Introduction to Water Treatment

For All Grades

Course # 3101

TN Department of Environment & Conservation

Fleming Training Center
Your Partner in Clean Water

State of Tennessee

Introduction to Water Treatment for All Grades

Course #3101
Week 1
January 29 – February 2, 2018

Monday, January 29

8:30	Registration	Amanda Carter
9:00	Overview of Water Treatment	
10:15	Source Water Protection	
11:00	Lunch	
12:00	Preliminary Treatment	
1:15	Coagulation / Flocculation	

Tuesday, January 30

8:30	Sedimentation	Amanda
9:45	Filtration	
11:00	Lunch	
12:15	Rules/Regs/Design Criteria	
2:15	Safety	

Wednesday, January 31

8:30	Disinfection / Chlorination	Amanda
11:30	Lunch	
12:30	Tour - to be announced	

Thursday, February 1

8:30	Lab Procedures	Amanda
11:30	Lunch	
12:45	Water Tanks	
1:45	Taste and Odor	

Friday, February 2

8:30	Exam Review	Amanda
11:00	Lunch	
12:15	First Week Exam	

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Table of Contents

Overview of Water Treatment

Purpose of water treatment – to provide safe drinking water that does not contain objectionable taste, odor or color; to provide adequate quantities of water for domestic, commercial, industrial and fire protection needs.

All water produced by public water systems must be drinking water quality, even though only about 1% of water produced is used for drinking and cooking.

Schematic of conventional water treatment:

- Water is withdrawn from a lake, reservoir or river at the intake
- It is screened to remove debris
- Water then enters the flash mixing tank where coagulants and other chemicals are added
- Then it is divided into the flocculation basin
- After flocculation, the water enters the settling basins where solids are removed
- Filtration then removes particles that are too small to settle by gravity
- The water is disinfected using some form of chlorine
- Other chemicals such as fluoride, phosphate corrosion inhibitors or pH adjustment chemicals may be added
- After a minimum detention time, the water may be pumped to the distribution systems

Other processes may occur, such as pre-oxidation or activated carbon treatment.

Groundwater treatment is much less involved than surface water treatment. Groundwater has fewer impurities. Aeration may be required to remove dissolved gases and aid in the removal of dissolved minerals. Fluoride is sometimes added, but often the only step is disinfection. Addition of chemicals to reduce corrosion may also be needed.

Various regulations exist to control contaminants in drinking water in order to ensure public safety. Part of an operator's job is to collect samples, test them and report the results to the state, which enforces these regulations. Operators must be able to recognize problems in the treatment process that could result in violations. They should also be familiar with the limits of certain substances in water so they can recognize when lab tests indicate violations.

Treatment Process	Purpose
Raw Water	
Screens	Removes leaves, sticks, fish and other large debris.
Prechlorination (optional)	Kills most disease-causing organisms and helps control taste and odor causing substances.
Chemicals (coagulants, carbon)	Coagulants cause very fine particles to clump together into larger particles. Carbon can be added in the flash mix to help control taste and odor causing substances.
Flash Mix	Mixes chemicals with raw water containing fine particles that will not readily settle or filter out of the water.
Coagulation - Flocculation	Gathers together fine, light particles to form larger particles (floc) to aid the sedimentation and filtration process.
Sedimentation	Settles out larger suspended particles.
Filtration	Filters out remaining suspended particles.
Postchlorination	Kills/inactivates disease causing organisms. Provides chlorine residual for distribution system.
Chemicals	Phosphates control corrosion, fluoride helps prevent dental decay.
Clear Well	Provides chlorine contact time for disinfection. Stores water for high demand.
Finished Water	

Common Abbreviations

ASTM – America Society for Testing and Materials
AWWA – America Water Works Association
CCR – consumer confidence report
CWS – community water system
DBP – disinfection byproduct
DO – dissolved oxygen
EBCT – empty bed contact time
GAC – granular activated carbon
HAA – haloacetic acids
HPC – heterotrophic plate count
HTH – high test hypochlorite; calcium hypochlorite
LCR – lead and copper rule
LSI – Langelier saturation index
MCL – maximum contaminant levels
MCLG – maximum contaminant level goal
MF – membrane filter
MGD – million gallons per day
MPN – most probable number
MRDL – maximum residual disinfection level
MTF - multiple-tube fermentation
NCWS – non-community water system
NOM – natural organic material
NSF – National Sanitation Foundation
NTNCWS – non-transient non-community water system
NTU – nephelometric turbidity units
OSHA – Occupational Safety and Health Act
P-A – presence-absence
PAC – powder activated carbon
PN – public notification
PPE – personal protective equipment
PPM – parts per million; mg/L
PSI – pounds per square inch
PWS – public water system
RPBP – reduced pressure backflow preventor
RTCR – revised total coliform rule
SCBA – self-contained breathing apparatus
SCD – streaming current detector
SDS - safety data sheet
SDWA – Safe Drinking Water Act
sMCL – secondary maximum contaminant level
SOC – synthetic organic carbon
SOP – standard operating procedures
TDS – total dissolved solids
THM – trihalomethane
TOC – total organic carbon
TWS – transient non-community water system
USEPA – United States Environmental Protection Agency
UV – ultraviolet
VOC – volatile organic chemical

Chemical Formula	Common Name(s)
$Al(OH)_3$	aluminum hydroxide; jellylike floc particles
$Al_2(SO_4)_3 \bullet 7H_2O$	alum; aluminum sulfate
AsO_3	arsenite
AsO_4	arsenate
Br_2	bromine
$CaCl_2$	calcium chloride
$CaCO_3$	calcium carbonate
$Ca(HCO_3)_2$	calcium bicarbonate
CaO	calcium oxide; unslaked lime; quicklime
$Ca(OCl)_2$	calcium hypochlorite; HTH
$Ca(OH)_2$	calcium hydroxide; lime; hydrated lime; slaked lime
$CaSO_4$	calcium sulfate
CH_4	methane
Cl_2	chlorine
ClO_2	chlorine dioxide
CO_2	carbon dioxide
$CuSO_4 \bullet 5H_2O$	copper sulfate; bluestone; copper sulfate pentahydrate
Fe	iron
$FeCl_3$	ferric chloride
$Fe(OH)_3$	ferric hydroxide
Fe_2S_2	iron sulfide
$Fe_2(SO_4)_3$	ferric sulfate
$Fe_2(SO_4)_3 \bullet 7H_2O$	ferrous sulfate
HCl	hydrochloric acid; muriatic acid
H_2O	water
$HOCl$	hypochlorous acid
H_2S	hydrogen sulfide
H_2SiF_6	fluorosilicic acid; hydrofluorosilicic acid; silly acid
H_2SO_4	sulfuric acid
I_2	iodine
$KMnO_4$	potassium permanganate
$MgCl_2$	magnesium chloride
$MgCO_3$	magnesium carbonate
$Mg(HCO_3)_2$	magnesium bicarbonate
$Mg(OH)_2$	magnesium hydroxide
$MgSO_4$	magnesium sulfate
Mn	manganese

Chemical Formula	Common Name(s)
$Na_2Al_2O_4$	sodium aluminate
Na_2CO_3	sodium carbonate; soda ash
NaF	sodium fluoride
$NaHCO_3$	sodium bicarbonate; baking powder
$Na_2O \bullet (SiO_2)_3$	sodium silicate
NaOCl	sodium hypochlorite; bleach
NaOH	sodium hydroxide; caustic soda
$Na_4P_2O_7$	tetrasodium pyrophosphate
$(NaPO)_{14}Na_2O$	sodium hexametaphosphate; sodium polyphosphate
Na_2SiF_6	sodium fluorosilicate; sodium silicofluoride
NCl_3	trichloramine
NH_2Cl	monochloramine
$NHCl_2$	dichloramine
NO_3	nitrate
O_3	ozone
OCl	hypochlorite
SO_4	sulfate
$Zn_3(PO_4)_2$	zinc orthophosphate

Suggested Water Treatment Exam References

The following are approved as reference sources for the water treatment examinations. Operators should use the latest edition of these reference sources to prepare for the exam.

Textbooks

American Water Works Association (AWWA) Web site: www.awwa.org
Principles and Practices of Water Supply Operations Series:

- Water Sources
- Water Treatment
- Water Transmission and Distribution
- Water Quality
- Basic Science Concepts and Applications

Other AWWA References:

- Water Quality and Treatment
- Water System Security, A Field Guide

Association of State Drinking Water Administrators (ASDWA) and National Rural Water Association (NRWA) Web site: www.asdwa.org (available online in PDF format;

- Security Vulnerability Self Assessment Guide for Small Drinking Water Systems

California State University, Sacramento (CSUS) Foundation, Office of Water Programs (www.owp.csus.edu)

- **Water Treatment Plant Operation, Volumes I and II**
- **Manage for Success**

Regulations

- Code of Federal Regulations, Title 40, Part 141 (www.gpo.gov)
- Community Public Water Systems Design Criteria, State of Tennessee, Department of Environment and Conservation, Division of Water Supply, Nashville, 2008.
- Regulations for Public Water Systems and Drinking Water Quality, State of Tennessee, Department of Environment and Conservation, Division of Water Supply, Nashville. June 2009.
- Rules Governing Water and Wastewater Operator Certification, State of Tennessee, Department of Environment and Conservation, Board of Certification for Water and Wastewater Operators, Nashville, TN, December 2009, Section 1200-5-3.

Study Guides

American Water Works Association, Operator Certification Study Guide: A Guide to Preparing for Water Treatment and Distribution Operator Certification Exams (www.awwa.org;

Suggested Primary Water Treatment Exam References

The following are approved as reference sources for the ABC water treatment examinations. Operators should use the latest edition of these reference sources to prepare for the exam. These reference are not the only reference an operator should use in studying for the exam, however, these are the primary references used in developing the exam.

Water Treatment 1

- ****CSUS Water Treatment Plant Operation Volume I**
- ****CSUS Water Treatment Plant Operation Volume II**
- ***Regulations for Public Water Systems and Drinking Water Quality State of Tennessee Department of Environment and Conservation Division of Water Supply Nashville, Latest Revision***
- **AWWA Basic Science Concepts and Applications**
- *Community Public Water Systems Design Criteria State of Tennessee Department of Environment and Conservation Division of Water Supply Nashville, Latest Revision*
- *Rules Governing Water and Wastewater Operator Certification, State of Tennessee, Department of Environment and Conservation, Board of Certification for Water and Wastewater Operators, Nashville, Latest Revision*

Water Treatment 2

- ****CSUS Water Treatment Plant Operation Volume I**
- ****CSUS Water Treatment Plant Operation Volume II**
- ***Regulations for Public Water Systems and Drinking Water Quality State of Tennessee Department of Environment and Conservation Division of Water Supply Nashville, Latest Revision***
- **AWWA Basic Science Concepts and Applications**
- **AWWA Water Treatment**
- *Community Public Water Systems Design Criteria State of Tennessee Department of Environment and Conservation Division of Water Supply Nashville, Latest Revision*
- *Rules Governing Water and Wastewater Operator Certification, State of Tennessee, Department of Environment and Conservation, Board of Certification for Water and Wastewater Operators, Nashville, Latest Revision*

Water Treatment 3

- ****CSUS Water Treatment Plant Operation Volume I**
- ****CSUS Water Treatment Plant Operation Volume II**
- **AWWA Basic Science Concepts and Applications**
- ***Regulations for Public Water Systems and Drinking Water Quality State of Tennessee Department of Environment and Conservation Division of Water Supply Nashville, Latest Revision***
- **AWWA Water Treatment**
- **AWWA Water Quality and Treatment**
- *Community Public Water Systems Design Criteria State of Tennessee Department of Environment and Conservation Division of Water Supply Nashville, Latest Revision*
- *Rules Governing Water and Wastewater Operator Certification, State of Tennessee, Department of Environment and Conservation, Board of Certification for Water and Wastewater Operators, Nashville, Latest Revision*

Water Treatment 4

- ****CSUS Water Treatment Plant Operation Volume I**
- ****CSUS Water Treatment Plant Operation Volume II**
- ***Regulations for Public Water Systems and Drinking Water Quality State of Tennessee Department of Environment and Conservation Division of Water Supply Nashville, Latest Revision***
- **AWWA Basic Science Concepts and Applications**
- **AWWA Water Treatment**
- *Community Public Water Systems Design Criteria State of Tennessee Department of Environment and Conservation Division of Water Supply Nashville, Latest Revision*
- *Rules Governing Water and Wastewater Operator Certification, State of Tennessee, Department of Environment and Conservation, Board of Certification for Water and Wastewater Operators, Nashville, Latest Revision*

There are 2-3 primary references for each of exam. The ** denotes that 20+ of the exam items are linked to the noted reference.

Bold items have at least three items linked to them. Any references that are not in bold, have only 1-2 items linked to them.

The Tennessee State references are included, however, there is a sixth reference if the sixth had at least three items linked to it; in some cases this was a tie of 2-3 references with just a few items each. State of Tennessee references are italicized.

ABC
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ABC

Association of Boards of Certification

Water Treatment Need-to-Know Criteria

A Need-to-Know Guide when preparing for the ABC Water Treatment Certification Examination.

Acknowledgement

The Association would like to thank the members of the 2010-2011 Water Treatment Validation and Examination Committee for their effort in conducting the job analysis and developing the ABC Need-to-Know Criteria for Water Treatment Operators. Committee members included:

- Brian Thorburn, British Columbia (Chair)
- Gary Coleman, New Jersey
- Kim Dyches, Utah
- Ander Houlihan, Nova Scotia
- Bob Hoyt, Massachusetts
- Ken Kerri, California
- Chuck Kingston, Oregon
- Gerald Samuel, Alberta
- Scott Williams, Tennessee

Introduction

As part of the development of its certification exams, the Association of Boards of Certification (ABC) conducted a job analysis of water treatment operators in 2010. As part of this process, ABC conducted a national survey of water treatment operators. This *Need-to-Know Criteria* was developed from the results of ABC's 2010 water treatment operator job analysis.

How the *Need-to-Know Criteria* Was Developed

Review of Task Survey

The results of the 2010 task analysis survey were provided to the ABC Water Treatment V&E Committee. In the task analysis survey, operators rated job tasks and capabilities for frequency of performance and seriousness of inadequate or incorrect performance. These two rating scales were used because they provide useful information (i.e., how critical each task is and how frequently each task is performed) pertaining to certification. Of the 1192 individuals in the water treatment industry who completed the survey, 169 were class I operators, 254 were class II operators, 224 were class III operators, and 349 were class IV operators.

Analysis of Ratings

The composite criticality ratings and percentage of operators reporting that they performed the tasks were presented to the Water Treatment V&E Committee in January 2011 to begin development of the new *Need-to-Know Criteria*. V&E committee members were given the opportunity to retain tasks which did not meet decision criteria (a criticality value of at least 10.5, and a percent performing value of at least 50%) if a significant rationale could be provided for their importance on the examination. The V&E committee members were also given the opportunity to remove any tasks which met criteria on the survey but were deemed untestable or inappropriate for the water treatment certification examination. Final examination blueprint weights were calculated by summing the criticality values of all remaining tasks, and dividing the criticality value of each task by the grand total criticality value. Weights of individual tasks were summed for each core competency area to determine the proportion of the water treatment certification examination devoted to each core competency.

Core Competencies

The essential tasks and capabilities that were identified through this process are called the core competencies. The following pages list the core competencies for water treatment operators. The core competencies are clustered into the following job duties:

- Monitor, Evaluate, and Adjust Treatment Processes
- Laboratory Analyses
- Comply with Drinking Water Regulations
- Operate and Maintain Equipment
- Perform Security, Safety, and Administrative Procedures
- Evaluate Characteristics of Source Water

The level of knowledge (i.e., comprehension, application, analysis) required for each task is also identified in the following pages.

- **Comprehension** is the most basic level of understanding and remembering. Items written at the comprehension level require examinees to recognize, remember, or identify important ideas.
- Items written at the **application** level require examinees to interpret, calculate, predict, use or apply information and solve problems.
- Items written at the **analysis** level require examinees to compare, contrast, diagnose, examine, analyze, and relate important concepts.

The level of knowledge is a hierarchy from basic comprehension to analysis. The level of knowledge tested is cumulative. Therefore, tasks identified as application may include questions written at both the application and comprehension levels. Tasks identified as analysis may include questions written at the comprehension, application, and analysis levels.

About the Association of Boards of Certification

Established in 1972, the Association of Boards of Certification (ABC) is a non-profit member-driven organization dedicated to protecting public health and the environment by advancing the quality and integrity of environmental certification programs. ABC membership includes almost 100 certifying authorities, representing more than 40 states, nine Canadian provinces as well as several international programs. Existing solely for its members, ABC is the voice for the profession and serves as the conduit for information in an ever-changing industry.

Over 70 certification programs currently test approximately 35,000 operators and laboratory analysts annually through ABC's industry-leading Certification & Testing Services. Over 400,000 water and wastewater operators, laboratory analysts, and backflow prevention assembly testers have taken an ABC exam since the testing program began in 1982.

ABC Vision
Promote integrity in environmental certification throughout the world.

ABC Mission
ABC is dedicated to advancing the quality and integrity of environmental certification programs.

ABC Objectives
- Promote certification as a means of protecting public health, the infrastructure, and the environment.
- Promote uniformity of standards and best practices in certification.
- Serve as the technical resource for certification entities.
- Facilitate the transfer of certification between certifying authorities.
- Serve the needs of our members.

ABC Water Treatment Certification Exams

The ABC water treatment certification exams evaluate an operator's knowledge of tasks related to the operation of water treatment systems. The ABC Water Treatment V&E Committee determined the content of each exam based on the results of the national task analysis survey. To successfully take an ABC exam, an operator must demonstrate knowledge of the core competencies in this document.

Four levels of certification exams are offered by ABC, with class I being the lowest level and class IV the highest level. The specifications for the exams are based on a weighting of the job analysis results so that they reflect the criticality of tasks performed on the job. The specifications list the percentage of questions on the exam that fall under each job duty. For example, 27% of the questions on the ABC class I water treatment exam relate to the job duty "Operate and Maintain Equipment." For a list of tasks and capabilities associated with each job duty, please refer to the list of core competencies on the following pages.

ABC Water Treatment Exam Specifications

Blueprint Area	Class I	Class II	Class III	Class IV
Monitor, Evaluate, and Adjust Treatment Processes	30%	28%	31%	31%
Laboratory Analyses	12%	13%	11%	11%
Comply with Drinking Water Regulations	12%	12%	11%	10%
Operate and Maintain Equipment	27%	26%	24%	25%
Perform Security, Safety, and Administrative Procedures	13%	16%	18%	18%
Evaluate Characteristics of Source Water	6%	5%	5%	5%

Monitor, Evaluate, and Adjust Treatment Processes	Class I	Class II	Class III	Class IV
Chemical Addition				
Chemical pretreatment	Comprehension	Comprehension	Application	Analysis
Chlorine dioxide disinfection	Analysis	Analysis	Analysis	Analysis
Chlorine gas disinfection	Analysis	Analysis	Analysis	Analysis
Corrosion control	Comprehension	Comprehension	Application	Analysis
Fluoridation	Comprehension	Analysis	Analysis	Analysis
Ozone disinfection	Comprehension	Comprehension	Application	Application
pH adjustment	Application	Application	Analysis	Analysis
Sodium hypochlorite disinfection	Analysis	Analysis	Analysis	Analysis
Ultraviolet disinfection	Comprehension	Comprehension	Application	Application

Monitor, Evaluate, & Adjust Treatment Processes Continued	Class I	Class II	Class III	Class IV
Coagulation and Flocculation				
Chemical coagulants	Comprehension	Application	Application	Analysis
Flocculation tanks	Comprehension	Application	Application	Analysis
Rapid mix units	Comprehension	Application	Application	Analysis
Clarification and Sedimentation				
Dissolved air flotation	Comprehension	Application	Application	Analysis
Inclined-plate sedimentation	Comprehension	Application	Application	Analysis
Sedimentation basins	Comprehension	Application	Application	Analysis
Tube sedimentation	Comprehension	Application	Application	Analysis
Up-flow solids-contact clarification	Comprehension	Application	Application	Analysis
Filtration				
Cartridge filters	Application	Application	Application	Application
Diatomaceous earth filters	Comprehension	Comprehension	Comprehension	Application
Direct filtration	Comprehension	Application	Application	Analysis
Gravity filtration	Comprehension	Application	Application	Analysis
Membranes (ultrafiltration, nanofiltration, reverse osmosis)	Application	Application	Application	Application
Microscreens	Comprehension	Comprehension	Application	Analysis
Pressure or greensand filtration	Application	Application	Application	Application
Slow sand filters	Comprehension	Application	Application	Analysis
Residuals Disposal				
Discharge to lagoons	N/A	N/A	Comprehension	Comprehension
Discharge to lagoons and then raw water source	N/A	N/A	Comprehension	Comprehension
Discharge to raw water	N/A	N/A	Application	Analysis
Disposal to sanitary sewer	N/A	N/A	Comprehension	Comprehension
Land application	N/A	N/A	Comprehension	Comprehension
Mechanical dewatering	N/A	N/A	Application	Analysis
On-site disposal	N/A	N/A	Comprehension	Comprehension

Monitor, Evaluate, & Adjust Treatment Processes Continued	Class I	Class II	Class III	Class IV
Residuals Disposal Continued				
Solids composting	N/A	N/A	Comprehension	Comprehension
Additional Treatment Tasks				
Aeration	Comprehension	Application	Application	Analysis
Backwash aids	Comprehension	Application	Application	Analysis
Coagulation aids	Comprehension	Application	Application	Analysis
Copper sulfate treatment	Application	Application	Application	Application
Electrodialysis	Comprehension	Comprehension	Comprehension	Application
Filter aids	Comprehension	Application	Application	Analysis
Ion-exchange/softening	Application	Application	Application	Application
Iron manganese/softening	Application	Application	Application	Application
Lime-soda ash softening	Comprehension	Comprehension	Application	Analysis
Packed tower aeration	Comprehension	Comprehension	Comprehension	Comprehension
Powdered activated carbon	Application	Application	Application	Application

Required Capabilities

Knowledge of:

- Analysis and interpretation
- Basic chemistry
- Chemical properties
- Drinking water treatment concepts
- General electrical principles
- Monitoring requirements
- Normal chemical range
- Physical science
- Principles of measurement
- Proper application of chemicals
- Proper chemical handling and storage

Ability to:

- Adjust chemical feed rates
- Adjust flow patterns
- Adjust process units
- Calculate dosage rates
- Confirm chemical strength
- Diagnose/trouble shoot
- Discriminate between normal and abnormal conditions
- Evaluate facility performance
- Evaluate process units
- Interpret data
- Maintain processes in normal operating condition
- Measure chemical weight/volume
- Perform basic math
- Perform physical measurements
- Perform process control calculations
- Prepare chemicals
- Recognize abnormal analytical results

Laboratory Analysis	Class I	Class II	Class III	Class IV
Algae identification	Comprehension	Comprehension	Application	Application
Asbestos	Comprehension	Comprehension	Application	Application
Biological	Application	Application	Application	Application
Chemical	Comprehension	Application	Application	Application
Chlorine	Analysis	Analysis	Analysis	Analysis
Coliform bacteria	Application	Application	Application	Analysis
Complete chain-of-custody	Comprehension	Application	Application	Analysis
Corrosivity	Comprehension	Comprehension	Comprehension	Comprehension
Disinfectant by-products (THM/HAA)	Comprehension	Comprehension	Application	Analysis
Dissolved oxygen	Comprehension	Comprehension	Comprehension	Comprehension
Hexavalent chromium	Comprehension	Comprehension	Comprehension	Comprehension
Inorganic minerals	Comprehension	Comprehension	Comprehension	Comprehension
Jar test	Comprehension	Comprehension	Application	Analysis
Langelier Index	Comprehension	Analysis	Analysis	Analysis
Metals	Application	Application	Application	Application
Organics	Comprehension	Comprehension	Analysis	Analysis
pH	Application	Application	Analysis	Analysis
Physical parameters	Analysis	Analysis	Analysis	Analysis
Radiological parameters	Analysis	Analysis	Analysis	Analysis
Saturation Index	Comprehension	Comprehension	Comprehension	Comprehension
Solids	Comprehension	Comprehension	Comprehension	Comprehension
Streaming current analysis	Comprehension	Comprehension	Comprehension	Comprehension

Required Capabilities

Knowledge of:

- Basic chemistry
- Basic laboratory techniques
- Biological science
- Chemical properties
- Data collection
- Laboratory equipment
- Material Safety Data Sheet
- Monitoring requirements
- Normal characteristics of water
- Normal chemical range
- Personal protective equipment
- Pesticides

Ability to:

- Accurately transcribe data
- Communicate in writing
- Communicate verbally
- Determine what information needs to be recorded
- Follow written procedures
- Interpret data
- Measure chemical weight/volume
- Perform basic math
- Perform laboratory calculations
- Perform physical measurements
- Prepare chemicals

Required Capabilities Continued

Knowledge of:

- Physical science
- Principles of measurement
- Proper sampling procedures
- Quality control/quality assurance practices
- Safety procedures
- Standard methods

Ability to:

- Recognize abnormal analytical results
- Record information

Comply with Drinking Water Regulations	Class I	Class II	Class III	Class IV
40 CFR 141 Subpart A: General (definitions, coverage, variances and exemptions, siting requirements, and effective dates)	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart B: Maximum Contaminant Levels (arsenic, nitrate, turbidity)	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart C: Monitoring and Analytical Requirements (turbidity, coliforms, organic contaminants, organic contaminants)	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart D: Reporting and Recordkeeping Requirements	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart E: Special Regulations, Including Monitoring Regulations and Prohibition on Lead Use	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart F: Maximum Contaminant Level Goals and Maximum Residual Disinfectant Level Goals	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart G: National Primary Drinking Water Regulations: Maximum Contaminant Levels and Maximum Residual Disinfectant Levels	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart H: Filtration and Disinfection	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart I: Control of Lead and Copper	Comprehension	Comprehension	Application	Application

Comply with Drinking Water Regulations Continued	Class I	Class II	Class III	Class IV
40 CFR 141 Subpart K: Treatment Techniques	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart L: Disinfectant Residuals, Disinfection Byproducts, and Disinfection Byproduct Precursors	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart P:Enhanced Filtration and Disinfection Systems Serving 10,000 or More People	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart Q: Public Notification of Drinking Water Violations	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart S: Ground Water Rule	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart T: Enhanced Filtration and Disinfection Systems Serving Fewer Than 10,000 People	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart U: Initial Distribution System Evaluations	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart V: Stage 2 Disinfection Byproducts Requirements	Comprehension	Comprehension	Application	Application
40 CFR 141 Subpart W: Enhanced Treatment for Cryptosporidium	Comprehension	Comprehension	Application	Application
40 CFR 143: National Secondary Drinking Water Regulations	Comprehension	Comprehension	Application	Application

Required Capabilities

Knowledge of:

- Code of federal regulation
- Regulations
- Reporting
- Safe Drinking Water Act

Operate and Maintain Equipment	Class I	Class II	Class III	Class IV
Evaluate Operation of Equipment				
Check speed of equipment	Comprehension	Application	Application	Analysis
Inspect equipment for abnormal conditions	Comprehension	Application	Application	Analysis
Measure temperature of equipment	Comprehension	Application	Application	Analysis
Read charts	Application	Application	Application	Analysis
Read meters	Application	Application	Application	Analysis
Read pressure gauges	Application	Application	Application	Analysis
Operate Equipment				
Blowers and compressors	Application	Application	Application	Application
Chemical feeders	Analysis	Analysis	Analysis	Analysis
Computers (SCADA systems, HMI, etc.)	Application	Application	Application	Application
Drives	Application	Application	Application	Application
Electronic testing equipment	Application	Application	Application	Application
Engines	Application	Application	Application	Application
Gates	Application	Application	Application	Application
Generators	Application	Application	Application	Application
Hand tools	Application	Application	Application	Application
Hydrants	Application	Application	Application	Application
Hydraulic equipment	Application	Application	Application	Application
Instrumentation	Application	Application	Application	Application
Motors	Application	Application	Application	Application
Pneumatic equipment	Application	Application	Application	Application
Power tools	Application	Application	Application	Application
Pumps	Application	Application	Application	Application
Valves	Application	Application	Application	Application

Operate and Maintain Equipment Continued	Class I	Class II	Class III	Class IV
Perform Maintenance				
Backflow prevention devices	Application	Application	Application	Analysis
Blowers and compressors	Application	Application	Application	Application
Bulk chemical storage systems	Application	Application	Application	Analysis
Calibration of chemical feeders	Application	Application	Application	Analysis
Chemical feeders	Application	Application	Application	Application
Drives	Comprehension	Application	Application	Application
Electrical grounding	Comprehension	Application	Application	Application
Engines	Comprehension	Application	Application	Application
Gates	N/A	N/A	N/A	Comprehension
Generators	Comprehension	Comprehension	Comprehension	Comprehension
Hydrants	N/A	N/A	N/A	Comprehension
Hydraulic equipment	N/A	N/A	N/A	Comprehension
Instrumentation	Application	Application	Application	Application
Lock-out/tag-out	Application	Application	Application	Application
Motors	Application	Application	Application	Application
Pipes	Comprehension	Comprehension	Comprehension	Comprehension
Pneumatic equipment	Comprehension	Comprehension	Comprehension	Comprehension
Pumps	Application	Application	Application	Application
Treatment units	Comprehension	Application	Application	Application
Valves	Application	Application	Application	Application

Required Capabilities

Knowledge of:

- Facility operation and maintenance
- Function of tools
- General electrical principles
- HVAC equipment
- Hydraulic principles
- Internal combustion engines
- Lubricant and fluid characteristics
- Mechanical equipment
- Mechanical principles
- Operation and maintenance practices
- Personal protective equipment
- Pneumatics

Ability to:

- Adjust equipment
- Assign work to proper trade
- Calibrate equipment
- Communicate in writing
- Communicate verbally
- Diagnose/troubleshoot
- Differentiate between preventative and corrective maintenance
- Discriminate between normal and abnormal conditions
- Evaluate operation of equipment
- Monitor equipment

Required Capabilities Continued

Knowledge of:

- Process control instrumentation
- Proper lifting procedures
- Start up and shut down procedures
- Storage

Ability to:

- Operate safety equipment
- Order spare parts
- Organize information
- Perform general maintenance
- Perform general repairs
- Perform physical measurements
- Recognize unsafe work conditions
- Record information
- Report findings
- Translate technical language into common terminology
- Use hand tools

Perform Security, Safety, and Administrative Procedures	Class I	Class II	Class III	Class IV
Write/complete reports (state/provincial)	Comprehension	Application	Application	Analysis
Manage Facility				
Administer safety program	Comprehension	Comprehension	Comprehension	Comprehension
Develop budget	N/A	N/A	Comprehension	Comprehension
Respond to complaints	Analysis	Analysis	Analysis	Analysis
Respond to Emergencies				
Facility upset	Application	Application	Application	Application
Major spill response	Application	Application	Application	Application
Natural disasters	Comprehension	Application	Application	Analysis
System contamination	Analysis	Analysis	Analysis	Analysis
Safety Procedures				
Calibration of atmospheric testing devices	Application	Application	Application	Application
Chemical hazards and chemical spill response	Application	Application	Application	Application
Confined space entry	Analysis	Analysis	Analysis	Analysis

Perform Security, Safety, and Administrative Procedures Continued	Class I	Class II	Class III	Class IV
Safety Procedures Continued				
General safety and health	Analysis	Analysis	Analysis	Analysis
Pathogens	Application	Application	Application	Application
Personal protective equipment	Analysis	Analysis	Analysis	Analysis
Record Information				
Compliance	Application	Application	Analysis	Analysis
Corrective actions	Application	Application	Analysis	Analysis
Customer complaints	Application	Application	Application	Application
Facility operation	Application	Application	Application	Application
Laboratory	Comprehension	Application	Application	Analysis
Maintenance	Application	Application	Application	Analysis

Required Capabilities

Knowledge of:

- Arbitration procedures
- Building codes
- Disciplinary procedures
- Emergency plans
- Legislative process
- Local codes and ordinances
- Material Safety Data Sheet
- Personal protective equipment
- Potential causes of disasters in facility
- Potential impact of disasters on facility
- Principles of finance
- Principles of management
- Principles of public relations
- Principles of supervision
- Proper chemical handling and storage
- Proper lifting procedures
- Public administration procedures
- Recordkeeping policies
- Regulations
- Reporting requirements
- Retrieval
- Risk management
- Safety procedures
- Safety regulations

Ability to:

- Assess likelihood of disaster occurring
- Communicate in writing
- Communicate verbally
- Conduct meetings
- Conduct training programs
- Coordinate emergency response with other organizations
- Demonstrate safe work habits
- Determine what information needs to be recorded
- Develop a budget
- Develop a public relations campaign
- Develop a staffing plan
- Develop a work unit
- Evaluate employee performance
- Evaluate promotional materials
- Evaluate proposals
- Generate capital plans
- Generate long and short term plans
- Generate written safety procedures
- Identify potential safety hazards
- Negotiate contracts
- Operate safety equipment
- Perform impact assessments
- Prepare proposals
- Recognize unsafe work conditions
- Report findings
- Select safety equipment

Evaluate Characteristics of Source Water	Class I	Class II	Class III	Class IV
Algae control	Comprehension	Comprehension	Comprehension	Application
Bacteriological	Application	Analysis	Analysis	Analysis
Biological	Comprehension	Comprehension	Application	Application
Chemical	Comprehension	Comprehension	Application	Application
Chemical treatment (copper sulfate)	Application	Application	Application	Analysis
Identify and evaluate potential sources of source water contamination	Comprehension	Application	Analysis	Analysis
Monitor, evaluate, and adjust source water	Comprehension	Application	Analysis	Analysis
Physical	Comprehension	Comprehension	Application	Application
Stratification control	Comprehension	Comprehension	Application	Analysis

Required Capabilities

Knowledge of:

- Contaminants
- Hydrology
- Normal characteristics of water
- Watershed protection

Ability to:

- Communicate in writing
- Communicate verbally
- Discriminate between normal and abnormal conditions

References

The following are approved as reference sources for the ABC water treatment examinations. Operators should use the latest edition of these reference sources to prepare for the exam.

American Water Works Association (AWWA)

- Principles and Practices of Water Supply Operations Series:
  - *Water Sources*
  - *Water Treatment*
  - *Water Transmission and Distribution*
  - *Water Quality*
  - *Basic Science Concepts and Applications*
- Other AWWA References:
  - *Water Quality and Treatment*
  - *Water System Security, A Field Guide*

To order, contact:
American Water Works Association
6666 W Quincy Ave
Denver CO 80235
Web site: www.awwa.org
Phone: (800) 926-7337
Fax: (303) 347-0804
E-mail: custsvc@awwa.org

Association of State Drinking Water Administrators (ASDWA) and National Rural Water Association (NRWA)

- *Security Vulnerability Self Assessment Guide for Small Drinking Water Systems*

To order, contact:
ASDWA
1401 Wilson Blvd Ste 1225
Arlington VA 22209
Web site: www.asdwa.org
(available online in PDF format; select Security," then "Training and Tools")
Phone: (703) 812-9505
Fax: (703) 812-9506
E-mail: info@asdwa.org

California State University, Sacramento (CSUS) Foundation, Office of Water Programs

- *Water Treatment Plant Operation, Volumes I and II*
- *Manage for Success*

To order, contact:
Office of Water Programs
California State University, Sacramento
6000 J St
Sacramento CA 95819-6025
Web site: www.owp.csus.edu
Phone: (916) 278-6142 (916) 278-6142
Fax: (916) 278-5959
E-mail: wateroffice@owp.csus.edu

Record Maintenance
Water and Distribution Systems
State of Tennessee

Record	Must be kept for	Source
Bacteriological Analysis	5 years	0400-45-1-.20(1)(a)
Chemical Analysis	10 years	0400-45-1-.20(1)(a)
Actions to correct violations	3 years after last action	0400-45-1-.20(1)(b)
Written reports, summaries, communications relating to sanitary surveys	10 years after sanitary survey	0400-45-1-.20(1)(c)
Variances/exemptions	5 years after expiration	0400-45-1-.20(1)(d)
Turbidity	Next sanitary survey	0400-45-1-.20(1)(f)
Daily worksheets and shift logs	Next sanitary survey	0400-45-1-.20(1)(g)
Cross connection plans & inspection records	5 years	0400-45-1-.20(1)(h)
Complaint logs	5 years	0400-45-1-.20(1)(h)
Facility maintenance records	5 years	0400-45-1-.20(1)(h)
Storage tank inspections	5 years (required) life of tank recommended	0400-45-1-.20(1)(h)
Lead & copper	12 years	0400-45-1-.33(12)
Bacteriological records indicating disinfection of mains, tanks, filters, wells	5 years	0400-45-1-.17(8)
Flush and free chlorine residual for new taps where main is uncovered	Next sanitary survey or 3 years	0400-45-1-.17(33)
SDS	At least 30 years	29 CFR1910.1020

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Water Sources & Characteristics

Developing the Water Supply

AWWA WSO: Water Sources

1

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Learning Objectives

- Hydrologic Cycle
- Characteristics of Groundwater and Surface Water
- Sources of Groundwater and Surface Water
- Water Rights
- Source Development and Protection
- Wells Operation and Maintenance
- Regulatory Publications and Rules

2

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Water Supply Hydrology and the Hydrologic Cycle

- Hydrologic Water Cycle
  - movement of water from the surface of the earth to the atmosphere and back
- Process of evaporation and transpiration
- Condensation forms water vapor droplets
- Precipitation returns water to earth
- Water penetrates ground via infiltration, percolation, and runoff
  - Surface runoff occurs when ground is saturated

3

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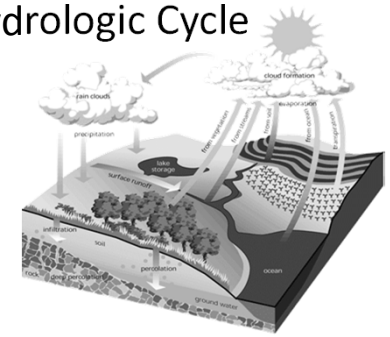
Hydrologic Cycle



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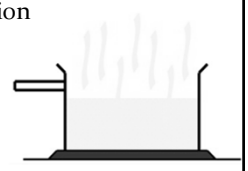
Hydrologic Cycle

- Evaporation and Transpiration
  - Evaporation
    - the changing of liquid to gas (water to water vapor)
  - Water is constantly evaporating from the earth
  - Transpiration
    - the process in which water from the earth is absorbed by plants and transferred to the air through the leaves



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Hydrologic Cycle

- Condensation and Precipitation
  - Condensation
    - occurs when water vapor condenses as it cools and forms tiny droplets of water or clouds
  - Precipitation
    - occurs when the droplets become too heavy to stay airborne
    - these droplets fall back to earth as rain, snow, sleet or hail

6

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Hydrologic Cycle

- Infiltration and Percolation
  - As precipitation falls, it soaks into the ground
  - Infiltration
    - the movement of water through the soil
  - Some of the water goes back to the surface due to *capillary action*
    - the movement of water above a water surface
  - The rest percolates (continues downward) to the water table

7

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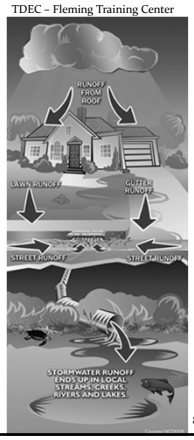
Hydrologic Cycle

- Surface Runoff
  - When the soil can hold no more water, it flows downward over the ground surface
  - It flows into streams or lakes or, eventually, the ocean



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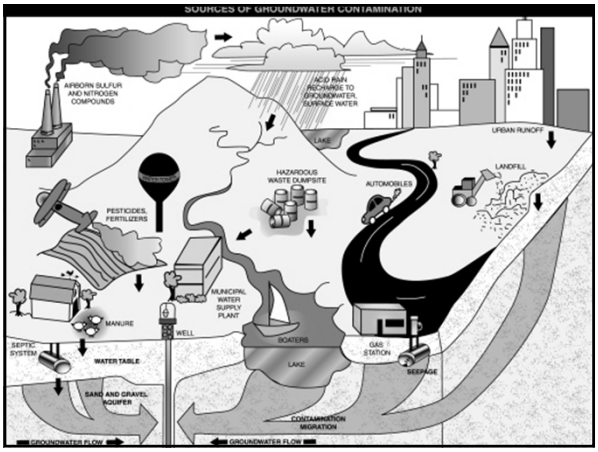

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Groundwater

- Water below the surface
- Hidden resource
- Provides 20% of water used in the US
- Has few contaminants
- Resultant of infiltration and percolation
- Relatively free from micro contamination
- Characterized by:
  - high TDS
    - Fe & Mn
  - high dissolved gases
    - radon, CH_4, H_2S
  - low dissolved oxygen
  - low color
  - high hardness
- Can be influenced by natural and human activities

10

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Groundwater

- Sources
  - Aquifers
    - confined and unconfined
  - Springs
- Half of the world's groundwater resource is located within one mile of the ground surface
- Other half is found in deep aquifers

11

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Aquifers

Unconfined Aquifers

- Upper surface is free to rise and fall
- Water table wells
  - wells constructed to reach an unconfined aquifer
- Amount of water produced varies widely as water table rises and falls in relation to rainfall
- Indicates water table level of surrounding aquifer

12

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Aquifers

Confined Aquifers

- Also known as Artesian Aquifer
- Permeable layer confined by an upper level and lower level of low permeability material
- Water recharge area usually higher than main part of aquifer
- Water is usually under pressure
- Flowing artesian well
  - pressure causes water to rise above ground surface
- Non-flowing artesian well
  - water doesn't rise to the surface
- Piezometric surface
  - height that water rises

13

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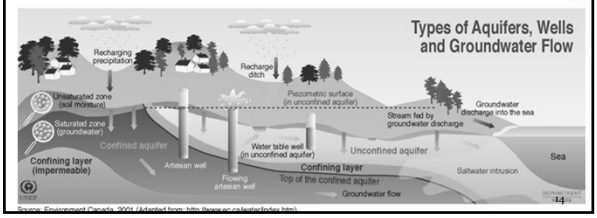
Aquifers

- Characteristics
  - Underground layer of gravel, sand, sandstone, shattered rock, or limestone
  - Impermeable layer of rock, clay or granite keeps water from sinking downward
  - Water table is upper surface of an aquifer
  - Classified as water table or artesian and confined or unconfined

07



14

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Aquifers Terms & Materials

- Porosity
  - amount of water the material will hold
- Hydraulic conductivity
  - how easily the water will flow thought the aquifer material
- Both determine how much the aquifer will yield
- Pumping rates are higher in coarser material and cost less
  - less pumping head loss
- Consolidated aquifer formations consist of limestone and fractured rock and produce large quantities of water

15

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Groundwater Movement Characteristics

- Movement of water is naturally downhill
- Rainfall percolates down to the water table
- Water moves slowly through soil which removes suspended particles
- Soil acts as a natural filtration process
  - Dissolved pollutants cannot be removed
  - Contaminants can be picked up
- Water table is never completely level

16

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Springs

- Occur if water table intersects the ground surface
- Difficult to determine source of springs
- They should be considered contaminated until sanitary survey is conducted
- Flows vary considerably and are influenced by artesian pressures
- Enclose intake in a concrete spring box

17

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Surface Water Characteristics

- Higher turbidity
- Suspended solids
- More color
- Microbial contamination
- Impurities in snow and rain
- Impurities from runoff
  - soluble formations such as limestone, gypsum, & rock salt affect characteristics
- Precipitation dissolves gases in atmosphere
- Dust and solids from industrial processes
- Usually soft, low in solids and alkalinity, and pH slightly below 7
- Usually corrosive
- Seasonal changes

18

Surface Water Supply and Operating Problems

- Contamination
- Loss of water source by evaporation & seepage
- Weather (rain and snowfall)
- Exposure to environmental changes
- Icing
- Rainfall intensity and droughts
- Soil composition
- Human influences
- More and varied treatment processes

19

Wells

You surface water people stay awake!
This is a GROUNDWATER people session.

