermal route. At higher concentrations this substance may be severely irritating to the eyes and skin. Inhalation of fumes causes coughing and choking and may cause severe respiratory tract irritation and pulmonary edema. Ingestion causes irritation and corrosion of mucous membranes with pain and vomiting.

The toxicity and corrosivity of this substance is a function of concentration. Industrial grades of higher concentrations than household bleach (approximately 5%) may be associated with corrosive damage by all routes of exposure.

For further information call or write the address shown on page 1 of the MSDS.

DISPOSAL CONSIDERATIONS

Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal Law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional Office for guidance.

HMIS HAZARD RATINGS:

HEALTH HAZARD: 3

FIRE HAZARD: 0

REACTIVITY: 2

WARNING LABEL INFORMATION

This product is registered with the United States Environmental Protection Agency (EPA) as a pesticide, as required under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). It is shipped under a FIFRA approved product label. It is a violation of Federal law to use this product for pesticidal applications in a manner inconsistent with the FIFRA labeling. Repackers or formulators must obtain their own EPA registration and FIFRA approved label to legally market this product for pesticidal applications. This product may be used by manufacturers of non-pesticidal products provided no pesticidal claim is made.

©2004. TAUD. All rights reserved.

 ©2004. TAUD. All Rights Reserved.