20

Wells

- Advantages
  - Provide 20% of water used in US
  - Facilities cost less to operate
  - Water is less turbid
  - Contains fewer bacteriological and viral contaminants
    - require less treatment
  - Maintain uniform temperature

21

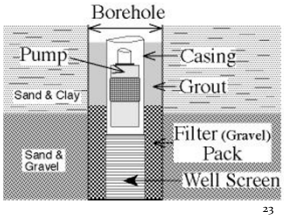
Parts of a Well

- **Sanitary seal**
  - prevents contamination
  - seal has openings for discharge pipe, pump controls, and air vent
- **Well casing**
  - liner to prevent walls from caving in
  - protects water quality
- **Well casing vent**
  - prevents pump vacuum and contamination from entering

22

Parts of a Well

- **Grout**
  - cement or other material that prevents water from the surface from entering well
- **Intake screen**
  - prevents sand or other material from entering the well and allows water to flow freely



23

Well Terms

- **Static water level**
  - water surface level when no water is being drawn
- **Pumping water level**
  - level at which water drops and stabilizes as it is pumped
- **Drawdown**
  - drop between static and pumping level

24

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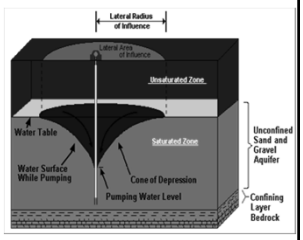
Well Terms

- **Cone of depression**
  - depression in the water level around a well during pumping
- **Zone of influence**
  - length and depth of Radius of Influence
  - determined by Cone of Depression



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Well Terms

- **Residual drawdown**
  - difference between the original water level and water level after pumping has stopped
- **Well yield**
  - rate of water withdrawal that a well can supply over a long period of time
- **Safe yield**
  - maximum amount of water that can be withdrawn continuously during the driest periods
- **Specific capacity**
  - yield per unit of drawdown (can indicate problems)

26

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Well Location and Sanitary Considerations

- Located to produce max yield while being protected
- Deep as possible to prevent contamination from the surface
- If shallow groundwater source, ensure casing and hole grouted
- Prefer a 2 foot deep layer of clay within a 50 foot radius around the well

27

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Well Operation and Maintenance

- Record Keeping
  - Static water level after pump has been idle for a period of time
  - Pumping water level
  - Drawdown
  - Well production
  - Well yield
  - Time required for recovery after pumping
  - Specific capacity

28

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Well Operation and Maintenance

- Regular Maintenance
  - Plugging of screen most common problem
    - encrustation of biological growth
    - precipitates of Fe, Mn, and hardness
  - Can be cleaned using hydrochloric acid (muriatic acid)
    - refer to AWWA manual M21
  - Well can fail if screen collapses or corrodes
  - Bacteriological samples should be periodically
  - Disinfection may be needed sometimes

29

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Procedures for Well Abandonment

- Eliminate any physical hazards
- Take measures to prevent groundwater contamination and protect other nearby wells
- Conservation of the aquifer
- Return to geological conditions present before well was constructed
- Private wells must be properly abandoned and plugged
  - can be a cross connection if home is connected to both a well and public water supply
  - it should be permanently disconnected
- **Must be done properly**

30

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Surface Water Source Development

- Includes all tributary streams and drainage basins, natural lakes and artificial reservoirs or impoundments above the point of water supply intake

31

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Surface Water Source Development

- Factors
  - Quantity
  - Quality
  - Structures
  - Impoundments and reservoirs
    - Site preparation
    - Construction
- Tennessee Public Water System Design Criteria part 3

32

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Groundwater Source Development

- Includes all water obtained from drilled wells or springs
- General Well Construction Requirements
- Tennessee Public Water System Design Criteria part 3.3

33

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Safe Drinking Water Act

- SDWA
  - Establishes primary drinking water standards
  - Secondary standards
  - Public notification procedures and requirements
  - Federal Enforcement
  - Established a cooperative program among local, state, and federal agencies
  - EPA executive agency
  - Established MCL's (Maximum Contaminate Level)
  - Established sampling and testing requirements

34

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Tennessee Water Program

- Governing agency
  - Department of Environment and Conservation Bureau of Environment Division of Water Resources
  - Rules/Regulations
    - Chapter 0400-45-1 Public Water Systems
  - Sanitary surveys
  - Technical assistance
  - Laboratory services
  - Enforcement
  - Environmental Field Offices(EFOs)
  - Design criteria

35

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Water Quality Characteristics

- Four categories:
  - Physical
  - Chemical
  - Biological
  - Radiological

36

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Physical Characteristics of Water

- Relates to sensory qualities of water
- Temperature
  - most familiar characteristic
  - effects lake turnovers, dissolving of chemicals and palatability
  - most desirable drinking water is considered cool
- Turbidity
  - cloudiness of water
  - indicator of health significance
  - operational considerations
  - aesthetics
- Color
  - indicates contamination, dissolved organics, and humic substances that could form THMs
- Taste & odor
  - degradation aesthetic quality

37

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Chemical Characteristics of Water

- Inorganic
  - pH
    - indicator of acidity or alkalinity
  - Hardness
  - Dissolved oxygen
    - measured in mg/L
  - Dissolved solids
    - toxic minerals include
      - chromium
      - arsenic
      - lead
      - barium
      - mercury
      - fluoride
      - silver
      - nitrate
- Organic
  - Includes
    - pesticides
    - herbicides
    - domestic wastes
    - industrial wastes
    - watershed runoff
  - Can cause taste, odor, and toxicity problems

38

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Biological Characteristics of Water

- Aquatic life (algae)
- Bacteria
- Coliforms
- Viruses
- Protozoa
- Spores
- Cysts
- Many originate with fecal discharges
- Not easily identified and isolated

39

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Radiological Factors in Water

- Development of atomic energy and mining of radioactive materials made it necessary to examine safe limits
- Divided into two categories:
  - Natural and Man-made
- Sources are
  - Natural deposits and Man-made deposits

If someone is glowing, Be Suspicious! ☺

40

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Water Source Protection

41

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Fundamental Principles

- The quality of source water is influenced by natural and human activities
- It is the responsibility of the operators to minimize harm from both of these
- Surface waters are more influenced by human activities
- Groundwater can also be influenced

42

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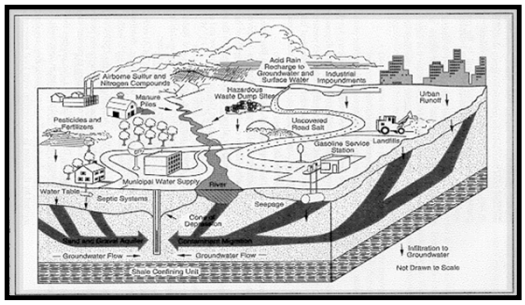
Source of Groundwater Contamination



43

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Benefits of Source Water Protection Program

- Source control is the first barrier in a multiple-barrier treatment plan
- Water treatment methods are not 100% effective in removing contaminants
  - The risks of residual contaminants can be too high
- As the quality of source water deteriorates, the cost of treatment goes up and can become prohibitive

44

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Benefits of Source Water Protection Program

- Increase in public confidence
- Decrease in public health risks
- Due to difficulty to analyze, remove, and/or disinfect pathogens with conventional methods, keeping pathogens out of the source water may be the only way of providing protection

45

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Developing a Source Water Protection Program

- Inventory and characterize the water source
- Identify pollutant sources and relative impact
- Assess vulnerability of intake to contaminants
- Establish source water protection goals

46

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Developing a Source Water Protection Program

- Develop source water protection strategies
- Implement the program
- Monitor and evaluate program effectiveness

47

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Developing a Source Water Protection Program

- Identify area that needs protection and who has an interest in protecting it
  - For wellhead protection
    - aquifer delineation
  - For surface water sources
    - watershed mapping

48

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Developing a Source Water Protection Program

- Aquifer Delineation (Wellhead Protection Area)
  - Define the land area over the portion of the aquifer that influences the quality of the water
  - Should be identified and inventoried for potential of contamination
  - For microbiological contaminants, a small area is suitable

49

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Developing a Source Water Protection Program

- Aquifer Delineation (Wellhead Protection Area)
  - Chemical contaminants can travel from several thousand feet for relatively deep wells
  - USGS maps are a good place to start
  - 1986 SDWA amendments require each state to develop a Wellhead Protection Program
  - Limit activities in area to protect well and aquifer from contamination

50

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Developing a Source Water Protection Program

- Watershed Mapping
  - Surface water sources
  - Watershed is area sloped toward water source that drains to it
  - Watershed should be identified and inventoried for potential sources of contaminantion
  - USGS (United States Geological Survey)

51

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Developing a Source Water Protection Program

- Watershed Mapping
  - If utility can purchase lands in the watershed, it can limit activities that could affect water quality
  - If land cannot be bought, buffer zones for logging and agriculture operations should be implemented
  - Promote community activities that emphasize protection of watershed

52

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Developing a Source Water Protection Program

- Identify Pollutant Sources and Relative Impact
  - Sewage disposal
  - Urban, industrial, agricultural and mine runoff
  - Animal population
  - Forestry/soil disturbance runoff
  - Recreation

53

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Developing a Source Water Protection Program

- Assess Vulnerability of Intake to Contaminants
  - Purpose
    - identify contaminant
    - identify amount of contaminant
    - correlate land use to contaminant level
  - Assessment methods
    - water quality monitoring
    - modeling
    - onsite assessment

54

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Developing a Source Water Protection Program

- Strategies
  - Land use controls
    - buffer zones
    - land acquisition
    - comprehensive planning
    - watershed/recharge area inspections

55

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Developing a Source Water Protection Program

- Vandalism and Terrorism
  - Before 9/11/01, no serious threat
  - Protect intakes
  - Safeguard area around source, if possible
  - Monitoring and surveillance may be required if threat is serious
  - Be alert of suspicious events

56

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Developing a Source Water Protection Program

- Title IV Drinking Water Security and Safety
  - Must have assessment of system
  - Dateline is dependent on size of system
  - ERPs (Emergency Response Plans) are due 6 months after assessment
  - Plans include actions, procedures, and identification of equipment which can prevent or lessen the impact of a terrorist act

57

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Developing a Source Water Protection Program

- Source of Contamination
  - After WHPA or watershed boundary for a water source has been determined, inventory of potential contaminant sources is to be performed
  - Community volunteer effort along with utility personnel is encouraged
    - volunteer fire dept., citizen group, etc.

58

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Developing a Source Water Protection Program

- Regulations
  - Tennessee Regulations for Wellhead Protection
    - Section 0400-45-1-.34

59

Water Sources and Characteristics Review Questions

1. Draw the basic hydrologic cycle.

2. What is the water table?

3. Define the term aquifer.

4. What two things determine the amount of water an aquifer will yield?
   - ➢
   - ➢

5. Describe the differences in water characteristics of groundwater and surface water.

6. Define the term watershed.

7. List six factors that influence the amount of surface runoff.
   - ➢
   - ➢
   - ➢
   - ➢
   - ➢
   - ➢

8. What is the purpose of an impoundment?

Water Sources & Treatment Vocabulary

A. Acid rain
B. Appropriative
C. Aquifer
D. Artesian
E. Capillary fringe
F. Contamination
G. Cross connection
H. Detention Time
I. Direct runoff
J. Drawdown
K. Evaporation
L. Evapotranspiration
M. Hydrologic cycle
N. Impermeable
O. Infiltration
P. Microorganisms
Q. Nonpotable
R. Pathogenic organisms
S. Percolation
T. Potable water
U. Precipitation
V. Raw water
W. Safe Drinking Water Act
X. Safe yield
Y. Stratification
Z. Transpiration
AA. Trihalomethanes
BB. Turbidity
CC. Water table

_____ 1. Water that does not contain objectionable pollution, contamination, minerals, or infective agents and is considered satisfactory for drinking.

_____ 2. The introduction into water of microorganisms, chemicals, toxic substances, wastes or wastewater in concentration that makes the water unfit for its next intended use.

_____ 3. Precipitation which has been rendered acidic by airborne pollutants.

_____ 4. The process of evaporation of water into the air and its return to earth by precipitation, including transpiration, groundwater movement, and runoff into rivers, streams and the ocean.

_____ 5. The upper surface of the zone of saturation of groundwater in an unconfined aquifer.

_____ 6. An act passed by the US Congress in 1974 that establishes a cooperative program among local, state and federal agencies to ensure safe drinking water for consumers.

_____ 7. Living organisms that can be seen individually only with the aid of a microscope.

_____ 8. Water rights to or ownership of a water supply which is acquired for the beneficial use of water by following a specific legal procedure.

_____ 9. The drop in the water table or level of water in the ground when water is being pumped from a well.

_____ 10. The process by which water vapor passes into the atmosphere from living plants.

_____ 11. Derivatives of methane in which three halogen atoms are substituted for three of the hydrogen atoms. Often formed by chlorination of organic matter.

_____ 12. Organisms capable of causing diseases in a host.

_____ 13. Water that may contain objectionable pollution, contamination, minerals or infective

_____ 14. A connection between a drinking water system and an unapproved water supply.

_____ 15. The annual quantity of water that can be taken from a source of supply over a period of years without depleting the source permanently.

_____ 16. The slow passage of water through a filter medium or the gradual penetration of soil & rocks by water.

_____ 17. Water flows over the ground surface or through the ground directly into streams, rivers, or lakes.

_____ 18. The process by which water vapor is released to the atmosphere by living plants.

_____ 19. The cloudy appearance of water caused by the presence of suspended and colloidal matter.

_____ 20. The process by which atmospheric moisture falls onto a land or water surface as rain, snow, hail, or other forms of moisture.

_____ 21. The formation of separate layers in lake or reservoir.

_____ 22. The process by which water or other liquid becomes a gas.

_____ 23. The porous material just above the water table which may hold water by capillarity in the smaller void spaces.

_____ 24. The seepage of groundwater into a sewer system, including service connections.

_____ 25. The theoretical time required for a small amount of water to pass through a tank at a given rate of flow.

_____ 26. Water in its natural state, prior to any treatment.

_____ 27. A natural underground layer of porous, water bearing materials usually capable of yielding a large amount or supply of water.

_____ 28. The property of a material or soil that does not allow, or allows only with great difficulty, the movement or passage of water

_____ 29. Pertaining to groundwater, a well or underground basin where the water is under a pressure greater than atmospheric and will rise above the level of its upper confining surface if given an opportunity to do so.

Answers

1. T	7. P	13. Q	19. BB	25. H
2. F	8. B	14. G	20. U	26. V
3. A	9. J	15. X	21. Y	27. C
4. M	10. L	16. S	22. K	28.
5. CC	11. AA	17. I	23. E	29. D
6. W	12. R	18. Z	24. O	

Parts of a Well – Matching

Draw a line from the term to its definition:

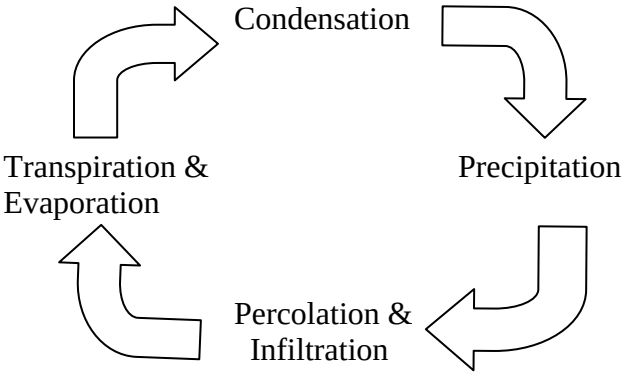
Sanitary Seal	Allows water to flow freely from an aquifer to a well; keeps sand out of a well.
Well Casing	Concrete area placed around the casing to support pumping equipment.
Intake Screen	A liner placed in the bore hole of a well to prevent the walls from caving in.
Grout	Prevents contamination from entering the well at the surface.
Well Slab	Seals the space between the casing and the bore hole.

Well Terms – Matching

Draw a line from the term to its definition:

Static Water Level	Inverted cone-shaped depression in water level while pump is operating.
Pumping Water Level	Water level when no water is being pumped from the aquifer.
Drawdown	Difference between original water level and the level after pumping has stopped.
Cone of Depression	Well yield ÷ drawdown.
Zone of Influence	Level to which water drops and stabilizes as it is pumped.
Residual Drawdown	Length and depth of radius of influence as determined by the cone of depression.
Well Yield	The drop between the static water level and the pumping water level.
Specific Capacity	The rate of water withdrawal that can be supplied over a period of time.

Answers to Water Sources and Characteristics Review Questions

1. 

2. The water table is the upper surface of an aquifer.

3. An aquifer is a porous, water-bearing geological formation.

4. The porosity and hydraulic conductivity determine the amount of water an aquifer will yield.

5. Groundwater:
   - High dissolved solids
   - Dissolved gasses
   - Low color
   - High hardness
   - Free from microbes

   Surface water:
   - Suspended solids
   - Higher turbidity
   - Higher color
   - Lower hardness
   - Microbial contamination

6. A watershed is the land area that is sloped toward a water source and drains into it.

7. Six factors influencing the amount of surface runoff are:
   rainfall intensity, rainfall duration, soil composition, soil moisture, ground slope, vegetation cover

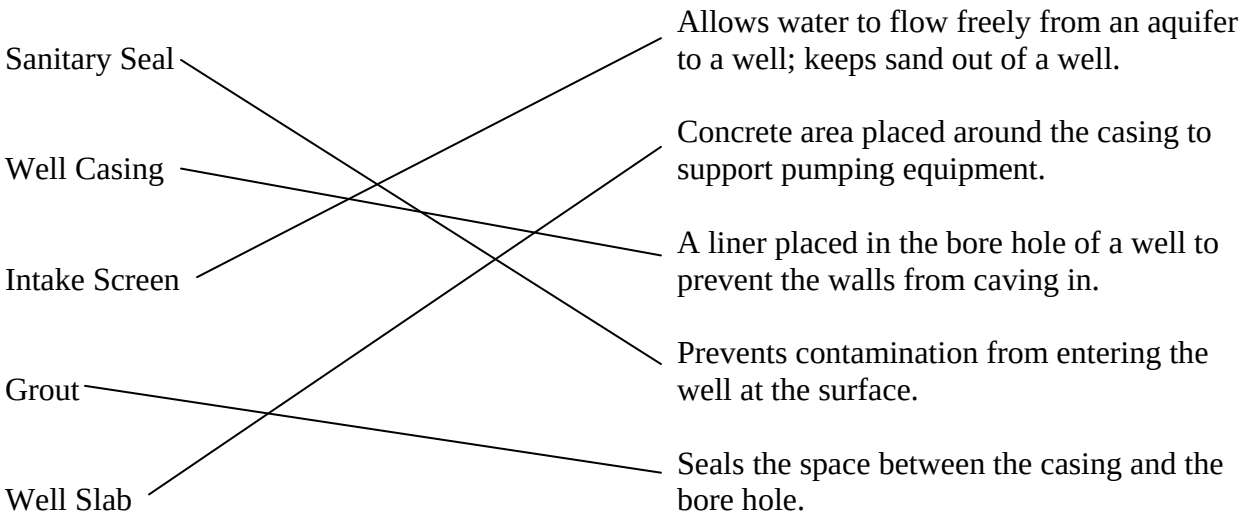
8. An impoundment stores water for use during water deficiencies.

Answers to Water Supply Vocabulary:

1. D
2. H
3. L
4. C
5. K
6. M
7. G
8. A
9. E
10. I
11. J
12. B
13. N
14. F

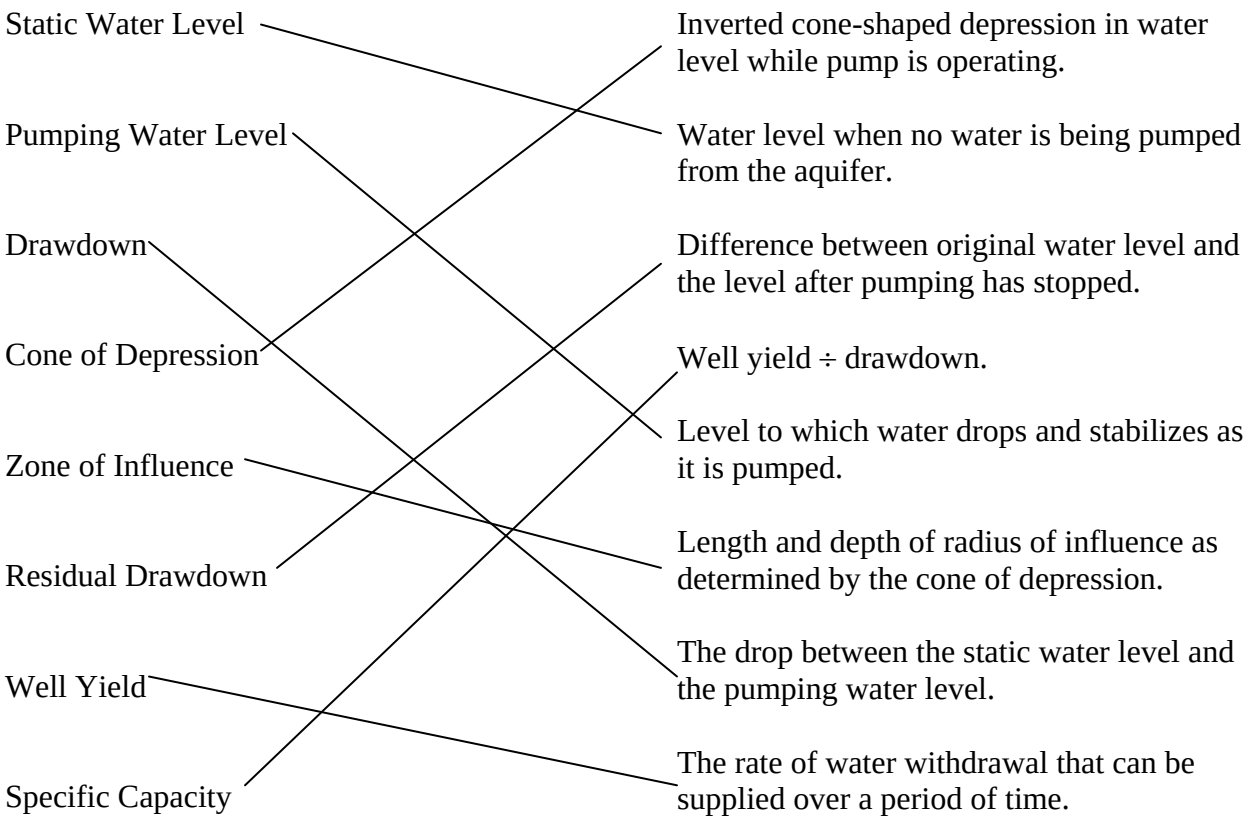
Parts of a Well – Matching

Draw a line from the term to its definition:



Well Terms – Matching

Draw a line from the term to its definition:



RESERVOIRS AND INTAKES

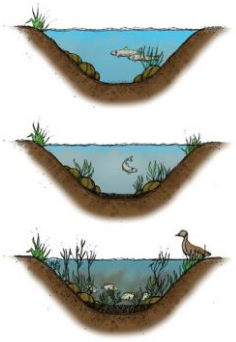
CSUS – Water Treatment Plant Operation Vol. I

FACTORS AFFECTING WATER QUALITY

- Climate
  - Temperature, intensity and direction of wind movements, type, pattern, intensity, and duration of precipitation
- Watershed and Drainage Areas
  - Geology, topography, type and extent of vegetation, and use by native animals
- Wildfires
  - Caused by lightning
- Reservoir Area
  - Geology, land form including depth, area, and bottom topography, and surface vegetation at the time the reservoir is filled

CAUSES OF WATER QUALITY PROBLEMS

- Nutrients
  - Act as a fertilizer
    - Phosphate
    - Nitrate
    - Organic nitrogen compounds
  - Lake will become eutrophic – rich in nutrients and plant life



CAUSES OF WATER QUALITY PROBLEMS

- Algal Blooms
  - Eutrophic lakes support large populations of phytoplankton (very small plants) and zooplankton (very small animals)
  - A sudden large increase in phytoplankton is called an algal bloom
    - Can last from a few days to several weeks or months
  - Problems:
    - Taste and odor problems
    - Shortened filter runs of traditional treatment plants
    - Increased pH
      - Reduction in chlorine efficiency
    - Dissolved oxygen depletion
    - Organic Loading

CAUSES OF WATER QUALITY PROBLEMS

- Tastes and Odors
  - Often related to occurrence of algal blooms
  - Common taste and odors caused
    - Fishy
    - Aromatic
    - Grassy
    - Septic
    - Musty
    - Earthy
  - Odors most noticeable when hot water is in use
  - Geosmin and MIB (methyl-isoborneol) can be detected at just a few parts per trillion (ppt)

CAUSES OF WATER QUALITY PROBLEMS

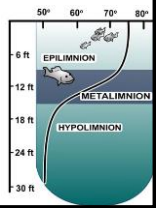
- Shortened Filter Runs
  - Clogged filters caused by diatoms and plankton in large numbers
- Increased pH
  - pH will increase during daylight
    - Photosynthesis decreases carbon dioxide in water, increasing the pH
  - pH will decrease during dark
    - Respiration increases carbon dioxide, lowering the pH

CAUSES OF WATER QUALITY PROBLEMS

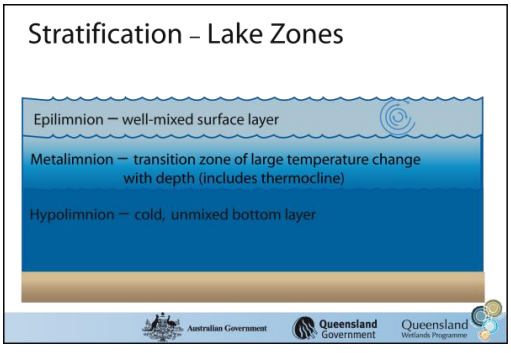
- Dissolved Oxygen Depletion
  - Algal blooms increase the amount of DO as a result of photosynthesis
  - When algal cells die, bacteria decomposing the cells consume the dissolved oxygen
    - Can result in a fish kill
- Organic Loading
  - Result in color and chlorine demand increase
  - Increase disinfection by-product (DBP) precursors

CAUSES OF WATER QUALITY PROBLEMS

- Thermal Stratification
  - Layers of different temperature water within a lake or reservoir
  - Different temperatures result in different densities
    - Decrease in density of warmer water on top slows the vertical mixing action and forms a barrier between the upper and lower levels
  - Epilimnion – upper, warmer layer
  - Metalimnion – middle transition layer
    - Aka thermocline
  - Hypolimnion – bottom, colder layer
    - Anaerobic environment
  - As temperatures drop, the lake will destratify or "turnover"



Stratification – Lake Zones



CAUSES OF WATER QUALITY PROBLEMS

- Anaerobic conditions
  - Problems caused by reduction – removal of oxygen or sulfur when oxygen is absent
  - Noted by the presence of a rotten egg odor
  - Iron and manganese in bottom sediments pass into solution
    - Iron is changed from the oxidized ferric state into the soluble ferrous state
    - Manganese is changed from the oxidized maganic state into the soluble manganous state

RESERVOIR MANAGEMENT

WATERSHED MANAGEMENT

- Primary purpose should be to control, minimize or eliminate any practices within the watershed area that are harmful to water quality within the domestic water supply reservoir
- Wastewater
  - Nutrient loading of the lake
  - Microbial contamination
  - Major source is septic systems
    - Two dependable solutions:
      - Replace all septic systems with sewer
      - Adopt ordinances that regulate the design and installation of septic systems

WATERSHED MANAGEMENT

- Fertilization
  - Results in large amounts of nitrogen in water
  - Cause eutrophication and algal blooms
  - Best solution is public education
- Soil Grading and Farming Practices
  - Contributes to turbidity of surface water
  - Can be controlled through regulations and ordinances
    - Limit the time of year of soil disturbance
    - Limit amount of time soil is left exposed

WATERSHED MANAGEMENT

- Livestock Grazing
  - Increase erosion, turbidity and eutrophication
- Wildfires
  - Large amounts of debris, nutrients, silt and other pollutants
  - Fire prevention and control programs are a must
- Highway Stormwater Runoff
  - Toxic metals, nutrients, bacteriological constituents, oil and grease, floating materials, trash and litter, pesticides, herbicides, and deicing salts

ALGAE CONTROL BY CHEMICAL METHODS

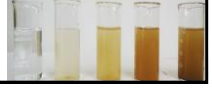
- Purpose of Chemical Methods
  - To prevent or control taste and odor problems resulting from algal blooms
  - To reduce the overall biological productivity
  - To maintain acceptable aesthetic conditions in the lake or reservoir

ALGAE CONTROL BY CHEMICAL METHODS

- Chemicals Available
  - Copper sulfate pentahydrate ($CuSO_4 \bullet 5\ H_2O$)
    - Aka bluestone
    - Primary algicide
    - Toxic to many species of algae but does not present health hazard to workers or consumers
    - Can be a hazard to trout
    - Must monitor copper levels in distribution system
  - Chlorine
    - Used as a bactericide or oxidizing agent, may also produce the effects of an algicide
    - High chance of producing DBPs

ALGAE CONTROL BY CHEMICAL METHODS

- Chemical Doses
  - Three major water quality indicators affect the effectiveness of copper sulfate
    - Alkalinity
      - If methyl orange alkalinity < 50, dose 0.9 lb/ac-ft
      - If methyl orange alkalinity > 50, dose 5.4 lb/acre
    - Suspended Matter
      - Can reduce effectiveness by adsorbing copper sulfate
    - Temperature
      - Higher dosage feed rates required below 50°F (10°C)



ALGAE CONTROL BY CHEMICAL METHODS

- Chemical Doses
  - pH
    - The lower the pH, the more effective the copper sulfate
      - More copper ions are present making it more effective
    - The higher the pH, the less effective the copper sulfate
      - Copper more likely to precipitate out leaving none available as an algicide
  - EPA's Lead and Copper Rule limit the concentration allowed for dosing of the water
    - Copper action level = 1.3 mg/L

ALGAE CONTROL BY CHEMICAL METHODS

- Methods of Chemical Application
  - Drag burlap bags containing the copper material through the water using a boat
    - Simplest method
    - Very small lakes and reservoirs
  - Dump dry copper sulfate crystals into hopper mounted on a boat and fed into a broadcaster
  - Mix copper sulfate into solution and spray it onto the reservoir surface
    - Most efficient and safest method
    - Mount pipe with holes behind a boat

EXAMPLE 1

- A small storage reservoir has a surface area of 5 acres and contains 80 acre feet of water. How many pounds of copper sulfate pentahydrate are needed for a 0.5 mg/L dose of copper? Copper sulfate pentahydrate contains 25% copper. Assume the alkalinity is 40 mg/L.

Known	**Unknown**
Area = 5 Acres	Copper Sulfate, lbs = ?
Volume = 80 ac-ft	
Dose = 0.5 mg/L	
Purity = 25%	
Alkalinity = 40 mg/L	

$$feed\ rate, \frac{lbs}{day} = \frac{(dose, \frac{mg}{L})(capacity, MGD)(8.34 \frac{lb}{ga})}{\%\ purity}$$

Known
Area = 5 Acres
Volume = 80 ac-ft
Dose = 0.5 mg/L
Purity = 25%
Alkalinity = 40 mg/L

Unknown
Copper Sulfate, lbs = ?

$$\frac{lbs}{day} = \frac{(^{mg}/_{L})(MGD)(8.34\ ^{lb}/_{gal})}{\%\ purity}$$

$$\left(\frac{80\ ac-ft}{1}\right)\left(\frac{326{,}000\ gal}{1\ ac-ft}\right)\left(\frac{1\ MG}{1{,}000{,}000\ gal}\right) = 26.08\ MG$$

$$lbs = \frac{(0.5\ ^{mg}/_{L})(26.08\ MG)(8.34\ ^{lb}/_{gal})}{0.25}$$

$$lbs = 435\ lbs$$

ALGAE CONTROL BY CHEMICAL METHODS

- Monitoring
  - Historical data can show when an algal bloom may occur
  - Monitoring should be carried out before, during and after the use of chemicals
- Recordkeeping
  - Important part of algae control program
  - Used to evaluate current and historical treatment programs
    - Designing new or revising existing programs
    - Showing compliance with regulations

ALGAE CONTROL BY CHEMICAL METHODS

- Safety
  - Follow proper procedures for handling and chemical application
    - Wear special PPE for dust
  - Follow water safety procedures

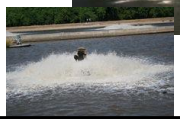
REAERATION AND DESTRATIFICATION

- Terminology
  - Aeration – The process of adding air to water
  - Reaeration – The introduction of air through forced air diffusers into the lower layers of the reservoirs
  - Destratification – the development of vertical mixing within a lake or reservoir to eliminate separate layers of temperature, plant or animal life
  - Reaeration-destratification – using air to destratify the reservoir

REAERATION AND DESTRATIFICATION

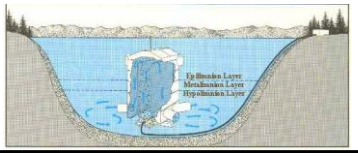
- Purposes of Reaeration-Destratification Programs
  - To eliminate, control, or minimize the negative effects on domestic water quality
  - To increase recreational values of the reservoirs
  - To reduce winter fish kills in water that becomes anaerobic during winter freezes





REAERATION AND DESTRATIFICATION

- Methods of Reaeration
  - Destratification
    - Alters or totally eliminates thermal stratification
  - Hypolimnetic reaeration
    - Adds dissolved oxygen directly to the hypolimnion without significantly altering the pattern of the thermal stratification

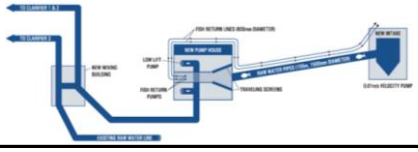


REAERATION AND DESTRATIFICATION

- Destratification
  - Accomplished by inducing vertical mixing within the reservoir
    - Mechanically by pumping hypolimnetic waters to the surface or by pumping surface waters downward
    - Through the use of diffused air
      - Diffusers release air near the bottom of the lake
      - As the bubbles rise, they carry the cold, denser water upward
      - The cold, dense water will eventually settle back to the bottom, creating vertical circulation
      - Disadvantage: deeper waters may become warmer than desired for domestic water and for certain species of fish

INTAKE STRUCTURES

- Purpose of Intake Structures
  - Used to deliver water to water treatment plants
  - Should be constructed on the basis of the specific function that they must serve at a give source
  - Must be capable of supplying the maximum rate or flow required for the water treatment plant
  - Should be constructed to prevent algal scums, trash, logs, and fish from entering the system

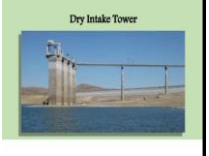


INTAKE STRUCTURES

- Types of Intake-Outlet Structures
  - Single-level intakes
    - Located in the deepest portion of the stream or reservoir so that water service can still be provided even when the body of water is down to its minimum operating level
    - Most suitable in relatively shallow lakes that do not stratify significantly and have fairly uniform water from top to bottom

INTAKE STRUCTURES

- Types of Intake-Outlet Structures
  - Multilevel intakes
    - Found in vertical towers located in deeper portions of the lake and extending above the water surface
    - Each inlet is equipped with an individually operated gate or valve at the point of inlet
    - Some intakes are inclined rather than vertical
      - Commonly located on inclined face of a dam



INTAKE STRUCTURES

- Types of Intake-Outlet Structures
  - Single-level intakes
    - Advantages
      - Less complicated so less costly to construct on multilevel structures
      - Easier and less costly to operate and maintain
    - Disadvantages
      - Major water quality issues due to be located in the hypolimnion
        - Water may be anaerobic, have high levels of Fe & Mn, or contain hydrogen sulfide
  - Multilevel intakes
    - Advantage: they make it possible to serve water from the depth where the best water quality is located

INTAKE STRUCTURES

- Types of Intake Gates
  - Most common are slide gates, gate valves, and butterfly valves
- Intake Screens and Trash Racks
  - Type depends on several factors
    - Depth(s) at which the inlets are located
    - Location of the intake structure in relation to where debris accumulates in the reservoir or stream
    - Frequency and intensity of algal scum or algal mass accumulations
    - Quantity and type of debris encountered
    - Size, depth, distribution, and number of fish, crayfish, and other forms of aquatic life

INTAKE STRUCTURES

- Operation and Maintenance Procedures
  - Major causes of faulty operation of gates and valves
    - Settlement or shifting of support structure, which could cause binding of gates
    - Worn, corroded, loose, or broken parts
    - Lack of use
    - Lack of lubrication
    - Vibration
    - Improper operating procedures
    - Design errors or deficiencies
    - Failure of power source or circuit failure
    - Vandalism
  - To adjust the tension on a travelling screen, turn the capstan

Vocabulary

A. Adsorption
B. Aeration
C. Aerobic
D. Anaerobic
E. Coliform
F. Colloids
G. Conductivity
H. Decomposition
I. Destratification
J. Diatoms
K. Electrolyte
L. Epilimnion
M. Eutrophic
N. Eutrophication
O. Evapotranspiration
P. Hypolimnion
Q. Inorganic
R. Metalimnion
S. Organic
T. Overturn
U. Oxidation
V. Potable
W. Precipitate
X. Reduction
Y. Septic
Z. Stratification
AA. Threshold Odor Number

_____ 1. The conversion of chemically unstable materials to more stable forms by chemical or biological action.

_____ 2. The upper layer of water in a thermally stratified lake or reservoir.

_____ 3. The gathering of a gas, liquid, or dissolved substance on the surface or interface zone of another material.

_____ 4. An insoluble, finely divided substance which is a product of a chemical reaction within a liquid.

_____ 5. Substances that comes from animal or plant sources and always contain carbon.

_____ 6. The addition of oxygen, removal of hydrogen, or the removal of electrons from an element or compound.

_____ 7. The increase in the nutrient levels of a lake or other body of water.

_____ 8. A measure of the ability of a solution (water) to carry an electric current.

_____ 9. The middle layer in a thermally stratified lake or reservoir.

_____ 10. The addition of hydrogen, removal of oxygen, or addition of electrons to an element or compound.

_____ 11. The greatest dilution of a sample with odor-free water that still yields a just-detectable odor.

_____ 12. A condition in which atmospheric or dissolved molecular oxygen is present in the aquatic (water) environment.

_____ 13. The development of vertical mixing within a lake or reservoir to eliminate separate layers of temperature, plant, or animal life.

_____ 14. A condition in which atmospheric or dissolved molecular oxygen is NOT present in the aquatic (water) environment.

_____ 15. A substance which dissolves (separates) into two or more ions when it is dissolved in water .

_____ 16. Material such as sand, salt, iron, calcium salts and other minerals materials.

_____ 17. The formation of separate layers (of temperature, plant, or animal life) in a lake or reservoir.

_____ 18. Water that does not contain objectionable pollution, contamination, minerals, or infective agents and is considered satisfactory for drinking.

_____ 19. A group of bacteria found in the intestines of warm-blooded animals and also in plants, soil, air and water. Their presence is an indication that the water is polluted and may contain pathogenic (disease causing) organisms.

_____ 20. The process of adding air to water. Air can be added to water by either passing air through water or passing water through air.

_____ 21. The process by which water vapor passes into the atmosphere from living plants.

_____ 22. Very small, finely divided solids that remain dispersed in a liquid for a long time due to their small size and electrical charge.

_____ 23. Reservoirs and lakes which are rich in nutrients and very productive in terms of aquatic animal and plant life.

_____ 24. The most spontaneous mixing of all layers of water in a reservoir or lake when the water temperature becomes similar from top to bottom.

_____ 25. A condition produced by bacteria when all oxygen supplies are depleted.

_____ 26. The lowest layer in a thermally stratified late or reservoir.

_____ 27. Unicellular (single cell), microscopic algae with a rigid internal structure consisting mainly of silica.

1. H
2. L
3. A
4. W
5. S
6. U
7. N
8. G
9. R
10. X
11. AA
12. C
13. I
14. D
15. K
16. Q
17. Z
18. V
19. E
20. B
21. O
22. F
23. M
24. T
25. Y
26. P
27. J

Reservoirs and Intakes

Review Questions

1. Large quantities of what nutrients are undesirable in a water supply reservoir?

2. What is an “algal bloom”?

3. What types of tastes and odors are produced by algae?

4. What problems do algae cause on filters?

5. What is the influence of algal blooms on pH?

6. What is the influence of algal blooms on dissolved oxygen?

7. Increased organic loadings from algal blooms can cause what kind of water quality problems?

8. When a lake warms in the spring or summer, how does the decrease in density of the warmer surface water influence mixing action within the lake?

9. What problems are caused by anaerobic conditions in reservoirs?

10. What should be the primary purpose of a watershed management program?

11. What problems can be caused in reservoirs from raw wastewater contamination?

12. How can the adverse impacts of soil disturbances from farming, logging, and construction be minimized?

13. What problems can be created as a result of a wildfire?

14. Why are chemicals used in domestic water supply reservoirs to prevent or control attached and floating aquatic growths?

15. What chemical other than copper sulfate may be used as an algicide?

16. How does suspended particulate matter in a reservoir reduce the effectiveness of copper as and algicide?

17. What is the major factor limiting the maximum rate of application of copper sulfate in the sources of a domestic water supply?

18. What safety precautions should be taken by a person applying copper sulfate in the dry form?

19. What is the primary purpose of reaeration-destratification programs in domestic water supply reservoirs?

20. What are the most common types of intake gates?

21. List the factors that influence the type of screen needed in a specific reservoir.

Reservoirs and Intakes
Review Questions Answers

1. Phosphate, nitrate, and organic nitrogen compounds

2. Very large increase in plankton (algae) population over a very short period of time

3. fishy, aromatic, grassy, septic, musty, and earthy

4. clog filters reducing filter rates and run times

5. fluctuations in pH from day to night

6. increases DO during the bloom; decreases DO when algae dies

7. decreased oxygen levels, increase color and chlorine demand; increase DBP precursors

8. The decrease in density of the warmer water reduces the mixing action within the lake and a barrier is formed between the upper and lower layers

9. Causes the release of hydrogen sulfide and cause iron and manganese in bottom sediments to go into solution into the water

10. To control, minimize, or eliminate practices within the watershed of a domestic water supply reservoir that would lower water quality

11. Nutrient loading and microbial contamination

12. Ordinances that limit such activities to those times of the year when the danger of erosion from surface runoff is at a minimum

13. During the runoff period, large quantities of debris, nutrients, silt, and other pollutants may enter a water supply reservoir

14. to prevent or control taste and odor problems resulting from algal blooms

15. chlorine

16. reduces the effectiveness of copper as an algicide by providing sites or masses other than algal bodies where the copper is adsorbed

17. regulations limiting the concentration of copper in potable water

18. special clothing, gloves, and breathing apparatus, personal flotation advice

19. to eliminate, control, or minimize the negative effects on domestic water quality that occur during periods of thermal stratification and dissolved oxygen depletion

20. slide gates, gate valves, and butterfly valves

21. depth(s) at which the inlets are located, location of the intake structure in relation to where debris accumulates in the reservoir or stream, frequency and intensity of algal scum or algal mass accumulations, quantity and type of debris encountered, size, depth, distribution, and number of fish, crayfish, and other forms of aquatic life

COAGULATION AND FLOCCULATION

California State University: Sacramento
Volume I

Coagulation and Flocculation

- Nature of Particulate Impurities in Water
  - Surface water contains suspended and dissolved organic and inorganic material
  - Settleable solids – Larger sized particles that can be removed from water by slowing down the flow to allow for gravity settling
  - Nonsettleable solids – smaller sized particles that do not readily settle
    - Treatment is required to produce larger particles that are settleable
    - AKA Colloidal matter
      - Has a net negative charge

3

- Natural Forces Between Particles
  - Zeta potential
    - repelling force between any two particles of like charge
  - Van der Waals force
    - attraction between particles pulling them together
  - Particles will stay in suspension of zeta potential is greater than the van der Waals force

Coagulation and Flocculation

- Need for Coagulation and Flocculation
  - To remove particulate impurities, particularly nonsettleable solids and colors
  - Chemicals are added that will cause the particles to clump together in the coagulation process
  - The particles to gather together to form larger particles in the flocculation process

5

Coagulation and Flocculation

- Coagulation
  - reduces the zeta potential so that van der Waals force can pull particles together to form *microfloc*
- Flocculation
  - brings the microfloc particles together to form larger particles called *macrofloc*

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Coagulation

- Process Description
  - Coagulation describes the effect produced when certain chemicals are added to raw water
  - Flash mixing
    - The mixing of the coagulant chemical and raw water
    - Equally distributes the chemical through the water
    - Chemical process occurs very quickly (in 2-5 seconds)
    - Forms very small particles (microfloc)
  - Detention time is **less than 30 seconds**

Coagulants

- Polymers are commonly used as coagulation chemicals
  - Primary coagulants neutralize the electrical charges of the particles, which causes them to being to clump together
  - Coagulant aids add density to slow settling floc and toughness to minimize the floc breaking up
  - Metallic salts – alum, ferric sulfate, ferrous sulfate
  - Synthetic organic polymers – cationic, anionic, nonionic

Coagulants

- Metallic salts react with other ions in the water
  - Chemical quantities must be sufficient to exceed the solubility limit of the metal hydroxide
    - This will result in the formation of floc
    - The floc will adsorb onto the turbidity in the water
- Polyelectrolytes are polymers that contain ionizable groups
  - Cationic polyelectrolytes – polymers with positive charge
  - Anionic polyelectrolytes – polymers with negative charge
  - Nonionic polyelectrolytes – polymers without a charge

Coagulants

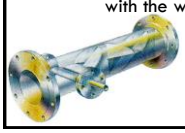
- Considerations when choosing a coagulant
  - Polymer overdosing will adversely affect coagulation efficiency
  - Not all water supplies can be treated with equal success
  - Some polymers lose their effectiveness when used in the presence of a chlorine residual
  - Some polymers are dosage limited

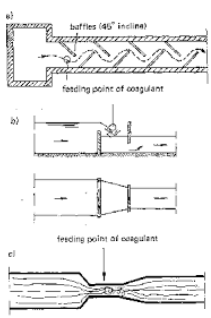
Basic Coagulant Chemistry

- Coagulation is a physical and chemical reaction
- Best pH range is 5 to 7 s.u.
- Coagulants react with the alkalinity in the water and serves as a buffer to prevent pH from changing
  - If alkalinity in source water is too low, complete precipitation of coagulant may not occur
  - Alkalinity can be increased by addition of lime or soda ash

Process Performance Considerations

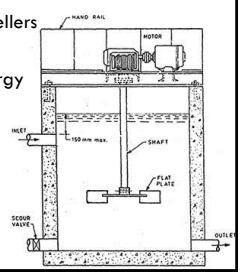
- Methods of Mixing
  - Hydraulic mixing using flow energy in the systems
    - With baffles or throttling valves if sufficient velocity to cause turbulence
    - Turbulence mixes chemicals with the water





Process Performance Considerations

- Methods of Mixing
  - Mechanical mixing
    - Paddles, turbines, and propellers
    - Versatile and reliable
    - Use greatest amount of energy

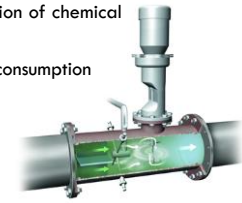


Process Performance Considerations

- Methods of Mixing
  - Diffusers and grid systems
    - Perforated tubes or nozzles
    - Equally distribute flow over entire basin
    - Sensitive to flow changes
    - Require frequent adjustments

Process Performance Considerations

- Methods of Mixing
  - Pumped blenders
    - Coagulant added directly to the water being treated through a diffuser in a pipe
    - Can provide rapid dispersion of chemical
    - No significant head loss
    - Considerably low energy consumption



Process Performance Considerations

- Coagulation Basins
  - Accomplished in a special rectangular tank with mixing devices
  - Can occur in the influent channel or pipeline
  - Shape of basin is part of system design

Flocculation

- Process Description
  - Slow stirring process that causes the gathering together of small, coagulated particles into larger, settleable particles
- Floc Formation
  - Controlled by rate at which collisions occur between particles
  - Purpose is to create a floc of good size, density, and toughness
  - Best floc size rages from 0.1 mm to 3 mm

Flocculation

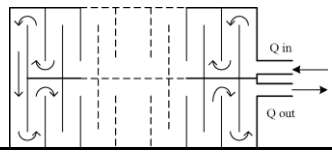
- Process Performance Consideration
  - Insufficient mixing will result in ineffective collisions and poor floc formation.
  - Excessive mixing may tear apart or shear the floc that has been formed
- Detention Time
  - Required for the necessary chemical reactions to take place
  - Minimum 30 minutes with 45 minutes recommended

Flocculation

- Types of Flocculators
  - Paddle wheel flocculators
    - Horizontal
      - Submerged mechanics
    - Vertical
      - Requires less maintenance
      - Propeller, paddle, or turbine types

Flocculation

- Types of Flocculators
  - Turbulence resulting from the roughness in conduits or channels
    - Limited use due to very localized distribution of turbulence, inadequate detention time, and widely variable turbulence



Flocculation

- Flocculation Basins
  - Rectangular for horizontal flocculators
  - Nearly square for vertical flocculators
  - Compartmentalized basis achieve best flocculation
    - Separated by baffles
    - Prevents short circuiting
  - Solids-contact basins (upflow clarifiers)
    - Combines coagulation, flocculation and sedimentation process into a single basin

Interaction with Other Treatment Processes

- The effectiveness of the sedimentation and filtration processes depends upon successful coagulation-flocculation
- Disinfection can be affected by poor coagulation-flocculation performance
- Effective coagulation-flocculation promotes the removal of natural organic matter

Process Control

- Most important consideration is selection of the proper type and amount of coagulant chemical
- Determined by jar testing

Coagulation & Flocculation

Process Actions

- Monitor process performance
- Evaluate water quality conditions (raw and treated)
  - Visual observations and routine laboratory tests
    - Turbidity, alkalinity, pH, color, temperature, chlorine demand
- Check and adjust process controls and equipment
- Visually inspect facilities
  - Observation of turbulence of water in flash mix
  - Observation of size & distribution of floc in floc basins
    - Uneven distribution could mean short-circuiting

Formulas

- Detention Time

$$DT = \frac{Volume}{Flow}$$

  - Units must be compatible

Example

- A water treatment plant treats a flow of 2.4 MGD. The flash-mix chamber is 2.5 feet square and the depth of the water is 3 feet. Calculate the detention time in seconds.

Known	Unknown
Flow = 2.4 MGD	DT = seconds
Length = 2.5 ft	
Width = 2.5 ft	
Depth = 3 ft	

$$DT = \frac{Volume}{Flow}$$

Example

Known	Unknown
Flow = 2.4 MGD	DT = seconds
Length = 2.5 ft	
Width = 2.5 ft	
Depth = 3 ft	

$$DT = \frac{Volume}{Flow}$$

$$Volume = (L)(W)(d)(7.48\frac{gal}{ft^3})$$

$$Volume = (2.5\ ft)(2.5\ ft)(3\ ft)(7.48)$$

$$Volume = 140.25\ gal$$

$$DT = \frac{140.25\ gal}{2{,}400{,}000\ gpd}$$

$$DT = 0.0000584\ days$$

$$sec = \left(\frac{0.0000584\ days}{1}\right)\left(\frac{24\ hr}{1\ day}\right)\left(\frac{60\ min}{1\ hr}\right)\left(\frac{60\ sec}{1\ min}\right)$$

$$sec = 5.0\ sec$$

Preparation of Chemical Solutions

- Concentration depends on type of polymer and the polymer's molecular weight
  - The higher molecular weight, the more difficult it is to mix the polymer into solution
    - Solution becomes very viscous (thick)
  - Anionic and nonionic dry polymers often prepared as very weak solutions (0.25%-1%)
  - Cationic dry polymers have small molecular weights so they can be prepared at high solutions (5%-10%)

Recordkeeping

- Source of water quality
  - pH, turbidity, temperature, alkalinity, chlorine demand, and color
- Process water quality
  - pH, turbidity, and alkalinity
- Process production inventories
  - Chemicals used, chemical feed rates, amount of water processed, and amount of chemicals in storage
- Process equipment performance
  - Types of equipment in operation, maintenance procedures performed, equipment calibration and adjustments
- Entries should include date, time, and operator initials

Abnormal Conditions

- Changes in source water turbidity
  - Verify the effectiveness of coagulant and dosage
  - Best accomplished by running a jar test
- Visual observations of flash-mixing intensity as well as the condition of the floc in the floc basins
  - Adjust mixer speed or coagulant dose

Abnormal Conditions

- Alkalinity, pH, and temperature changes impact floc formation
  - Temperature change may require adjustment of mixing intensity
- Sudden increases in filtered water turbidity
  - Due to poor coagulation-flocculation performance
  - Add filter-aid, such as nonionic polymer
  - Run jar tests to see how to best adjust the process

Troubleshooting

Source Water Quality Changes	Operator Actions	Possible Process Changes
• Turbidity • Temperature • Alkalinity • pH • Color	• Perform necessary analyses to determine extent of change • Evaluate overall process performance • Perform jar tests if indicated • Make appropriate process changes • Increase frequency of process monitoring • Verify response to process changes at appropriate time	• Change coagulant(s) • Adjust coagulant dosage • Adjust flash-mixer/flocculator mixing intensity • Adjust coagulant aid or filter aid • Adjust alkalinity or pH

Troubleshooting

Source Water Quality Changes	Operator Actions	Possible Process Changes

• Turbidity
• Alkalinity
• pH
	• Evaluate source water quality
	• Perform jar tests if indicated
	• Verify process performance:
	  • Coagulant feed rate
	  • Flash-mixer operation
	• Make appropriate process changes
	• Verify response to process changes at appropriate time
		• Change coagulant(s)
		• Adjust coagulant dosage
		• Adjust flash-mixer intensity
		• Adjust alkalinity or pH

Troubleshooting

Source Water Quality Changes	Operator Actions	Possible Process Changes

• Floc formation	• Observe floc condition in basin:
	  • Dispersion
	  • Size
	  • Floc strength (breakup)
	• Evaluate overall process performance
	• Perform jar tests if indicated:
	  • Evaluate floc size, settling rate, and strength
	  • Evaluate quality of supernatant: clarity (turbidity), pH, and color
	• Make appropriate process changes
	• Verify response to process changes at appropriate time
		• Change coagulant(s)
		• Adjust coagulant dosage
		• Adjust flash-mixer/flocculator mixing intensity
		• Adjust coagulant aid
		• Adjust alkalinity or pH

Enhanced Coagulation

- Process designed to remove NOM from water by adjusting both the coagulant dose and the pH
  - Adjust pH by adding acid or alkali
  - Differs from "sweep" method where pH range is achieved by overdosing the coagulant
- Natural organic matter comprised of organic acids called humic substances
  - Composed of humic and fulvic acids

Enhanced Coagulation

- Chemical Reactions
  - Fulvic and humic substances in water are negatively charged
  - Negative charge is neutralized and destabilized by positively charged coagulants
  - Destabilized particles come together and form larger floc particles that can be settled out
  - Chemistry that deals with this particular coagulation process is known as charge chemistry

Enhanced Coagulation

- Chemical Reactions
  - pH range for color removal with aluminum sulfate is 5.5 – 7.0
    - Optimum pH is 5.8
  - pH range for color removal with ferric sulfate is 4.0 – 6.2
    - Optimum pH is 4.5
  - At the lower (optimum) pH, four effects take place that enhance coagulation
    - Humic and fulvic molecules dissociate
    - Coagulant demand decreases
    - Flocculation is improved at lower pH
    - Sulfuric acid addition preconditions the organic compounds

Enhanced Coagulation

- Process Control
  - Color results from presence of minerals, inorganic chemicals, metals, decomposition of organic matter from soils, aquatic organisms, and vegetation
  - True color – color of the water from which turbidity has been removed (filtered)
  - Apparent color – color of the water that includes the color and the suspended matter
  - Measured in color units
  - Color is reported in whole numbers from 1 to 500
  - Sample pH is always reported with color units
    - Color determinations will increase as the pH of the water increases

Enhanced Coagulation

- Process Control
  - pH optimization necessary for coagulation
    - Automated pH is a must
    - pH backfeed process control loop required
    - Must have pH monitoring meter located after flash mix and feed valve controllers for acid and alkalinity chemical addition

Enhanced Coagulation - Troubleshooting

Treatment Condition Flocculator Effluent	Corrective Action
High coagulation pH with optimum color removal	1. Increase acid feed 2. Decrease alkalinity adjustment in raw water source
High coagulation pH without optimum color removal	1. Increase coagulant 2. Decrease acid feed to maintain optimum pH
Low coagulation pH with optimum color removal	1. Decrease acid feed 2. Increase alkalinity adjustment in raw water source
Low coagulation without optimum pH color removal	1. Decrease acid if below optimal pH zone 2. Increase coagulant and alkalinity
Loss of acid feed	1. Increase coagulant to achieve optimal pH

Enhanced Coagulation - Troubleshooting

Treatment Condition Flocculator Effluent	Corrective Action
Optimal pH without optimized color removal	1. Increase coagulant, decrease acid, or increase alkalinity
Optimal pH and color removal with floc carryover	1. Decrease coagulant 2. Increase polymer 3. Increase removal of settled floc 4. Decrease flow-through velocities
High turbidities and coagulant residuals in settled water	1. Check for floc carryover 2. Adjust polymer feed to enhance settling 3. Jar test to determine optimum acid and coagulant dosage

Laboratory Tests

- Process Control Water Quality Indicators
  - Turbidity, alkalinity, chlorine demand, color, pH, temperature, odor, and appearance
- Sampling Procedures
  - Either grab samples or continuous sampling
  - Process samples must be representative
    - Water that is nearly as identical in content and consistency as possible to that in the larger body of water being sampled

Process and Support Equipment Operation and Maintenance

- Types of Equipment
  - Liquid (solution) feeders
    - A diluted solution of known concentration is fed directly into water being treated
    - Fed through metering pumps and rotameters
  - Dry feeders
    - Deliver a measured quantity of dry chemical during a specified time
    - Volumetric feeders – deliver a specific volume of chemical during a given time
    - Gravimetric feeders – delivers a predetermined weight of chemical in a specific unit of time
      - More accurate

Process and Support Equipment Operation and Maintenance

- Equipment Operation
  - Before starting equipment, be sure unit is properly lubricated and its operational status is known
  - After start up, always check for excessive noise and vibration, overheating, and leakage

Process and Support Equipment Operation and Maintenance

- Preventive Maintenance Procedure
  - Keep motors free of dirt and moisture
  - Ensuring good ventilation in equipment work areas
  - Checking pumps for leaks, unusual noise, vibrations, or overheating
  - Maintaining proper lubrication and oil levels
  - Inspecting for alignment of shafts and couplings
  - Checking bearings for wear, overheating, and proper lubrication
  - Exercising infrequently used valves on a regular schedule and checking all valves for proper operation
  - Calibrating flowmeters and chemical feeders

Coagulation and Flocculation

Vocabulary

A. Alkalinity
B. Anionic Polymer
C. Apparent Color
D. Cationic Polymer
E. Coagulants
F. Coagulation
G. Colloids
H. Composite Sample
I. Disinfection By-product
J. Floc
K. Flocculation
L. Grab Sample
M. Jar Test
N. Natural Organic Matter (NOM)
O. Nonionic Polymer
P. Particulate
Q. Polymer
R. Precipitate
S. Representative Sample
T. Total Organic Carbon
U. Trihalomethanes
V. True Color
W. Turbidimeter
X. Turbidity

_____ 1. An insoluble, finely divided substance which is a product of a chemical reaction within a liquid.

_____ 2. A single sample of water collected at a particular time and place which represents the composition of the water only at the time and place.

_____ 3. An instrument for measuring and comparing the turbidity of liquids passing light through them and determining how much light is reflected by the particles in the liquid.

_____ 4. A polymer having positively charged groups of ions. Often used as a coagulant aid.

_____ 5. A polymer having negatively charged groups of ions.

_____ 6. A sample portion of material or water that is a nearly identical in content and consistence as possible to that in the larger body of material or water being sampled.

_____ 7. Very small, finely divided solids (particles that do not dissolve) that remain dispersed in a liquid for a long time due to their small size and electrical charge.

_____ 8. A laboratory procedure that simulates a water treatment plant's coagulation/flocculation units with differing chemical doses and also energy of rapid mix, energy of slow mix, and settling time.

_____ 9. Color of the water that includes not only the color due to substances in the water but suspended matter as well.

_____ 10. Derivatives of methane often formed during chlorination by reactions with natural organic materials in the water.

_____ 11. The clumping together of very fine particles into larger particles (floc) caused by the use of chemicals (coagulants).

_____ 12. A contaminant formed by the reaction of disinfection chemicals with other substances in the water being disinfected.

_____ 13. A polymer that has no net electrical charge.

_____ 14. Clumps of bacteria and particulate impurities that have come together and formed a cluster.

_____ 15. The cloudy appearance of water caused by the presence of suspended and colloidal matter.

_____ 16. A very small solid suspended in water which can vary widely in size, shape, density, and electrical charge.

_____ 17. Chemicals that cause very fine particles to clump (floc) together into larger particles.

_____ 18. Humic substances composed of humic and fulvic acids that come from decayed vegetation.

_____ 19. The gathering together of fine particles after coagulation to form larger particles by a process of gentle mixing

_____ 20. Color of the water from which turbidity has been removed.

_____ 21. A collection of individual samples obtained at regular intervals.

_____ 22. The capacity of water to neutralize acids or resist a change in pH.

_____ 23. A measure of the amount of organic carbon in water.

_____ 24. A long-chain molecule formed by the union of many monomers; used with coagulants to aid in binding small suspended particles to large chemical flocs.

Answers

1. R	4. D	7. G	10. U	13. O	16. P	19. K	22. A
2. L	5. B	8. M	11. F	14. J	17. E	20. V	23. T
3. W	6. S	9. C	12. I	15. X	18. N	21. H	24. Q

Coagulation and Flocculation
Review Questions

1. What is the purpose of coagulation and flocculation?

2. What happens in the coagulation and flocculation processes?

3. What is the primary purpose of flash mixing?

4. Why are both primary coagulants and coagulant aids used in the coagulation process?

5. List four methods of mixing coagulant chemicals into the plant flow.

6. What is a hydraulic mixing device?

7. What is flocculation?

8. How long is the typical mixing time in the coagulation process?

9. What is the recommended minimum detention time for flocculation?

10. What is an advantage of vertical flocculators over horizontal flocculators?

11. Why is coagulation-flocculation important to other treatment processes?

12. How is the effectiveness of the solids removal processes commonly monitored?

13. List the typical functions performed by an operator in the normal operation of the coagulation-flocculation process.

14. Which laboratory tests would you use to monitor the coagulation-flocculation process?

15. What would you look for when visually observing the performance of a coagulation-flocculation process?

16. What information should be recorded for all entries in a record book?

17. What kinds of sudden changes in either raw or filtered water quality are signals that you should immediately review the performance of the coagulation-flocculation process?

18. What is the relationship between pH and color in a water sample?

19. List the process control water quality indicators of importance in the operation of the coagulation-flocculation process.

20. How do chemical liquid feeders work in the coagulation process?

21. Selection of a chemical feeder for a given application depends on what factors?

Answers

1. To remove particulate impurities and color from the water being treated
2. Chemicals are added that will cause the particles to begin to clump together
3. To rapidly mix and uniformly distribute the coagulant chemical throughout the water
4. Primary coagulants are used to neutralize the electrical charge of the particles and cause the particles and cause the particles
5. Hydraulic mixing, mechanical mixing, diffusers and grid systems, pumped blenders

6. Hydraulic mixing devices rely on the turbulence created by flowing water to mix chemicals with the water
7. A slow stirring process that causes the gathering together of small, coagulated particles into larger, settleable floc particles
8. 2-5 seconds with 30 seconds as maximum detention time
9. 30 minutes minimum with 45 minutes recommended
10. Vertical flocculators usually require les maintenance since they eliminate submerged bearings and packings
11. It influences the effectiveness of the sedimentation, filtration, and disinfection processes. It causes bacteria and other disease-causing organisms to be bound up in suspended solids and floc.
12. By measuring the turbidity of filtered water
13. Monitor process performance, evaluate water quality conditions, check and adjust process controls and equipment, visually inspect facilities
14. Turbidity, alkalinity, temperature, color, pH, and chlorine demand
15. Observe the degree of agitation of the water in the flash mix and observe the size and distribution of floc in the flocculation basin
16. Date, time of an event, and initials of the operator making the entry
17. pH, alkalinity, temperature, or chlorine demand
18. Color determinations are always extremely pH dependent and will always increase as the pH of the water increases
19. Turbidity, temperature, alkalinity, chlorine demand, color, pH, odor and appearance
20. They feed a solution of known concentration directly into the water being treated
21. Type of chemical compound, availability of chemical, chemical form (dry or liquid), and the amount to be fed daily

Sedimentation

California State University: Sacramento

1

TDEC - Fleming Training Center

Process Definition

- To remove suspended solids that are denser than water and to reduce the load on the filters
- Suspended solids
  - Natural state
    - bacteria, clays or silts
  - Modified/preconditioned
    - to form floc
  - Precipitated impurities
    - hardness, iron precipitates formed by the addition of chemicals

2

Factors Affecting Sedimentation

- Particle size and distribution
  - larger particles will settle out faster
- Shape of particles
  - smoother circular particles will settle faster
- Density of particles
  - Denser particles settle out better
- Temperature of water
  - Decrease in temperature increases settling time required
- Electrical charge on particles
  - Colloidal particles are generally negatively charged

3

Factors Affecting Sedimentation

- Dissolved substances in water
- Flocculation characteristics of the suspended material
- Environmental conditions (e.g. wind effects)
- Sedimentation basin hydraulic and design characteristics (i.e. inlet conditions & basin shape)

4

Factors Affecting Sedimentation

- Sand and silt particles > 10 microns can be removed by sedimentation

Source	Diameter of Particle(microns)
Coarse turbidity	1 - 1,000
Algae	3 - 1,000
Silt	10
Bacteria	0.3 - 10
Fine turbidity	0.1 - 1
Viruses	0.02 - 0.26
Colloids	0.001 - 1

1 micron = 0.001 mm

5

Currents

- Types
  - Surface currents
    - caused by winds
  - Density currents
    - caused by differences in suspended solids concentrations and temperature differences
  - Eddy currents
    - produced by the flow of the water coming into and leaving the basin
- Can cause suspended particles to distribute unevenly
- Can be reduced with baffled inlets or basin covers

6

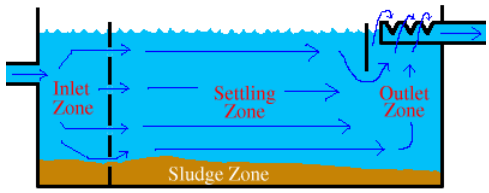
Detention Time

- 2 definitions
  - The actual time required for a small amount of water to pass through a sedimentation basin at a given rate of flow
  - The theoretical (calculated) time required for a small amount of water to pass through a basin at a given rate of flow
- Factors affecting detention time
  - Short circuiting
  - Effective exchange volume
    - Portion of basin through which the water flows
  - Other hydraulic conditions
    - Basin inlet and outlet design

7

Sedimentation Basins

- 4 zones
  - Inlet zone
  - Settling zone
  - Sludge zone
  - Outlet zone



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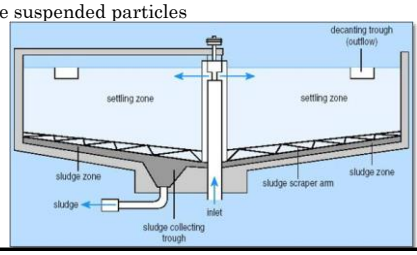
Inlet Zone

- Provides a smooth transition from flocculation basin
- Distributes flocculated water uniformly over the entire cross section of the basin
- If properly designed, it will decrease short circuiting
- Inlet baffle wall will
  - Minimize density currents due to temperature differences
  - Minimize wind currents
  - Minimize tendency of water to flow at the inlet velocity straight through the basin

9

Settling Zone

- Largest portion of basin
- Provides calm, undisturbed storage of the flocculated water to permit effective settling of the suspended particles



10

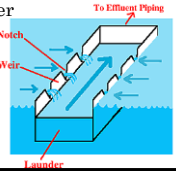
Sludge Zone

- Serves as a temporary storage place for the settled particles
- Located at the bottom of the sedimentation basin
- If sludge becomes too great
  - Decrease effective depth of the basin
  - Cause localized high flow velocities
  - Cause sludge scouring
  - Decrease in process efficiency
- Sludge removed by scraper or vacuum moving along bottom of basin
  - If removal devices do not cover full length of basin, it may have to be drained and flushed to remove the sludge

11

Outlet Zone

- Provides smooth transition from sedimentation basin to settled water conduit or channel
- Can control basin's water level
- Launders are used to uniformly collect settled/clarified water
- V-notch weirs are attached to launders to enable a uniform draw-off of basin water
- If water leaves sedimentation basin unevenly or at too high a velocity, floc can be carried over to the filters



12

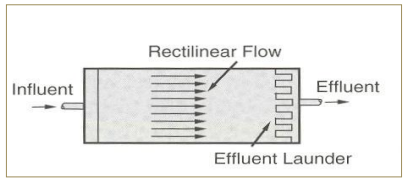
Basin Types

- Rectangular Basin
- Double-Deck Basin
- Circular and Square Basins
  - Referred to as clarifiers
- High Rate Settlers
- Solids Contact Units

13

Types of Sedimentation Basins

- Rectangular Basins
  - Flow is in one direction
    - parallel to the basin length
    - called *rectilinear flow*
  - High tolerance to changing water conditions



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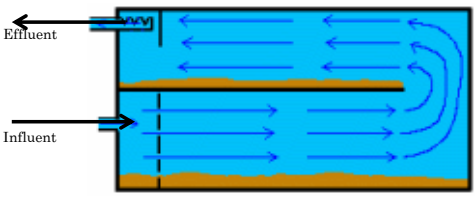
Types of Sedimentation Basins

- Double Deck Basin
  - Stack one rectangular basin on top of another
  - Doubles the effective sedimentation surface area



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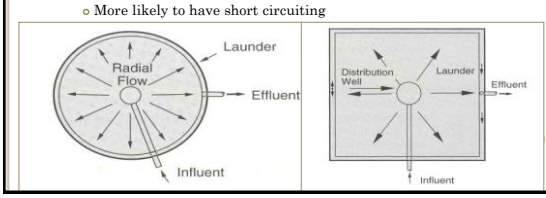
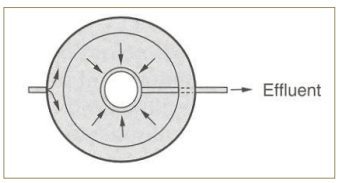
Types of Sedimentation Basins

- Circular and Square Basins (center feed)
  - Often called clarifiers
  - Water flows radially from center to outside
    - Must keep velocity and flow as even as possible
    - Bottom is conical and slopes downward for easier sludge removal
    - More likely to have short circuiting



Types of Sedimentation Basins

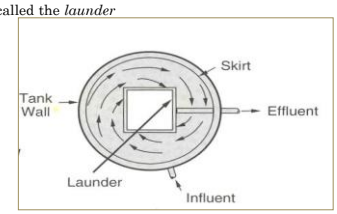
- Circular Basins (peripheral feed with radial flow)
  - Flow is from the outside edge (periphery) to the center of the basin
  - Design is similar to central feed, radial flow



17

Types of Sedimentation Basins

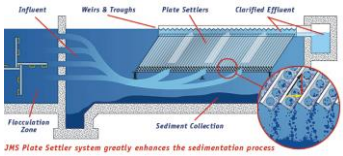
- Circular Basins (peripheral feed with spiral flow)
  - Water enters at outside edges
  - Flows in a circle around the basin
  - Leaves at the center collector
    - called the *launder*

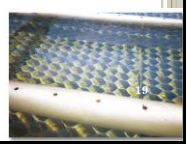


18

Types of Sedimentation Basins

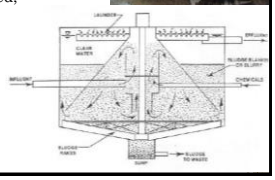
- High-Rate Settlers aka Tube Settlers
  - Increases settling efficiency of conventional rectangular sedimentation basins
  - Water enters the tubes and flows upward
  - Settled particles collect on surfaces of tubes or settle to bottom of basin
  - Can be tube design or plate design of settlers





Types of Sedimentation Basins

- Solids-Contact Units
  - Improves overall solids removal process under certain design conditions
  - Combine coagulation, flocculation and sedimentation into a single basin
  - Water flows upward through a sludge blanket or slurry of flocculated, suspended solids



Types of Sedimentation Basins

- Solids-Contact Units
  - Uniform sludge blanket must be maintained
  - Sludge blanket sensitive to changes in water temperature
  - Changes in rate of flow should be made infrequently, slowly, and carefully
  - Operational factors of importance
    - Temperature
    - Control of chemical dosage
    - Mixing of chemicals
    - Control of sludge blanket
  - Perform a drawdown on sludge blanket to check thickness and concentration
    - AWWA: check solids concentration 2 times a day
    - State of TN: check solids concentration every 8 hours (3 times a day)

Solids-Contact Clarification - Process

- Known as solids-contact clarifiers, upflow clarifiers, reactivators, and precipitators
- Sludge – settled materials from coagulation or settling
- Slurry – the suspended floc clumps in the clarifier
- Internal mechanism consists of 3 distinct processes that function in the same way as conventional treatment
- Sludge produce by the unit is recycled through the process to act as a coagulant aid

Solids-Contact Clarification - Process

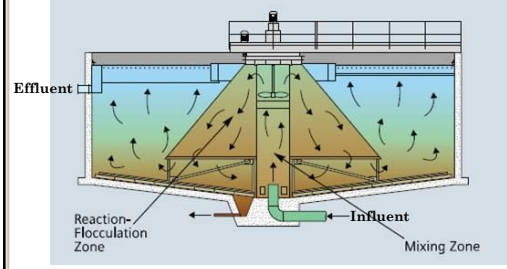
- Advantages
  - Reduced maintenance costs since all 3 processes are in one basin
  - Ability to adjust volume slurry
    - Operator can increase amount of slurry during good periods and remove it during periods when the coag process isn't functioning well
- Disadvantages
  - Requires a high level of operator knowledge and skill
  - Instability during rapid changes in flow, turbidity level, and temperature

Solids-Contact Clarification – Fundamentals of Operation

- Chemical Dosage
  - Must be sufficient alkalinity
  - Always run jar test before making any changes
- Sludge Control
  - Accumulated sludge on bottom of clarifier (settling zone) is removed via hydraulic means (water pressure)
- Recirculation Rate
  - Established by speed of impeller, turbine, pumping unit or air injection
  - Entire mass of suspended floc clumps billows and flows within the chamber
    - This recirculating sludge mixes with the raw water and goes through coagulation & flocculation in the reaction zone

25

Solids-Contact Clarification – Fundamentals of Operation



Recirculation Zone – where coagulation & flocculation occur

26

Solids-Contact Clarification – Sludge Handling

- Sludge must be removed from bottom of basins
  - To prevent interference with the settling process
  - To prevent the sludge from becoming septic or providing an environment for the growth of microorganisms
  - To prevent excessive reduction in the cross-sectional area of the basin (reduction in DT)
- Mechanical sludge removal devices
  - Mechanical rakes
  - Drag-chain and flights
  - Traveling bridges

27

Solids-Contact Clarification – Sludge Handling

- Mechanical rakes
  - Used in circular or square basins to push sludge toward a center outlet of sloped basin floor
- Drag-chain & flights
  - Simplest mechanism for rectangular basins
  - Endless chain with scrapers (flights) pushes sludge into a sump
  - Has high operation and maintenance costs
- Traveling bridges
  - Spans width of sedimentation basin and travels along basin walls
  - Sweeps hung from bridge remove sludge from basin floor with suction pumps or by siphon action

28

Mechanical Rake

Travelling Bridge

Drag-chain and Flights

29

Solids-Contact Clarification – Operation of Sludge Removal Equipment

- Sludge removal frequency depends on
  - Rate of sludge buildup
    - Dependent on amount of suspended material & flock removed
  - Size and capacity of sludge pump
- Sludge level measured by
  - Sludge blanket sounder
  - Bubbler tube
  - Aspirator
  - Ultrasonic level indicator
- If sludge is too thick and bulks, increase removal frequency
- If sludge is too low in solids (soupy), decrease removal frequency

30

Solids-Contact Clarification – Process Control

- Performance of sedimentation basin depends on
  - Settling characteristics of suspended particles
  - Flow rate through basin
- To control settling characteristics of particles
  - Adjust coagulant dose
  - Adjust coagulation-flocculation process
- Flow rate through basin controls process efficiency
  - Higher rate of flow means lower efficiency

31

Normal Operating Procedures

- Monitor
  - Turbidity of water entering and leaving the sedimentation basin
    - Entering indicates the load on the sedimentation process
    - Leaving reveals effectiveness of sedimentation
  - Temperature of entering water
    - Colder water means slower settling
- Uneven distribution of floc may indicate raw water quality change or operational problems

32

Normal Operating Procedures – Process Actions

- Floc observation
  - Floc should only be visible for a short distance in sedimentation basin
  - If visible for long distance beyond inlet, sedimentation is poor
- Sludge blanket
  - Normal density but close to surface means more sludge should be wasted
  - Light density indicates coag-floc process must be adjusted
  - Floc coming over weir at end of basin indicate density currents, short circuiting, too deep sludge blankets, or high flows
  - Frequent clogging of sludge discharge line indicates too high sludge concentration

33

Normal Operating Procedures – Process Actions

- Sludge solids volume analysis - used to determine sludge solids concentration
  - Collect sludge sample and pour known volume into a drying dish
  - Place sample dish in drying oven and evaporate sample to dryness at 103-105°C
  - Weigh remaining solids

$$\text{Sludge solids, \%} = \frac{(\text{Weight of sample, mg})(1\text{ mL})}{(\text{Volume of sample, mL})(1000\text{ mg})} \times 100$$

34

Record Keeping

- Influent and effluent turbidity and influent temperature
- Process production inventory
  - Amount of water processed and volume of sludge produced
- Process equipment performance
  - Types of equipment in operation, maintenance procedures performed, and equipment calibration

35

Abnormal Operating Conditions – Process Actions

- Measurement of turbidity levels at inlet and outlet of sedimentation basin shows process removal efficiency
- If coagulant dosage increases, sludge removal frequency may also increase
- Decreasing water temperature decreases settling rate and vice versa
- Increased settled water turbidity can lead to premature clogging of filters

36

Sedimentation Process Troubleshooting

Source Water Quality Change	Operator Action	Possible Process Changes
Turbidity Temperature Alkalinity pH Color	1. Perform necessary analyses to determine extent of change 2. Evaluate overall process performance 3. Perform jar tests 4. Make process changes 5. Increase frequency of process monitoring 6. Verify response to process changes	1. Change coagulant 2. Adjust coagulant dosage 3. Adjust flash mixer/ flocculator mixing intensity 4. Change frequency of sludge removal 5. Increase alkalinity by adding lime, caustic soda, or soda ash

37

Sedimentation Process Troubleshooting

Flocculation Process Effluent Quality Changes	Operator Actions	Possible Process Changes
Turbidity Alkalinity pH	1. Evaluate overall process performance 2. Perform jar tests 3. Verify performance of coag-floc process 4. Make process changes 5. Verify response to process changes	1. Change coagulant 2. Adjust coagulant dosage 3. Adjust flash mixer/ flocculator mixing intensity 4. Adjust improperly working chemical feeder

38

Sedimentation Process Troubleshooting

Sedimentation Basin Changes	Operator Actions	Possible Process Changes
Floc settling Rising or floating sludge	1. Observe floc settling characteristics: • Dispersion • Size • Settling rate 2. Evaluate overall process performance 3. Perform jar tests • Assess floc size and settling rate • Assess quality of settled water 4. Make process changes 5. Verify response to process changes	1. Change coagulant 2. Adjust coagulant dosage 3. Adjust flash mixer/ flocculator mixing intensity 4. Change frequency of sludge removal 5. Remove sludge from basin 6. Repair broke sludge rakes

39

Sedimentation Process Troubleshooting

Sedimentation Process Effluent Quality Changes	Operator Actions	Possible Process Changes
Turbidity color	1. Evaluate overall process performance 2. Perform jar tests 3. Verify process performance • Coag-floc process • Floc settling characteristics 4. Make process changes 5. Verify response to process changes	1. Change coagulant 2. Adjust coagulant dosage 3. Adjust flash mixer/ flocculator mixing intensity 4. Change frequency of sludge removal

40

Types of Equipment

- Sludge removal equipment
- Sludge pumps
- Sump pumps
- Valves
- Flowmeters and gauges
- Water quality monitors
- Control systems

41

Equipment Operation

- Before starting equipment, ensure proper lubrication
- After start up and during operation,
  - Check for excessive noise, vibration, overheating, and leakage
  - Check pump's suction and discharge pressures to make sure they aren't plugged
- Sludge collectors, discharge lines, and troughs should be periodically flushed to maintain a free sludge flow.

42

TDEC - Fleming Training Center

Safety Considerations – Electrical Equipment

- Avoid electric shock (use protective gloves)
- Avoid grounding yourself in water or on pipes
- Ground all electric tools
- Use the buddy system
- Use a lockout and tag system whenever electrical equipment or electrically driven mechanical equipment is out of service or being worked on

43

TDEC - Fleming Training Center

Safety Considerations – Mechanical Equipment

- Keep protective guards on rotating equipment
- Do not wear loose clothing around rotating equipment
- Keep hands out of valves, pumps and other pieces of equipment (lock out and tag power switches before cleaning)
- Clean up all lubricant and sludge spills
- Use a lockout and tag systems whenever mechanical equipment is out of service or being worked on

44

TDEC - Fleming Training Center

Safety Considerations – Open Surface Water Filled Structures

- Use safety devices such as handrails and ladders
- Close all openings and replace safety gratings when finished working
- Know the location of all life preservers
- Use the buddy system

45

TDEC - Fleming Training Center

Safety Considerations – Valve and Pump Vaults, Sumps

- Be sure all underground or confined structures are free of hazardous atmospheres
- Only work in well-ventilated structures
- Use the buddy system
- Lock or chain valves when working in an area that could be flooded

46

TDEC - Fleming Training Center

Preventive Maintenance

- Keeping electrical motors free of dirt and moisture
- Ensuring good ventilation in equipment work areas
- Checking pumps and motors for leaks, unusual noise and vibrations, overheating, or signs of wear
- Maintaining proper lubrication and oil levels
- Inspecting for alignment of shafts and couplings
- Checking bearings for wear, overheating, and proper lubrication
- Checking for proper valve operation
- Checking for free flow of sludge in sludge removal collection and discharge systems

47

Sedimentation
Vocabulary

A. Absorption
B. Adsorption
C. Clarifier
D. Complete Treatment
E. Density
F. Detention Time
G. Dewater
H. Direct Filtration
I. Effluent
J. Influent
K. Launders
L. Overflow Rate
M. Plug Flow
N. Precipitate
O. Representative Sample
P. Sedimentation
Q. Septic
R. Shock Load
S. Short-Circuiting
T. Slurry
U. Supernatant
V. Tube Settler
W. Turbidity

_____ 1. A watery mixture or suspension (not dissolved) matter; a thin, watery mud or any substance resembling it.

_____ 2. To remove or separate a portion of the water present in a sludge or slurry.

_____ 3. The gathering of a gas, liquid, or dissolved substance on the surface or interface zone of another material.

_____ 4. A sample portion of material or water that is as nearly identical in content and consistency as possible to that in the larger body of water being sampled.

_____ 5. A measure of the cloudiness of water.

_____ 6. A type of flow that occurs in tanks, basins or reactors when a slug of water moves through a tank without ever dispersing or mixing with the rest of the water flowing through the tank.

_____ 7. Water or other liquid flowing from a reservoir, basin, treatment process, or treatment plant.

_____ 8. A larger circular or rectangular tank or basin in which water is held for a period of time during which the heavier suspended solids settle to the bottom.

_____ 9. The theoretical (calculated) time required for a small amount of water to pass through a tank at a given rate of flow.

_____ 10. Liquid removed from settled sludge.

_____ 11. Sedimentation basin and filter discharge channels consisting of overflow weir plates and conveying troughs.

_____ 12. A condition that occurs in tanks or basins when some of the flowing water entering a tank flows along a nearly direct pathway from the inlet to the outlet.

_____ 13. A measure of how heavy a substance (solid, liquid, or gas) is for its size.

_____ 14. A condition produced by bacteria when all oxygen supplies are depleted.

_____ 15. A method of treating water consists of the addition of coagulant chemicals, flash mixing, coagulation, minimal flocculation, and filtration.

_____ 16. The taking in or soaking up of one substance into the body of another by molecular or chemical action.

_____ 17. The arrival at a water treatment plant of raw water containing unusual amounts of algae, colloidal matter, color, suspended solids, turbidity or other pollutants.

_____ 18. A device that uses bundles of small-bore tubes installed on an incline as an aid to sedimentation.

_____ 19. A water treatment process in which solid particles settle out of the water being treated in a large clarifier or sedimentation basin.

_____ 20. A method of treating water which consists of the addition of coagulant chemicals, flash mixing, coagulation-flocculation, sedimentation and filtration. Also called conventional treatment.

_____ 21. One of the guidelines for the design of settling tanks and clarifiers in treatment plants;

_____ 22. An insoluble, finely divided substance which is a product of a chemical reaction within a liquid.

_____ 23. Water or other liquid flowing into a reservoir, basin, treatment process, or treatment plant.

Answers

1. T	7. I	13. E	19. P
2. G	8. C	14. Q	20. D
3. B	9. F	15. H	21. L
4. O	10. U	16. A	22. N
5. W	11. K	17. R	23. J
6. M	12. S	18. V	

Review Questions
Sedimentation

1. List as many factors as you can recall that affect particle setting in a sedimentation basin.

2. What types of currents may be found in a typical sedimentation basin?

3. List the four zones into which a typical sedimentation basin can be divided.

4. What is the purpose of the settling zone in a sedimentation basin?

5. What are launders?

6. List three possible shapes for sedimentation basins.

7. Why are rectangular sedimentation basins often preferred over circular basins?

8. During the operation of a solids-contact unit, what items should be of particular concern to the operator?

9. List two advantages of solids-contact units.

10. List the devices that may be used to provide recirculation in a solids-contact unit.

11. Why must accumulated sludge be removed periodically from the bottom sedimentation basins?

12. How can the depth of sludge in a sedimentation basin be measured?

13. The actual performance of sedimentation basins depends on what two major factors?

14. What items should an operator monitor during the normal operation of the sedimentation process?

15. What should be attempted if the sludge line plugs frequently?

16. In the routine operation of the sedimentation process, what types of records should be maintained?

Sedimentation Review Questions
Answers

1. (1) Particle size and distribution, (2) shape of particles, (3) density of particles, (4) temperature of water, (5) electrical charge on particles, (6) dissolved substances in water, (7) flocculation characteristics of the suspended material, (8) environmental conditions, (9) sedimentation basin hydraulic and design characteristics

2. (1) Surface currents induced by winds, (2) density currents caused by differences in suspended solids concentrations and temperature differences, and (3) eddy currents produced by the flow of the water coming into and leaving the basin

3. (1) Inlet zone, (2) settling zone, (3) sludge zone, (4) outlet zone

4. To provide a calm, undisturbed storage place for the flocculated water for a sufficient time period to permit effective settling of the suspended particles in the water being treated

5. Launders are skimming or effluent troughs used to uniformly collect settled water. Adjustable V-notch weirs are generally attached to the launders for controlling the water level in the sedimentation basin

6. Sedimentation basins are available in circular, rectangular, or square shapes

7. Rectangular sedimentation basins are often preferred over circular basins because circular basins are generally more sensitive to short-circuiting and achieve poorer solids removal.

8. Care must be exercised to ensure that a uniform sludge blanket is formed and is subsequently maintained throughout the solids removal process. Other important factors include control of chemical dosages, mixing of chemicals, and control of the sludge blanket.

9. (1) Only one reaction unit to contend with, (2) ability to accumulate slurry during periods of severe taste and odor problems, (3) use slurry accumulation to carry plant when coagulation fails because of increased algal activities

10. Recirculation in a solids-contact unit may be provided by impellers, turbines, pumping units, or by air injection.

11. (1) Prevent interference with the settling process, (2) prevent the sludge from becoming septic or providing an environment for the growth of microorganisms that can create taste and odor problems, (3) prevent excessive reduction in the cross-sectional area of the basin

12. The depth of sludge in a sedimentation basin can be measured with a sludge blanket sounder, a bubbler tube, an aspirator, or an ultrasonic level indicator.

13. (1) the settling characteristics of the suspended particles, (2) the flow rate through the sedimentation basins

14. The operator should monitor the turbidity of the water entering and leaving the basin and the temperature of the water entering the basin.

15. Frequent clogging of the sludge discharge line is an indication that the sludge concentration is too high. If this occurs, try increasing the frequency of operation of the sludge removal equipment.

16. (1) influent and effluent turbidity and influent temperature, (2) process production inventory, and (3) process equipment performance

FILTRATION

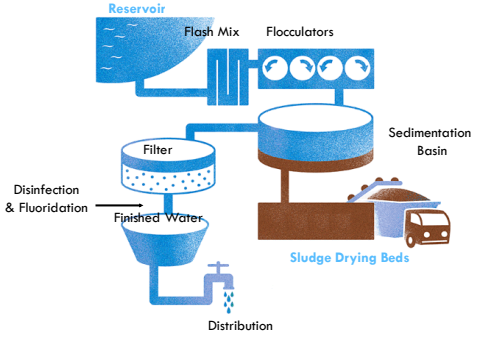
CALIFORNIA STATE UNIVERSITY: SACRAMENTO

WATER TREATMENT PLANT OPERATION VOL. I

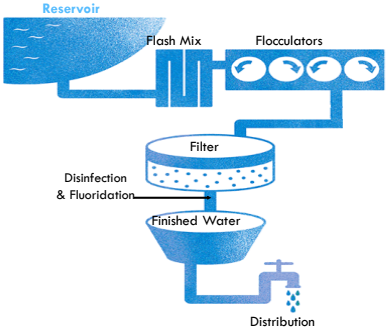
FILTRATION

- Process Description
  - Process of passing water through a material to remove floc and particulate matter (colloids)
    - Filter through a bed of sand, coal, or other granular substances
  - Conventional Filtration
    - Coagulation, flocculation, sedimentation and filtration
  - Direct Filtration
    - Sedimentation step is omitted

CONVENTIONAL FILTRATION

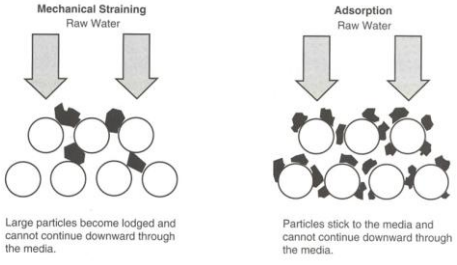


DIRECT FILTRATION



FILTRATION MECHANISMS

- Physical and chemical process
- Removal mechanisms
  - Sedimentation on media
  - Adsorption
  - Biological action
  - Absorption
  - Straining
- Removal mechanisms based on
  - Chemical characteristics of the water being treated
  - Nature of suspension
  - Types and degree of pretreatment
  - Filter type and operation



TYPES OF FILTERS

- Gravity filtration
  - Sand, dual media, and mixed media
- Pressure filtration
  - Mixed media
- Diatomaceous earth
  - Precoat filtration
- Slow sand filtration

GRAVITY FILTRATION

- Particulate impurities are removed in/on the media
- Water level or pressure (head) above the media forces water through the filter
- Types of gravity filters
  - Single media
    - Depth of at least 30 inches
  - Dual media
    - Sand (10 inches) and crushed anthracite (20 inches)
  - Multimedia
    - To be approved by department
- Filtration Rates
  - 2 gpm/ft^2 for turbidity removal
  - 3 gpm/ft^2 for iron removal plants

GRAVITY FILTRATION

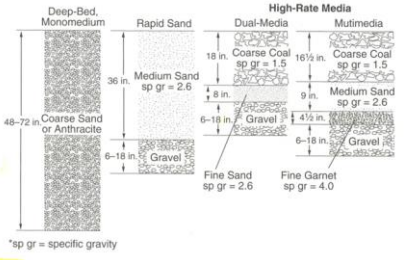
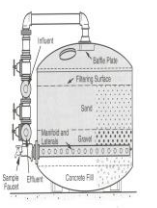


FIGURE 6–8 Comparison of deep-bed, rapid sand, and high-rate filter media

PRESSURE FILTRATION

- Similar to gravity filter except completely enclosed in a pressure vessel
- Lower installation and operation costs ins small filtration plants

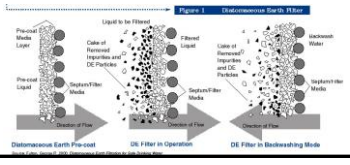


Courtesy of Celtis Corporation

FIGURE 6–37 Vertical sand pressure filter tank

DIATOMACEOUS EARTH (DE) FILTRATION

- Aka precoat filtration
- Filter media is added to the water as a slurry, then collected on a septum or screening device
- After the initial precoat application, water is filtered by passing it through the coated stream
- Primarily a straining process
- Can be operated as gravity, pressure, or vacuum filter



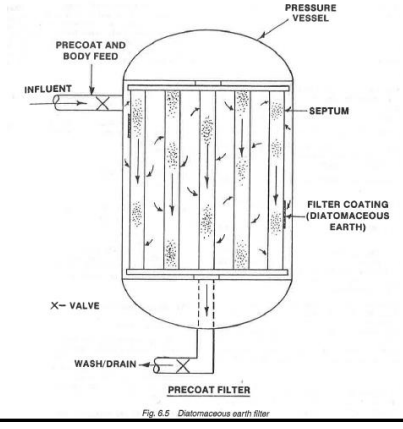
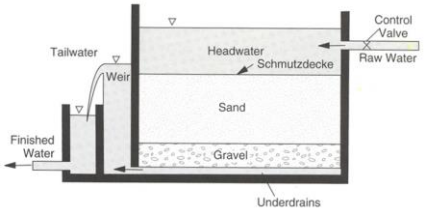


Fig. 6.5 Diatomaceous earth filter

SLOW SAND FILTRATION

- Water drawn through the filter media by gravity
- Filtration rates are very low
- Most particulate matter removed in top several inches of sand
- Entire layer must be physically removed when filter becomes clogged
  - No backwashing
  - Schmutzdecke – fine sand and a sticky mat of suspended matter that forms on the sand surface

SLOW SAND FILTRATION



Source: Barrett et al. (1991).

FIGURE 6–7 Schematic cross section of a slow sand filter

FILTER MEDIA

- Classified by
  - Effective size (ES) – size of a sieve opening that permits 10% of the particles to pass through
    - If limiting head loss is a problem, but turbidity breakthrough is not, consider larger media size
    - If turbidity breakthrough is a problem but not limiting head loss, smaller media may be considered
    - If both head loss and turbidity breakthrough are a constant problem, use a deeper filter bed with larger media
  - Uniformity coefficient (UC) – the ratio of particle diameters comprising 60% and 10% media weight
    - Media with lower uniformity coefficients are composed of more uniform particles
  - Specific gravity
  - Hardness

OPERATIONAL CRITERIA

- Filter Production and Filtration Rate
  - Measures of the amount of water that can be processed through an individual filter in a given period of time
  - Filter production – measured in MGD (millions of gallons per day)
  - Filtration rate – used to measure flow of water through a filter
    - Measured in gallons per minute per square foot (gpm/ft^2)
    - Aka hydraulic loading
  - Filtration Rates (TN Design Critieria)
    - 2 gpm/ft^2 for turbidity removal
    - 3 gpm/ft^2 for iron removal plants

OPERATIONAL CRITERIA

- Filtration Efficiency
  - Measured by overall plant reduction in turbidity
  - Removal efficiency depends on
    - The quality of the water being treated
    - The effectiveness of the pretreatment (coag/floc) processes
    - Filter operation
    - Filter design
    - Media type and thickness
      - Sand filters have fine, light grains on top that stop all particulates at the surface
      - Dual media filters have lighter larger diameter grains at the top that stop the larger particles; smaller particles are usually stopped farter down in the filter

FILTER OPERATION

- Filtration Mode
  - Water containing suspended solids is applied to the surface of the filter media
  - Clogging – buildup of head loss (pressure drop) across the filter media
    - Total design head loss ranges from 6 to 10 feet
  - Clogging leads to breakthrough – a condition in which solids are no longer removed
    - Solids pass into the filter effluent where they appear as increased turbidity

FILTER OPERATION

- Backwashing
  - Process of reversing the flow of water through the filter media to remove entrapped solids after
    - Maximum head loss reached
    - Breakthrough occurs
    - Specified time period has passed
  - Filter media must be fluidized (expanded) by reversing flow
  - Backwash rates of 10-25 gpm/ft^2 required
  - Insufficient backwashing may not adequately clean filter
  - Too high backwash rate may cause excessive loss of media
  - Higher backwash rates are required at higher temperatures due to less viscous water
  - TN Design Criteria
    - 50% bed expansion

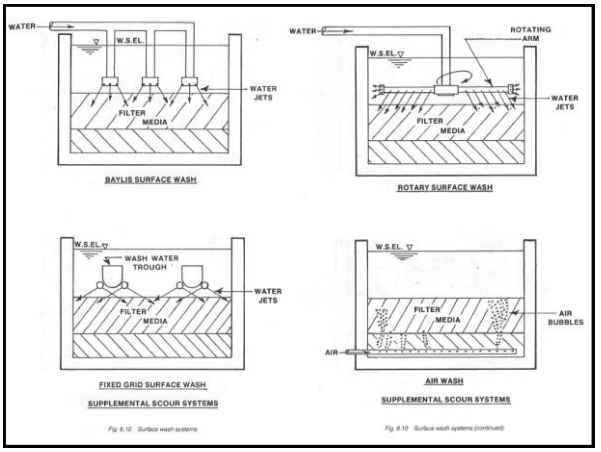
FILTER OPERATION

- Backwashing
  - Water use for backwashing may be recycled directly to the headworks (ahead of the flash mix)
  - Filter Backwash Rule requires that recycled filter backwash water, sedimentation basin sludge thickener supernatant, and liquids from sludge dewatering processes be returned upstream of all conventional treatment systems
    - Systems may apply to the State for approval
    - Purpose is to improve performance at filtration pants by reducing opportunity for microbes such as *Cryptosporidium* to pass through the treatment process

https://youtu.be/QrWXJ25wEkU

FILTER OPERATION

- Surface Wash
  - Provides additional scrubbing action to remove attached floc and other entrapped solids from the filter media
  - 4 types:
    - Baylis
    - Fixed grid
    - Rotary
    - Air scour



FILTER OPERATION

- Filter Control Systems
  - Regulate flow rates through the filter
  - Control system types
    - Rate-of-flow – each filter effluent control valve is connected to a flow meter
      - As the media begins to clog, the control valve opens to maintain a constant flow
      - All filters operate at same flow rate
    - Split-flow
      - Equal flow to each filter influent is split or divided by a weir
      - Effluent valve position controlled by water level in the filter

FILTER OPERATION

- Filter Control Systems
  - Regulate flow rates through the filter
  - Control system types
    - Declining-rate
      - Flow rate varies with head loss
      - Each filter operates the same but has variable, water surface levels
    - Self-backwashing (or Streicher design)
      - Influent flow to each filter is divide by a weir
      - Water surface level varies according to head loss while flow rate remains constant
      - Reduces amount of equipment needed

FILTRATION

- Activated Carbon Filters
  - High adsorptive capacity of activated carbon enables it to remove taste and odor causing compounds and other organics
- Importance of Pretreatment
  - Floc particles carried over into the filter must be small enough to penetrate the upper filter media
  - Floc that is too large will clog the top portion of the filter bed rapidly
  - Floc removal is accomplished by contact with the media grains
    - Ripening period - time after initial coating of media surfaces with floc; subsequent applications of floc will build up on the material previously deposited
      - High effluent turbidities may occur during the ripening period

FILTRATION

- In-line Filtration
  - The addition of coagulant chemicals immediately before the water enters the filtration system
  - Filter aids are added directly to the filter inlet pipe and mixed by the flowing water
    - Separate flocculation and sedimentation facilities are eliminated
  - Not as efficient as conventional or direct filtration
- Important process control guidelines
  - Filter influent water quality – turbidity
  - Filter performance - head loss buildup rate and filter run time
  - Filter effluent water quality - turbidity

NORMAL OPERATING CONDITIONS

- Filter effluent turbidities will give a good indication of overall process performance
- Operator should monitor filter influent turbidity as well as filter effluent turbidity levels
- Monitor head loss buildup and filter effluent color
- Guidelines would help evaluate normal process conditions and in recognizing abnormal conditions

PROCESS ACTIONS

- Measurement of head loss buildup can indicate performance of solids removal process
  - Total designed head loss in a gravity filter is usually about 10 feet
  - Loss-in-head – actual head loss from a point above the filter media to a reference point in the effluent
  - Sudden increase in head loss may indicate surface sealing of the filter media (lack of depth penetration)

PROCESS ACTIONS

- Filter Run Time or Length
  - Should be calculated based on head loss, effluent turbidity and/or elapsed run time
  - A predetermined value set for each parameter as a cutoff point for filter operation
    - When any one of these levels is reached, the filter is backwashed
  - Filter run length not a satisfactory basis for comparing filter runs without considering filtration rate as well

PROCESS ACTIONS

- Unit Filter Run Volume (UFRV)
  - Volume of water produced by the surface area of the filter during the course of the filter run divided by the surface area of the filter
  - Expressed in gallons per square foot (gal/ft^2)
  - UFRV > 5,000 gal/ft^2 is good
  - UFRV < 10,000 gal/ft^2 is better
- Examine and evaluate filter media annually
  - Measure media thickness
    - Can be lost during backwash
  - Measure mudball accumulation
    - Indicates insufficient backwashing

PROCESS ACTIONS

- Observe backwash process to assess process performance
  - Watch for media boils, media carryover, waste wash water clarity
- Never "bump" filter to avoid backwashing
  - Bumping is the act of opening the backwash valve during the course of a filter run to dislodge the trapped solids and increase the filter run
- Observe the condition of the media surface and check for filter sidewall or media surface cracks
  - After completion of backwash cycle

FORMULAS

- Calculate the filtration rate in gal/ft² for a filter with a surface length of 25 feet and a width of 20 feet when they applied flow is 2 MGD.

$$flow, gpm = \left(\frac{2\ MGD}{1}\right)\left(\frac{694\ gpm}{1\ MGD}\right)$$

$$= 1388\ gpm$$

$$Area = (L)(W)$$

$$A = (25\ ft)(20\ ft)$$

$$A = (500 ft^2)$$

$$filtration\ rate = \frac{flow, gpm}{filter\ area, ft^2}$$

$$gpm/_{ft^2} = \frac{1388\ gpm}{500 ft^2}$$

$$gpm/_{ft^2} = 2.78\ gpm/ft^2$$

FORMULAS

- Convert ta filter backwash rate from 25 gallons per minute per square foot to inches per minute of rise.

$$in/_{min} = \frac{\left(rate, gpm/_{ft^2}\right)\left(12\ in/_{ft}\right)}{7.48\ gal/_{ft^3}}$$

$$in/_{min} = \frac{\left(25\ gpm/_{ft^2}\right)\left(12\ in/_{ft}\right)}{7.48\ gal/_{ft^3}}$$

$$in/_{min} = 40.1\ in/_{min}$$

RECORDKEEPING

- Accurate records should be maintained
  - Process water quality
    - Turbidity and color
  - Process operation
    - Filters in service, filtration rates, loss of head, length of filter runs, frequency of backwash, backwash rates, UFRV
  - Process water production
    - Water processed, amount of backwash water used, and chemicals used
  - Percent of water production used to backwash filters
  - Process equipment performance
    - Types of equipment in operation, equipment adjustments, maintenance procedures performed, and equipment calibration

INDICATORS OF ABNORMAL CONDITIONS

- Rapid changes in head loss buildup or turbidity breakthrough may be indicators of abnormal operation conditions:
  - Mudballs in filter media
  - Media cracking or shrinkage
  - Media boils during backwash
  - Excessive media loss or visible disturbance
  - Short filter runs
  - Filters that will not come clean during backwash
  - Algae on walls and media

PROCESS ACTIONS

- If filter turbidity removal efficiency is decreasing, evaluate coag/floc process and coagulant dosage
- Increases in source water turbidity may require a decrease in filtration rates or backwash filters more frequently
- Adding filter aids chemicals can help when pretreatment processes don't readily respond to source water quality changes
  - Overdosing can cause sealing of the filter media
- Decrease in alkalinity and pH can affect filtration since the coag/floc process performance can decrease

PROCESS ACTIONS

- Increases in filter effluent turbidity may also result from floc carryover from the sedimentation process
- Short filter runs can be caused by increased solids loading, filter aid overdosing, excessively high filtration rates, excessive mudball formation, or clogging of the filter underdrain system
- Backwash problems can be resolved by adjusting backwash flow rates, surface wash flow rates or duration, or adjusting the time sequence or duration of the backwash cycle
- Improper backwashing can result in mudball formation or filter cracks and shrinkage

AIR BINDING

- Caused by the release of dissolved air in saturated cold water due to a decrease in pressure
- Air is released from the water when passing through a filter bed by differences in pressure produced by friction through the bed
- The released air is entrapped in the filter bed
- Whenever a filter is operated to a head loss that exceeds the head of water over the media, air will be released
  - Occurs more frequently when large head losses are allowed to develop in filter
- Causes shortened filter runs due to water flow being restricted due to bound air

EXCESSIVE HEAD LOSS

- Filter underdrain system and head loss measurement equipment should be checked if excessive head losses remain after backwashing
- Can be caused by reduction in size and number of underdrain openings
  - Due to media clogging, corrosion, or chemical deposits

START UP PROCEDURES - BACKWASH

- Filters should be washed before placing them in service
  - Check length of cycle times set for backwash and surface wash cycles are correct
  - Surface wash should be activated before the backwash cycle starts and stopped before completion of the backwash cycle
  - Filter wash should begin slowly and provide uniform expansion of the filter bed
  - When backwash water coming up through filter becomes clear, media is clean (3-8 minutes)
  - Reduce backwash rate if media carryover or flooding of water troughs occurs
  - Waste backwash water is either recycled or sent to settling basin
    - Supernatant is then recycled through the plant

SURFACE WATER TREATMENT RULE (SWTR)

- Set of treatment technique requirements that apply to all water systems using surface water and those using groundwater that is under the influence of surface water (subpart H systems)
- Defines surface water as “all water open to the atmosphere and subject to surface runoff”
- Requires that all systems properly filter the water
- Requires that all systems using surface water to disinfect the water (no exceptions)
- At least 99.9% (3-log) removal and/or inactivation of *Giardia* cysts
- At least 99.99% (4-log) removal and/or inactivation of enteric (intestinal) viruses

TURBIDITY REQUIREMENTS

Type of Filtration	Monitoring Frequency	Turbidity Level
Conventional	Every 4 hours	< 0.3 NTU
Direct	Every 4 hours	< 0.3 NTU
Diatomaceous Earth	Every 4 hours	< 1.0 NTU
Slow Sand	Once per day*	< 1.0 NTU

- All filtration systems must meet these standards in 95% of the measurements taken for each month (0400-45-01-.31)

*For any system using slow sand filtration or filtration treatment other than conventional treatment, direct filtration, or diatomaceous earth filtration, the Department may reduce the sampling frequency to once per day if it determines that less frequent monitoring is sufficient to indicate effective filtration performance.

PARTICLE COUNTERS

- A device which counts and measures the size of individual particles in water
  - Particles are divided into size ranges and the number of particles is counted in each of these ranges
- One of the best monitoring tools available to optimize plant performance for the removal of particles
  - i.e. *Giardia* and *Cryptosporidium*
  - Monitors the removal efficiency of particles in the same size range as *Giardia* and *Crypto*
- Cannot replace other analytical tests for *Giardia* and *Crypto*
  - Cannot tell difference between clay particle and microorganism

Filtration
Vocabulary

A. Absorption

B. Activated Carbon

C. Adsorption

D. Air Binding

E. Backwashing

F. Breakthrough

G. Colloids

H. Conventional Filtration

I. Diatomaceous Earth

J. Diatoms

K. Direct Filtration

L. Fluidized

M. Head Loss

N. Uniformity Coefficient

_____ 1. Adsorptive particles or granules of carbon usually obtained by heating carbon.

_____ 2. A method of treating water which consists of the addition of coagulant chemicals, flash mixing, coagulation, minimal flocculation, and filtration.

_____ 3. The head, pressure or energy (they are the same) lost by water flowing in a pipe or channel as a result of turbulence caused by the velocity of the flowing water and the roughness of the pipe, channel walls, or restriction caused by fittings.

_____ 4. The ration of the diameter of a grain of a size that is barely too large to pass through a sieve that allows 60% material (by weight) to pass through

_____ 5. The process of reversing the flow of water back through the filter media to remove the entrapped solids.

_____ 6. Very small, finely divided solids that remain dispersed in a liquid for a long time due to their small size and electrical charge.

_____ 7. A fine, siliceous (made of silica) “earth” composed mainly of the skeletal remains of diatoms.

_____ 8. The clogging of a filter due to the presence of air released from water.

_____ 9. The gathering of a gas, liquid, or dissolved substance on the surface or interface zone of another material.

_____ 10. A method of treating water that consists of the addition of coagulant chemicals, flash mixing, coagulation-flocculation, sedimentation and filtration.

_____ 11. Unicellular (single cell), microscopic algae with a rigid internal structure consisting mainly of silica.

_____ 12. A mass of solid particles that is made to flow like a liquid by injection of water or gas

_____ 13. A crack or break in a filter bed allowing the passage of floc or particulate matter through a filter.

_____ 14. The taking in or soaking up of one substance into the body of another by molecular or chemical action.

Answers

1. B
2. K
3. M
4. N
5. E
6. G
7. I
8. D
9. C
10. H
11. J
12. L
13. F
14. A

Filtration
Review Questions

1. What is the major difference between conventional filtration and direct filtration?

2. List the particle removal mechanisms involved in the filtration process.

3. List the four specific classes of filters.

4. What material is used for precoat and body-feed operations?

5. Filtration rate is commonly expressed in what units?

6. What is the major operation difference between sand and dual-media filters?

7. What two main factors influence the time period before a filter becomes clogged?

8. Under what conditions is the filtration process stopped and the filter taken out of service for cleaning or backwashing?

9. List four types of surface wash systems for filters.

10. What is the primary purpose of using activated carbon (granular form) as filter media?

11. What is in-line filtration?

12. When and where are filter aid chemicals used?

13. What factors must an operator measure to control the performance of the filtration process on a day to day basis?

14. What is the most important water quality indicator used to monitor the filtration process?

15. List some of the typical functions performed by operators in the normal operation of the filtration process.

16. What could cause a sudden increase in head loss through a filter?

17. What types of records should be kept when operating a filtration process?

18. How would you identify an upset or failure in the filtration process or pretreatment processes?

19. List the indicators of abnormal filtration process conditions.

20. How could you make a quick determination of filtration removal efficiency?

21. What problems may be encountered during backwash?

22. How does a filter become air bound?

23. What is the SWTR definition of surface water?

24. Particle counters can be used as a substitute for indicating the potential removal of what two microorganisms that are a threat to public health when found in drinking water?

Filtration
Review Question Answers

1. Filtration, preceded by coagulation, flocculation, and sedimentation, is commonly referred to as conventional filtration process, the sedimentation step is omitted. Flocculation facilities are reduced in size or may be omitted.

2. Sedimentation on media, adsorption, biological action, absorption, straining

3. Gravity filtration, pressure filtration, diatomaceous earth filtration, slow sand filtration

4. Diatomaceous earth

5. Gallons per minute per square foot

6. Sand filters require more frequent backwashing because of their smaller media grain size. Dual media filters permit a higher filtration rate without a high head loss.

7. The amount of suspended solids in the water being treated and the filtration rate

8. A filter is operated until just before clogging or breakthrough occurs, a specified time period has passed or a specific head loss is reached.

9. Baylis, fixed grid, rotary, air scour

10. To remove taste and odor causing compounds, as well as other trace organics from the water

11. Inline filtration refers to the addition of filter aid chemicals immediately prior filtration. Chemicals are added directly to the filter inlet pipe and are mixed by the flowing water

12. Filter aid chemicals are usually added just prior to filtration in the solids removal process during normal operation and during periods of pretreatment process upset, or when operating at high filtration rates.

13. Filter influent water quality (turbidity), filter performance, filter effluent water quality

14. Filter influent and effluent turbidity

15. Monitor process performance, evaluate water quality conditions and make appropriate changes, Check and adjust process equipment, backwash filters, evaluate filter media conditions, visually inspect facilities

16. Surface sealing of the filter media

17. Process water quality, process operation, process water production, percent of water production used to backwash filters, process equipment performance

18. Rapid changes in head loss buildup in the filter or turbidity breakthrough

19. Mudballs in filter media, media cracking or shrinkage, media boils during backwash, excessive media loss or visible disturbance, short filter runs, rapid head loss buildup, turbidity breakthrough, filters that will not come clean during backwash, algae on walls and media

20. Comparing filter influent and effluent turbidity levels with those of recent record

21. Media boils, media loss, and failure of the filter to come clean during the backwash process

22. By the release of dissolved air in saturated cold water due to the decrease in pressure

23. All water open to the atmosphere and subject to surface runoff

24. *Giardia* and *Cryptosporidium*

Record Category	Time frame required to keep records	Source
Microbiological Records		0400-45-1-.20(1)(a)
Routine distribution	5 years	
Line repair records	5 years	0400-45-1-.17(8)(a)
New line records	5 years	
Bacteriological sampling plan	Keep updated, at least every 3 years	
Chemical Analysis		0400-45-1-.20(1)(a)
Inorganics/ secondaries	10 years	
SOC's	10 years	
VOC's	10 years	
THM's and HAA5's	10 years	
Radionuclides	10 years	
Lead and copper	12 years	0400-45-1-.33(12)
Miscellaneous		
Action regarding violations	3 years	0400-45-1-.20(1)(b)
Certified Letters to Fire Departments regarding Class C hydrants	5 years	0400-45-1-.17(18)
Complaint file	5 years	0400-45-1-.20(1)(h)
Consumer Confidence Reports	3 years	0400-45-1-.35(h)
Cross connection plans and inspection records	5 years	0400-45-1-.20(1)(h)
Daily worksheets, strip charts, shift logs	5 years	0400-45-1-.20(1)(g)
Disinfection Profile	10 years	
Disinfection SOP	Keep updated	
Distribution map	Keep updated, submit copy to DWS every 5 years	0400-45-1-.17(15)
Distribution SOP	Keep updated	
Emergency Operation Plan	Keep updated	0400-45-1-.34(4)(a)
Facility Maintenance Records	5 years	0400-45-1-.20(1)(h)
Flushing records	Survey to survey or 3 years	0400-45-1-.17(10)
MOR's	5 years	
MSDS	At least 30 years	29 CFR 1910.1020
New tap records	Survey to survey or 3 years	0400-45-1-.17(32)
Notice of Construction	Survey to survey or 3 years	
Plant SOP	Keep updated	
Public Notices	3 years	0400-45-1-.20(i)
Sanitary surveys	10 years	
Storage Tank Inspection Records	5 years	0400-45-1-.17(33), 0400-45-1-.20(1)(h)
Tank maintenance records	Life of tank	0400-45-1-.17(33)
Turbidity analysis: daily worksheets, calibration data and strip charts	5 years	0400-45-1-.20(1)(f)
Variances or Exemptions	5 years	0400-45-1-.20(1)(d)

RULES
OF
THE TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION
BOARD OF WATER AND WASTEWATER OPERATOR CERTIFICATION

CHAPTER 0400-49-01
RULES GOVERNING WATER AND WASTEWATER OPERATOR CERTIFICATION

TABLE OF CONTENTS

0400-49-01-.01 APPLICATION FOR CERTIFICATE.

(1) Application for certification by examination.

(a) A separate application for each certification shall be made on an original form approved by the Board for that purpose and available upon request from the Secretary of the Board.

(b) An application for certification must be submitted to the Secretary of the Board and include the following items:

1. A sworn application signed by the applicant.

2. Payment of a non-refundable $100 fee for each application for examination.

3. A copy of any verifying document in support of an application must be submitted with the application unless the applicant has previously provided such documentation to the Secretary of the Board. This includes, but is not limited to, proof of high school education or equivalent of the applicant. College transcripts, if needed to document experience credit, must be submitted directly from the college and/or university to the Secretary to the Board. Credit for enrollment in special training courses and programs will only be granted to an applicant upon verification that he/she satisfactorily completed all course or program requirements. If training credit is requested, a copy of a course attendance card, a class roster, or a certificate of completion must be submitted to the Secretary. Verification of work experience must be provided in a written document signed by a certified operator of a similar or higher classification, familiar with the applicant's work experience. However, if no such person is available, it may be documented by a person in authority with the system. The Board may exempt applicants from the verification of work experience requirement where there are unusual circumstances.

(c) A complete application must be received by the Secretary sixty (60) days or more in advance of the scheduled examination date for consideration. Applications received less than sixty (60) days prior to an examination date will be reviewed for the next examination. Upon written request by an applicant, the Board may choose to review,

(Rule 0400-49-01-.02, continued)

(5) An applicant shall be notified in writing whether his/her examination score was satisfactory for the issuance of a certificate.

(6) An applicant who fails to achieve a satisfactory score may reapply for the next examination by submitting an abbreviated application for examination with fees, but he/she shall not be eligible to take another examination for the particular operator classification which he/she failed until five months have elapsed from the date that examination was taken.

(7) All examinations shall be administered by the Board or its authorized representatives who are empowered to maintain the integrity of all examinations.

(8) (a) An applicant shall be guilty of cheating upon a written examination who does an act including, but not limited to, the following:

1. violates paragraph (2) of this rule; or

2. without express authorization from examination officials,

(i) removes examination materials furnished by the Board or the written examination itself, in whole or in part, from the examination room, or

(ii) aids another applicant in answering examination questions during a written examination; or

3. violates the examination rules.

(b) Upon a determination by the Commissioner that an applicant is guilty of cheating upon a written examination for a particular operator classification, the applicant shall not be issued an initial certificate of competency for that classification.

(c) An applicant shall be ineligible to again apply for certification in that same operator classification for one year from the date the determination of cheating becomes final.

Authority: *T.C.A. §§ 4-5-201 et seq. and 68-221-901 et seq.* ***Administrative History:*** *Original rule filed May 21, 2014; effective August 19, 2014. Rule renumbered from 1200-05-03. Amendments filed January 18, 2017; effective April 18, 2017.*

0400-49-01-.03 FEES.

(1) Fees for Certification

(a) Fees for certification shall be required of each applicant and paid in advance as follows:

1. Application fee for each operator examination or reciprocity request applied for ……..……..……..…….$100

2. Discount annual renewal fee for each operator certificate:
(Payment prior to February 1)……..……$50

3. Standard annual renewal fee for each operator certificate:
(Payment from February 1 through June 30.)…..……..……$100

(b) No application fee will be returned.

(Rule 0400-49-01-.03, continued)

(c) Upon payment of an application fee and approval by the Board, an applicant may take any one scheduled examination during the following twelve (12) months. If an applicant chooses not to take or fails to appear for, the first examination offered after receiving approval, the applicant must register on a form approved by the Board to be scheduled for a subsequent exam within the established time. The registration must occur sixty (60) days in advance of the examination he/she wishes to take. If an applicant does not take the examination within twelve (12) months of the Board's approval, he/she must reapply by submitting a new application with fees in order to be considered to take a subsequent examination.

(d) Each year a certified operator shall submit to the Board for the following year a completed certificate renewal application and a fee for the renewal of each operator certificate he/she possesses. Applications received prior to February 1 of each year shall be subject to discount renewal fees. Applications received February 1 through June 30 of each year shall be subject to standard renewal fees. Any person failing to meet the June 30 deadline may, within sixty (60) days of the deadline, request that the Board grant a variance. A variance may be granted when the delay was caused by Board or staff error, Board action, or documented postal error. A completed certificate renewal application or appropriate annual renewal fee for an expired certificate not received by the Board by June 30 shall preclude the recertification of the operator in his/her expired classification until he/she shall have fulfilled all the requirements for the issuance of an initial certificate in that classification, including the satisfactory completion of a written examination. When an operator classification is upgraded, the certificate he/she was upgraded from becomes void; and no additional fee payment is necessary until renewal.

(2) Fees for Cross Connection Control Training Registration

(a) Fees for Cross Connection Control Training registration shall be required of each person and paid in advance as follows:

1. Registration fee for a Cross Connection Control Basic Class (full time employees of public water systems as defined in T.C.A. § 68-221-703 and Department employees who assist with cross connection control training or testing classes are exempt)..... ……..$275

2. Registration fee for a Cross Connection Control Renewal Class (full time employees of public water systems as defined in T.C.A. § 68-221-703 and Department employees who assist with cross connection control training or testing classes are exempt)..…….... $110

(b) No registration fee will be returned.

(c) The registration fee must be received thirty (30) days in advance of the class he/she wishes to take.

(3) Fees for Cross Connection Control Testing Application

(a) Fees for Cross Connection Control Testing Application shall be required of each person and paid in advance as follows:

1. Application for a Cross Connection Control Basic Test (Department employees who assist with cross connection control training or testing are exempt)….....….....…….....$60

(Rule 0400-49-01-.03, continued)

2. Application fee for Cross Connection Control Renewal Test (Department employees who assist with cross connection control training or testing are exempt)..... .....$60

(b) Application fees are not refundable or transferable.

(c) The application for testing conducted by the Department must be received a minimum of thirty (30) days in advance of the test he/she wishes to take, however, applications from private institutions may be received the day the test materials are submitted to the Fleming Training Center.

(d) Prior to sitting for a test, an applicant must present proof of completion of training accepted by the Department for the appropriate test. Basic training may be accepted by the Department if it has a minimum class length of 480 minutes (300 minutes minimum in classroom), including but not limited to the following topics: hydraulic and backflow principles, theory of backflow and cross connection, codes and regulations of a cross connection control program, responsibilities and actions in a cross connection control program and mechanical equipment for cross connection control. Acceptable training must also provide a minimum of one working practice station and test kit for each three students. Renewal training may be accepted by the Department if it has a minimum class length of 300 minutes (180 minutes minimum in classroom) including but not limited to the following topics: hydraulic and backflow principles, theory of backflow and cross connection, codes and regulations of a cross connection control program, responsibilities and actions in a cross connection control program and mechanical equipment for cross connection control. Acceptable training must also provide a minimum of one working station and test kit for each three students.

(e) An applicant must take the test within twelve (12) months of receipt of the training certificate.

Authority: *T.C.A. §§ 4-5-201 et seq., 68-203-101 et seq., 68-221-901 et seq.* ***Administrative History:*** *Original rule filed May 21, 2014; effective August 19, 2014. Rule renumbered from 1200-05-03. Amendments filed January 18, 2017; effective April 18, 2017.*

0400-49-01-.04 GENERAL.

(1) Certification under T.C.A. §§ 68-221-901 et seq., being the "Water and Wastewater Operator Certification Act," is available to any operator of a water treatment plant, a wastewater treatment plant, a water distribution system, or a wastewater collection system who meets the minimum qualifications of a given classification.

(2) Each person in direct charge at a water treatment plant, a wastewater treatment plant, a water distribution system, or a wastewater collection system shall hold a certificate in a grade equal to or higher than the grade of the treatment plant, distribution system, or collection system he/she operates. The grade of a facility will be established by the criteria set forth in this chapter of rules.

(3) All operating personnel making process control/system integrity decisions about water quality or quantity that affect public health must be certified. A designated certified operator must be available for each operating shift.

(4) Each water supply system and wastewater system required to have a certified operator shall, no later than the first day of August annually, inform the Board, through its designated agent, the Division of Water Resources, in writing of the name of each person who is a certified operator in direct charge of any water treatment plant, wastewater treatment plant, water

(Rule 0400-49-01-.04, continued)

distribution system or wastewater collection system it operates. A system shall notify the Division of Water Resources in writing within thirty (30) days of its loss of the services of a certified operator in direct charge.

(5) A certified operator shall be responsible for keeping the Board Secretary informed of his/her current address.

Authority: *T.C.A. §§ 4-5-201 et seq. and 68-221-901 et seq.* ***Administrative History:*** *Original rule filed May 21, 2014; effective August 19, 2014. Rule renumbered from 1200-05-03.*

0400-49-01-.05 DEFINITIONS.

(1) "Available" means that a certified operator must be on site or able to be contacted as needed to initiate the appropriate action in a timely manner, based on system size, complexity and the quality of either the source water or the receiving stream.

(2) "Board" means the board of certification as described in T.C.A. § 68-221-905.

(3) "Commissioner" and "Department" mean the Commissioner of the Tennessee Department of Environment and Conservation or his/her duly authorized representative.

(4) "Operating Shift" is that period of time during which operator decisions that affect public health are necessary for proper operation of the system.

(5) "Process control/system integrity decisions" means decisions regarding the manipulation of equipment, chemicals or processes that determine the quality and quantity of the water supplied by a water treatment plant or a water distribution system, or the quality of the effluent from a wastewater treatment plant or the integrity of a wastewater collection system.

(6) "Person in direct charge" as used in these rules means the person or persons expressly designated to be in direct charge and so named in writing to the Board's authorized representative by each water supply system and wastewater system, whose decisions and directions to system personnel control the manipulation of equipment and thereby determine the quality and quantity of the water supplied by a water treatment plant or a water distribution system, or the quality of the effluent from a wastewater treatment plant or the integrity of a wastewater collection system.

Authority: *T.C.A. §§ 4-5-201 et seq. and 68-221-901 et seq.* ***Administrative History:*** *Original rule filed May 21, 2014; effective August 19, 2014. Rule renumbered from 1200-05-03.*

0400-49-01-.06 CLASSIFICATION OF WATER TREATMENT PLANTS AND WATER DISTRIBUTION SYSTEMS.

(1) Water treatment plants shall be classified by the Board or its authorized representative into one of five groups, designated either as Small Water, Grade I, II, III, or IV. These classifications shall be made according to the number of population served, the type of treatment plant, and the complexity of treatment required for a particular water.

(2) The classification of a water treatment plant or a water distribution system may be changed by the Board or its authorized representative because of changes in the conditions or the circumstances upon which the original classification was based. Notice of such a classification change shall be given to the management officers of the plant or system.

(3) Types of Water Systems:

(Rule 0400-49-01-.08, continued)

Push-button or visual methods for simple tests such as pH, settleable solids ..... 3 pts.
Additional procedures such as DO, COD, BOD, gas analysis, titrations, solids, volatile content ..... 5 pts.
More advanced determinations such as specific nutrients, total oils, phenols, etc ..... 7 pts.
Highly sophisticated instrumentation such as atomic absorption and gas chromatography .....10 pts.

These terms describe the minimum level of effluent quality attainable for treated wastewater under standard design conditions in terms of the arithmetic mean of the values for effluent samples collected in a period of thirty (30) consecutive days for the following parameters: five-day biochemical oxygen demand (BOD_5); total suspended solids (TSS); and acidity/alkalinity (pH).

1. "Equivalent to secondary wastewater treatment" means the 30-day average for BOD_5 does not exceed 45 mg/l and there is no ammonia limit.

2. "Secondary wastewater treatment" means the 30-day average for BOD_5 does not exceed 30 mg/l and there is no ammonia limit.

3. "Advanced secondary wastewater treatment" means that the biochemical oxygen demand is expressed as the carbonaceous form ($CBOD_5$) that is equal to or greater than 10 mg/l and is equal to or less than 25 mg/l; and there is an ammonia limit.

4. "Tertiary wastewater treatment" means that the $CBOD_5$ is less than 10 mg/l and there is an ammonia limit.

(b) Grade I Collection System. This classification is for a wastewater collection system that uses collector and/or transmission lines to transport wastewater to a treatment plant and which serves no more than five thousand (5,000) service connections.

(c) Grade II Collection System. This classification is for a wastewater collection system that uses collector and/or transmission lines to transport wastewater to a treatment plant and which serves more than five thousand (5,000) service connections.

Authority: *T.C.A. §§ 4-5-201 et seq. and 68-221-901 et seq.* ***Administrative History:*** *Original rule filed May 21, 2014; effective August 19, 2014. Rule renumbered from 1200-05-03.*

0400-49-01-.09 CLASSIFICATIONS AND QUALIFICATIONS OF WASTEWATER TREATMENT PLANT OPERATORS AND WASTEWATER COLLECTION SYSTEM OPERATORS.

(1) (a) Grade IV Wastewater Treatment Plant Operator

Certification as an operator in this classification will be made only upon the satisfactory completion by the applicant of the requirements of either parts 1 or 2 of this subparagraph.

1. An applicant must have a bachelor degree in engineering, chemistry or a related science from an accredited college or university, must have twelve (12) months of operating experience at a Grade III or a Grade IV Wastewater Treatment plant, and must satisfactorily complete a written examination.

(Rule 0400-49-01-.09, continued)

Pumps
Lift stations
Valves
Lines and equipment
Pipeline installation
Service connection installation
Leak detection
TV crew activities
Line repairs
Line cleaning
Manhole maintenance
Pretreatment

(5) Summary of Wastewater Treatment Plant and Collection System Operator Education and Experience

Wastewater Treatment Plant Operators

Classification	Experience			Maximum Training or College Classwork Substitution	Maximum Related Work Substitution
	Experience needed with:	HS Education	BS Degree		
Grade IV	Gained at a Grade III or IV Wastewater Plant	*60 months	12 Months	36 Months	24 Months
*Regardless of the substitution allowances, a minimum of 1 year of actual work experience is required					
Grade III	Gained at a Grade II or III Wastewater Plant	12 Months		3 Months	
Grade II	Gained at a Grade I or II Wastewater Plant	12 Months		3 Months	
Grade I	Gained at a Grade I Wastewater Plant	12 Months		3 Months	
	Gained at Biological/Natural and Grade I Wastewater Plant	12 Months 6 Months			
Grade BNS	Gained at a BNS Wastewater Plant	12 Months		3 Months	

COLLECTION SYSTEM OPERATORS

Classification	Experience		Maximum Training or College Classwork Substitution	Maximum Related Work Substitution
	Experience needed with:	HS Education		
Grade II	Gained at a Collection I or II System	12 Months	3 Months	
Grade I	Gained at a Collection I or II System	12 Months	3 Months	

Authority: *T.C.A. §§ 4-5-201 et seq. and 68-221-901 et seq.* ***Administrative History:*** *Original rule filed May 21, 2014; effective August 19, 2014. Rule renumbered from 1200-05-03.*

0400-49-01-.10 CONTINUING EDUCATION.

At least once during every continuing education period each certified operator shall satisfactorily complete the required number of continuing education hours approved by the Board for the particular type of certificate he/she holds. The continuing education period for a certified operator shall begin either with the date the certified operator obtained his/her certificate or the date the certified operator last satisfactorily completed the required number of continuing education hours and shall end at the conclusion of the annual continuing education term three (3) calendar years thereafter. An annual continuing education

(Rule 0400-49-01-.10, continued)
term shall begin each year on October 1 and shall end on September 30 of the following year. The failure of an operator to satisfactorily complete the required number of continuing education hours approved by the Board Secretary during his/her continuing education period shall be grounds for the denial of his/her application for the renewal of his/her certificate. An operator shall notify the Board Secretary upon his/her satisfactory completion of the continuing education requirement by furnishing appropriate documentation of course completion. Notification by the operator is not necessary in those cases where an agency notifies the Board Secretary of such activity. An operator that fails to satisfactorily complete the required number of continuing education hours during his/her continuing education period due to an unusual event such as an incapacitating illness or similar unavoidable circumstances may make a written request to the Board for an extension of time to do so. All requests by an operator for an extension of time to meet the continuing education requirement must be made in writing to the Board either within two (2) months of the elapsed continuing education period or by the date of return of the operator to active employment, whichever is later. All such requests must be accompanied by complete supporting documentation of the circumstances causing the failure to meet the continuing education requirement.

Authority: *T.C.A. §§ 4-5-201 et seq. and 68-221-901 et seq.* ***Administrative History:*** *Original rule filed May 21, 2014; effective August 19, 2014. Rule renumbered from 1200-05-03.*

0400-49-01-.11 SUMMARY SUSPENSION AND REVOCATION OF CERTIFICATE.

(1) An operator's certificate may be revoked when:

(a) In accordance with paragraph (2) of this rule, an operator has not used reasonable care, judgment, or the application of his/her knowledge in the performance of his/her duties as a certified operator, or

(b) In accordance with paragraph (3) of this rule, an operator is incompetent to perform those duties properly; or

(c) In accordance with paragraph (4) of this rule, an operator has practiced fraud or deception.

(2) An operator shall be deemed to have not used reasonable care, judgment, or the application of his/her knowledge in the performance of his/her duties if he/she does not comply with the laws, rules, permit requirements, or orders of any governmental agency or court which govern the water supply system or the wastewater system he/she operates. Such acts of noncompliance include but are not limited to the following:

(a) The intentional or the negligent failure by the operator or persons under his/her supervision to act that results in a water supply system facility or a wastewater system facility not operating in the manner in which it is capable of being operated for the performance of its designed function.

(b) The intentional or the negligent failure by the operator or persons under his/her supervision to comply with the monitoring, sampling, analysis, or reporting requirements for a water supply system facility or a wastewater system facility.

(c) The intentional or the negligent unlawful discharge of wastes from a water supply system facility or a wastewater system facility.

(d) The intentional or the negligent failure by the operator or persons under his/her supervision to notify the Department of conditions: which may affect the quantity or quality of water being supplied to the customers of a water supply system; which cause the pollution of the waters of the State of Tennessee; or, which are violative of a standard of water quality promulgated by any governmental agency.

(Rule 0400-49-01-.11, continued)

(3) An operator shall be deemed to be incompetent to perform his/her duties properly when he/she does not possess the basic skills and knowledge necessary to operate a water supply system facility or a wastewater system facility including laboratory functions or if he/she fails to have a system of verification and oversight of employees under his/her charge. Incompetency shall be determined by examining the technical skills of the operator in operating the type of facility of which he/she is in direct charge.

(4) An operator shall be deemed to have practiced fraud or deception as follows:

(a) Obtained his/her certificate through fraud, deceit, or the submission of inaccurate data regarding his/her qualifications upon his/her application for a certificate.;

(b) Has practiced fraud or deception during the performance of his/her duties as a certified operator; or

(c) Has prepared and/or signed reports of laboratory analysis results for the system that:

1. Contain inaccurate data and are known or should be known by the operator to be false; or,

2. Contain inaccurate data because the operator has not used reasonable care, judgment, or the application of his/her knowledge either in the performance of the laboratory analysis or in the preparation of the laboratory analytical reports.

(5) Revocation

(a) The Commissioner may initiate the process to revoke a certificate when he/she believes an operator has engaged in any of the activities set forth in paragraph (1) of this rule.

(b) The Commissioner shall give notice by mail to the affected operator of facts or conduct that warrants revocation of the certificate and give the affected operator an opportunity to show compliance with these rules by conducting an informal hearing as provided in T.C.A. § 4-5-320(c).

(c) After the T.C.A. § 4-5-320(c) informal hearing, if the Commissioner determines that the affected operator has failed to demonstrate compliance, the Commissioner shall issue a notice of hearing for revocation and include a recommendation to the Board to revoke and reinstate or not to reinstate the certificate. Any recommendation of reinstatement of the certificate shall include terms for such reinstatement.

(d) The notice of hearing for revocation shall contain the information required by part 1 of this subparagraph and be served in accordance with part 2 of this subparagraph.

1. The notice shall include:

(i) A statement of the time, place, nature of the hearing, and the right to be represented by counsel;

(ii) A statement of the legal authority and jurisdiction under which the hearing is to be held, including a reference to the particular sections of the statute and rules involved; and

(Rule 0400-49-01-.11, continued)

(iii) A short and plain statement of the facts or conduct that warrant a revocation. (If the Commissioner is unable to state the matters in detail at the time the notice is served, the initial notice may be limited to a statement of the issues involved. Thereafter, upon timely, written application a more definite and detailed statement shall be furnished ten (10) days prior to the time set the hearing.)

2. A copy of the notice of hearing shall be:

(i) Served upon the operator no later than thirty (30) days prior to the hearing date; and

(ii) Served by personal service, return receipt mail or equivalent carrier with a return receipt,

A person making personal service on the operator affected shall return a statement indicating the time and place of service, and a return receipt must be signed by the operator affected. However, if the affected operator evades or attempts to evade service, service may be made by leaving the notice or a copy of the notice at the affected operator's dwelling house or usual place of abode with some person of suitable age and discretion residing therein, whose name shall appear on the proof of service or return receipt card. Service may also be made by delivering the notice or copy to an agent authorized by appointment or by law to receive service on behalf of the affected operator, or by any other method allowed by law in judicial proceedings.

(6) Summary Suspension and Revocation

(a) The Commissioner may initiate the process of summary suspension and revocation of the certificate when the Commissioner believes that an emergency action is needed to protect the public health, safety or welfare.

(b) The Commissioner shall give a notice to the affected operator by any reasonable means and shall inform the affected operator of the intended action, the acts or conduct that warrants summary suspension and revocation of the certificate and hold an informal hearing, as provided in T.C.A. § 4-5-320(d), to give the operator an opportunity to address the issue of whether there is an emergency.

(c) The Commissioner shall appoint a hearing officer to conduct this T.C.A. § 4-5-320(d) hearing and the hearing shall be recorded and transcribed.

(d) After the informal hearing as provided in T.C.A. § 4-5-320(d), if the Commissioner determines that an emergency action is warranted, the Commissioner shall issue an Order of Summary Suspension and a notice of hearing for revocation and include a recommendation to the Board to reinstate or not to reinstate the certificate. Any recommendation of reinstatement of the certificate shall include terms for such reinstatement.

(e) The Order of Summary Suspension and the notice for revocation shall contain the information required by part (5)(d)1 of this rule and be served in accordance with part (5)(d)2 of this rule.

(f) When the Commissioner has issued an Order of Summary Suspension and Notice of Revocation, the Board shall conduct its revocation hearing and render a decision within ninety (90) days of the operator's summary suspension. In the event the Board does

(Rule 0400-49-01-.11, continued)

not render its decision within ninety (90) days of the operator's summary suspension, the Order of Summary Suspension shall expire and no longer be in force or effect. However, the Commissioner may reissue an Order of Summary Suspension in accordance with this paragraph, for a period not to exceed ninety (90) days.

(7) The revocation hearing before the Board shall be held in accordance with T.C.A. §§ 4-5-301 et seq. and Rule Chapter 1360-04-01 Uniform Rules of Procedure for Hearing Contested Cases Before State Administrative Agencies.

(8) The Board may revoke the certificate of an operator when it is found that the operator has practiced fraud or deception; that reasonable care, judgment or the application of such operator's knowledge was not used in performance of such operator's duties; or that the operator is incompetent to properly perform such operator's duties. If the certificate is revoked and is to be reinstated, the Board shall determine the timing, terms and conditions for reinstatement.

(9) An operator who receives an order of the Board for the revocation of his/her certificate may appeal the order to the Chancery Court of Davidson County within sixty (60) days.

(10) An operator whose certificate is revoked for failure to use reasonable care, judgment or the application of operator knowledge in performing the operator's duties or for incompetency shall be ineligible to again apply for certification as an operator for a minimum of one (1) year. An operator whose certificate is revoked for practicing fraud or deception, willfully violating regulations or permit conditions, or falsifying records and reports shall be ineligible to again apply for certification as an operator for a minimum of five years. When an operator whose certificate has been revoked has applied for a certificate after the minimum time has passed, the Board shall determine whether the operator has taken appropriate action to address the circumstances that were the cause of the revocation. The Board may request records and review his/her experience, education, training and past performance. The Board may request the former operator's presence at a meeting of the Board and interview him/her to assess the potential of future violations. After the reviews, the Board shall decide to accept or refuse the application.

Authority: *T.C.A. §§ 4-5-201 et seq. and 68-221-901 et seq.* ***Administrative History:*** *Original rule filed May 21, 2014; effective August 19, 2014. Rule renumbered from 1200-05-03.*

0400-49-01-.12 CIVIL PENALTIES.

(1) The Commissioner may assess the civil penalty authorized by law against a municipality, utility district, corporation, or any person operating a water supply system or a wastewater system if the competency of the person in direct charge of a system facility has not first been certified in accordance with these rules.

(2) A certified operator may be assessed the civil penalty authorized by law for the same acts and omissions that would constitute grounds for the revocation of his/her certificate by the Board.

(3) Prior to issuing an order that assess a civil penalty, in accordance with paragraphs (1) and (2) of this rule the Commissioner may hold a show cause meeting with the person or entity to whom the order is proposed to be issued.

Authority: *T.C.A. §§ 4-5-201 et seq. and 68-221-901 et seq.* ***Administrative History:*** *Original rule filed May 21, 2014; effective August 19, 2014. Rule renumbered from 1200-05-03.*

RULES
OF
TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

DIVISION OF WATER RESOURCES

CHAPTER 0400-45-01
PUBLIC WATER SYSTEMS

TABLE OF CONTENTS

0400-45-01-.01 AUTHORITY.

(1) These rules and regulations are issued under the authority of Public Acts of 1983, Chapter 324.

(2) The Division of Water Supply is responsible for the supervision of public water systems.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.02 PURPOSE.

(1) The purpose of these rules and regulations is to provide guidelines for the interpretation of T.C.A. § 68-221-701 et seq. and to set out the procedures to be followed by the Department in carrying out the Department's primary enforcement responsibility under the Federal Safe Drinking Water Act. These rules and regulations set out the requirements which agents, employees or representatives of public water systems must meet in the following areas: in the preparation and submission of plan documents for public water systems; in the supervision of all phases of construction; in supplying safe drinking water meeting all applicable maximum contaminant levels or treatment technique requirements; in providing

(Rule 0400-45-01-.02, continued)

adequate operation and maintenance of the system; and in complying with procedural requirements for appealing orders issued by the Commissioner of the Tennessee Department of Environment and Conservation against a public water system.

(2) Where the terms “shall” and “must” are used, practice and usage is sufficiently standardized to indicate a mandatory requirement, insofar as any complaint action by the Department is concerned. Other items, such as should, recommend, preferred, and the like, indicate desirable procedures or methods.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.03 SCOPE.

These rules will apply to all public water supply systems that provide water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen (15) service connections or regularly serves an average of at least twenty-five (25) individuals daily at least sixty (60) days out of the year. A public water supply system is either a community water system or a non-community water system. A community water system is a public water supply system which serves at least fifteen (15) service connections used by year-round residents or regularly serves at least twenty-five (25) year-round residents. A non-community water system is a public water supply system that is not a community water system and which generally serves a transient population such as hotels, motels, restaurants, camps, service stations churches, industry, etc. A Non-Transient Non-Community Water System is a non-community water system that regularly serves at least 25 of the same persons over six (6) months per year. These rules do not apply to public water systems which meet all of the following criteria:

(1) consists only of distribution and storage facilities (and does not have any collection and treatment facilities);

(2) obtains all of its water from, but is not owned or operated by, a public water system to which such regulations apply;

(3) does not sell water to any person; and

(4) is not a carrier which conveys passengers in interstate commerce.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.04 DEFINITIONS.

(1) "Action level" is the concentration of lead or copper in water which may determine the treatment requirements that a water system is required to complete.

(2) “Bag Filters” are pressure-driven separation devices that remove particulate matter larger than 1 micrometer using an engineered porous filtration media. They are typically constructed on a non-rigid fabric filtration media housed in a pressure vessel in which the direction of flow is from the inside of the bag to outside.

(3) “Bank Filtration” is a water treatment process that uses a well to recover surface water that has naturally infiltrated into ground water through a river bed or bank(s). Infiltration is typically enhanced by the hydraulic gradient imposed by nearby pumping water supply or other wells.

(Rule 0400-45-01-.04, continued)

(4) “Benchmark” A disinfection benchmark is the lowest monthly average value of the monthly logs of Garidia Lamblia inactivation.

(5) “Business Plan” means a document which identifies source(s) of income or revenue sufficient to meet expenses over a three (3) year period. The business plan will identify costs related to retaining a certified operator, estimated annual infrastructure repair costs, depreciation, facility maintenance fees, estimated annual monitoring costs, estimated costs of providing public notices, estimated administrative costs, and any and all other operational, treatment, and related costs (e.g. chemicals and other supplies used to treat water, etc.). The business plan must include the re-payment of borrowed and amortized funds.

(6) “Capacity Development Plan” means a document(s) identifying what actions a public water system is taking or shall take to become a “viable water system.” Such plan shall include information concerning retention of a Certified Operator in direct charge; system ownership and accountability; staffing and organizational structure; fiscal management and controls, source water assessment and protection plan; “business plan;” and any and all other information identifying any further action that shall be taken.

(7) “Cartridge filters” are pressure-driven separation devices that remove particulate matter larger than 1 micrometer using an engineered porous filtration media. They are typically constructed a rigid or semi-rigid self-supporting filter elements housed in pressure vessels in which flow is from the outside of the cartridge to the inside.

(8) "Clean compliance history” is, for the purposes of Rule 0400-45-01-.41, a record of no MCL violations under paragraph (4) of Rule 0400-45-01-.06; no monitoring violations under Rule 0400-45-01-.07 or Rule 0400-45-01-.41; and no coliform treatment technique trigger exceedances or treatment technique violations under Rule 0400-45-01-.41.

(9) “Coagulation” means a process using coagulant chemicals and mixing by which colloidal and suspended materials are destabilized and agglomerated into flocs.

(10) "Combined distribution system” is the interconnected distribution system consisting of the distribution systems of wholesale systems and of the consecutive systems that receive finished water.

(11) "Community Water System" means a public water system which serves at least fifteen (15) service connections used by year round residents or regularly serves at least twenty five (25) year round residents.

(12) "Compliance cycle" means the nine year calendar year cycle during which public water systems must monitor for certain contaminants. Each compliance cycle consists of three three year compliance periods. The first calendar year cycle begins January 1, 1993 and ends December 31, 2001; the second begins January 1, 2002 and ends December 31, 2010; the third begins January 1, 2011 and ends December 31, 2019.

(13) “Compliance period" means a three year calendar year period within a compliance cycle. Each compliance cycle has three three year compliance periods. Within the first compliance cycle, the first compliance period runs from January 1, 1993 to December 31, 1995; the second from January 1, 1996 to December 31, 1998; the third from January 1, 1999 to December 31, 2001.

(14) "Comprehensive performance evaluation (CPE)” is a thorough review and analysis of a treatment plant’s performance based capabilities and associated administrative, operation and maintenance practices. It is conducted to identify factors that may be adversely impacting a plant’s capability to achieve compliance and emphasizes approaches that can be implemented without significant capital improvements. For purposes of compliance, the

(Rule 0400-45-01-.04, continued)

comprehensive performance evaluation must consist of at least the following components: assessment of plant performance; evaluation of major unit processes; identification and prioritization of performance limiting factors; assessment of the applicability of comprehensive technical assistance; and preparation of a CPE report.

(15) "Confluent growth" means a continuous bacterial growth covering the entire filtration area of a membrane filter, or a portion thereof, in which bacterial colonies are not discrete.

(16) “Connection” means the point at which there is a meter or service tap if no meter is present.

(17) "Consecutive system is a public water system that receives some or all of its finished water from one or more wholesale systems. Delivery may be through a direct connection or through the distribution system of one or more consecutive systems.

(18) "Contaminant” means any physical, chemical, biological, or radiological substance or matter in water.

(19) "Conventional filtration treatment" means a series of processes including coagulation, flocculation, sedimentation, and filtration resulting in substantial particulate removal.

(20) "Corrosion inhibitor" means a substance capable of reducing the corrosivity of water toward metal plumbing materials, especially lead and copper, by forming a protective film on the interior surface of those materials.

(21) "CT" or "CTcalc" is the product of "residual disinfectant concentration" (C) in mg/1 determined before or at the first customer, and the corresponding "disinfectant contact time" (T) in minutes, i.e., "C" x "T". If a public water system applies disinfectants at more than one point prior to the first customer, it must determine the CT of each disinfectant sequence before or at the first customer to determine the total percent inactivation or "total inactivation ratio". In determining the total inactivation ratio, the public water system must determine the residual disinfectant concentration of each disinfection sequence and corresponding contact time before any subsequent disinfection application point(s). "CT99.9" is the CT value required for 99.9 percent (3 log) inactivation of Giardia lamblia cysts. CT99.9 for a variety of disinfectants and conditions appear in Tables 1.1 through 1.6, 2.1, and 3.1 of part (5)(b)3 of Rule 0400-45-01-.31.

$$\frac{CTcalc}{CT_{99.9}}$$

is the inactivation ratio. The sum of the inactivation ratios, or total inactivation ratio shown as

$$\sum \frac{(CTcalc)}{(CT_{99.9})}$$

is calculated by adding together the inactivation ratio for each disinfection sequence. A total inactivation ratio equal to or greater than 1.0 is assumed to provide a 3 log inactivation of Giardia lamblia cyst. Disinfectant concentrations must be determined by tracer studies or an equivalent demonstration approved by the Department.

(22) "Department” when used in these regulations shall mean the Division of Water Supply, Tennessee Department of Environment and Conservation, or one of the Division's Field Offices.

(23) "Diatomaceous earth filtration" means a process resulting in substantial particulate removal in which (1) a precoat cake of diatomaceous earth filter media is deposited on a support membrane (septum), and (2) while the water is filtered by passing through the cake on the

(Rule 0400-45-01-.04, continued)

septum, additional filter media known as body feed is continuously added to the feed water to maintain the permeability of the filter cake.

(24) "Direct filtration" means a series of processes including coagulation and filtration but excluding sedimentation resulting in substantial particulate removal.

(25) "Disinfectant" means any oxidant, including but not limited to chlorine, chlorine dioxide, chloramines, and ozone added to water in any part of the treatment or distribution process, that is intended to kill or inactivate pathogenic microorganisms.

(26) "Disinfectant contact time" ("T" in CT calculations) means the time in minutes that it takes for water to move from the point of disinfectant application or the previous point of disinfectant residual measurement to a point before or at the point where residual disinfectant concentration ("C") is measured. Where only one "C" is measured, "T" is the time in minutes that it takes for water to move from the point of disinfectant application to a point before or at where residual disinfectant concentration ("C") is measured. Where more than one "C" is measured, "T" is (a) for the first measurement of "C", the time in minutes that it takes for water to move from the first or only point of disinfectant application to a point before or at the point where the first "C" is measured and (b) for subsequent measurements of "C", the time in minutes that it takes for water to move from the previous "C" measurement point to the "C" measurement point for which the particular "T" is being calculated. Disinfectant contact time in pipelines must be calculated based on "plug flow" by dividing the internal volume of the pipe by the maximum hourly flow rate through that pipe. Disinfectant contact time within mixing basins and storage reservoirs must be determined by tracer studies or an equivalent demonstration.

(27) "Disinfection" means a process which inactivates pathogenic organisms in water by chemical oxidants or equivalent agents.

(28) "Disinfection profile" is a summary of daily Giardia lamblia inactivation through the treatment plant. The procedure for developing a disinfection profile is contained in 40 CFR 141.172.

(29) "Distribution System" means all water lines up to the point of a meter. For unmetered systems distribution system includes all lines up to the customer's service tap.

(30) "Domestic or other non distribution system plumbing problem" means a coliform contamination problem in a public water system with more than one service connection that is limited to the specific service connection from which the coliform positive sample was taken.

(31) "Dose Equivalent" means the product of the absorbed dose from ionizing radiation and such factors as account for differences in biological effectiveness due to the type of radiation and its distribution in the body as specified by the International Commission on Radiological Units and Measurements (ICRU).

(32) "Dual sample set" is a set of two samples collected at the same time and same location, with one sample analyzed for TTHM and the other sample analyzed for HAA5. Dual sample sets are collected for the purposes of conducting an IDSE under the provisions of Rule 0400-45-01-.37 and determining compliance with the TTHM and HAA5 MCLs under the provisions of Rule 0400-45-01-.38.

(33) "Effective corrosion inhibitor residual" for the purpose of the lead and copper rules only, means a concentration sufficient to form a passivating film on the interior walls of a pipe.

(34) "Engineer" means the person or firm who designed the public water system and conceived, developed, executed or supervised the preparation of the plan documents.

(Rule 0400-45-01-.04, continued)

(35) “Enhanced coagulation” means the addition of sufficient coagulant for improved removal of disinfection byproduct precursors by conventional filtration treatment.

(36) “Enhanced softening” means the improved removal of disinfection byproduct precursors by precipitative softening.

(37) "Filter profile” is a graphical representation of individual filter performance, based on continuous turbidity measurements or total particle counts versus time for an entire filter run, from startup to backwash inclusively, that includes an assessment of filter performance while another filter is being backwashed.

(38) “Filtration” means a process for removing particulate matter from water by passage through porous media.

(39) "Finished water” is water that is introduced into the distribution system of a public water system and is intended for distribution and consumption without further treatment, except as treatment necessary to maintain water quality in the distribution system (e.g., booster disinfection, addition of corrosion control chemicals).

(40) “First draw sample" means a one liter sample of tap water, for the purposes of the lead and copper rules, that has been standing in plumbing pipes at least 6 hours and is collected without flushing the tap.

(41) “Flooculation” means a process to enhance agglomeration or collection of smaller floc particles into larger, more easily settleable particles through gentle stirring by hydraulic or mechanical means.

(42) “Flowing stream” is a course of running water flowing in a definite channel.

(43) “GAC10” means granular activated carbon filter beds with an empty-bed contact time of 10 minutes based on average daily flow and a carbon reactivation frequency of every 180 days, except that the reactivation frequency for GAC10 used as best available technology for compliance with disinfection byproducts shall be 120 days.

(44) "GAC20” means granular activated carbon filter beds with an empty-bed contact time of 20 minutes based on average daily flow and a carbon reactivation frequency of every 240 days.

(45) "Gross Alpha Particle Activity" means the total radioactivity due to alpha particle emission as inferred from measurements on a dry sample.

(46) “Gross Beta Particle Activity" means the total radioactivity due to beta particle emission as inferred from measurements on a dry sample.

(47) “Ground water under the direct influence of surface water” means any water beneath the surface of the ground with significant occurrence of insects or other macroorganisms, 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 Department. The Department 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.

(48) "Haloacetic acids (five) (HAA5)” mean the sum of the concentrations in milligrams per liter of the haloacetic acid compounds (monochloroacetic acid, dichloroacetic acid, trichloroacetic

(Rule 0400-45-01-.04, continued)

acid, monobromoacetic acid, and dibromoacetic acid), rounded to two significant figures after addition.

(49) “Halogen” means one of the chemical elements chlorine, bromine or iodine.

(50) "Human Consumption” - means the use of water that involves any drinking or ingestion of the water by humans, any human skin contact or food preparation where the food is not brought to boiling temperatures after contact with the water.

(51) “Initial compliance period" means the first full three year compliance period which begins January 1, 1993. For public water systems having fewer than 150 service connections initial compliance period shall be January 2, 1996, for the following contaminants:

(a)	Antimony	(m)	endrin
(b)	Beryllium	(n)	glyphosate
(c)	Cyanide	(o)	oxamyl
(d)	Nickel	(p)	picloram
(e)	Thallium	(q)	simazine
(f)	dichloromethane	(r)	benzo(a)pyrene
(g)	1,2,4-trichlorobenzene	(s)	di(2ethylhexyl)adipate
(h)	1,1,2-trichloroethane	(t)	di(2ethylhexyl)phthalate
(i)	dalapon	(u)	hexachlorobenzene
(j)	dinoseb	(v)	hexachlorocyclopentadiene
(k)	diquat	(w)	2,3,7,8 TCDD
(l)	endothall		

(52) "Lake/reservoir” refers to a natural or man-made basin or hollow on the earth’s surface in which water collects or is stored that may or may not have a current or single direction of flow.

(53) "Large water system" for the purpose of lead and copper rule, means a water system that serves more than 50,000 persons.

(54) "Lead service line" means a service line made of lead which connects the water main to the building inlet and any lead pigtail, gooseneck or other fitting which is connected to such lead line.

(55) “Legionella” means a genus of bacteria, some species of which have caused a type of pneumonia called Legionnaires Disease.

(56) "Level 1 assessment” is an evaluation to identify the possible presence of sanitary defects, defects in distribution system coliform monitoring practices, and (when possible) the likely reason that the system triggered the assessment. It is conducted by the system operator or owner. Minimum elements include review and identification of atypical events that could affect distributed water quality or indicate that distributed water quality was impaired; changes in distribution system maintenance and operation that could affect distributed water quality (including water storage); source and treatment considerations that bear on distributed water quality, where appropriate (e.g., whether a ground water system is disinfected); existing water quality monitoring data; and inadequacies in sample sites, sampling protocol, and sample processing. The system must conduct the assessment consistent with any Department directives that tailor specific assessment elements with respect to the size and type of the system and the size, type, and characteristics of the distribution system.

(57) "Level 2 assessment” is an evaluation to identify the possible presence of sanitary defects, defects in distribution system coliform monitoring practices, and (when possible) the likely

(Rule 0400-45-01-.04, continued)

reason that the system triggered the assessment. A Level 2 assessment provides a more detailed examination of the system (including the system's monitoring and operational practices) than does a Level 1 assessment through the use of more comprehensive investigation and review of available information, additional internal and external resources, and other relevant practices. It is conducted by an individual approved by the Department, which may include the system operator. Minimum elements include review and identification of atypical events that could affect distributed water quality or indicate that distributed water quality was impaired; changes in distribution system maintenance and operation that could affect distributed water quality (including water storage); source and treatment considerations that bear on distributed water quality, where appropriate (e.g., whether a ground water system is disinfected); existing water quality monitoring data; and inadequacies in sample sites, sampling protocol, and sample processing. The system must conduct the assessment consistent with any Department directives that tailor specific assessment elements with respect to the size and type of the system and the size, type, and characteristics of the distribution system. The system must comply with any expedited actions or additional actions required by the Department in the case of an E. coli MCL violation.

(58) "Locational running annual average (LRAA)" is the average of sample analytical results for samples taken at a particular monitoring location during the previous four calendar quarters.

(59) "Man-Made Beta Particle and Photon Emitter" means all radionuclides emitting beta particles and/or photons listed in "Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure, NBS Handbook 69", except the daughter products of thorium 232, uranium 235 and uranium 238..

(60) "Maximum Contaminant Level" means the maximum permissible level of a contaminant in water which is delivered at the free flowing outlet of the ultimate user of a public water system, except in the case of turbidity where the maximum permissible level is measured at the point of entry to the distribution system. Contaminants added to the water under circumstances controlled by the user, except those resulting from corrosion of piping and plumbing caused by water quality, are excluded from this definition.

(61) "Maximum contaminant level goal" or "MCLG" means that the maximum level of the contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety. Maximum contaminant level goals are non-enforceable health goals.

(62) "Maximum residual disinfectant level (MRDL)" means a level of a disinfectant added for water treatment that may not be exceeded at the consumer's tap without an unacceptable possibility of adverse health effects. For chlorine and chloramines, a PWS is in compliance with the MRDL when the running annual average of monthly averages of samples taken in the distribution system, computed quarterly, is less than or equal to the MRDL. For chlorine dioxide, a PWS is in compliance with the MRDL when daily samples are taken at the entrance to the distribution system and no two consecutive daily samples exceed the MRDL. MRDLs are enforceable in the same manner as maximum contaminant levels under Section 1412 of the Safe Drinking Water Act. There is convincing evidence that addition of a disinfectant is necessary for control of waterborne microbial contaminants. Notwithstanding the MRDLs, operators may increase residual disinfectant levels of chlorine or chloramines (but not chlorine dioxide) in the distribution system to a level and for a time necessary to protect public health to address specific microbiological contamination problems caused by circumstances such as distribution line breaks, storm runoff events, source water contamination, or cross-connections.

(63) "Maximum Total Trihalomethane Potential (MTP)" means the maximum concentration of total trihalomethanes produced in a given water containing a disinfectant residual after 7 days at a temperature of 25°C or above.

(64) "Medium- size water system" for the purpose of the lead and copper rule means a water system that serves greater than 3,300 and less than or equal to 50,000 persons.

(65) "Membrane filtration" is a pressure or vacuum driven separation process in which particulate matter larger than 1 micrometer is rejected by an engineered barrier, primarily through a size exclusion mechanism, and which has a measurable removal efficiency of a target organism that can be verified through the application of a direct integrity test. This definition includes the common membrane technologies of microfiltration, ultrafiltration, nanofiltration, and reverse osmosis.

(66) "Near the first service connection" means at one of the twenty percent of all service connections in the entire system that are nearest the water supply treatment facility, as measured by the water transport time within the distribution system.

(67) "Non-Community Water System" means a public water system that is not a community water system. A non-community water system is either a "transient non-community water system" (TNCWS) or a "non-transient non-community water system" (NTNCWS).

(68) "Non-Transient Non-Community Water System" or NTNCWS" means a non-community water system that regularly serves at least twenty five (25) of the same persons over six (6) months per year.

(69) "Optimal corrosion control treatment" for the purpose of lead and copper rule only means the corrosion control treatment that minimizes the lead and copper concentrations at user's taps while insuring that the treatment does not cause the water system to violate any primary drinking water regulation.

(70) "Person" means any individual, corporation, company, association, partnership, State, municipality, utility district, water cooperative, or Federal agency.

(71) "Picocurie" (pCi) means that quantity of radioactive material producing 2.22 nuclear transformations per minute.

(72) "Plan Documents" mean reports, proposals, preliminary plans, survey and basis of design data, general and detailed construction plans, profiles, specifications and all other information pertaining to public water system planning.

(73) "Plant intake" refers to the works or structures at the head of a conduit through which water is diverted from a source (e.g., river or lake) into the treatment plant.

(74) "Point of disinfectant application" is the point where the disinfectant is applied and water downstream of that point is not subject to recontamination by surface water runoff.

(75) "Point-of-Entry Treatment Device" (POE) means a device applied to the drinking water entering a house or building for the purpose of reducing contaminants in the drinking water distributed throughout the house or building.

(76) "Point-of-Use Treatment Device" (POU) means a treatment device applied to a single tap used for the purpose of reducing contaminants in drinking water at that one tap.

(77) "Presedimentation" is a preliminary treatment process used to remove gravel, sand and other particulate material from the source water through settling before the water enters the primary clarification and filtration processes in a treatment plant.

(Rule 0400-45-01-.04, continued)

(78) "Primary Drinking Water Regulation" means a regulation promulgated by the Department which:

(a) applies to public water systems;

(b) specifies contaminants which, in the judgment of the Department, may have any adverse effect on the health of persons;

(c) specified for each such contaminant either;

1. a maximum contaminant level, if, in the judgment of the Department, it is economically and technologically feasible to ascertain the level of such contaminant in water in public water systems, or

2. if, in the judgment of the Department, it is not economically or technologically feasible to so ascertain the level of such contaminant, each treatment technique known to the Department which leads to a reduction in the level of such contaminant sufficient to satisfy the requirements of Rule 0400-45-01-.06; and

(d) contains criteria and procedures to assure a supply of drinking water which dependably complies with such maximum contaminant levels; or treatment techniques including quality control and testing procedures to insure compliance with such levels and to insure proper operation and maintenance of the system, and requirements to (i) the minimum quality of water which may be taken into the system and (ii) siting for new facilities for public water systems.

(79) “Public Water System” means a system for the provision of piped water for human consumption if such serves 15 or more connections or which regularly serves 25 or more individuals daily at least 60 days out of the year and includes:

(a) any collection, treatment, storage or distribution facility under control of the operator of such system and used primarily in connection with such system; and

(b) any collection or pre-treatment storage facility not under such control which is used primarily in connection with such system,

The population of a water system shall be determined by actual count or by multiplying the household factor by the number of connections in the system. The household factor shall be taken from the latest federal census for that county or city. Water systems serving multi-family residences such as apartment complexes and mobile home parks shall include each individual residence unit as a connection in determining the population for the system.

(80) "Rem" means the unit of dose equivalent from ionizing radiation to the total body or any internal organ or organ system. A "millerem (mrem)" is 1/1000 of a rem.

(81) "Repeat compliance period" means any subsequent compliance period after the initial compliance period.

(82) "Residual disinfectant concentration" ("C" in CT calculations) means the concentration of disinfectant measured in mg/l in a representative sample of water.

(83) "Safe Drinking Water Act" means the Federal law codified in 42 United States Code 300f et seq., Public Law 93 523, dated December 16, 1974 and subsequent amendments.

(Rule 0400-45-01-.04, continued)

(84) "Sanitary defect" is a defect that could provide a pathway of entry for microbial contamination into the distribution system or that is indicative of a failure or imminent failure in a barrier that is already in place.

(85) "Sanitary Survey" means an on-site review of the water source, facilities, equipment, operation and maintenance of a public water system for the purpose of evaluating the adequacy of such sources, facilities, equipment, operation and maintenance for producing and distributing safe drinking water.

(86) "Seasonal system" is a non-community water system that is not operated as a public water system on a year-round basis and starts up and shuts down at the beginning and end of each operating season.

(87) "Secondary Drinking Water Regulation" mean a regulation promulgated by the Department which applies to public water systems and which specifies the maximum contaminant levels which, in the judgment of the Department are requisite to protect the public welfare. Such regulations may apply to any contaminant in drinking water

(a) which may adversely affect the odor or appearance of such water and consequently may cause the persons served by the public water system providing such water to discontinue its use, or

(b) which may otherwise adversely affect the public welfare. Such regulations may vary according to geographic and other circumstances.

(88) "Sedimentation" means a process for removal of solids before filtration by gravity or separation.

(89) "Service line sample" means a one liter sample of water collected in accordance with part (7)(b)3 of Rule 0400-45-01-.33, that has been standing for at least 6 hours in a service line.

(90) "Single family structure" for the purpose of lead and copper rules means a building constructed as a single family residence that is currently used as either a residence or a place of business.

(91) "Slow sand filtration" means a process involving passage of a raw water through a bed of sand at low velocity (generally less than 0.4 m/h) resulting in substantial particulate removal by physical and biological mechanisms.

(92) "Small water system" for the purpose of the lead and copper rules only, means a water system that serves 3,300 or fewer persons.

(93) "Subpart H systems" means public water systems using surface water or ground water under the direct influence of surface water as a source that are subject to the requirements of Rules 0400-45-01-.17, 0400-45-01-.31 and 0400-45-01-.39.

(94) "Supplier of Water" means any person who owns or operates a public water system.

(95) "Surface water" means all water which is open to the atmosphere and subject to surface runoff.

(96) "SUVA" means Specific Ultraviolet Absorption at 254 nanometers (nm), an indicator of the humic content of water. It is a calculated parameter obtained by dividing a sample's ultraviolet absorption at a wavelength of 254 nm (UV 254/ (in m) by its concentration of dissolved organic carbon (DOC) (in mg/L).

(Rule 0400-45-01-.04, continued)

(97) "System with a single service connection" means a system which supplies drinking water to consumers via a single service line.

(98) "Too numerous to count" means that the total number of bacterial colonies exceeds 200 on a 47 millimeter diameter membrane filter used for coliform detection.

(99) “Total Organic Carbon” (TOC) means total organic carbon in mg/L measured using heat, oxygen, ultraviolet irradiation, chemical oxidants, or combinations of these oxidants that convert organic carbon to carbon dioxide, rounded to two significant figures.

(100) "Total trihalomethane" (TTHM) means the sum of concentration in milligrams per liter of the trihalomethane compounds trihalomethane (chloroform), dibromochloromethane, bromodichloro-methane and tribomomethane (bromoform), rounded to two significant figures.

(101) “Transient Non-Community Water System” or “TNCWS” means a non-community water system that regularly serves at least twenty-five (25) individuals daily at least sixty (60) days out of the year. A transient non community water system is a public water supply system that generally serves a transient population such as hotels, motels, restaurants, camps, service stations churches, industry, and rest stops.

(102) "Trihalomethane" (THM) means one of the family of organic compounds, named as derivatives of methane, wherein three of the four hydrogen atoms in methane are each substituted by a halogen atom in the molecular structure.

(103) “Two-stage lime softening” is a process in which chemical addition and hardness precipitation occur in each of two distinct unit clarification processes.

(104) “Uncovered finished water storage facility” is a tank, reservoir, or other facility used to store water that will undergo no further treatment except residual disinfection and is open to the atmosphere.

(105) “Viable Water System” means a public water system which has the commitment and the financial, managerial and technical capacity to consistently comply with the Tennessee Safe Drinking Water Act and these regulations.

(106) "Virus" means a virus of fecal origin which is infectious to humans by waterborne transmission.

(107) “Waterborne disease outbreak" means a significant occurrence of acute infectious illness, epidemiologically associated with the ingestion of water from a public water system which is deficient in treatment, as determined by the appropriate local or State agency.

(108) “Wholesale system” is a public water system that treats source water as necessary to produce finished water and then delivers some or all of that finished water to another public water system. Delivery may be through a direct connection or through the distribution system of one or more consecutive systems.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01. Amendments and new rules filed November 24, 2015; effective February 22, 2016.*

0400-45-01-.05 SUPERVISION OF DESIGN AND CONSTRUCTION.

(1) Engineering - Plan documents for public water systems shall be submitted to the Department at least thirty (30) days prior to the date on which action by the Department is desired.

(Rule 0400-45-01-.05, continued)

(13) Delegation of Plans Review Authority – Under T.C.A § 68-221-706, any unit of local government may petition the Commissioner for certification to review and approve plans for water distribution facilities within its jurisdiction. The unit of local government must have adequate experience and expertise in water distribution and must adopt standards and impose requirements which are at least as stringent as the Department's. The request for certification must be in writing and contain at least the following:

(a) The names of the individual(s) responsible for the review and approval together with his/her experience and education. This person(s) must be employed by the unit of local government and be a registered professional engineer in Tennessee.

(b) A copy of the standards, requirements and design criteria legally adopted and enforceable by the unit of local government.

(c) The type of projects the unit of local government wishes to receive certification to review. This may include but is not limited to water lines, distribution pumping stations and distribution storage tanks.

(d) Procedures for maintaining records of all projects reviewed and approved by the unit of local government.

(e) The wording to be used on the approval stamp.

(f) Plans review authority fee.

The Division of Water Supply will be responsible for reviewing the application for certification and shall have up to 60 days from the receipt of the complete application to make a written response. Units of local government will not be certified to review projects involving state or federal funds, raw water pump stations, new water sources, treatment facilities, sludge handling facilities, or any project designed by the staff of the local government. Any unit of local government which receives certification for plans review shall submit one copy of any plan documents it has approved to the Division of Water Supply. This shall be done within 10 days of the local government's approval. The commissioner may periodically review the unit of local government's plans review program and prescribe changes as deemed appropriate. The Division of Water Supply may execute a written agreement with a unit of local government which has received plans review certification. Failure to comply with the terms of the agreement may result in revocation of the plans review certification.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.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.

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

CONTAMINANT	LEVEL, MILLIGRAMS PER LITER

(Rule 0400-45-01-.06, continued)

1.	Antimony	0.006
2.	Arsenic	0.010
3.	Asbestos	7 million fibers/liter (longer than 10 microns)
4.	Beryllium	0.004
5.	Barium	2.0
6.	Cadmium	0.005
7.	Chromium	0.1
8.	Cyanide (as free cyanide)	0.2
9.	Fluoride	4.0
10.	Mercury	0.002
11.	Nickel	0.1
12.	Nitrate	10.0 (as Nitrogen)
13.	Nitrite	1.0 (as Nitrogen)
14.	Total nitrate and nitrate	10.0 (as Nitrogen)
15.	Selenium	0.05
16.	Thallium	0.002

(2) Organic Chemicals - The following are the maximum contaminant levels for organic chemicals.

(a) The following maximum contaminant levels for organic contaminants apply to community water systems and non-transient non-community water systems. The maximum contaminant levels for volatile organic chemicals are given in paragraph (2) of Rule 0400-45-01-.25.

	CONTAMINANT	LEVEL, MILLIGRAMS PER LITER
1.	Alachlor	0.002
2.	Atrazine	0.003
3.	Carbofuran	0.04
4.	Chlordane	0.002
5.	Dibromo chloropropane (DBCP)	0.0002
6.	2,4 Dichlorophenoxyacetic acid	0.07
7.	Ethylene dibromide	0.00005
8.	Heptachlor	0.0004
9.	Heptachlor epoxide	0.0002
10.	Lindane	0.0002
11.	Methoxychlor	0.04
12.	Polychlorinated biphenyls	0.0005
13.	Toxaphene	0.003
14.	2,4,5 Trichlorophenoxyproprionic acid	0.05
15.	Pentachlorophenol	0.001
16.	Benzo(a)pyrene	0.0002
17.	Dalapon	0.2
18.	Di(2-ethylhexyl) adipate	0.4
19.	Di(2-ethylhexyl)phthalate	0.006
20.	Dinoseb	0.007
21.	Diquat	0.02
22.	Endothall	0.1
23.	Glyphosate	0.7
24.	Hexachlorobenzene	0.001
25.	Hexachlorocyclopentadiene	0.05
26.	Oxamyl (Vydate)	0.2
27.	Picloram	0.5
28.	Simazine	0.004

(Rule 0400-45-01-.06, continued)

29.	2,3,7,8-TCDD (Dioxin)	0.00000003
30.	Endrin	0.002

(3) Turbidity - The requirements of paragraph (3) of Rule 0400-45-01-.06 apply to filtered surface systems until June 29, 1993. The requirements in this paragraph apply to unfiltered systems that the Department has determined, in writing, must install filtration until June 29, 1993, or until filtration is installed, whichever is later.

The maximum contaminant level for turbidity is applicable to public water systems using surface water source(s) in whole or in part. Furthermore, the maximum contaminant level for turbidity is applicable to those systems using ground water which are required to install turbidimeters pursuant to paragraph (11) of Rule 0400-45-01-.05. The maximum contaminant levels for turbidity in drinking water, measured at a representative entry point(s) to the distribution system are:

(a) One (1.0) turbidity unit, as determined by monthly average pursuant to Rule 0400-45-01-.08.

(b) Two (2.0) turbidity units based on an average for two consecutive days pursuant to Rule 0400-45-01-.08.

To meet the maximum contaminant level for turbidity, a public water system must meet both subparagraphs (a) and (b) of this paragraph.

(4) Microbiological - The maximum contaminant levels for microbiologicals are applicable to both community water systems and non-community water systems.

(a) Until March 31, 2016, the total coliform maximum contaminant level (MCL) is based on the presence or absence of total coliforms in a sample, rather than coliform density. Beginning April 1, 2016, the MCL for total coliform shall no longer be in effect.

The number of total coliform positive samples shall not exceed any of the following:

1. For a system which collects at least 40 samples per month, if no more than 5.0 percent of the samples collected during a month are total coliform-positive, the system is in compliance with the MCL for total coliforms.

2. For a system which collects fewer than 40 samples/month, if no more than one sample collected during a month is total coliform-positive, the system is in compliance with the MCL for total coliforms.

3. A public water system which has exceeded the MCL for total coliforms must report the violation to the Department no later than the end of the next business day after it learns of the violation and notify the public in accordance with the schedule of Rule 0400-45-01-.19 using the language specified in Rule 0400-45-01-.19.

4. A public water system which has failed to comply with the coliform monitoring requirements, including a sanitary survey requirement must report the monitoring violation to the Department within ten (10) days after the system discovers the violation and notify the public in accordance with Rule 0400-45-01-.19.

(b) Until March 31, 2016, any fecal coliform-positive repeat sample or E. coli-positive repeat sample, or any total coliform-positive repeat sample following a fecal coliform-positive or E. coli-positive routine sample, constitutes a violation of the MCL for total

(Rule 0400-45-01-.06, continued)

coliforms. For purposes of the public notification requirements in Rule 0400-45-01-.19, this is a violation that may pose an acute risk to health.

(c) Fecal coliforms/Escherichia coli (E. coli) testing

1. If any routine or repeat sample is total coliform-positive, the system must analyze that total coliform-positive culture medium to determine if fecal coliforms are present, except that the system may test for E. coli in lieu of fecal coliforms. If fecal coliforms or E. coli are present, the system must notify the Department by the end of the day when the system is notified of the test result, unless the system is notified of the result after the Department office is closed, in which case the system must notify the Department before the end of the next business day.

2. The Department has the discretion to allow a public water system, on a case-by-case basis, to forgo fecal coliform or E. coli testing on a total coliform-positive sample if that system assumes that the total coliform-positive sample is fecal coliform-positive or E. coli-positive. Accordingly, the system must notify the Department as specified in part 1 of this subparagraph and the provisions of subparagraph (b) of this paragraph apply.

(d) A public water system must determine compliance with the MCL for total coliforms in subparagraph (a) and (b) of this paragraph for each month in which it is required to monitor for total coliforms.

(e) No variance or exemptions from the maximum contaminant level for total coliforms are permitted.

(f) Maximum contaminant level goals for microbiological contaminants.

1. MCLGs for the following contaminants are as indicated:

Contaminant		MCLG
(i)	*Giardia lamblia*	zero
(ii)	Viruses	zero
(iii)	*Legionella*	zero
(iv)	Total coliforms (including fecal coliforms and *Escherichia coli*)	zero
(v)	*Cryptosporidium*	zero
(vi)	*Escherichia coli (E. coli)*	zero

2. The MCLG identified in subpart 1(iv) of this subparagraph is no longer applicable beginning April 1, 2016.

(g) Beginning April 1, 2016, a system is in compliance with the MCL for E. coli for samples taken under the provisions of Rule 0400-45-01-.41 unless any of the conditions identified in parts 1 through 4 of this subparagraph occur. For purposes of the public notification requirements in Rule 0400-45-01-.19, violation of the MCL may pose an acute risk to health.

1. The system has an E. coli-positive repeat sample following a total coliform positive routine sample.

2. The system has a total coliform positive repeat sample following an E. coli-positive routine sample.

(Rule 0400-45-01-.06, continued)

3. The system fails to take all required repeat samples following an E. coli-positive routine sample.

4. The system fails to test for E. coli when any repeat sample tests positive for total coliform.

(h) Until March 31, 2016, a public water system must determine compliance with the MCL for total coliforms in subparagraphs (a) and (b) of this paragraph for each month in which it is required to monitor for total coliforms. Beginning April 1, 2016, a public water system must determine compliance with the MCL for E. coli in subparagraph (g) of this paragraph for each month in which it is required to monitor for total coliforms.

(i) The EPA Administrator, pursuant to section 1412 of the Federal Safe Drinking Water Act, hereby identifies the following as the best technology, treatment techniques, or other means available for achieving compliance with the maximum contaminant level for total coliforms in subparagraphs (a) and (b) of this paragraph and for achieving compliance with the maximum contaminant level for E. coli in subparagraph (g) of this paragraph:

1. Protection of wells from fecal contamination by appropriate placement and construction;

2. Maintenance of a disinfectant residual throughout the distribution system;

3. Proper maintenance of the distribution system including appropriate pipe replacement and repair procedures, main flushing programs, proper operation and maintenance of storage tanks and reservoirs, cross connection control, and continual maintenance of positive water pressure in all parts of the distribution system;

4. Filtration and/or disinfection of surface water, as described in Rules 0400-45-01-.17, 0400-45-01-.31 and 0400-45-01-.39, or disinfection of ground water, as described in Rule 0400-45-01-.40, using strong oxidants such as chlorine, chlorine dioxide, or ozone; and

5. For systems using ground water, compliance with the requirements of an EPA-approved State Wellhead Protection Program developed and implemented under section 1428 of the Federal Safe Drinking Water Act.

(j) The EPA Administrator, pursuant to section 1412 of the Federal Safe Drinking Water Act, hereby identifies the technology, treatment techniques, or other means available identified in subparagraph (i) of this paragraph as affordable technology, treatment techniques, or other means available to systems serving 10,000 or fewer people for achieving compliance with the maximum contaminant level for total coliforms in subparagraphs (a) and (b) of this paragraph and for achieving compliance with the maximum contaminant level for E. coli in subparagraph (g) of this paragraph.

(5) Radionuclides-

(a) The following maximum contaminant levels for radium-226, radium-228, and gross alpha particle radioactivity are applicable to all community water systems:

1. Combined radium-226 and radium-228: The maximum contaminant level for combined radium-226 and radium-228 is 5 pCi/L. The combined radium-226 and radium-228 value is determined by the addition of the results of the analysis for radium-226 and the analysis for radium-228.

2. Gross alpha particle activity (including radium-226 but excluding radon and uranium): The maximum contaminant level for gross alpha particle activity (including radium-226 but excluding radon and uranium) is 15 pCi/L.

(b) Maximum contaminant levels for beta particle and photon radioactivity from man-made radionuclides in community water systems shall be as follows:

1. The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than four (4) millirem/year.

2. Except for the radionuclides listed in Table A, the concentration of man-made radionuclides causing four (4) mrem total body or organ dose equivalents shall be calculated on the basis of a two (2) liter per day drinking water intake using the 168 hour data listed in "Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure," NBS Handbook 69 as amended August, 1963, U.S. Department of Commerce. If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any organ shall not exceed four (4) millirem/year.

Table A
Average Annual Concentrations Assumed
to Produce a Total Body or Organ Dose of a 4 mrem/yr.

Radionuclide	Critical Organ	pCi per Liter
Tritium	Total Body	20,000
Strontium-90	Bone Marrow	8

(c) MCL for uranium. The maximum contaminant level for uranium is 30 micrograms per liter.

(d) Compliance dates.

1. Compliance dates for combined radium-226 and -228, gross alpha particle activity, gross beta particle and photon radioactivity, and uranium: Community water systems must comply with the MCLs listed in subparagraphs (a), (b), and (c) of this paragraph, beginning December 8, 2003 and compliance shall be determined in accordance with the requirements of Rule 0400-45-01-.11. Compliance with reporting requirements for the radionuclides under Appendix A to Consumer Confidence Reports (Rule 0400-45-01-.35) and Appendices A and B to Public Notification (Rule 0400-45-01-.19) is required on December 8, 2003.

(e) Best Available Technologies

The Department hereby identifies as indicated in the following table the best technology available for achieving compliance with the maximum contaminant levels for combined radium-226 and -228, uranium, gross alpha particle activity, and beta particle and photon radioactivity.

Table B
BAT for Combined Radium-226 and Radium-228, Uranium, Gross Alpha Particle Activity, and Beta Particle and Photon Radioactivity

(Rule 0400-45-01-.06, continued)

Contaminant	BAT
1. Combined radium-226 and radium-228	Ion exchange, reverse osmosis, lime softening.
2. Uranium	Ion exchange, reverse osmosis, lime softening, coagulation/filtration
3. Gross alpha particle activity (excluding Radon and Uranium)	Reverse osmosis
4. Beta particle and photon radioactivity	Ion exchange and reverse osmosis

(f) No variance or exemption for compliance with the MCLs listed in paragraph (5) of this rule are allowed.

(g) Small systems compliance technologies list for radionuclides.

Table C
List of Small Systems Compliance Technologies for Radionuclides
and Limitations to Use

Unit Technologies	Limitations (see foot-notes)	Operator skill level required [1]	Raw water quality range and considerations.[1]
1. Ion Exchange (IE)	(a)	Intermediate	All ground waters.
2. Point of use (POU[2]) IE	(b)	Basic	All ground waters.
3. Reverse osmosis (RO)	(c)	Advanced	Surface waters usually require pre-filtration.
4. POU[2] RO	(b)	Basic	Surface waters usually require pre-filtration.
5. Lime softening	(d)	Advanced	All waters.
6. Green sand filtration	(e)	Basic	
7. Co-precipitation with Barium Sulfate	(f)	Intermediate to Advanced	Ground waters with suitable water quality.
8. Electrodialysis/ electrodialysis reversal		Basic to imtermediate	All ground waters.
9. Pre-formed hydrous Manganese oxide filtration	(g)	Intermediate	All ground waters.
10. Activated alumia	(a)(h)	Advanced	All ground waters; competing anion concentrations may affect regeneration frequency.
11. Enhanced coagulation/filtration	(i)	Advanced	Can treat a wide range of water qualities

[1] National Research Council (NRC). Safe Water from Every Tap: Improving Water Service to Small Communities. National Academy Press. Washington, D.C. 1997.

[2] A POU, or “point-of-use” technology is a treatment device installed at a single tap used for the purpose of reducing contaminants in drinking water at that one tap. POU devices are typically installed at the kitchen tap. See the April 21, 2000 NODA for more details.

Limitations Footnotes: Technologies for Radionuclides:

(a) The regeneration solution contains high concentrations of the contaminant ions. Disposal options should be carefully considered before choosing this technology.

(Rule 0400-45-01-.06, continued)

(b) When POU devices are used for compliance, programs for long-term operation, maintenance, and monitoring must be provided by water utility to ensure proper performance.

(c) Reject water disposal options should be carefully considered before choosing this technology. See other RO limitations described in the SWTR Compliance Technologies Table.

(d) The combination of variable source water quality and the complexity of the water chemistry involved may make this technology too complex for small surface water systems.

(e) Removal efficiencies can vary depending on water quality.

(f) This technology may be very limited in application to small systems. Since the process requires static mixing, detention basins, and filtration, it is most applicable to systems with sufficiently high sulfate levels that already have a suitable filtration treatment train in place.

(g) This technology is most applicable to small systems that already have filtration in place.

(h) Handling of chemicals required during regeneration and pH adjustment may be too difficult for small systems without an adequately trained operator.

(i) Assumes modification to a coagulation/filtration process already in place.

Table D
Compliance Technologies by System Size Category for Radionuclide NPDWR's

Contaminant	Compliance Technologies [1] for system size categories (population served)		
	25-500	501-3,300	3301-10,000
1. Combined radium-226 and radium-228	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9
2. Gross alpha particle activity	3.4	3.4	3,4
3. Beta particle activity and photon activity	1,2,3,4	1,2,3,4	1,2,3,4
4. Uranium	1,2,4,10,11	1,2,3,4,5,10,11	1,2,3,4,5,10,11

Note:[1] Numbers correspond to those technologies found listed in Table C.

(6) Disinfectant Residuals and Disinfectant Byproducts

(a) Bromate and chlorite. The maximum contaminant levels (MCLs) for bromate and chlorite are as follows:

Disinfection by-product	MCL (mg/L)
Bromate	0 .010
Chlorite	1 .0

1. Compliance dates for CWSs and NTNCWSs. Subpart H systems serving 10,000 or more persons must comply with this subparagraph beginning January 1, 2002. Subpart H systems serving fewer than 10,000 persons and systems using only ground water not under the direct influence of surface water must comply with this subparagraph beginning January 1, 2004.

2. The Administrator, pursuant to section 1412 of the Federal Safe Drinking Water Act, hereby identifies the following as the best technology, treatment techniques, or other means available for achieving compliance with the maximum contaminant levels for bromate and chlorite identified in this subparagraph:

Disinfection by-product	Best available technology

(Rule 0400-45-01-.06, continued)

Bromate	Control of ozone treatment process to reduce production of bromate
Chlorite	Control of treatment processes to reduce disinfectant demand and control of disinfection treatment processes to reduce disinfectant levels

(b) TTHM and HAA5.

1. Running Annual Average compliance (Rule 0400-45-01-.36)

(i) Compliance dates. Subpart H systems serving 10,000 or more persons must comply with this part beginning January 1, 2002. Subpart H systems serving fewer than 10,000 persons and systems using only ground water not under the direct influence of surface water must comply with this this part beginning January 1, 2004. All systems must comply with these MCLs until the date specified for Locational Running Annual Average (Stage 2 Disinfection Byproducts Requirements (LRAA)) compliance in Rule 0400-45-01-.38.

Disinfection by-product	MCL (mg/L)
Total trihalomethanes (TTHM)	0.080
Haloacetic acids (five) (HAA5)	0.060

(ii) The Administrator, pursuant to section 1412 of the Federal Safe Drinking Water Act, hereby identifies the following as the best technology, treatment techniques, or other means available for achieving compliance with the maximum contaminant levels for TTHM and HAA5 identified in this part.

Disinfection by-product	Best available technology
Total trihalomethanes (TTHM) and Haloacetic acids (five) (HAA5)	Enhanced coagulation or enhanced softening or GAC10, with chlorine as the primary and residual disinfectant

2. LRAA compliance (Rule 0400-45-01-.38)

(i) Compliance dates. The Stage 2 Disinfection Byproducts Requirements (LRAA) MCLs for TTHM and HAA5 must be complied with as a locational running annual average (LRAA) at each monitoring location beginning the date specified for Stage 2 Disinfection Byproducts Requirements (LRAA) compliance in subparagraph (1)(c) of Rule 0400-45-01-.38.

Disinfection by-product	MCL (mg/L)
Total trihalomethanes (TTHM)	0.080
Haloacetic acids (five) (HAA5)	0.060

(ii) The Administrator, pursuant to section 1412 of the Federal Safe Drinking Water Act, hereby identifies the following as the best technology, treatment techniques, or other means available for achieving compliance with the maximum contaminant levels for TTHM and HAA5 identified in this part for all systems that disinfect their source water:

Disinfection by-product	Best available technology
Total trihalomethanes (TTHM) and Haloacetic acids (five) (HAA5)	Enhanced coagulation or enhanced softening or GAC10; nanofiltration and with a molecular weight cutoff of equal to or less than 1000 Daltons;

(Rule 0400-45-01-.06, continued)

	or GAC20

(iii) The Administrator, pursuant to section 1412 of the Federal Safe Drinking Water Act, hereby identifies the following as the best technology, treatment techniques, or other means available for achieving compliance with the maximum contaminant levels for TTHM and HAA5 identified in this part for consecutive systems and applies only to the disinfected water that consecutive systems buy or otherwise receive:

Disinfection by-product	Best available technology
Total trihalomethanes (TTHM) and Haloacetic acids (five) - (HAA5).	Systems serving 10,000 or more: Improved distribution system and storage tank management to reduce residence time, plus the use of chloramines for disinfectant residual maintenance. Systems serving <10,000: Improved distribution system and storage tank management to reduce residence time.

(c) Maximum residual disinfectant levels.

1. Maximum residual disinfectant levels (MRDLs) are as follows:

Disinfectant residual	MRDL (mg/L)
Chlorine	4.0 (as Cl_2).
Chloramines	4.0 (as Cl_2).
Chlorine dioxide	0.8 (as ClO_2).

(d) Compliance dates.

1. CWSs and NTNCWSs. Subpart H systems serving 10,000 or more persons must comply with MRDLs beginning January 1, 2002. Subpart H systems serving fewer than 10,000 persons and systems using only ground water not under the direct influence of surface water must comply with MRDLs beginning January 1, 2004.

2. Transient NCWSs. Subpart H systems serving 10,000 or more persons and using chlorine dioxide as a disinfectant or oxidant must comply with the chlorine dioxide MRDL beginning January 1, 2002. Subpart H systems serving fewer than 10,000 persons and using chlorine dioxide as a disinfectant or oxidant and systems using only ground water not under the direct influence of surface water and using chlorine dioxide as a disinfectant or oxidant must comply with the chlorine dioxide MRDL beginning January 1, 2004.

(e) Best Available Control Technology

1. The following are identified as the best technology, treatment technology or other means available for achieving compliance with the maximum residual disinfectant level:

(i) Control of the treatment processes to reduce disinfectant demand and control of disinfection treatment processes to reduce disinfectant levels.

(Rule 0400-45-01-.07, continued)

persons may collect all required samples on a single day if they are taken from different sites.

(f) A public water system that uses surface water or ground water under the direct influence of surface water, and does not practice filtration in compliance with Rule 0400-45-01-.31 must collect at least one sample near the first service connection each day the turbidity level of the source water exceeds 1 NTU. This sample must be analyzed for the presence of total coliforms. When one or more turbidity measurements in any day exceed 1 NTU, the system must collect this coliform sample within 24 hours of the first exceedance, unless the Department determines that the system, for reasons outside the system's control cannot have the sample analyzed within 30 hours of collection. Sample results from this coliform monitoring must be included in determining compliance with the MCL for total coliforms in paragraph (4) of Rule 0400-45-01-.06.

(g) Special purpose samples, such as those taken to determine whether disinfection practices are sufficient following pipe placement, replacement, or repair, shall not be used to determine whether the coliform treatment technique trigger has been exceeded compliance with the MCL for total coliforms in paragraph (4) of Rule 0400-45-01-.06 provided the water is not served to customers before negative analytical results are obtained. Samples representing water served to customers prior to obtaining analytical results shall not be special purpose samples and shall not count toward compliance with the MCL for total coliforms in paragraph (4) of Rule 0400-45-01-.06 with the MCL for total coliforms in paragraph (4) of Rule 0400-45-01-.06. After March 31, 2016, this subparagraph is no longer applicable.

(2) Repeat Monitoring

(a) If a routine sample is total coliform-positive, the public water system must collect a set of repeat samples within 24 hours of being notified of the positive result. A system which collects more than one routine sample per month must collect no fewer than three repeat samples for each total coliform-positive sample found. A system which collects one routine sample per month or fewer must collect no fewer than four repeat samples for each total coliform-positive sample found. The Department may extend the 24-hour limit on a case-by-case basis if the system has a problem in collecting the repeat samples within 24 hours that is beyond its control. In the case of an extension, the Department must specify how much time the system has to collect the repeat samples.

(b) The system must collect at least one repeat sample from the sampling tap where the original total coliform-positive sample was taken, and at least one repeat sample at a tap within five service connections upstream and at least one repeat sample at a tap within five service connections downstream of the original sampling site. If a total coliform-positive sample is at the end of the distribution system, or one away from the end of the distribution system, the Department may waive the requirement to collect at least one repeat sample upstream or downstream of the original sampling site.

(c) The system must collect all repeat samples on the same day and within 24 hours of being notified of a positive result, except that the Department may allow a system with a single service connection to collect the required set of repeat samples over a four consecutive day period or to collect a larger volume repeat sample(s) in one or more sample containers of any size, as long as the total volume collected is at least 400 ml (300 ml for systems which collect more than one routine sample per month.)

(Rule 0400-45-01-.07, continued)

.06(4)(c) that was initiated by a total coliform-positive sample taken before April 1, 2016, is completed, as well as analytical method, reporting, recordkeeping, public notification, and consumer confidence report requirements associated with that monitoring and testing. Beginning April 1, 2016, the provisions of Rule 0400-45-01-.41 are applicable, with systems required to begin regular monitoring at the same frequency as the system specific frequency required on March 31, 2016.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01. Amendments and new rules filed November 24, 2015; effective February 22, 2016. Amendments filed March 7, 2016; effective June 5, 2016.*

0400-45-01-.08 TURBIDITY SAMPLING AND ANALYTICAL REQUIREMENTS.

(1) Ground water sampling – Samples shall be taken by suppliers of water that serve more than 50 connections or that have been directed to conduct monitoring under paragraph (11) of Rule 0400-45-01-.05 for both community water systems and non–community water system at a representative entry point(s) to the water distribution system at least once per day for the purpose of making turbidity measurements to determine compliance with paragraph (3) of Rule 0400-45-01-.06. Public water systems using water from a source not under the direct influence of surface water are not required to monitor turbidity unless directed to do so under the provisions of paragraph (11) of Rule 0400-45-01-.05.

(2) Turbidity measurements of surface water and ground water under the direct influence that employs filtration - The minimum sampling requirements for systems using filtration treatment shall be as follows:

(a) Turbidity measurements must be performed on representative samples of the system's filtered water every four hours, (or more frequently, as authorized by the rules) that the system serves water to the public. A public water system may substitute continuous turbidity monitoring for grab samples if approved in writing by the Department. For systems serving 500 or fewer persons per day, the Department may allow the sampling frequency to be reduced to once per day if it determines that less frequent monitoring is sufficient to indicate effective filtration performance. Systems filtering surface water and ground water under the direct influence of surface water shall comply with the treatment technique standards found in paragraph (4) of Rule 0400-45-01-.31.

(3) Ground water systems under the direct influence of surface water and do not filter and have qualified to avoid filtration - The minimum sampling requirements for ground water systems under the direct influence of surface water and not employing filtration shall be as follows:

(a) 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, as authorized by the rules) 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 Department. Turbidity must comply with the limits specified in part (2)(a)2 of Rule 0400-45-01-.31.

(4) Reporting

(a) Ground water systems - All community water systems using a ground water source with turbidity removal facilities and not designated as ground water under the direct influence of surface water shall be required, if the results of a turbidity analysis indicate that the maximum allowable limit has been exceeded, to confirm by resampling as soon as practicable and preferably within one (1) hour. If the repeat sample confirms

(Rule 0400-45-01-.11, continued)
Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.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.

Maximum Contaminant Level

Contaminant		Milligrams per Liter (unless otherwise indicated)
(a)	Chloride	250
(b)	Color	15 (Color Units)
(c)	Copper	1
(d)	MBAS (Methyl Blue Active Substance)	0.5
(e)	Iron	0.3
(f)	Manganese	0.05
(g)	Odor	3 (Threshold Odor Number)
(h)	pH	6.5-8.5
(i)	Sulfate	250
(j)	TDS (Total Dissolved Solids)	500
(k)	Zinc	5
(l)	Fluoride	2
(m)	Aluminum	0.2
(n)	Silver	0.1

(2) The system may apply for monitoring waivers from the monitoring frequency specified in paragraph (1) of this rule. The Department may issue monitoring waivers after considering: historical data, whether or not there have been customer complaints concerning the contaminant to be waived, any corrective action taken by the water supplier to correct the secondary contaminant problem, and whether or not the system routinely monitors for the contaminant as part of its treatment process monitoring program. The Department shall determine the frequency, if any, a system must monitor after considering the historical data available, the number and nature of customer complaints and other factors that may affect the contaminant concentration, and specify the decision in writing to the system.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.13 ALTERNATIVE ANALYTICAL TECHNIQUES.

If an alternative analytical technique is acceptable to the Administrator of the U.S. Environmental Protection Agency as being substantially equivalent to the prescribed test in both precision and accuracy as it relates to the determination of compliance with any maximum contaminant level, they shall become a part of these rules and regulations by inference.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

(Rule 0400-45-01-.15, continued)

by the Environmental Protection Agency will have compliance with the MCL determined on the analytical results of its sampling.

(3) Those public water systems which purchase all their water and elect to use the analytical results of the system from which it purchases water shall be deemed to be in compliance with the monitoring and MCL requirements provided the seller of water is in compliance. Any violation of an MCL or monitoring requirement by the seller of water will constitute a violation for all systems which purchase water unless samples are taken as described in paragraph (2) of this rule.

(4) All public notification requirements as contained in Rule 0400-45-01-.19 are the responsibility of the individual public water system regardless of which public water system conducts the analysis.

(5) All public water systems must maintain records as required by Rule 0400-45-01-.20 of all analytical results which pertain to the system regardless of which system actually did the analysis.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.16 SITING REQUIREMENTS.

(1) Before a person may enter into a financial commitment for or initiate construction of a new public water system or increase capacity of an existing public water system, he shall notify the Department and, to the extent practicable, avoid locating part or all of the new or expanded facility at a site which:

(a) Is subject to a significant risk from earthquakes, floods, fires, or other disasters which could cause a breakdown of the public water system or a portion thereof; or

(b) Except for intake structures, is within the flood plain of a 100-years flood.

(2) All other siting requirements shall be in accordance with those set forth in “Design Criteria for Public Water Systems” as published by the Department.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01.*

0400-45-01-.17 OPERATION AND MAINTENANCE REQUIREMENTS.

(1) All community water systems which are designated as a surface supply and classified as a filtration system and all iron removal plants which use gravity filters must have an operator in attendance and responsible for the treatment process when the plant is in operation. Gravity iron removal plants which have installed continuous monitoring equipment including equipment for turbidity and chlorine residual with alarms and/or shutdown ability may seek approval from the Department to operate the treatment plant in an automated mode without an operator in attendance. All iron removal plants with pressure filters and using a ground water source from an approved sand and gravel formation will not be required to have an operator in attendance during all periods of operation provided suitable protection, acceptable to the Department, is provided.

Non–community water systems which are classified as a surface supply will be required to have a full time operator in attendance unless certain continuous monitoring equipment is installed.

(Rule 0400-45-01-.17, continued)

Pursuant to T.C.A. § 68-221-904, all operators in direct responsible charge of a water supply system, including the treatment plant and/or distribution system, must be certified by the Department as competent to operate same.

Because the proper operation and maintenance of water systems is critical to a system's ability to provide safe water to the public and to comply with these rules, all water supply systems must comply with the provisions of Chapter 0400-49-01. A violation of those rules is a violation of this rule as well.

(2) All community water systems and those non-community water systems classified as a surface source shall compile and maintain accurate daily operating records of the water works system on forms prepared and furnished by the Department. The daily operating records shall be submitted in a timely manner so they are received by the Department no later than ten days after the end of the reporting month. Any special reports, deemed necessary by the Department to assure continuous satisfactory operation of the water system, shall be submitted to the Department.

Water systems which desire to use their own forms to report the daily operating results to the Department must have prior approval of the form from the Department.

(3) All water quality tests, other than those listed in Rule 0400-45-01-.06 shall be made in accordance with the latest edition of "Standard Methods for the Examination of Water and Wastewater" or alternate methods acceptable to the Department. The schedule of laboratory tests followed in controlling the operation of a waterworks system will vary with the character of the water; therefore, all waterworks systems must have the equipment necessary to perform all laboratory tests pertinent to the control of the plant or system operation, and the equipment shall be maintained in good working order at all times. Laboratory tests pertinent to proper operation shall be prescribed by the Department for each community water system.

(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.

(5) All systems submitting samples for microbiological examination to the State laboratory must submit said sample in the bottle(s) provided by the State and return the samples to 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.

(6) Pursuant to T.C.A. § 68-221-711(6) the installation, allowing the installation, or maintenance of any cross–connection, auxiliary intake, or bypass is prohibited unless the source and quality of water from the auxiliary supply, the method of connection, and the use and

(Rule 0400-45-01-.17, continued)

operation of such cross–connection, auxiliary intake, or bypass has been approved by the Department. The arrangement of sewer, soil, or other drain lines or conduits carrying sewage or other wastes in such a manner that the sewage or waste may find its way into any part of the public water system is prohibited.

All community water systems must adopt an ordinance or policy prohibiting all of the above and submit a copy of the executed ordinance or policy to the Department for approval. All community water systems shall develop a written plan for a cross–connection control program to detect and eliminate or protect the system from cross–connections. The written plan must be approved by the Department.

After adoption and approval of the cross–connection ordinance or policy and plan, each community water system must establish an ongoing program for the detection and elimination of hazards associated with cross–connections. Records of the cross–connection control program must be maintained by the water supplier and shall include such items as date of inspection, person contacted, recommendations, follow–up, and testing results.

(a) Public water systems must develop and implement an ongoing cross-connection program. Cross-connection plans and policies shall present all information in conformance with the "Design Criteria for Community Public Water Systems" as published by the Department.

(b) The public water system shall ensure that cross-connections between the distribution system and a consumer's plumbing are surveyed and/or inspected and determined not to exist or contain a significant risk or are eliminated or controlled by the installation of an approved backflow preventer commensurate with the degree of hazard.

(7) All community water system shall prepare and maintain an emergency operations plan in order to safeguard the water supply and to alert the public of unsafe drinking water in the event of natural or man-made disasters. Emergency operation plans shall be consistent with guidelines established by the Department and shall be reviewed and approved by the Department. Systems shall include a drought management plan as a part of the emergency operations plan. The drought management plans portions of the emergency operations shall be submitted for approval as follows:

(a) Systems serving 3,000 or more connections including consecutive systems: June 30, 2016.

(b) Systems serving more than 1,000 connections and less than 3,000 connections including consecutive systems: June 30, 2017.

(c) Systems serving 1,000 connections or less: June 30, 2018.

(8) (a) General-Public water systems, construction contractors and engineers shall follow and document sanitary practices used in inspecting, constructing or repairing water lines, finished water storage facilities, filters and wells. In lieu of writing their own disinfection standard operating procedures, public water systems, engineers and contractors may chose to follow the latest edition of the AWWA standards C-651, C-652 or equivalent methods provided the method has been approved in writing by the department and is available during the inspection, construction, maintenance or repair activity. The documentation shall include bacteriological sample results, construction logs, standard operating procedures and may include photographs where appropriate. All pipes, tanks, filters, filter media and other materials shall be properly disinfected prior to being placed in service. Any disinfectant used to disinfect shall be NSF approved or plain household bleach and used in a manner that assures sufficient contact time and concentration to inactivate any pathogens present. Bacteriological results including line

(Rule 0400-45-01-.17, continued)

repair records indicating adequacy of disinfection shall be maintained on file by the water system for five years. All public water systems, contractors, and engineers shall prepare and follow standard disinfection procedures approved by the Department when inspecting, maintaining, repairing or constructing lines, tanks, filters and wells. Procedures to ensure that water containing excessive concentrations of disinfectant is not supplied to the customers or discharged in such manner as to harm the environment shall be implemented.

All materials used for new or repaired water lines, storage facilities, filters, filter media, and wells will be inspected prior to use for any evidence of gross contamination. Any contamination observed shall be removed and the materials protected during installation.

(b) Disinfection of New Facilities-Bacteriological samples will be collected and analyzed to verify the effectiveness of the disinfection practices prior to placing new facilities in service. Bacteriological samples shall be collected to determine the effectiveness of the installation process including protecting the pipe material during storage, installation, and disinfection. This can be demonstrated by collecting two sets of microbiological samples 24 hours apart or collecting a single set of microbiological samples 48 hours or longer after flushing the highly chlorinated water from the lines. In either case microbiological samples in each set will be collected at approximately 2,500-foot intervals with samples near the beginning point and at the end point unless alternate sampling frequency and distance between sampling points approval has been obtained from the Department. Where sanitary conditions were not maintained before, during or after construction, an additional bacteriological sample shall be collected from a location representing the water from the contaminated area. Unsanitary conditions include failure to document the sanitary handling of materials, to conduct construction inspections and to maintain records, and to document sanitary practices during construction and other hazards such trench flooding during construction. If the constructed facility yields positive bacterial samples, additional flushing, disinfection and bacteriological sampling shall be repeated until the water is coliform free.

(c) Disinfection of Existing Facilities-Drinking water mains, storage facilities and filters that have been partially dewatered during inspection or repair shall, after the repair or inspection is completed, be disinfected, and flushed prior to placing it back in service. Bacteriological samples shall be collected immediately or as soon as possible after the repair is completed and from a location representing the water contained in the repaired line, tank or filter. The repaired facility may be returned to service prior to obtaining bacteriological results. If the repaired facility yields positive bacterial samples, additional flushing, disinfection and bacteriological sampling shall be repeated until the water is coliform free.

1. If one-half or more of either the original or repeat bacteriological samples collected from the repaired or renovated facility are total coliform positive, the system shall notify the Department within 30 days that it has reviewed its disinfection and sampling practices in an attempt to identify why the positive samples occurred and revise its disinfection and sampling plans accordingly.

2. If any public water system collects a fecal coliform positive repeat sample or e-coli positive repeat sample or a total coliform positive repeat sample following an initial positive fecal coliform or e-coli sample collected from the repaired or renovated facility, the system shall notify the Department within 24-hours and issue a tier 1 public notice using the language specified in Appendix B of Rule 0400-45-01-.19.

(Rule 0400-45-01-.17, continued)

(d) Inspectors, contractors, operators, public water systems or engineers that fail to document and follow adequate disinfection procedures, and fail to collect bacteriological samples during repairs, inspections or maintenance activities that potentially would compromise the microbial quality of the water shall issue a boil water advisory to the customers served by that portion of the public water system prior to returning the facility to service. The boil water advisory shall remain in effect until satisfactory microbial tests results are obtained.

(9) All community water systems shall be operated and maintained to provide minimum positive pressure of twenty (20) psi throughout the distribution system. No person shall install or maintain a water service connection to any premises where a booster pump has been installed unless such booster pump is equipped with a low pressure cut-off mechanism designed to cut off the booster pump when the pressure on the suction side of the pump drops to twenty (20) psi gauge.

(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 paragraph (4) of this rule 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 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 cylinders 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 part 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.

Community public water systems serving more than 50 service connections 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. Noncommunity systems and community systems serving less than 50 connections which use a hypochlorinator and show deficiencies in the disinfection process shall also be required to have duplicate disinfection units.

(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.

(Rule 0400-45-01-.17, continued)

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.

(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.

(13) All community water systems serving 50 connections or more shall install duplicate pumps for the raw water, finished water, and distribution pumping stations. A water system will not be required to have duplicate pumps in a distribution pumping station under the following conditions: limited number of service connections, availability of replacement pumps, maintaining adequate flows and pressures without the pumping station, and for emergency use only. All community public water systems using ground water supplies and having more than 50 service connections must have duplicate wells and/or duplicate pumps in a spring supply unless fed by gravity flow.

(14) All community water systems serving 50 connections or more are required to have 24 hours of distribution storage based on the average daily demand for the past twelve months. Distribution storage must be located so that the instantaneous demand can be met in all areas at any time.

(a) Systems which purchase water for resale may utilize the storage of the supplier provided the supplier has adequate distribution storage. Water systems that have large ground storage tanks will be given credit for distribution storage provided auxiliary power is available to pump water to the distribution system.

(b) Systems which have more than three (3) treatment facilities, have more than one source of water, and which have special power arrangements so that it is unlikely that all units would be down at the same time are not required to have distribution storage provided the peak demand can be met.

(c) Water systems which have an average daily demand of 10 million gallons or more are not required to have 24 hours of distribution storage provided the system has adopted a contingency plan for emergencies that has been approved by the Department. The contingency plan must demonstrate the water system is able to provide residential service to all customers for a 24 hour period during any emergency involving the shut down of the treatment facility.

(Rule 0400-45-01-.17, continued)

(d) Public water systems which utilize wells and provide only disinfection, pH adjustment, corrosion inhibitor and/or fluoridation as treatment, may use the capacity of the wells and the plant as part of the distribution storage under the following conditions:

1. The existing distribution storage tank(s) are adequate to meet the peak demands on the system,

2. The well(s), disinfection equipment and other pumping facilities needed to supply water to the distribution storage tank are equipped with an auxiliary power source with automatic controls, and

3. The well field capacity is determined by removing the largest well from consideration.

(e) Public water systems may take into account private distribution storage facilities in the following manner:

1. Private distribution storage may be counted as water system storage provided the private storage tank floats on the water utility's system and the water used serves both the private and utility system demand.

2. The water utility may reduce the amount of needed distribution storage by subtracting the average daily volume of any water user that has its own storage tank. This can be done provided the private storage tank is used on a daily basis.

3. Private distribution storage tanks used strictly for fire protection by the private owner cannot be in the water systems distribution storage capacity.

(15) All community water systems serving 50 or more service connections must have and maintain up-to-date maps of the distribution system. These maps must show the locations of the water mains, sizes of mains, valves, blow-offs or flush hydrants, air-release valves, and fire hydrants. One up-to-date copy of the overall system distribution map(s) is to be submitted to the Division of Water Supply every five years.

(16) All vents on wells, springs, storage tanks, overflows and clearwells shall be properly screened. All overflows on springs and tanks shall be screened and protected.

(17) All buildings and equipment used in and for the production and distribution of water (to include chemical and other storage buildings) must be well maintained and be reliable and fit for the purpose for which they are used. This includes, but is not limited to:

(a) When a water treatment plant is not producing water and an operator is not in attendance, plant entrances must be locked.

(b) Equipment such as chemical feeders, pumps, turbidimeters, pumpage meters, alarm systems, and air tanks shall be maintained and in good working condition. Pumps, tanks, hoses, and other equipment used by system personnel shall be disinfected and dedicated to its use if it comes into contact with water that may be consumed by humans.

(c) Duplicate or backup equipment shall be available as necessary to maintain the production of water meeting drinking water standards. Backup equipment or alternate treatment means shall be available for feeding all chemicals critical for adequate water treatment.

(Rule 0400-45-01-.17, continued)

(18) All community water systems planning to or having installed hydrants must protect the distribution system from contamination. All water mains designed for fire protection must be six inches or larger and be able to provide 500 gallons per minute with 20 pounds per square inch residual pressure. Fire hydrants shall not be installed on water mains less than six inches in diameter or on water mains that cannot produce 500 gpm at 20 psi residual pressure unless -the tops are painted red. Out of service hydrants shall have tops painted black or covered with a black shroud or tape.

Existing Class C hydrants (hydrants unable to deliver a flow of 500 gallons per minute at a residual pressure of 20 pounds per square inch (psi) shall have their tops painted red by January 1, 2008.

The water system must provide notification by certified mail at least once every five years beginning January 1, 2008, to each fire department that may have reason to utilize the hydrants, that fire hydrants with tops painted red (Class C hydrants) cannot be connected directly to a pumper fire truck. Fire Departments may be allowed to fill the booster tanks on any fire apparatus from an available hydrant by using the water system's available pressure only (fire pumps shall not be engaged during refill operations from a Class C hydrant).

(19) Before any new or modified community water treatment facility can be placed in service, it must be inspected and approved in writing by the Department.

(20) Each water system adjusting the fluoride content to the finished water must monitor for fluoride quarterly using a certified laboratory and the calculation of the fluoride level will be by running annual average. The recommended level of fluoridation in the finished water is 0.7 mg/l. Any public water system which determines to cease fluoridation treatment of its water supply shall notify the local environmental field office within the department of environment and conservation and the commissioner of the department of health of its decision to discontinue fluoridation within the timeframe as specified by T.C.A. § 68-221-708(c).

(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.

(22) All pipe, pipe or plumbing fitting or fixture, solder, or flux which is used in the installation or repair of any public water system shall be lead free. The term "lead free" shall have the meaning given it in T.C.A. § 68-221-703.

(23) All dead end water mains and all low points in water mains shall be equipped with a blow-off or other suitable flushing mechanism capable of producing velocities adequate to flush the main.

(24) All community water systems must establish and maintain a file for customer complaints. This file shall contain the name of the person with the complaint, date, nature of complaint, date of investigation and results or actions taken to correct any problems.

(25) The Department may, upon written notice, require confirmation of any sampling results and also may require sampling and analysis for any contaminant when deemed necessary by the Department to protect the public health or welfare.

(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:

(Rule 0400-45-01-.17, continued)

(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 0400-45-01-.17(30)1 and 0400-45-01-.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 0400-45-01-.17(30)1

Assumed Log Removals by Filtration Method
and Required Levels of Disinfection

Treatment	Assumed Log Removal		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 0400-45-01-.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

(Rule 0400-45-01-.17, continued)

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.

(31) Each public water system must certify annually in writing to the Department 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.

(32) New service taps on existing mains that must be uncovered to make the tap, shall be flushed and the free chlorine residual measured and recorded prior to connecting the service lines. These records shall be retained until the next sanitary survey or for three years.

(33) All public water systems shall properly maintain their distribution system finished water storage tanks. Each community water system shall establish and maintain a maintenance file on each of its finished water and distribution storage tanks. These maintenance files must be available for inspection by Department personnel. These files must include the dates and results of all routine water storage tank inspections by system personnel, any reports of detailed professional inspections of the water storage tanks by contractor personnel, dates and details of routine tank cleanings and surface flushings, and dates and details of all tank maintenance activities. The tank inspection records shall include dates of the inspections; the sanitary, coating and structural conditions of the tank; and all recommendations for needed maintenance activities. Community Water Systems shall have a professional inspection performed and a written report produced on each of their finished water and distribution storage tanks at least once every five years. Non-community water systems shall have a professional inspection and written report performed on each of their atmospheric pressure finished water and distribution storage tanks no less frequently than every five years. Records of these inspections shall be available to the Department personnel for inspection. Persons conducting underwater inspections of finished water storage tanks shall comply with AWWA standard C652-92 or later versions of the standard.

(34) Paints and coatings for the interior of potable water storage facilities must be acceptable to the Department. Paints and coatings accepted by the Environmental Protection Agency (EPA) and/or the National Sanitation Foundation (NSF) for potable water contact are generally acceptable to the Department. Paint systems for steel tanks shall be consistent with AWWA Standard D102-78. Factory coated bolted steel tanks shall be in accordance with AWWA D103-87. Wire-wound circular prestressed concrete tanks shall be in accordance with AWWA D110-86.

(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 capability. Such systems shall perform a rewash cycle, or filter to waste each time a filter is backwashed. The

(Rule 0400-45-01-.17, continued)

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.

(36) By January 1, 1995, all chemicals, additives, coatings or other materials used in the treatment, conditioning and conveyance of drinking water must have been approved by the National Sanitation Foundation (NSF) or American National Standards Institute (ANSI) certified parties as meeting NSF product standard 60 and 61. Until 1995, products used for treatment, conditioning and conveyance of drinking water shall have been listed as approved by the US EPA or NSF.

(37) Any new Community Water System or Non-Transient Non-Community Water System commencing operation after September 30, 1999 shall have a “Capacity Development Plan” and be a “viable water system.”

(38) Public Water Systems identified as not complying or potentially not complying with the requirements of the Safe Drinking Water Act and in accordance with the priorities established in the Department’s Capacity Development Strategy shall prepare a “Capacity Development Plan” and demonstrate viability.

(39) Public water systems are not permitted to construct uncovered finished water reservoirs after the effective date of this subparagraph.

(40) Benchtop and continuous turbidimeters used to determine compliance with limits set forth in this rule chapter must be calibrated at least every three months with primary standards and documented. Documentation shall be maintained for a period not less than five years. Primary standards are Formazin, AMCO clear, Stablcal, or alternatives approved in writing by the Department. Dilute Formazin solutions are unstable and must be prepared on the day of calibration. Manufacturers’ recommendations on calibration procedure must be followed.

(41) Verifications for benchtop turbidimeters are comparisons to approved reference materials. Verifications for continuous turbidimeters are comparisons to approved reference materials or comparisons to a properly calibrated benchtop turbidimeter. Secondary reference materials are assigned a value immediately after acceptable primary calibration has been completed. Acceptable verifications for turbidity measurements greater than 0.5 NTU must agree within $\pm$10% from the reading assigned to the reference material after primary calibration. Acceptable verifications for measurements 0.5 NTU or less must be within $\pm$0.05 NTU or less from the reading assigned to the reference material after primary calibration. When comparisons are made from a continuous turbidimeter to a benchtop turbidimeter, the continuous measurement must be within $\pm$10% of the benchtop reading for measurements above 0.5 NTU and $\pm$0.05 NTU for reading 0.5 NTU or less. When acceptable verifications are not achieved the instrument must be re-calibrated with primary standards according to paragraph (40) of this rule. Approved reference materials for benchtop turbidimeters are primary standards and materials suggested by the manufacturer such as sealed sample cells filled with metal oxide particles in a polymer gel. The 0.5 NTU ICE-PIC™ from Hach is an approved reference material for secondary turbidity verifications for Hach continuous

(Rule 0400-45-01-.17, continued)

turbidimeters when utilized as per Manufacturers' recommendations. All other reference materials for turbidimeter verifications must be approved in writing by the Department. Verifications for turbidimeters must be performed according to the following:

(a) Verification of benchtop turbidimeters must be performed daily and documented. Verifications must include a sample in the expected working range of the instrument or as close to the working range as possible. Documentation must include: assigned reference material value after calibration, recorded daily reading for all reference standards, instrument identification, and date.

(b) Combined filter effluent turbidimeters as required by part (5)(c)1 of Rule 0400-45-01-.31 must be verified daily and documented. When reference material is utilized documentation must include: instrument identification, date, assigned reference material value after calibration, and daily value for reference material. When comparisons to benchtop turbidimeters are utilized documentation must include: instrument identification, date, continuous turbidimeter value, and benchtop turbidimeter value.

(c) Individual filter turbidimeters as required by part (5)(c)4 of Rule 0400-45-01-.31 must be verified weekly.

Authority: *T.C.A. §§ 68-221-701 et seq. and 4-5-201 et seq.* ***Administrative History:*** *Original rule filed August 1, 2012; effective October 30, 2012. Rule was previously numbered 1200-05-01. Amendments and new rules filed November 24, 2015; effective February 22, 2016. Amendments filed March 7, 2016; effective June 5, 2016.*

0400-45-01-.18 REPORTING REQUIREMENTS.

(1) Except where a shorter period is specified in this Chapter, the supplier of water shall report to the Department the results of any test measurement or analysis required by this part within (a) the first ten days following the month in which the result is received or (b) the first ten days following the end of the required monitoring period as stipulated by the Department, which ever of these is shortest.

(2) All systems shall report to the Department within forty-eight (48) hours of the failure to comply with Departmental drinking water regulations or other requirements (including failure to comply with monitoring, maximum contaminant level or treatment technique requirements) set forth in these rules and regulations, and in case of any of the following events shall immediately notify the Department and responsible local officials:

(a) any major breakdown or failure of equipment in water treatment process which affects the quality or quantity of the water leaving the treatment plant;

(b) any serious loss of water service due to a failure of transmission or distribution facilities; or

(c) any situation with the water system which presents or may present an imminent and substantial endangerment to health.

(3) Systems are not required to report analytical results to the Department in cases where a State laboratory performs the analysis and reports the results to the Department.

(4) The public water system, within 10 days of completing the public notification requirements under Rule 0400-45-01-.19 for the initial public notice and any repeat notices, must submit to the department a certification that it has fully complied with the public notification regulations. The public water system must include with this certification a representative copy of each

(Rule 0400-45-01-.19, continued)

Table 0400-45-01-.19(1)(a)

Violation Categories and Other Situations
Requiring a Public Notice

1. NPDWR violations:

   (i) Failure to comply with an applicable maximum contaminant level (MCL) or maximum residual disinfectant level (MRDL).
   (ii) Failure to comply with a prescribed treatment technique (TT).
   (iii) Failure to perform water quality monitoring, as required by the drinking water regulations.
   (iv) Failure to comply with testing procedures as prescribed by a drinking water regulation.

2. Variance and exemptions under sections 1415 and 1416 of SDWA:

   (i) Operation under a variance or an exemption.
   (ii) Failure to comply with the requirements of any schedule that has been set under a variance or exemption.

3. Special public notices:

   (i) Occurrence of a waterborne disease outbreak or other waterborne emergency.
   (ii) Exceedance of the alternate MCL for nitrate by non-community water systems (NCWS), where the non-community system has been granted an alternate standard by the department.
   (iii) Exceedance of the secondary maximum contaminant level (SMCL) for fluoride.
   (iv) Availability of unregulated contaminant monitoring data.
   (v) Other violations and situations determined by the department to require a public notice under this rule, not already listed in Appendix A.

(b) Public notice requirements are divided into three tiers to take into account the seriousness of the violation or situation and any potential adverse health effects that may be involved. The public notice requirements for each violation or situation listed in Table 0400-45-01-.19(1)(a) are determined by the tier to which it is assigned. Table 0400-45-01-.19(1)(b) provides the definition of each tier. Appendix A of this rule identifies the tier assignment for each specific violation or situation.

Table 0400-45-01-.19(1)(b)

Definition of Public Notice Tiers

1. Tier 1 public notice-required for NPDWR violations and situations with significant potential to have serious adverse effects on human health as a result of short-term exposure.

2. Tier 2 public notice--required for all other NPDWR violations and situations with potential to have serious adverse effects on human health.

3. Tier 3 public notice--required for all other NPDWR violations and situations not included in Tier 1 and Tier 2.

(c) Who must be notified?

(Rule 0400-45-01-.19, continued)

1. Each public water system must provide public notice to persons served by the water system, in accordance with this rule. Public water systems that sell or otherwise provide drinking water to other public water systems (i.e., to consecutive systems) are required to give public notice to the owner or operator of the consecutive system; the consecutive system is responsible for providing public notice to the persons it serves.

2. If a public water system has a violation in a portion of the distribution system that is physically or hydraulically isolated from other parts of the distribution system, the Department may allow the system to limit distribution of the public notice to only persons served by that portion of the system which is out of compliance. Permission by the department for limiting distribution of the notice must be granted in writing.

3. A representative copy of the each type of the notice distributed, published, posted and/or made available to the persons served by the system and/or to the media must also be sent to the Department within ten days of completion of each public notification.

(2) Tier 1 Public Notice-Form, manner, and frequency of notice.

(a) Violation of the MCL for total coliforms when fecal coliform or E. coli are present in the water distribution system as specified in Rule 0400-45-01-.06, or when the water system fails to test for fecal coliforms or E. coli when any repeat sample tests positive for coliform as specified in Rule 0400-45-01-.07; Violation of the MCL for E. coli (as specified in Rule 0400-45-01-.06(4)(f));

Table 0400-45-01-.19(2)(a)

Violation Categories and Other Situations
Requiring a Tier 1 Public Notice

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1. Violation of the MCL for total coliforms when fecal coliform or E. coli are present in the water distribution system as specified in Rule 0400-45-01-.06, or when the water system fails to test for fecal coliforms or E. coli when any repeat sample tests positive for coliform as specified in Rule 0400-45-01-.07;

2. Violation of the MCL for nitrate, nitrite, or total nitrate and nitrite, as defined in Rule 0400-45-01-.06, or when the water system fails to take a confirmation sample within 24 hours of the system's receipt of the first sample showing an exceedance of the nitrate or nitrite MCL, as specified in Rule 0400-45-01-.09;

3. Exceedance of the alternate MCL for nitrate by non-community water systems (NCWS), where the non-community system has been granted an alternate standard by the department;

4. Violation of the MRDL for chlorine dioxide, as defined in Rule 0400-45-01-.36, when one or more samples taken in the distribution system the day following an exceedance of the MRDL at the entrance of the distribution system exceed the MRDL, or when the water system does not take the required samples in the distribution system, as specified in Rule 0400-45-01-.36;

5. Violation of the turbidity MCL under Rule 0400-45-01-.06, where the department determines after consultation that a Tier 1 notice is required or where consultation does not take place within 24 hours after the system learns of the violation;

(Rule 0400-45-01-.19, continued)

6. Violation of the Surface Water Treatment Rule (SWTR) Rule 0400-45-01-.31, Interim Enhanced Surface Water Treatment Rule (IESWTR) or Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR) treatment technique requirement resulting from a single exceedance of the maximum allowable turbidity limit (as identified in Appendix A) where the department determines after consultation that a tier 1 notice is required or where consultation does not take place within 24 hours after the system learns of the violation;

7. Occurrence of a waterborne disease outbreak, as defined in Rule 0400-45-01-.04, or other waterborne emergency (such as a failure or significant interruption in key water treatment processes, a natural disaster that disrupts the water supply or distribution system, or a chemical spill or unexpected loading of possible pathogens into the source water that significantly increases the potential for drinking water contamination);

8. Other violations or situations with significant potential to have serious adverse effects on human health as a result of short-term exposure, as determined by the Department either in its regulations or on a case-by-case basis.

9. Detection of E. coli or enterococci in source water samples as specified in paragraph (3) of Rule 0400-45-01-.40.

(b) When is the Tier 1 public notice to be provided? What additional steps are required? Public water systems must:

1. Provide a public notice as soon as practical but no later than 24 hours after the system learns of the violation;

2. Initiate consultation with the Department as soon as practical, but no later than 24 hours after the public water system learns of the violation or situation, to determine additional public notice requirements; and

3. Comply with any additional public notification requirements (including any repeat notices or direction on the duration of the posted notices) that are established as a result of the consultation with the Department. Such requirements may include the timing, form, manner, frequency, and content of repeat notices (if any) and other actions designed to reach all persons served.

(c) What is the form and manner of the public notice? Public water systems must provide the notice within 24 hours in a form and manner reasonably calculated to reach all persons served. The form and manner used by the public water system are to fit the specific situation, but must be designed to reach residential, transient, and non-transient users of the water system. In order to reach all persons served, water systems are to use, at a minimum, one or more of the following forms of delivery:

1. Appropriate broadcast media (such as radio and television);

2. Posting of the notice in conspicuous locations throughout the area served by the water system;

3. Hand delivery of the notice to persons served by the water system; or

4. Another delivery method approved in writing by the department.

(3) Tier 2 Public Notice--Form, manner, and frequency of notice.

(Rule 0400-45-01-.19, continued)

(a) Which violations or situations require a Tier 2 public notice? Table 0400-45-01-.19(3)(a) lists the violation categories and other situations requiring a Tier 2 public notice. Appendix A to this rule identifies the tier assignment for each specific violation or situation.

Table 0400-45-01-.19(3)(a)

Violation Categories and Other Situations
Requiring a Tier 2 Public Notice

1.	All violations of the MCL, MRDL, and treatment technique requirements, except where a Tier 1 notice is required under subparagraph (2)(a) of this rule or where the department determines that a Tier 1 notice is required;
2.	Violations of the monitoring and testing procedure requirements, where the department determines that a Tier 2 rather than a Tier 3 public notice is required, taking into account potential health impacts and persistence of the violation; and
3.	Failure to comply with the terms and conditions of any variance or exemption in place.
4.	Failure to take corrective action or failure to maintain at least 4-log treatment of viruses (using inactivation, removal, or a Department-approved combination of 4-log virus inactivation and removal) before or at the first customer under subparagraph (4)(a) of Rule 0400-45-01-.40.

(b) When is the Tier 2 public notice to be provided?

1. Public water systems must provide the public notice as soon as practical, but no later than 30 days after the system learns of the violation. If the public notice is posted, the notice must remain in place for as long as the violation or situation persists, but in no case for less than seven days, even if the violation or situation is resolved. The department may, in appropriate circumstances, allow additional time for the initial notice of up to three months from the date the system learns of the violation. The department will not grant an extension to the 30-day deadline for any unresolved violation or to allow across-the-board extensions by rule or policy for other violations or situations requiring a Tier 2 public notice. Extensions granted by the department must be in writing.

2. The public water system must repeat the notice every three months as long as the violation or situation persists, unless the primacy agency determines that appropriate circumstances warrant a different repeat notice frequency. In no circumstance may the repeat notice be given less frequently than once per year. The Department will not through its rules or policies permit across-the-board reductions in the repeat notice frequency for other ongoing violations requiring a Tier 2 repeat notice. The Department will not allow through its rules or policies less frequent repeat notice for an MCL or treatment technique violation under Rule 0400-45-01-.07 (Monitoring) or Rule 0400-45-01-.41 (Revised Total Coliform Rule) or a treatment technique violation under Rule 0400-45-01-.31 (Filtration and Disinfection). Department determinations allowing repeat notices to be given less frequently than once every three months must be in writing.

3. For the turbidity violations specified in this paragraph, public water systems must consult with the Department as soon as practical but no later than 24 hours after the public water system learns of the violation, to determine whether a Tier 1 public notice under subparagraph (2)(a) of this rule is required to protect public

(Rule 0400-45-01-.19, continued)

health. When consultation does not take place within the 24-hour period, the water system must distribute a Tier 1 notice of the violation within the next 24 hours (i.e., no later than 48 hours after the system learns of the violation), following the requirements under subparagraphs (2)(b) and (c) of this rule. Consultation with the department is required for:

(i) Violation of the turbidity MCL under Rule 0400-45-01-.06; or

(ii) Violation of the SWTR, IESWTR or LT1ESWTR treatment technique requirement (Rule 0400-45-01-.31) resulting from a single exceedance of the maximum allowable turbidity limit.

(c) What is the form and manner of the Tier 2 public notice? Public water systems must provide the initial public notice and any repeat notices in a form and manner that is reasonably calculated to reach persons served in the required time period. The form and manner of the public notice may vary based on the specific situation and type of water system, but it must at a minimum meet the following requirements:

1. Unless directed otherwise by the department in writing, community water systems must provide notice by:

(i) Mail or other direct delivery to each customer receiving a bill and to other service connections to which water is delivered by the public water system; and

(ii) Any other method reasonably calculated to reach other persons regularly served by the system, if they would not normally be reached by the notice required in subpart (i) of this part. Such persons may include those who do not pay water bills or do not have service connection addresses (e.g., house renters, apartment dwellers, university students, nursing home patients, prison inmates, etc.). Other methods may include: publication in a local newspaper; delivery of multiple copies for distribution by customers that provide their drinking water to others (e.g., apartment building owners or large private employers); posting in public places served by the system or on the Internet; or delivery to community organizations.

2. Unless directed otherwise by the department in writing, non-community water systems must provide notice by:

(i) Posting the notice in conspicuous locations throughout the distribution system frequented by persons served by the system, or by mail or direct delivery to each customer and service connection (where known); and

(ii) Any other method reasonably calculated to reach other persons served by the system if they would not normally be reached by the notice required in subpart (i) of this part. Such persons may include those served who may not see a posted notice because the posted notice is not in a location they routinely pass by. Other methods may include: publication in a local newspaper or newsletter distributed to customers; use of E-mail to notify employees or students; or, delivery of multiple copies in central locations (e.g., community centers).

(4) Tier 3 Public Notice--Form, manner, and frequency of notice.

(a) Which violations or situations require a Tier 3 public notice? Table 0400-45-01-.19(4) lists the violation categories and other situations requiring a Tier 3 public notice.

(Rule 0400-45-01-.19, continued)

Appendix A to this rule identifies the tier assignment for each specific violation or situation.

Table 0400-45-01-.19(4)

Violation Categories and Other Situations Requiring a Tier 3 Public Notice

1.	Monitoring violations for the primary drinking water contaminants, except where a Tier 1 notice is required under subparagraph (2)(a) of this rule or where the department determines that a Tier 2 notice is required;
2.	Failure to comply with an approved departmental or EPA testing procedure, except where a Tier 1 notice is required under subparagraph (2)(a) of this rule or where the department determines that a Tier 2 notice is required;
3.	Operation under a variance granted under Section 1415 or an exemption granted under Section 1416 of the Safe Drinking Water Act;
4.	Availability of unregulated contaminant monitoring results, as required under paragraph (7) of this rule;
5.	Exceedance of the fluoride secondary maximum contaminant level (SMCL), as required under paragraph (8) of this rule; and
6.	Reporting and Recordkeeping violations under Rule 0400-45-01-.41.

(b) When is the Tier 3 public notice to be provided?

1. Public water systems must provide the public notice not later than one year after the public water system learns of the violation or situation or begins operating under a variance or exemption. Following the initial notice, the public water system must repeat the notice annually for as long as the violation, variance, exemption, or other situation persists. If the public notice is posted, the notice must remain in place for as long as the violation, variance, exemption, or other situation persists, but in no case less than seven days (even if the violation or situation is resolved).

2. Instead of individual Tier 3 public notices, a public water system may use an annual report detailing all violations and situations that occurred during the previous twelve months, as long as the timing requirements of part 1 of this subparagraph are met.

(c) What is the form and manner of the Tier 3 public notice? Public water systems must provide the initial notice and any repeat notices in a form and manner that is reasonably calculated to reach persons served in the required time period. The form and manner of the public notice may vary based on the specific situation and type of water system, but it must at a minimum meet the following requirements:

1. Unless directed otherwise by the Department in writing, community water systems must provide notice by:

(Rule 0400-45-01-.31, continued)

1. Representative samples of a system's filtered water effluent must be less than or equal to 1 NTU in at least 95 percent of the measurements taken each month. In systems using slow sand filtration, if the Department determines there is no significant interference with disinfection at a higher turbidity level, the Department may substitute this higher turbidity limit for a system.

2. The turbidity level of representative samples of a system's filtered water must at no time exceed 5 NTU.

(c) By December 31, 2001, subpart H systems that use conventional or direct filtration and serve 10,000 or more persons and by January 14, 2005, subpart H systems serving fewer than 10,000 persons 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 subparagraphs (5)(a) and (c) of this rule.

2. The turbidity level of representative samples of a system's filtered water must at no time exceed 1 NTU, measured as specified in subparagraphs (5)(a) and (c) of this rule.

3. A system that uses lime softening may acidify representative samples prior to analysis using a protocol approved by the Department.

(d) A public water system may use a filtration technology not listed in subparagraph (c) of this paragraph or in subparagraph (b) of this paragraph if it demonstrates to the Department, using pilot plant studies or other means, that the alternative filtration technology, in combination with disinfection treatment that meets the requirements of paragraph (30) of Rule 0400-45-01-.17, 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. The maximum allowable turbidity limits for subpart H systems serving fewer than 10,000 persons using an alternative filtration technology excluding slow sand and diatomaceous earth cannot exceed 1 NTU in 95 percent of the samples taken each month or 5 NTU on any single sample.

(5) Monitoring Requirements

(a) Reserved

(b) The public water system must comply with the maximum contaminant level (MCL) for total coliforms in paragraph (4) of Rule 0400-45-01-.06 and the MCL for E. coli in subparagraph (4)(g) of Rule 0400-45-01-.06. The system must achieve the standard at a frequency of at least 11 months of the 12 previous months that the system served water to the public, on an ongoing basis, unless the Department determines that failure to meet this requirement was not caused by a deficiency in treatment of the source water.

(Rule 0400-45-01-.31, continued)

[1] The day's samples cannot be taken at the same time. The sampling intervals are subject to Department 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. Until March 31, 2016, 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 paragraph (1) of Rule 0400-45-01-.07. Beginning April 1, 2016, 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 paragraphs (4) through (8) of Rule 0400-45-01-.41. The Department 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 Department determines that such points are more representative of treated (disinfected) water quality within the distribution system. Heterotrophic bacteria, measured as heterotrophic plate count (HPC) as specified in part (10)(a)4 of Rule 0400-45-01-.14, may be measured in lieu of residual disinfectant concentration.

(c) Until March 31, 2016, 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 paragraph (1) of Rule 0400-45-01-.07. Beginning April 1, 2016, 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 paragraphs (4) through (8) of Rule 0400-45-01-.41. The Department 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 Department determines that such points are more representative of treated (disinfected) water quality within the distribution system. Heterotrophic bacteria, measured as heterotrophic plate count (HPC) as specified in part (10)(a)4 of Rule 0400-45-01-.14, may be measured in lieu of residual disinfectant concentration.

1. Turbidity as required by paragraph (4) of this rule must be continuously measured and recorded on representative samples of the system's combined filtered water while the system serves water to the public. The highest turbidity value obtained during each four-hour period must be reported. A public water system may substitute grab sample monitoring if approved by the Department. For any system using slow sand filtration or filtration treatment other than conventional treatment, direct filtration, or diatomaceous earth filtration, the Department 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 Department may reduce the turbidity sampling frequency to once per day, regardless of the type of filtration treatment used, if the Department determines that less frequent monitoring is sufficient to indicate effective filtration performance. The highest turbidity measured each four hours must be reported according to the following four hour segments: 12:01 a.m. to 4:00 a.m., 4:01 to 8:00 a.m., 8:01 to 12 noon, 12:01 to 4:00 p.m., 4:01 p.m. to 8:00 p.m., 8:01 to 12 midnight. The intake of the combined filter effluent turbidity monitor shall be located at or near the entry point to the clearwell or at a location approved by the Department.

(Rule 0400-45-01-.31, continued)

[1] The day's samples cannot be taken at the same time. The sampling intervals are subject to Department 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. Until March 31, 2016, 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 paragraph (1) of Rule 0400-45-01-.07. Beginning April 1, 2016, 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 paragraphs (4) through (8) of Rule 0400-45-01-.41. The Department 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 Department determines that such points are more representative of treated (disinfected) water quality within the distribution system. Heterotrophic bacteria, measured as heterotrophic plate count (HPC) as specified in part (10)(a)4 of Rule 0400-45-01-.14, may be measured in lieu of residual disinfectant concentration.

(c) Until March 31, 2016, 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 paragraph (1) of Rule 0400-45-01-.07. Beginning April 1, 2016, 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 paragraphs (4) through (8) of Rule 0400-45-01-.41. The Department 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 Department determines that such points are more representative of treated (disinfected) water quality within the distribution system. Heterotrophic bacteria, measured as heterotrophic plate count (HPC) as specified in part (10)(a)4 of Rule 0400-45-01-.14, may be measured in lieu of residual disinfectant concentration.

1. Turbidity as required by paragraph (4) of this rule must be continuously measured and recorded on representative samples of the system's combined filtered water while the system serves water to the public. The highest turbidity value obtained during each four-hour period must be reported. A public water system may substitute grab sample monitoring if approved by the Department. For any system using slow sand filtration or filtration treatment other than conventional treatment, direct filtration, or diatomaceous earth filtration, the Department 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 Department may reduce the turbidity sampling frequency to once per day, regardless of the type of filtration treatment used, if the Department determines that less frequent monitoring is sufficient to indicate effective filtration performance. The highest turbidity measured each four hours must be reported according to the following four hour segments: 12:01 a.m. to 4:00 a.m., 4:01 to 8:00 a.m., 8:01 to 12 noon, 12:01 to 4:00 p.m., 4:01 p.m. to 8:00 p.m., 8:01 to 12 midnight. The intake of the combined filter effluent turbidity monitor shall be located at or near the entry point to the clearwell or at a location approved by the Department.

(Rule 0400-45-01-.31, continued)

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 Department 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 paragraph (1) of Rule 0400-45-01-.07. The Department 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 Department 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 subpart H system 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 subparagraph (10)(b) of Rule 0400-45-01-.14 and must calibrate turbidimeters using the procedure specified in paragraphs (40) and (41) of Rule 0400-45-01-.17. Systems must record the results of individual filter monitoring every 15 minutes. In addition to monitoring required by parts 1, 2 and 3 of this subparagraph by January 14, 2005, a subpart H system serving fewer than 10,000 persons using conventional filtration treatment or direct filtration must conduct continuous monitoring of turbidity for each individual filter using an approved method in subparagraph (10)(b) of Rule 0400-45-01-.14 and must calibrate turbidimeters using the procedure specified in paragraphs (40) and (41) of Rule 0400-45-01-.17. 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.

COMMUNITY

PUBLIC WATER SYSTEMS

DESIGN CRITERIA

Division of Water Supply

Tennessee Department of Environment and Conservation

2008

TABLE OF CONTENTS

Page

INTRODUCTION

This publication is a revised edition of our Design Criteria for Community Public Water Systems. They have been prepared as a guide to water systems, design engineers, and our own staff. There has been no attempt to address every situation. We also know that there will be occasions when these criteria will not apply. Exceptions will be handled on an individual basis.

The Tennessee Safe Drinking Water Act of 1983 requires The Department of Environment & Conservation to:

> "Exercise general supervision over the construction of public water systems throughout the state. Such general supervision shall include all the features of construction of public water systems which do or may affect the sanitary quality or the quantity of the water supply. No new construction shall be done nor shall any change be made in any public water system until the plans for such new construction or change have been submitted and approved by the department."
> (Extract of part of Section 68-13-706, Tennessee Code)

Where the terms shall and must are used, it is intended to be a mandatory requirement. Other terms such as should, recommend, preferred, and the like, are intended to show desirable equipment, procedures, or methods.

We encourage development of new methods and equipment. However, any new developments must be demonstrated to be satisfactory before we can approve their use. Operating data from other installations, or demonstration of the equipment by a manufacturer's representative, or both, may be needed for our review.

These criteria are a compilation of information from a number of sources. The principle source, however, is Recommended Standards for Water Works, 1982 Edition. This publication is a report of "The Committee of the Great Lakes Upper Mississippi River Board of State Sanitary Engineers" and is commonly known as Ten-State Standards.

Part 4 - TREATMENT

4.0 GENERAL - The design of treatment processes and devices depends on evaluation of the nature and quality of the particular water to be treated and the desired quality of the finished water. Surface water treatment plants must provide treatment for cryptosporidium, giardia, bacteria and viruses in accordance with the requirements of Division of Water Supply surface water treatment rules. Surface water treatment plants must provide for taste and odor control if there is any history or potential of taste and odor problems/complaints. Surface water treatment plants must be designed for control and reduction of disinfection by-products and their precursors.

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 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.

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.

a. 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.

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

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

d. 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.

e. Plate Settlers – shall be designed, installed and loaded per the manufacturers recommendations.

f. 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.

g. 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.

h. 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.

i. 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.

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

k. 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.

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

m. 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.

4.1.5 Solids Contact Unit - Solids contact units are acceptable for clarification and/or softening. Clarifiers should be designed for the maximum uniform rate and should be adjustable to changes in flow which are less than the design rate and for changes in water characteristics. A minimum of 2 units is required. The following are design criteria for consideration, but any design shall be submitted in detail to be reviewed on a case-by-case basis.

a. Installation of equipment - Supervision by a representative of the manufacturer should be provided with regard to all mechanical equipment at the time of:

1. installation, and

2. initial operation.

b. Operating equipment - The following should be provided for plant operation:

1. a complete outfit of tools and accessories,

2. necessary laboratory equipment,

3. adequate piping with suitable sampling taps so located as to permit the collection of samples of water from critical portions of the units.

c. Chemical feed - Chemicals should be applied at such points and by such means as to insure satisfactory mixing of the chemicals with the water.

d. Mixing - Mixing devices employed should be so constructed as to:

1. provide good mixing of the raw water with previously formed sludge particles, and

2. prevent deposition of solids in the mixing zone.

e. Flocculation - Flocculation equipment should:

1. be adjustable,

2. provide for coagulation to occur in a separate chamber or baffled zone within the unit,

3. provide the flocculation and mixing period to be not less than 30 minutes.

f. Sludge concentrators - The equipment should provide either internal or external concentrators in order to obtain a concentrated sludge with a minimum of waste water.

g. Sludge removal - Sludge removal design should provide that:

1. sludge pipes shall be not less than three inches in diameter and so arranged as to facilitate cleaning,

2. entrance to sludge withdrawal piping shall prevent clogging,

3. valves shall be located outside the tank for accessibility,

4. operator may observe or sample sludge being withdrawn from the unit,

5. backflow from sanitary sewer systems be impossible.

h. Cross-connections:

1. blow-off outlets and drains should terminate and discharge at places satisfactory to the Department.

2. cross-connection control should be included for the potable water lines used to backflush sludge lines.

i. Detention period - Systems using a sludge blanket should have a minimum detention time of 1 hour with the flow rate not to exceed 1.0 gpm/ft2.

j. Suspended slurry concentrate - Units should be designed so that continuous slurry concentrates of 1% or more, by weight, can be satisfactorily maintained.

k. Water Losses

1. units should be provided with suitable controls for sludge withdrawal,

2. total water losses should not exceed:

(i) 5% for clarifiers,

(ii) 3% for softening units.

3. solids concentration of sludge bled to waste should be:

(i) 3% by weight for clarifiers,

(ii) 5% per cent by weight for softeners,

l. Weirs or orifices - The units should be equipped with either overflow weirs or orifices. Weirs shall be:

1. adjustable,

2. at least equivalent in length to the perimeter of the tank,

3. constructed so that surface water does not travel over 10 feet horizontally to the collection trough.

m. Weir loading - Should be same as conventional settling.

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/ft² 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.

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 depending on the quality and variability of the source water. All filters shall have dual or mixed media. 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,

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 at least 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. Dual Media (Sand/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.

iv. Granular activated carbon may be substituted for anthracite if approved by the Division of Water Supply

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.

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.

7. Media retention systems with no support gravel will be considered for approval on a case-by-case basis.

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.

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,

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,

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.

4.3 PACKAGE TREATMENT PLANTS, MEMBRANES AND OTHER TECHNOLOGIES - Will be reviewed on a case-by-case basis based on demonstrated performance criteria.

4.3.1 Package Treatment Plants – may be acceptable for source waters that are generally low in turbidity and do not experience large or frequent turbidity spikes. Filter backwash and clarifier flush/rinse frequencies along with water production efficiency must be considered for each application. Adequate detention times must be evaluated for oxidation processes, coagulation, TOC reduction and taste & odor control.

4.3.2 Membrane Filtration – is generally acceptable for turbidity/particulate removal. Each membrane module must have a continuous filtrate turbidity monitor and provisions for direct integrity testing. Other treatment processes such as coagulation, flocculation and oxidation must be used in conjunction with membranes where dissolved constituents such as TOC, iron and manganese are present in sufficient quantities to require treatment/removal. Clarification/sedimentation should be provided prior to membrane filtration where turbidity and suspended solids are very high in the raw water.

4.3.3 Cartridge and Bag Filters – will be considered for approval on a case-by-case basis depending on raw water quality and the size of the water system.

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.

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,

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).

4.4.5 Chlorine Dioxide – may be used for oxidation, disinfection and/or treatment of tastes and odors. Chlorine dioxide may be considered in conjunction with other treatment processes for meeting surface water treatment requirements or as an alternative to raw water chlorination where disinfection by-products must be reduced. Water systems that add chlorine dioxide must monitor for chlorine dioxide residual and chlorite.

4.4.6 UV Light - may be used for disinfection at water treatment plants in conjunction with chlorination and other treatment processes to meet surface water treatment requirements. UV light may also be used at groundwater treatment plants. Water systems using UV light must also provide chlorination for residual disinfection.

4.4.7 Ozone – may be used at water treatment plants for oxidation, disinfection, and meeting surface water treatment requirements. Water systems using ozone must monitor for bromate.

4.4.8 Hydrogen Peroxide – may be used at water treatment plants for raw water oxidation and/or disinfection. Hydrogen peroxide may be used to replace raw water chlorination where disinfection by-products must be reduced.

4.4.9 Permanganates – potassium permanganate or sodium permanganate may be used for raw water oxidation and/or disinfection. Permanganates may be used to replace raw water chlorination where disinfection by-products must be reduced.

4.4.10 Chloramines – will be considered for use in water distribution systems if other methods to reduce disinfection by-products have failed to achieve compliance. Effects of chloramination on water chemistry, corrosivity and microbiological water quality must be evaluated.

4. 5 SOFTENING - In all but a very few locations in Tennessee softening of available raw water is not needed. Unless there is a demonstrated need, softening should be avoided because of the additional expense and because of the increased sodium content of the water when ion exchange softening is used.

4.5.1 Lime-Soda Process - The applicable design standards for mixing, flocculation and sedimentation are the same for the lime-soda process as for conventional clarification. Where softening is included as a treatment process in conjunction with clarification, the clarification criteria shall govern(see sections 4.1.2, 4.1.3 and 4.1.4). For criteria pertaining to softening with solids contact units see section 4.1.5.

a. Aeration - Determinations should be made for the C02 content of the raw water. When concentrations exceed 10 mg/L, the economics of removal by aeration as opposed to removal with lime should be considered (See Section 4.6).

b. Stabilization - Equipment for stabilization of water softened by the lime-soda process is required.

c. Sludge Collection - Mechanical sludge removal equipment shall be provided in the sedimentation basin (see section 4.11 for sludge disposal).

d. Sludge Disposal - Provisions must be included for proper disposal of softening sludges(See Section 4.11).

e. Disinfection - The use of excess lime shall not be considered an acceptable substitution for chlorination or any other approved method of disinfection (See Section 4.4).

4.5.2 Cation Exchange Process - Iron, manganese, or a combination of the two, in the oxidized state or unoxidized state, should not exceed 0.3 mg/L in the water as applied to the ion exchange resin. Pretreatment is required when the content of iron, manganese, or a combination of the two, is 1 mg/L or more.

a. Design - The units may be of pressure or gravity type, using automatic or manual regeneration. Automatic regeneration is suggested for small plants.

b. Exchange Capacity - The design capacity for hardness removal should not exceed 20,000 grains per cubic foot when resin is regenerated with 0.3 pounds of salt per kilogram of hardness removed..

c. Depth of Media - The depth of the exchange material should not be less than 3 feet.

d. Flow Rates - the rate of softening should not exceed 7 gallons per square foot per minute and the backwash rate should be 6 to 8 gallons per square foot per minute. Rate-of-flow controllers or the equivalent must be installed for the above purposes.

e. Freeboard - The freeboard will depend upon the specific gravity of the media. Generally, the washwater collector should be 24 inches above the top of the media.

f. Underdrains and Supporting Gravel - The bottoms strainer systems, and support for the exchange material shall conform to criteria provided for rapid rate gravity filters (See Sections 4.2.lg and 4.2.1h).

g. Brine Distribution - Facilities should be included for even distribution of the brine over the entire surface.

h. Cross Connection Control - Backwash, rinse and air relief discharge pipes should be installed in such a manner as to prevent any possibility of back-siphonage.

i. Bypass - A bypass shall be provided around softening units to produce a blended water of desirable hardness. Meters should be installed on the bypass line and on each softener unit. An automatic proportioning or regulating device and shut-off valve should be provided on the bypass line. In some installations it may be necessary to treat the bypassed water to obtain acceptable levels of iron and/or manganese in the finished water.

j. Additional Limitations - Waters having 1.0 units or more turbidity should not be applied directly to the cation exchange softener. Silica gel materials should not be used for waters having a pH above 8.4 or containing less than 6 mg/L silica and should not be used when iron is present. The cation exchange material shall be a type that is not damaged by residual chlorine. Phenolic resin should not be used.

k. Sampling Taps - Smooth-nose sampling taps must be provided for the collection of representative samples for both bacteriological and chemical analyses. The taps shall be

located to provide for sampling of the softener influent, softener effluent, and the blended water. The sampling taps for the blended water shall be at least 20 feet downstream from the point of blending. Petcocks are not acceptable as sampling taps. Sampling taps should be provided on the brine tank discharge piping.

1. Brine and Salt Storage Tanks

    1. Salt dissolving or brine tanks and wet storage tanks must be covered and must be corrosion resistant.

    2. The make-up water inlet must be protected from back siphonage. Water for filling the tank should be distributed over the entire surface by pipes above the maximum brine level in the tank. The tanks should be provided with an automatic declining level control system on the make-up water line.

    3. Wet salt storage basins must be equipped with manholes or hatchways for access and for direct dumping of salt from truck or railcar. Openings must be provided with raised curbs and watertight covers having overlapping edges similar to those required for finished water reservoirs.

    4. Overflows, where provided, must be turned down, have a proper free fall discharge and be protected with corrosion resistant screens or self-closing flap valves.

    5. Two wet salt storage tanks or compartments designed to operate independently should be provided.

    6. The salt is to be supported on graduated layers of gravel under which is a suitable means of collecting the brine.

    7. Alternative designs which are conducive to frequent cleaning of the wet salt storage tank may be considered.

m. Storage Capacity - Salt storage basins should have sufficient capacity to store in excess of l-1/2 carloads or truckloads of salt, and to provide for at least 30 days of operation.

n. Stabilization - Stabilization for corrosion control shall be provided (See Section 4.9).

o. Waste Disposal - Suitable disposal must be provided for brine waste (See Section 4.11).

p. Construction Material - Pipes and contact materials must be resistant to the aggressiveness of salt. Plastic and red brass are acceptable piping material. Steel and concrete must be coated with a non-leaching protective coating which is compatible with salt and brine.

q. Housing - Salt Storage tanks and feed equipment should be enclosed and separated from other operating areas in order to prevent damage to equipment.

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,

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).

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 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/ft2 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/ft2.

e. Normal wash rate is 8 to 10 gpm/ft2.

f. Air washing should be provided.

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 only suitable only for concentrations of iron and manganese that are below the respective MCL's. 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.

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,

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.

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 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.

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.

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.

4.11 WASTE DISPOSAL - Provisions must be made for proper disposal of water treatment plant waste such as sanitary, laboratory, clarification, softening and ion sludges, filter backwash, and brines. The quantity of waste produced in water treatment shall be minimized by choice of treatment processes and chemicals. If supernatant water from backwash/sludge holding tanks or lagoons is to be recycled through the treatment plant, potential impacts on the treatment process must be considered. Recycled water must be returned to the head of the treatment plant or to an alternate location approved by the Division of Water Supply. Recycled water should be settled/clarified to reduce contaminants that may be concentrated in sludges and backwash water.

4.11.1 Waste Water and Sludge - The following means of waste and sludge disposal may be considered:

a. Lagoons - Design should provide:

1. location free from flooding,

2. when necessary, dikes, deflecting gutters, or other means of diverting surface water,

3. a minimum usable depth of 4 to 5 feet with adequate freeboard,

4. 3 to 5 years solids storage volume,

5. multiple cells,

6. adjustable decanting devices,

7. convenient cleaning,

8. effluent sampling point,

9. adequate safety provisions.

b. Sludge Beds - Beds for lime softening sludges should provide for an application of slurry of at least 12 inches. Multiple beds should be provided so designed as to permit a minimum of one year's total storage. The storage capacity should be based on assumption that for each part per million of hardness removed there will be two parts per million of dry solids, and the accumulated sludge density being 120 pounds per cubic foot. Distribution channels are required for spreading sludge over the entire area. Provisions must be made for easy access and for paved loading ramps and underdrains. See Section 4.11.1.1 for provisions on flooding and surface water diversion.

c. Disposal to Sanitary Sewer System

1. Approval must be obtained from sewer system officials.

2. Consideration shall be given to the effects the water plant waste will have at the sewer plant including:

i. effect on the sewage treatment process,

ii. additional sludge to be handled.

3. Consideration shall be given to the effects of disposal into the sewage collection system. A schedule for disposal shall be determined in conjunction with sewer system officials.

d. other methods - These include holding tanks, vacuum filters, centrifuging, and recalcining. Detailed studies should be made to justify their use.

4.11.2 Sanitary Waste - The sanitary waste from water treatment plants, pumping stations, etc., must receive treatment. Waste from these facilities must be discharged either directly to a sanitary sewer system or to an individual waste disposal facility providing suitable treatment.

Part 5 - CHEMICAL APPLICATION

5.0 GENERAL - Plans and specifications describing water treatment plants (new, modified or expanded) shall include the chemicals and chemical feed equipment to be used in the treatment process.

5.0.1 These plans and specifications shall include:

a. descriptions of feed equipment, including maximum and minimum feed ranges,

b. location of feeders, piping layout and points of application,

c. storage and handling facilities,

d. specifications for chemicals to be used,

e. operating and control procedures,

f. descriptions of testing equipment and procedures.

5.0.2 Chemical shall be applied to the water at such points and by such means as to:

a. provide maximum flexibility of operation through various points of application, when appropriate, and

b. prevent backflow at all points of feed.

5.1 FEED EQUIPMENT

5.1.1 Number of Feeders

a. Where chemical feed is essential to the production of safe drinking water or necessary for continuous operation

1. a minimum of two feeders shall be provided,

2. a standby unit or combination of units of sufficient capacity should be available to replace the largest unit during shut-downs.

b. Spare parts shall be available for all feeders to replace parts which are subject to wear and damage.

5.1.2 Design and Capacity - Design and capacity shall be such that:

a. feeders will be able to supply, at all times, the necessary amounts of chemical at an accurate rate, throughout the range of feed;

b. feeders are adjustable to handle all plant flow rates;

c positive displacement type solution feed pumps shall be used to feed liquid chemicals, and shall not be used to feed chemical slurries;

d. chemical solutions cannot be siphoned into the water supply;

e. service water supply cannot be contaminated by chemical solutions by:

1. equipping the supply line with backflow prevention devices (see Section 5.l.8.c), or

2. providing an air gap between supply line and solution tank.

f. chemical-contact materials and surfaces are resistant to the aggressiveness of the chemical solution;

g. dry chemical feeders will:

1. measure chemicals volumetrically or gravimetrically,

2. provide effective solution of the chemical in the solution pot,

3. provide gravity feed from solution pots, in open troughs when feasible,

4. completely enclose chemicals to prevent emission of dust to any of the operating areas (see Section 5.2.3d).

h. no direct connection exists between any sewer and a drain or overflow from the feeder or solution chamber or tank.

5.1.3 Location - chemical feed equipment

a. shall be conveniently located near points of application to minimize length of feed lines;

b. shall be readily accessible for

1. servicing, repair and calibration, and

2. observation of operation;

c. shall be located and protective curbing provided, so that chemicals from equipment failure, spillage or accidental drainage shall not enter the water through conduits, treatment or storage basins, or result in hazardous discharge.

5.1.4 Control

a. Feeders may be manually or automatically controlled, with automatic control reverting to manual control as necessary.

b. Process must be manually started following shutdown, unless otherwise approved by the Department.

c. Feed rates proportional to flow must be provided.

d. Automatic chemical dose or residual analyzers may be approved for use and must provide

1. alarms for critical values, and

2. recording charts.

5.1.5 Solution Tanks

a. Means shall be provided in a solution tank to maintain uniform strength of solution, consistent with the nature of the chemical solution; continuous agitation is necessary to maintain slurries in suspension.

b. Two solution tanks may be required for a chemical, of specific capacity, to assure continuity of supply in servicing a solution tank.

c. Each tank shall be provided with a drain;

1. No direct connection between any tank or drain and a sewer shall be permitted, and

2. Any drain must terminate at least two pipe diameters above the overflow rim of a receiving sump, conduit or waste receptacle.

d. Means shall be provided to indicate the solution level in the tank.

e. Make-up water shall enter the tank from above the maximum solution level, providing an air gap of two pipe diameters but not less than six inches, or shall be protected with an approved backflow prevention devices (see Section 5.1.8.c).

f. Chemical solutions shall be kept covered. Large tanks with access openings shall have such openings curbed and fitted with tight covers.

g. Subsurface locations for solution tanks shall:

1. be free from sources of possible contamination.

2. assure positive drainage for ground waters, accumulated water, chemical spills and overflows.

h. Overflow pipes, when provided, should:

1. be turned downward, with end screened.

2. have free discharge, and

3. be located where noticeable.

5.1.6 Weighing Scales

a. shall be provided for weighing cylinders, at all plants utilizing chlorine gas; for large plants, indicating and recording type are desirable;

b. shall be provided to measure the amount of fluoride fed with the exception of the use of a saturator, which shall have a water meter;

c. should be provided for volumetric dry chemical feeders;

d. should be accurate to measure increments of 0.5% of load;

5.1.7 Feed Lines

a. should be as short as possible in length of run, and

1. of durable, corrosion-resistant material,

2. easily accessible throughout entire length,

3. protected against freezing,

4. easily cleaned,

5. lime feed lines should be designed so they can be readily replaced, and

6. avoiding sharp bends when possible.

b. should slope upward from chemical source to feeder, when conveying gases;

c. should introduce corrosive chemicals in such manner as to minimize potential for corrosion;

d. shall be designed consistent with scale-forming or solids depositing properties of the water, chemical, solution or mixture conveyed;

e. shall not carry chlorine gas beyond chlorine storage and feeder room(s) except under vacuum;

f. should be color coded.

5.1.8 Service Water Supply

a. Water used for dissolving dry chemicals, diluting liquid chemicals or operating chemical feeders shall be:

1. only from a safe, approved source,

2. protected from contamination by appropriate means (see Section 5.1.8c),

3. ample in supply and adequate in pressure,

4. provided with means for measurement when preparing specific solution concentrations by dilution,

5. properly treated for hardness, when necessary.

b. Where a booster pump is required, duplicate equipment should be provided and, when necessary, standby power.

c. Back-flow prevention shall be achieved by appropriate means such as:

1. an air gap between fill pipe and maximum flow line of solution or dissolving tank equivalent to 2 pipe diameters but not less than 6 inches, or

2. an approved reduced pressure backflow preventer, consistent with the degree of hazard, aggressiveness of chemical solution, back pressure sustained, and available means for maintaining and testing the device, or

3. a satisfactory vacuum relief device.

5.2 CHEMICALS

5.2.1 Quality

a. Chemical containers shall be fully labeled to include:

1. chemical name, purity and concentration,

2. supplier name and address, and

3. expiration date where applicable.

b. Chemicals shall be listed under ANSI/NSF Standard 60(or equivalent) and meet American Water Works Association specifications, where applicable.

c. Provisions should be made for assay of chemicals delivered.

d. Chemicals shall not impart any toxic material to the water under recommended dosages.

5.2.2 Storage

a. Space should be provided for:

1. at least 30 days of chemical supply,

2. convenient and efficient handling,

3. dry storage conditions,

4. a minimum of 1-1/2 truck loads storage volume where purchase is by truck load lots,

5. protection against excessive, damaging or dangerous extremes in temperature.

b. Cylinders of chlorine shall be:

1. isolated from operating areas,

2. restrained in position to prevent upset,

3. stored inside for sufficient time before being connected to chlorinator that temperature has been approximately equalized,

4. provided shade from direct sun and given physical security if stored outside of building.

c. Liquid chemical storage tanks must:

1. have a liquid level indicator,

2. have an overflow and a receiving basin or drain capable of receiving accidental spills or overflows,

3. provide for protection against freezing and/or loss from solution due to temperature drop.

d. Special precautions must be taken with:

1. sodium chlorite, to eliminate any danger of explosion;

2. activated carbon, which is a potentially combustible material, requiring isolated, fireproof storage and explosion-proof electrical outlets, lights and motors in areas of dry handling.

3. calcium hypochlorite and potassium permanganate, which may ignite spontaneously on contact with combustible substances;

4. hydrofluosilicic acid, which is extremely corrosive. Fumes or spillage may damage equipment or structures.

5. liquid caustic (50% sodium hydroxide solution) which is hazardous and may be lost from solution at low temperature.

6. gaseous chlorine (see Sections 5.3.4-5.4).

7. on-site generation of sodium hypochlorite. Provisions must be included for dilution and venting of potentially explosive hydrogen gas.

e. Chemicals shall be stored in covered or unopened shipping containers, unless the chemical is transferred into an approved covered storage unit.

f. Solution storage or day tanks supplying feeders directly should have sufficient capacity for one day of operation.

g. Acid storage tanks must be vented to the outside atmosphere, but not through vents in common with day tanks.

5.2.3 Handling

a. Provisions shall be made for

1. measuring quantities of chemicals used to prepare feed solutions, and

2. for easy calibration of solution pumps measured from the suction side.

b. Storage tanks and pipelines for liquid chemicals shall be specific to the chemicals and not for alternates.

c. Chemicals that are incompatible shall not be fed, stored or handled together.

d. Provisions must be made for the proper transfer of dry chemicals from shipping containers to storage bins or hoppers, in such a way as to minimize the quantity of dust which may enter the room in which the equipment is installed; control should be provided by use of:

1. vacuum pneumatic equipment or closed conveyer systems, or

2. facilities for emptying shipping containers in special enclosures, or

3. exhaust fans and dust filters which put the hoppers or bins under negative pressure.

e. Precautions shall be taken with electrical equipment to prevent explosions, particularly in the use of sodium chlorite and activated carbon.

f. Acids shall:

1. be kept in closed, acid-resistant shipping containers or storage units;

2. not be handled in open vessels, but should be pumped in undiluted form from original containers, through suitable hose, to the point of treatment or to a covered day tank.

g. Carts, elevators and other appropriate means shall be provided for lifting chemical containers to minimize excessive lifting by operators.

h. Provisions shall be made for disposing of empty bags, drums or barrels, by approved procedures which will minimize exposure to dusts.

5.3 HOUSING

5.3.1 Structures, rooms and areas accommodating chemical feed equipment shall provide convenient access for

a. servicing and repair,

b. observation of operation.

5.3.2 Floor surfaces shall be smooth and impervious, slip-proof and well-drained with 2.5% slope, minimum.

5.3.3 open basins, tanks and conduits shall be protected from chemical spills or accidental drainage.

5.3.4 Chlorine gas feed and storage shall be:

a. enclosed and separated from other operating areas in order to prevent injury to personnel and damage to equipment; separate chlorine feed and storage rooms may be required for large installations;

b. provided with an inspection window to permit viewing of the interior of the room and the equipment;

c. provided with doors opening outward with a crash bar, assuring ready means of exit; doors opening to the building exterior only shall be provided.

d. provided with locks to prevent general public access.

5.3.5 Where chlorine gas is used, ventilation for each room shall be provided for one complete air change per minute; and

a. The air outlet from the room shall be near the floor and the point of discharge shall be so located as not to contaminate air inlets to any rooms or structures, or adversely affect the surrounding environment;

b. air inlets shall be through louvers near the ceiling, and temperature controlled to prevent adverse affect on chlorinator;

c. switches for fans and lights shall be outside of the room, at the entrance; signal light indicating fan operation shall be provided at each entrance when fan can be controlled from more than one point;

d. vents from feeders and storage shall discharge to the outside atmosphere, above grade.

5.3.6 Chlorinator rooms should be heated to 60 degrees F, but should be protected from excess heat; cylinders and gas lines should be protected from temperatures above that of the feed equipment.

5.3.7 Gaseous feed chlorine installations shall be equipped with a gas detection device connected to an audible alarm to prevent undetected, potentially dangerous leakage of chlorine gas.

5.4 OPERATOR SAFETY

a. Gases from feeders, storage and equipment exhausts shall be conveyed to the outside atmosphere, above grade and remote from air intakes.

b. Special provisions shall be made for ventilation of chlorine feed and storage rooms (see Section 5.3.5).

c. A M-S-A air mask, Model 401, Catalog No. 01-95066 or equal, complete with storage cabinet and 30 minute air cylinder shall be provided along with a 30 minute backup cylinder to prevent loss of utility while the primary air cylinder is being refilled or tested. The air mask shall be cabinet-mounted close by but not inside the chlorine room, and shall be easily accessible to the operator.

d. A bottle of ammonium hydroxide shall be available for chlorine leak detection during cylinder change.

e. All gaseous feed chlorine installations shall be equipped with appropriate leak repair kits.

f. At least one pair of rubber gloves with long gauntlets, a dust respirator of a type approved by the U.S. Bureau of Mines for toxic dusts, and an apron or other protective clothing shall be provided for each operator in any shift who will handle dry chemicals.

g. Rubber gloves with long gauntlets, rubber roots, goggles, rubber apron or other suitable protective clothing shall be provided for each operator preparing chemical solutions, or cleaning up spills.

h. Facilities shall be provided for washing of face, gloves and protective equipment.

i. A safety shower shall be provided in areas where hazardous chemicals are handled.

j. On-site generation of sodium hypochlorite must include dilution and venting of hydrogen gas.

Part 6 - LABORATORY FACILITIES

6.0 GENERAL - Laboratory equipment and facilities shall be compatible with the raw water source, intended design of the treatment plant, and the complexity of the treatment process involved. Recognized laboratory procedures must be utilized. See Parts 4 and 5 for related criteria.

6.1 EQUIPMENT - A list of testing equipment will be furnished by the Department.

6.2 LABORATORY SPACE AND FACILITIES

6.2.1 Laboratory facilities shall be located in a separate room from office/lunch activities and from the treatment units. Facilities shall be isolated by doors and not be located in the main traffic pattern.

6.2.2 Sufficient bench space, adequate ventilation, adequate lighting, storage room, laboratory sink, and auxiliary facilities shall be provided.

6.2.3 The bacteriological laboratory, if provided, shall have about 6-10 feet of counter space and shall be located in a separate room or area.

6.3 SAMPLE TAPS - Sample taps shall be provided so that water samples can be obtained from each water source and from appropriate locations in each unit operation of treatment. Taps shall be consistent with sampling needs and not be of petcock type. Sample lines and pumps where applicable shall be sized to minimize time lag between point of sampling and point of sample collection.

Part 7 - PUMPING FACILITIES

7.0 GENERAL - Pumping facilities shall be designed to maintain the sanitary quality of pumped water. Subsurface pits or pump rooms and inaccessible installations should be avoided. No pumping station shall be subject to flooding.

7.1 LOCATION - The pumping station shall be so located that the proposed site will meet the requirements of the sanitary protection of the water quality, hydraulics of the system and be protected against interruption of service by fire, flood or any other hazard.

7.1.1 Site Protection - The station shall be:

a. elevated to a minimum of one foot above the 100-year flood elevation, or protected to such elevation;

b. accessible at all times unless permitted to be out of service for period of inaccessibility;

c. graded around station so as to lead surface drainage away from the station;

d. protected to prevent vandalism and entrance by unauthorized persons or animals.

7.2 GROUND WATER FACILITIES - Where pumping facilities are used, wells and springs shall be vented by properly hooded and screened pipe extending at least 12 inches above the pump floor. Where necessary, provision shall be made for lubricating the pump from a point at least 6 inches above the top of the well cover, by means which will prevent contamination of the water supply.

7.2.1 Drilled Wells - Pumping stations located over drilled wells shall;

a. have riser pipe or casing extending at least 6 inches, and preferably 12 inches, above the floor, and be equipped with flange or suitable stuffing box;

b. have riser pipe or casing firmly connected to the pump structure to provide a water tight connection.

c. have base of pump not less than 6 inches above pump room floor;

d. have pump foundation and base designed to prevent water from coming into contact with the joint.

7.2.2 Submersible Pumps - Where a submersible pump is used, the top of the casing shall be effectively sealed against entrance of water under all conditions of vibration or movements of conductors or cables.

7.2.3 Discharge Piping - Discharge piping should be provided with means to pump to waste but shall not be directly connected to a sewer. The discharge line shall:

a. have control valves located above pump floor;

b. be protected against freezing;

c. be valved to permit testing and control of each well;

d. have watertight joints;

e. have all exposed valves protected.

7.3 SURFACE WATER FACILITIES - Pump stations normally associated with surface water sources, either as raw or finished water pump stations, shall:

a. have adequate space for the installation of additional units if needed, and for the safe servicing of all equipment;

b. be of durable character, fire and weather resistant and with outward opening doors;

c. have floor elevation of at least 6 inches above finished grade;

d. have underground structure waterproofed;

e. have all floors drained without impairing the quality of water being handled and if equipment is contained on the floor, the floor shall have sufficient slope to drain adequately.

f. provide suitable outlet for drainage from pump glands without discharging onto the floor.

7.3.1 Suction Well - Suction wells shall:

a. be watertight;

b. have floors sloped to permit removal of water and entrained solids;

c. be covered or otherwise protected against contamination; including pump lubricant.

7.3.2 Equipment Servicing - Pump facilities shall be provided with;

a. crane-ways, hoist beams, eye bolts, or other adequate facilities for servicing or removal of pumps, meters or heavy equipment;

b. openings in floors, roofs or wherever else needed for removal of heavy or bulky equipment;

c. a convenient tool board or other facilities as needed for proper maintenance of the equipment.

7.3.3 Stairways and Ladders - Stairways or ladder shall

a. be provided between all floors, in pits or compartments which must be entered.

b. have handrails on both sides, and treads of non-slip material.

Stairs are preferred in areas where there is frequent traffic or where supplies are transported by hand. They shall have risers not exceeding 9 inches and treads wide enough for safety.

7.3.4 Heating - Provision shall be made for adequate heating for:

a. comfort of the operator;

b. the safe and efficient operation of the equipment.

In pump houses not occupied by personnel, only enough heat need be provided to prevent freezing of equipment or treatment process.

7.3.5 Ventilation - Adequate ventilation shall be provided for all pumping stations. Forced ventilation of at least 6 changes of air per hour shall be provided for:

a. all rooms, compartments, pits and other enclosures below grade floor;

b. any area where unsafe atmosphere may develop or where excessive heat may be built up.

7.3.6 Dehumidification - In areas where excess moisture could cause hazards to safety or damage to equipment means for dehumidification shall be provided.

7.3.7 Lighting - Pump stations shall be adequately lighted throughout. All electrical work shall conform to the requirements of the American Insurance Association and related agencies and to relevant State and/or local codes.

7.3.8 Sanitary and Other Conveniences - Pumping stations which are manned for extended periods shall be provided with potable water, lavatory and toilet facilities. Plumbing must be so installed as to prevent contamination of a public water supply. Wastes shall be discharged in accordance with Section 4.11 of these standards.

7.3.9 Pumps - At least 2 pumping units shall be provided. Each pumping unit shall be capable of carrying the peak demand. If more than 2 units are installed, they shall have sufficient capacity so that any 1 pump can be taken out of service and the remaining pumps are capable of carrying the peak demand. The pumping units shall:

a. have ample capacity to supply the peak demand without dangerous overloading;

b. be driven by a prime mover able to operate against the maximum head and air temperature which may be encountered;

c. have spare parts and tools readily available.

3600 RPM pumps are not desirable and should be avoided if at all possible.

7.3.10 Suction Lift - Suction lift pumps will be considered on an individual basis based on justification of design engineer.

7.4 BOOSTER PUMPS - Booster pumps shall be located or controlled so that:

a. they will not produce negative pressure anywhere in the distribution system;

b. the pressure in the suction line shall be maintained at or above 20 psi by the use of a pressure sustaining valve or low pressure cutoff device.

c. automatic or remote control devices shall have a range between the start and cutoff pressure which will prevent excessive cycling.

7.4.1 In-line Booster Pumps - In addition to the other requirements of this section, in-line booster pumps shall be accessible for servicing and repairs.

7.4.2 The criteria in this section also apply to fire pumps.

7.4.3 Booster pumps shall not serve more than 50 service connections unless gravity storage is provided or service pressure can be maintained above 20 psi without the pumps running.

7.5 AUTOMATIC AND REMOTE CONTROLLED STATIONS - All automatic stations should be provided with automatic signaling apparatus which will report when the station is out of service. All remote controlled stations shall be electrically operated and controlled and shall have signaling apparatus of proven performance. Installation of electrical equipment shall conform with the National Electrical Code.

7.6 APPURTENANCES

7.6.1 Valves - Pumps shall be adequately valved to permit satisfactory operation, maintenance and repair of the equipment. If foot valves are necessary they shall have a net valve area of at least 2½ times the area of the suction pipe and they shall be screened. Each pump shall have a positive acting check valve on the discharge side between the pump and shutoff valve.

7.6.2 Piping - In general, piping shall:

a. be designed so that the friction head will be minimized;

b. not be subject to contamination;

c. have watertight joints;

d. be protected against surge or water hammer;

e. be such that each pump has an individual suction line or the lines shall be so manifolded that they will insure similar hydraulic and operation conditions.

7.6.3 Gauges and Meters - Each pump shall:

a. shall have a standard pressure gauge on its discharge line;

b. shall have a compound gauge on its suction line;

c. shall have recording gauges in larger stations;

d. should have a means for measuring the discharge.

The larger stations should have indicating, totalizing and recording metering of the total water pumped.

7.6.4 Water Seals - Water seals shall not be supplied with water of a lesser sanitary quality than that of the water being pumped.

7.6.5 Controls - Pumps, their prime movers and accessories, shall be controlled in such a manner that they will operate at rated capacity without dangerous overload. Where two or more pumps are installed, provision shall be made for proper alternation. Provision shall be made to prevent operation of the pump during the backspin cycle. Electrical controls should be located above grade.

7.6.6 Power - When power failure would result in cessation of minimum essential service, power supply shall be provided from at least two independent sources or standby or auxiliary source shall be provided.

7.6.7 Auxiliary Power Supply - When automatic pre-lubrication of pump bearings is necessary, and an auxiliary power supply is provided, the pre-lubrication line shall be provided with a valved by-pass around the automatic control.

Part 8 - FINISHED WATER STORAGE

8.0 GENERAL - The materials and designs used for finished water storage structures shall provide stability and durability as well as protect the quality of the stored water. Steel structures shall follow the current AWWA standards concerning steel tanks, standpipes, reservoirs, and elevated tanks wherever they are applicable. Prestressed concrete tanks shall meet applicable AWWA Standards. Other materials of construction are acceptable when properly designed to meet the requirements of this part.

8.0.1 Location

a. The bottom of ground-level reservoirs should be placed at the normal ground surface and above maximum flood level.

b. Where the bottom must be below normal ground surface, it should be placed above the ground water table. Sewers, drains, standing water, and similar sources of contamination must be kept at least 50 feet from the reservoir. Mechanical-joint water pipe, pressure tested in place to 50 psi without leakage, may be used for gravity sewers at lesser separations.

c. The top of a ground-level reservoir should not be less than 2 feet above normal ground surface and any possible flood level. Clearwells constructed under filters may be excepted from this requirement when the total design gives the same protection.

8.0.2 Protection - All new finished water storage structures shall have suitable watertight roofs or covers which exclude birds, animals, insects, and excessive dust.

8.0.3 Protection from Trespassers - Fencing, locks on access manholes, and other necessary precautions shall be provided to prevent trespassing, vandalism, and sabotage.

8.0.4 Drains - No drain on a water storage structure may have a direct connection to a sewer or storm drain. Splash pad and drainway shall be provided to prevent erosion.

8.0.5 Overflow - The overflow pipe of a water storage structure should be brought down near the ground surface and discharged over a drainage inlet structure or a splash plate and flow onto a drainway which is rip-rapped or otherwise protected to minimize erosion. No overflow may be connected directly to a sewer or storm drain.

a. When an internal overflow pipe is used, it shall be located in the access tube.

b. The overflow of a ground-level structure shall be high enough above normal or graded ground surface to prevent the entrance of surface water.

c. The overflow shall be protected with a twenty-four mesh non-corrodible screen and a flap valve.

8.0.6 Access - Finished water storage structures shall be designed with reasonably convenient access to the interior for cleaning and maintenance. Manholes on scuttles above waterline:

a. shall be framed at least 4 inches, and preferably 6 inches, above the surface of the roof at the opening; on ground-level structures manholes should be elevated 24 to 36 inches above the top or covering sod;

b. shall be fitted with a solid watertight cover which overlaps the framed opening and extends. down around the frame at least 2 inches;

c. should be hinged at one side;

d. shall have a locking device,

e. shall be a minimum of 20 inches in diameter or equivalent.

8.0.7 Vents - Finished water storage structures shall be vented by special vent structures. Open construction between the side wall and roof is not permissible. These vents:

a. shall prevent the entrance of surface water;

b. shall exclude birds and animals;

c. shall exclude insects and dust, as much as this function can be made compatible with effective venting; for elevated tanks and standpipes, 4-mesh non-corrodible screen may be used;

d. shall, on ground-level structures, terminate in an inverted U construction, the opening of which is 24 to 36 inches above the roof of sod and is covered with 24-mesh non-corrodible screen cloth.

8.0.8 Roof and Sidewall - The roof and sidewalls of all structures must be watertight with no openings except properly constructed vents, manholes, overflows, risers, drains, pump mountings, control ports, or piping for inflow and outflow.

a. Any pipes running through the roof or sidewall of a finished water storage structure must be welded or properly gasketed in metal tanks, or should be connected to standard wall castings which were poured in place during the forming of a concrete structure; these wall castings should have flanges embedded in the concrete.

b. openings in a storage structure roof or top, designed to accommodate control apparatus or pump columns, shall be curbed and sleeved with proper additional shielding to prevent the access of surface or slop water to the structure.

c. Valves and controls should be located outside the storage structure so that valve stems and similar projections will not pass through the roof or top of the reservoir.

8.0.9 Drainage for Roof or Cover - The roof or cover of the storage structure should be well drained, but downspout pipes shall not enter or pass through the reservoir; parapets, or similar construction which would tend to hold water and snow on the roof will not be approved.

8.0.10 Safety - The safety of employees must be considered in the design of the storage structure. As a minimum, such matters shall conform to pertinent laws and regulations.

a. Ladders, ladder guards, balcony railings, and safe location of entrance hatches shall be provided where applicable.

b. Elevated tanks with riser pipes over 8 inches in diameter shall have protective bars over the riser openings inside the tank.

8.0.11 Freezing - All finished water storage structures and their appurtenances, especially the riser pipes, overflows, and vents, shall be designed to prevent freezing which will interfere with proper functioning.

8.0.12 Grading - The area surrounding a ground-level structure should be graded in a manner that will prevent surface water from standing within 50 feet of the structure.

8.0.13 Silt stop - The discharge pipe of the reservoir shall be located in a manner that will prevent the flow of sediment into the distribution systems. Either a permanent or removable silt stop shall be provided at least 4 inches above the bottom of the storage structure.

8.0.14 Painting and/or Cathodic Protection - Proper protection should be given to metal surfaces by paints or other protective coatings, by cathodic protective devices, or by both.

a. Paint systems consistent with current American Water Works Association standards, or otherwise acceptable to the Department shall be used. All paints must be acceptable to FDA and EPA for contact with potable water.

b. Cathodic protection should be designed and installed by competent technical personnel.

8.0.15 Turnover of water - If the storage reservoir is sized larger than required for initial demand and there is more than 2 days storage, provisions shall be made for turnover of the water in the tank and/or booster chlorination. Internal piping arrangements to prevent water stratification in ground level standpipes are recommended. For large, ground level tanks/reservoirs, piping and/or check valves can be installed to force water in and out of the tank at different locations in order to minimize dead/stagnant water zones.

8.0.16 Sampling - A suitable sampling tap should be provided on all storage structures and be protected from public access.

8.0.17 Disinfection - Finished water storage structures shall be disinfected in accordance with AWWA Standard C652 before being put in service.

8.1 PLANT STORAGE - The applicable design standards of this part shall be followed for plant storage.

8.1.1 Washwater Tanks - If washwater tanks are used, they shall be sized, in conjunction with available pump units and finished water storage, to give the back wash water required by Section 4.2.1.K.

a. Consideration must be given to the possibility of having to wash more than one filter at a time, or several filters in succession.

8.1.2 Clearwell - Clearwell storage should be sized, in conjunction with distribution system storage, to relieve the filters from having to follow fluctuations in water use to meet peak demands, including filter backwash water. Design shall include features to minimize short circuiting.

a. When finished water storage is used to provide proper contact time for chlorine, (see Section 4.4.2), special attention must be given to size and baffling.

b. An overflow shall be provided and must be protected with a screen and flap valve.

8.1.3 Adjacent Compartments - finished water must not be stored or conveyed in a compartment adjacent to unsafe water when the two compartments are separated by a single wall.

8.1.4 Basins and Wet-Wells - Receiving basins and pump wet-wells for finished water shall be designed as finished water storage structures.

8.2 PRESSURE TANKS - Hydropneumatic (pressure) tanks may be acceptable in some circumstances where the number being served is 50 connections or less. When used, they shall meet ASME code requirements or equal which comply with the requirements of state and local laws and regulations for the construction and installation of unfired pressure vessels.

8.2.1 Location - The tank should be located above normal ground surface and be completely housed, or earth-mounted with one end projecting into an operating house, to prevent freezing.

8.2.2 Bypass - tank should have bypass piping to permit operation of the system while the tank is being repaired or painted.

8.2.3 Appurtenances - Each tank should have an access manhole, a drain, a control equipment consisting of pressure gage, water sight glass, automatic or manual air blow-off, mechanical means for adding air, and pressure-operated start-stop controls for the pumps.

8.2.4 Sizing -

a. The capacity of each well and/or pump in a hydropneumatic system should be at least ten times the average daily consumption rate of the community or the maximum peak demand whichever is greater.

b. The gross volume of the hydropneumatic tank, in gallons, should be at least 20 times the capacity of the largest pump, rated in gallons per minute.

8.2.5 Auxiliary power - Auxiliary power with automatic takeover capability shall be provided when positive pressures are not available from system gravity flow.

8.3 DISTRIBUTION STORAGE - The applicable design standards of this part shall be followed for distribution storage.

8.3.1 The purpose of system storage is to have sufficient water available to provide adequate flow and pressure at peak demand as well as to provide for fire flows when needed. For most water systems a satisfactory rule-of-thumb to meet these needs is to provide at least the average 24-hour demand in elevated storage. In the absence of an acceptable engineering study of the amount of water the system needs to meet customer demand and to provide for fire emergencies, the projected 24-hour demand at the end of the planning period will be the minimum requirement for elevated storage. This requirement may be reduced when the source, treatment facilities and pumps have sufficient capacity with standby power capability to supplement peak demands of the system.

8.3.2 Pressure Variation - System pressure variation on account of changes in level of water in storage structures should be minimized. Elevated storage tanks or large diameter ground tanks located on high ground should be the usual choices. Standpipes will not normally be approved and must be completely justified if proposed.

8.3.3 Drainage - Storage structures which float on the distribution system should be designed to drain for cleaning or maintenance without necessitating loss of pressure in the distribution system. The drains should discharge to the ground surface with no direct connection to a sewer or storm drain. (See Section 8.0.4). A nearby fire hydrant may be considered as a drain as long as service is not interrupted and suitable erosion protection is provided.

8.3.4 Level Controls - Adequate controls shall be provided to maintain levels in distribution system storage structures.

a. Telemeter equipment should be used when pressure-type controls are employed and any appreciable head loss occurs in the distribution system between the source and the storage structure.

b. Altitude valves or equivalent controls may be required for a second and subsequent structures on the system.

c. Overflow and low-level warnings or alarms should be located at places in the community where they will be under responsible surveillance on a 24-hour basis.

Rules and Regulation Exercise

Definitions:

1) **Define a Subpart H system.**

2) **Define public water system.**

MCL's

3) **The contract laboratory has reported this data (are these violations and if so, what is the MCL?):**

   a) **arsenic level at 0.05 mg/L.**

   b) **nitrate level at 12 mg/L.**

   c) **fluoride level at 4.3 mg/L.**

   d) **atrazine level at 0.005 mg/L.**

   e) **lindane level at 0.005 mg/L.**

   f) **chromium level at 0.4 mg/L.**

   g) **THM level at 0.09mg/L.**

   h) **HAA5 level at 0.55 mg/L.**

   i) **chlorine level at 4.3 mg/L.**

   j) **chlorine dioxide level at 0.79 mg/L.**

   k) **chloramine level at 3.9 mg/L.**

   l) **fecal coliform-positive repeat sample**

   m) **E. coli-positive repeat sample**

   n) **Total coliform-positive repeat sample following a fecal coliform-positive or E. coli-positive routine sample**

4) **The maximum contaminant levels for turbidity in drinking water, measured at a representative entry point(s) to the distribution system are _____ NTU as determined by monthly average pursuant or _____ NTU based on an average for two consecutive days.**

5) **The maximum contaminant level for microbiologicals are based on the presence or absence of total coliforms, these numbers shall not exceed any of the following:**

   a) **A system that collects at least _____ samples per month shall have no more than _____ % samples that are total coliform positive.**

   b) **A system that collects fewer than _____ shall have no more than _____ sample collected for the month that are total coliform positive.**

Sampling

6) **You serve a community of 32,000 people, how many samples would you need to collect per month for total coliform?**

7) **You serve a community of 8,200 people, how many samples would you need to collect per month for total coliform?**

8) **If a routine sample is total coliform-positive, you must collect a set of repeat samples within _____ hours of being notified of the positive result. The system must collect at least _____ repeat sample from the sampling tap where the original total coliform-positive sample was taken, and at least _____ repeat sample at a tap within _____ service connections upstream and at a tap within _____ service connections downstream of the original sampling site.**

9) **Turbidity measurements must be performed on representative samples of the system's filtered water every _____ hours.**

Operation and Maintenance Requirements

10) **All community water systems that are designed as a _____ supply and classified as a _____ system and all _____ removal plants that use gravity filters must have an _____ in attendance and responsible for the treatment process when the plant is in _____ .**

11) **Daily operating records shall be submitted so the Department receives them no later than _____ after the end of the reporting month.**

12) **All water quality tests shall be made in accordance with the latest edition of _____ or alternate methods acceptable to the Department.**

13) Free chlorine levels in the distribution system shall be maintained at no less than _____.

14) All community water systems shall develop a written plan for a _____ control program to detect and eliminate or protect the system from _____.

15) Newly constructed or repaired water distribution lines, finished water storage facilities, filters and wells shall be flushed and disinfected in accordance with _____ _____.

16) All community water systems shall be operated and maintained to provide a minimum positive pressure of _____ psi throughout the distribution system.

17) All community water systems having more than 50 service connections shall establish and maintain an adequate _____ program. Records must be maintained and shall include:

a) _____

b) _____

c) _____

d) _____

e) _____

18) All community public water systems serving more than 50 service connections and that have their own source of water shall be required to install, operate and maintain _____ disinfection equipment.

19) What is the filtration rate of a high rate filter?

20) How many inches of media are required?

a) Dual media:

i) Sand:

ii) Anthracite:

b) Mixed media beds:

21) All community water systems serving 50 connections or more are required to have _____ hours of distribution storage based on the _____ _____ demand for the past _____ months.

22) All community water systems serving 50 or more service connections must have and maintain up-to-date _____ of the distribution system. These maps must show the locations of the:

a) _____ **d) _____**

b) _____ **e) _____**

c) _____ **f) _____**

23) All vents on _____, springs, _____ _____, overflows and _____ shall be properly screened.

24) All community water systems planning to provide fire protection must have the distribution system designed to provide fire flow. All water mains designed for fire protection must be _____ inches or larger and be able to provide _____ gpm with _____ psi.

25) Public water systems that adjust the fluoride levels shall maintain the concentration of fluoride in the finished water between _____ mg/L and _____ mg/L.

26) All community water systems must establish and maintain a file for customer complaints. This file should include:

a) _____ **c) _____**

b) _____ **d) _____**

e) _____

27) 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 _____% (_____ log) and _____% (_____ 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 fist customer.

Public Notification Exercise

Identify:

1. Tier 1:

2. Tier 2:

3. Tier 3:

Instructions: List what Tier of PN you would take with each situation listed below, no PN can be a result also:

1. The contract laboratory has reported the fluoride result as 4.1 mg/L.

2. The system has received a positive result on Fecal coliform on analysis after a positive total coliform repeat sample.

3. The contract lab has notified the system that the samples submitted for TMH's were analyzed after the holding times had expired. The specific monitoring period has also passed. The lab sent the results to the system two weeks prior to their discovery of the holding time error. This result has already been reported to the state.

4. A system has been notified by their lab that the Alachlor level was 0.001mg/L.

5. A small system must collect two total coliform samples per month, but failed to do so last month.

6. The analysis for nitrate was 10.5 mg/L. A confirmation sample was collected within 24 hours. Its value was 9.3 mg/L.

7. The free chlorine residual is 5.0 mg/L in the distribution system.

8. A system had one positive total coliform sample during the month. All the repeat samples and distribution samples were negative for the month.

9. A system has a sodium level of 5.9 mg/L.

10. A water system had one positive total coliform test and one positive total coliform on a repeat sample during the same month.

11. The contract laboratory has reported the fluoride result as 3.7 mg/L.

12. A system that collects 60 samples per month had four positive total coliform samples during the month. All the repeat samples and distribution samples were negative for the month.

13. A system has been notified by their lab that the Dioxin level was 0.0000001mg/L.

Answers

Identify:

1. **violations and situations with significant potential to have serious adverse effects on human health as a result of short-term exposure**
2. **public notice – required for all other NPDWR violations and situations with potential to have serious adverse effects on human health**
3. **public notice – required for all other NPDWR violations and situations not included in Tier 1 and Tier 2**

Instructions: List what Tier of PN you would take with each situation listed below, no PN can be a result also:

4. **Tier 2 (Tier 3 if between 2-4 mg/L)**
5. **Tier 1**
6. **Tier 2 (Tier 3 if not reported to State)**
7. **NO PN, below MCL**
8. **Tier 3 (Tier 2 if chronic problem)**
9. **No PN because avg. samples = 9.9 mg/L < MCL**
10. **Tier 2**
11. **NO PN, can have 5%**
12. **NO PN, but notify State within 10 days, page 97**
13. **Tier 2**
14. **Tier 3**
15. **Tier 2**
16. **Tier 2**

Rules and Regulation Exercise

Definitions:

1) Public water systems using surface water or ground water under the direct influence of surface water as a source that are subject to the requirements of filtration. 1200-5-1-.04(87)

2) A system for the provision of piped water for human consumption if such serves 15 or more connections or which regularly serves 25 or more individuals daily at least 60 days out of the year. 1200-5-1-.04(75)

MCL's

3)

a) arsenic level at 0.05 mg/L. MCL is 0.05 mg/L **until 1/06, then 0.01 mg/L**

b) nitrate level at 12 mg/L. MCL is 10 mg/L

c) fluoride level at 4.3 mg/L. MCL 4.0 mg/L

d) atrazine level at 0.005 mg/L. MCL is 0.003 mg/L

e) lindane level at 0.005 mg/L. MCL is 0.0002 mg/L

f) chromium level at 0.4 mg/L. MCL is 0.1 mg/L

1200-5-1-.06 (1)(b) and (2)(a)

g) THM level at 0.09mg/L. MCL is 0.08 mg/L

h) HAA5 level at 0.55 mg/L. MCL is 0.06 mg/L

i) chlorine level at 4.3 mg/L. MCL is 4.0 mg/L

j) chlorine dioxide level at 0.79 mg/L. MCL is 0.8 mg/L

k) chloramine level at 3.9 mg/L. MCL is 4.0 mg/L

1200-5-1-.06 (6)(b) and (6)(c)

l) fecal coliform-positive repeat sample violation

m) E. coli-positive repeat sample violation

n) violation

1200-5-1-.06 (4)

4) 1.0 **and** 2.0 - Page 16, 1200-5-1-.06(3)

5) a) 40 **and** 5 , 1200-5-1-.06(4)(a)(1); **b)** 40 **and** 1, 1200-5-1-.06(4)(a)(1)

Sampling

6) 30, 1200-5-1-.07(1)(c)

7) 9, 1200-5-1-.07(1)(c)

8) 24, 1, 1, 5, 5; 1200-5-1-.07(2)(a) and (b)

9) 4, 1200-5-1-.08(2)(a)

Operation and Maintenance Requirements

10) surface, filtration, iron, operator, operation; 1200-5-1-.17(1)

11) 10 days; 1200-5-1-.17(2)

12) "Standard Methods for the Examination of Water and Wastewater"; 1200-5-1-.17(3)

13) 0.2 mg/L; 1200-5-1-.17(4)

14) cross-connection, cross-connections; 1200-5-1-.17(6)

15) AWWA standards C-651, C-652 or equivalent methods provided the method has been approved in writing by the department and is available during the inspection, construction, maintenance or repair activity; 1200-5-1-.17(8)(a)

16) 20; 1200-5-1-.17(9)

17) flushing; **a)** date, **b)** time, **c)** location, **d)** persons responsible, **e)**length of flushing; 1200-5-1-.17(10)

18) duplicate; 1200-5-1-.17(11)

19) 4.0 gpm per square foot; 1200-5-1-.17(12)(b)

20) **a) Dual media:** 30 inches, **i) Sand:** 10-12 inches, **ii) Anthracite:** 18-20 inches, **b) Mixed media beds:** 30 inches; 1200-5-1-.17(12)(b) and (d)

21) 24, average daily, 12; 1200-5-1-.17(14)

22) maps; **a)** water mains, **b)** sizes of mains, **c)** valves, **d)** blow-offs or flush hydrants, **e)** air-release valves, **f)** fire hydrants; 1200-5-1-.17(15)

23) wells, storage, tanks, clearwells; 1200-5-1-.17(16)

24) 6, 500, 20; 1200-5-1-.17(18)

25) 0.9, 1.3; 1200-5-1-.17(20)

26) a) name of person with complaint, **b)** date, **c)** nature of complaint, **d)** date of investigation, **e)** results or actions taken to correct any problems

27) 99.9, 3, 99.99, 4; 1200-5-1-.17(27)(a) and (b)

SAFETY

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ACCIDENT

- An accident is caused by either an unsafe act or an unsafe environment

2

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GENERAL DUTY CLAUSE

Federal – 29 CFR 1903.1

- EMPLOYERS MUST:
  - Furnish a place of employment free of recognized hazards that are causing or are likely to cause death or serious physical harm to employees
  - Comply with occupational safety and health standards promulgated under the Williams-Steiger Occupational Safety and Health Act of 1970.

3

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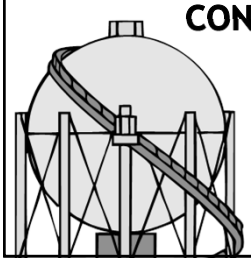
CONFINED SPACES



4

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CONFINED SPACE CONDITIONS

- Defined as any space where BOTH of the following conditions exist at the same time:
  - existing ventilation is insufficient to remove dangerous air contamination and/or oxygen deficiency which may exist or develop
  - ready access/egress for the removal of a suddenly disabled employee (operator) is difficult due to the location and/or size of opening(s)
- Large enough and so configured that an employee can bodily enter and perform assigned work
- Limited or restricted means of entry or exit
- Not designed for continuous employee occupancy

5

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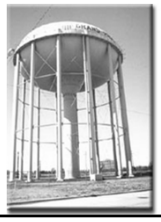
CONFINED SPACE EXAMPLES

- Vaults
- Silos
- Inside filters
- Basins
- Storage tanks
- Pits
- Hoppers



6

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EQUIPMENT NEEDED

- Safety harness with lifeline, tripod, and winch
- Electrochemical sensors
- Ventilation blower with hose

7

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EQUIPMENT NEEDED cont'd

- PPE
- Ladder
- Rope
- Breathing apparatus

8

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SPACES THAT REQUIRE PERMITS

- Contains or has potential to contain hazardous atmosphere
- Contains material with potential to engulf and entrant
- Entrant could be trapped or asphyxiated

9

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ATMOSPHERIC HAZARDS

- Need to have atmosphere monitored!!!
- Explosive or flammable air
- Toxic air
- Depletion or elimination of breathable oxygen

10

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HYDROGEN SULFIDE - H_2S

- Detected by the smell of rotten eggs
- Loss of ability to detect short exposures
- Not noticeable at high concentrations
- Exposures to 0.07% to 0.1% will cause acute poisoning and paralyze the respiratory center of the body
- At the above levels, death and/or rapid loss of consciousness occur

11

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METHANE GAS - CH_4

- Product of waste decomposition
- Leaks in natural gas pipelines can saturate the soil
- Explosive at a concentration of 5%
- Spaces may contain concentrations above the Lower Explosive Limits (LEL) and still have oxygen above the 19.5% allowable
- Gasoline storage tanks, gas stations, petroleum product pipelines, accidental spills by traffic accidents

12

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CARBON MONOXIDE - CO

- Decreases amount of oxygen present
- ALWAYS VENTILATE
- 0.15% (1500 ppm) = DEATH
- Will cause headaches at 0.02% in a two hour period
- Maximum amount of 0.04% in 60 minute period
- Colorless, odorless, tasteless, flammable and poisonous

13

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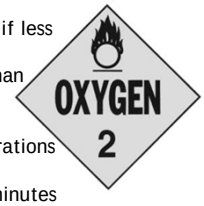
OXYGEN - O_2

- ALWAYS ventilate – normal air contains ~ 21%
- Oxygen deficient atmosphere if less than 19.5%
- Oxygen enriched at greater than 23.5%
  - Speeds combustion
- Leave area if oxygen concentrations approach 22%
- At 8%, you will be dead in 6 minutes
- At 6%, coma in 40 seconds and then you die



14

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OXYGEN - O_2

- When O_2 levels drop below 16%, a person experiences
  - Rapid fatigue
  - Inability to think clearly
  - Poor coordination
  - Difficulty breathing
  - Ringing in the ears
  - Also, a false sense of well-being may develop

15

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OXYGEN - O_2

- In a confined space, the amount of oxygen in the atmosphere may be reduced by several factors
  - Oxygen consumption
    - During combustion of flammable substances
    - Welding, heating, cutting or even rust formation
  - Oxygen displacement
    - Carbon dioxide can displace oxygen
  - Bacterial action

16

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ATMOSPHERIC ALARM UNITS

- Should continuously sample the atmosphere of the area
- Test atmospheres before entering
- Test for oxygen first
- Combustible gases second

17

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ATMOSPHERIC ALARM UNITS

- Alarms set to read flammable gasses exceeding 10% of the lower explosive limit
  - H_2S exceeds 10 ppm and/or O_2 percentage drops below 19.5%
- Calibrate unit before using
- Most desirable units simultaneously sample, analyze, and alarm all 3 atmospheric conditions

18

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WRITTEN ENTRY SYSTEM

- Employer shall document entry permits
- Entry supervisor signs permits
- Permit posted
- Shall not exceed time required
- Retain permits for at least 1 year

19

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INFORMATION ON PERMIT FORMS

- Space to be entered
- Purpose
- Date and authorized duration
- Attendant ID by name
- Authorized entrants ID by name
- Entry supervisor name and signature
- Hazards of permit space
- Measures to eliminate, isolate, or control the hazards
- Results of tests
- Rescue and emergency services
- Communications

20

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INFORMATION ON EQUIPMENT

- PPE (personal protective equipment)
- Testing equipment

21

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DUTIES OF ENTRANTS

- Know signs, symptoms, and consequence of exposure
- Properly use equipment
- Alert attendant of warning signs, symptoms and other possible hazards
- Exit when ordered to evacuate by supervisor or attendant

22

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DUTIES OF CONFINED SPACE ATTENDANT

- Know signs, symptoms, and consequences of exposure
- Possible behavioral effects of hazards
- Maintain accurate count of entrants
- Remain outside permit space
- Communicate with entrants
- Summon rescue and emergency units

23

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DUTIES OF CONFINED SPACE ATTENDANT

- Warn unauthorized persons to stay away
- Perform non-entry rescue
- Do not perform any duties that interfere with primary duty of monitoring and protecting entrants

24

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DUTIES OF SUPERVISORS AND MANAGERS

- Knowledge of signs, symptoms, and consequences of exposure
- Verify appropriate entries, procedures, tests and equipment
- Terminate entries and cancel permits if warranted
- Verify means for summoning rescue
- Ensure that acceptable conditions are maintained and operations remain consistent with entry permit

25

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REQUIRED TRAINING

- Employer shall train all employees on hazards, procedures, and skills to perform their jobs safely
- Employees trained before first assigned duty
- Employer shall certify training of employees
- Maintain individual training records of employees

26

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RECORD KEEPING

- Identification and evaluation of all hazardous areas in workplace
- Entrance permits filed
- Training certification
- Written confined space program

27

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GENERAL REQUIREMENTS

- Identify, evaluate, and monitor hazards in permit-required confined spaces
- Post signs “Permit Required”
- Prevent unauthorized entries
- Re-evaluate areas
- Inform contractors
- Have a written program available for employees
- Have proper PPE
- Annual training (OSHA requirement)

28

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CONFINED SPACE REQUIREMENTS

- All electrodes removed and machines disconnected from power sources
- Gas supply shut off
- Gas cylinders outside of work area
- All employees entering must undergo confined space training
- Ventilation used to keep toxic fumes, gasses, and dusts below max levels

29

LOCKOUT / TAGOUT

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LOCKOUT/TAGOUT

General Requirements

- Written program
- Utilize tagout system if energy isolating device not capable of being locked out
- Lockout/tagout hardware provided
- Devices used only for intended purposes
- Tagout shall warn:
  - **DO NOT START. DO NOT ENERGIZE. DO NOT OPERATE.**
- Only trained employees shall perform lockout/tagout

31

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LOCKOUT/TAGOUT

Requirements When Lockout of Equipment

- Notify employees
- Employees notified after completion of work and equipment are re-energized

32

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LOCKOUT/TAGOUT

Recommended Steps for Lockout/Tagout

- Notify employees that device is locked and tagged out
- Turn off machinery normally
- De-activate energy
- Use appropriate lockout/tagout equipment
- Release any stored energy
- Try to start machine by normal means

33

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LOCKOUT/TAGOUT

Steps for Restoring Equipment

- Check area for equipment or tools
- Notify all employees in the area
- Verify controls are in neutral
- Remove lockout/tagout devices and re-energize device
- Notify employees maintenance and/or repairs are complete and equipment is operational

34

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LOCKOUT/TAGOUT

Training Requirements

- Employer shall train all employees
- All new employees trained
- Recognition of applicable hazardous energy
- Purpose of program
- Procedures
- Consequences
- ANNUAL REQUIREMENT

35

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LOCKOUT/TAGOUT

Inspections

- Conduct periodic inspection, at least annually
- Shall include review between the inspector and each authorized employee
- Recommendation
  - Frequent walk-throughs of work areas and observation of Maintenance and Operation area

36

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LOCKOUT/TAGOUT

Required Record Keeping

- Written lockout/tagout program
- Training
  - Annually and new employees
- Inspections
  - Annual including new equipment, inspection of devices, and procedures

37

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MOST CITED INDUSTRY STANDARDS BY TOSHA

- No written Hazard Communication Program
- Inadequate Hazard Communication Training
- PPE Hazard Assessment not done
- No Energy Control Program (Lockout/Tagout)
- No MSDS on site
- No one trained in first aid
- No Emergency Action Plan
- Metal parts of cord and plug equipment not grounded
- Unlabeled containers of hazardous chemicals

38

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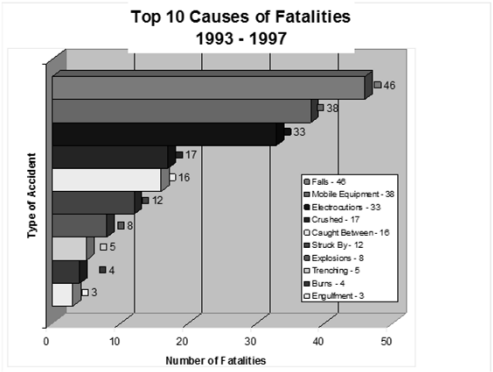

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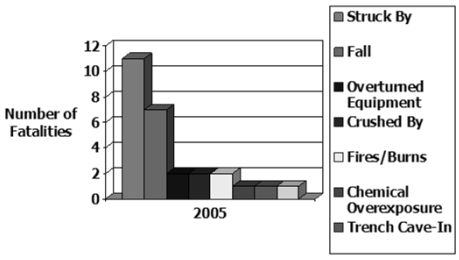
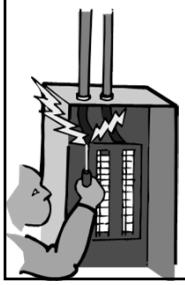
WHAT KILLS IN TN - 2005



Courtesy of TOSHA Winter 2007 Newsletter

40



ELECTRICAL SAFETY

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ELECTRICAL SAFETY

OSHA says:

- Any electrical installations shall be done by a professionally trained electrician
- Any employee who is in a work area where there is a danger of electric shock shall be trained
- Employees working on electrical machinery shall be trained in lockout/tagout procedures

42

TRANSFORMER

- Allows energy to be transferred in an AC system for one circuit to another
- Used to convert high voltage to low voltage
  - High voltage is 440 volts or higher
- Standby engines should be run weekly to ensure that it is working properly
- Relays are used to protect electric motors

43

FIRE PROTECTION

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FIRE PROTECTION

Equipment

- Fire extinguishers shall be located where they are readily accessible
- Shall be fully charged and operable at all times
- All fire fighting equipment is to be inspected at least annually

45

FIRE PROTECTION

Fire Protection Equipment

- Portable fire extinguishers inspected at least monthly and records kept
- Hydrostatic testing on each extinguisher every five years
- Fire detection systems tested monthly if battery operated

46

TYPES OF FIRE EXTINGUISHERS

- **Class A**
  - Used on combustible materials such as wood, paper or trash
  - Can be water based

- **Class B**
  - Used in areas where there is a presence of a flammable or combustible liquid
  - Shall not be water based
  - Example is dry chemical extinguisher
  - An existing system can be used but not refilled

47

TYPES OF FIRE EXTINGUISHERS

- **Class C**
  - Use for areas electrical
  - Best is carbon dioxide extinguisher
  - Using water to extinguish a class C fire risks electrical shock
- **Class D**
  - Used in areas with combustible metal hazards
  - Dry powder type
  - Use no other type for this fire

48

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FIRE EXTINGUISHERS

Types of Fire Extinguishers

Class	Material	Method
A	Wood, paper	Water
B	Flammable liquids (oil, grease, paint)	Carbon dioxide, foam, dry chemical, Halon
C	Live electricity	Carbon dioxide, dry chemical, Halon
D	Metals	Carbon dioxide

49

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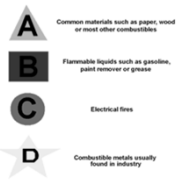
TYPES OF FIRE EXTINGUISHERS

- Combination ABC are most common
- Have the types of extinguishers available depending upon analyses performed in each area



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FIRE EXTINGUISHERS

- To operate a fire extinguisher, remember the word **PASS**
  - **P**ull the pin. Hold the extinguisher with the nozzle pointing away from you.
  - **A**im low. Point the extinguisher at the base of the fire.
  - **S**queeze the lever slowly and evenly.
  - **S**weep the nozzle from side-to-side.

51

CHEMICAL SAFETY

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PERSONAL PROTECTIVE EQUIPMENT (PPE)

- Gloves
- Coveralls/overalls
- Face shield/goggles
- Respirator/SCBA
- Boots
- Ear plugs/muffs

53

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RTK LABELS

- "Right to Know"
  - In 1983, OSHA instituted Hazard Communication Standard 1910-1200, a rule that gives employees the right to know the hazards of chemicals to which they may be exposed in the workplace.

54

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NFPA

- National Fire Protection Association
- Chemical hazard label
  - Color coded
  - Numerical system
    - Health
    - Flammability
    - Reactivity
  - Special precautions
- Labels are required on all chemicals in the lab

55

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CHEMICAL HAZARD LABEL

Degrees of Hazard

- Each of the colored areas has a number in it regarding the degree of hazard
  - 4 → extreme
  - 3 → serious
  - 2 → moderate
  - 1 → slight
  - 0 → minimal

56

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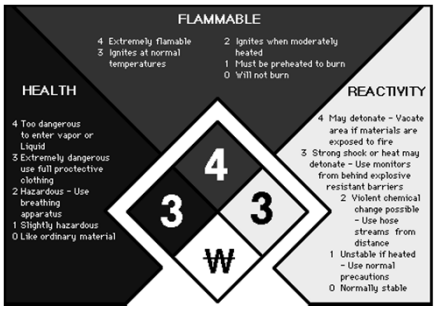
CHEMICAL HAZARD LABEL



57

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CHEMICAL HAZARD LABEL

Health

- 4 (extreme)→highly toxic material
  - Very short exposure can cause death or major residual injury even with prompt medical treatment
  - A known/suspected carcinogen, mutagen, or teratogen
- 3 (serious) → toxic material
  - Short term exposure may cause serious temporary or residual injury even with prompt medical treatment
  - A know/suspected small animal carcinogen, mutagen, or teratogen

58

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CHEMICAL HAZARD LABEL

Health

- 2 (moderate) → moderately toxic material
  - Intense or continued exposure could cause temporary incapacitation or possible residual injury even with prompt medical treatment
- 1 (slight) → slightly toxic material
  - May cause irritation by only minor residual injury even without treatment
  - Recognized innocuous material when used with responsible care
- 0 (minimal) → no chemical is without some degree of toxicity

59

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CHEMICAL HAZARD LABEL

Flammability

- 4 (extreme) → extremely flammable
  - Flashpoint below 73ºF
- 3 (serious) → flammable
  - Vaporizes readily and can be ignited under almost all ambient conditions
  - May form explosive mixtures with or burn rapidly in air
  - May burn rapidly due to self-contained oxygen
  - May ignite spontaneously in air
  - Flash point at or above 73ºF but less than 100ºF

60

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CHEMICAL HAZARD LABEL

Flammability

- 2 (moderate) → combustible
  - Must be moderately heated or exposed to relatively high temps for ignition to occur
  - Solids which readily give off flammable vapors
  - Flash point at or above 100ºF but less than 200ºF
- 1 (slight) → slightly combustible
  - Must be preheated for ignition to occur
  - Will burn in air when exposed at 1500ºF for 5 min
  - Flash point at or above 200ºF
- 0 (minimal)
  - Will not burn
  - Will not exhibit a flash point
  - Will not burn in air when exposed at 1500ºF for 5 min

61

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CHEMICAL HAZARD LABEL

Reactivity

- 4 (extreme)
  - Can explode or decompose violently at normal temperature and pressure
  - Can undergo a violent self-accelerating exothermic reaction with common materials or by itself
  - May be sensitive to mechanical or local thermal shock at normal temperature and pressure

62

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CHEMICAL HAZARD LABEL

Reactivity

- 3 (serious)
  - Can detonate or explode but requires a strong initiating force or confined heating before initiation
  - Readily promotes oxidation with combustible materials and may cause fires
  - Sensitive to thermal or mechanical shock at elevated temp
  - May react explosively with water without requiring heat or confinement

63

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CHEMICAL HAZARD LABEL

Reactivity

- 2 (moderate)
  - Normally unstable and readily undergoes violent change but does not detonate
  - May undergo chemical change with rapid release of energy at normal temp and pressure
  - May react violently with water
  - Forms potentially explosive mixtures with water
- 1 (slight)
  - Normally stable material which can become unstable at high temperature and pressure
- 0 (minimal)
  - Normally stable material which is not reactive with water

64

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CHEMICAL HAZARD LABEL

Special

- W → water reactive
- Ox → oxidizing agent

65

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SAFETY DATA SHEET

- OSHA moving from HCS (Hazard Communication Standard) to GHS (Globally Harmonized System)
- Revised criteria for chemical hazard classification, labeling & new format for Safety Data Sheets (SDS)
- Final rule effective May 25, 2012 but compliance dates are phased in:
  - Complete training on new label formats: 12/1/13
  - Comply with label and SDS requirements: 6/1/15
  - Update Hazcom programs: 6/1/16

66

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MINIMUM INFO FOR SDS

- Product identification
- Hazard Identification
- Composition/info on ingredients
- First-aid measures
- Fire-fighting measures
- Accidental release measures
- Handling and storage
- Exposure controls
- Physical/chemical properties
- Stability & reactivity
- Toxicological information
- Ecological information*
- Disposal considerations*
- Transport information*
- Regulatory information*
- Other information (including date of SDS or last revision)*

* Non mandatory

67

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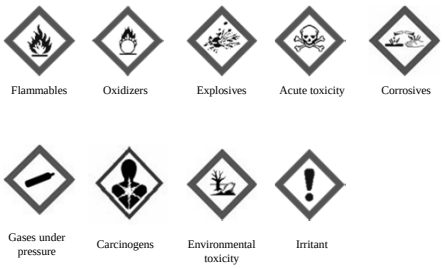
OSHA PICTOGRAMS



Flammables | Oxidizers | Explosives | Acute toxicity | Corrosives

Gases under pressure | Carcinogens | Environmental toxicity | Irritant

68

TN Department of Environment and Conservation

WORKPLACE LABELING

- Can HMIS or NFPA system be used?
- While, the hazard category does not appear on the label, consider

GHS Category	Hazard	HMIS/NFPA Category	Hazard
1	highest	1	slight
2	high	2	moderate
3	medium →	3	serious
4	low	4	severe

NFPA categories were intended for emergency response, not workplace hazards; only considers acute effects, does not consider chronic effects

69

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TERMS

- Lower Explosive Level (LEL)
  - minimum concentration of flammable gas or vapor in air that supports combustion
- Upper Explosive Level (UEL)
  - maximum concentration of flammable gas or vapor in air that will support combustion
- Teratogen
  - causes structural abnormality following fetal exposure during pregnancy
- Mutagen
  - capable of altering a cell's genetic makeup

70

CHLORINE & HYPOCHLORITE SAFETY

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CHLORINE GAS - Cl_2

- 2.5 times as dense as air
- Liquid expands easily into gas at room temperature 460 times
- Pungent, noxious odor
- Greenish-yellow color
- Toxic by inhalation, ingestion and through skin contact
- May irritate or burn skin

72

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CHLORINE GAS - Cl_2

- Inhalation can cause serious lung damage and may be fatal
  - 1000 ppm (0.1%) is likely to be fatal after a few deep breaths
    - half that concentration, fatal after a few minutes
- It takes as little as 3 ppm to be detected as a distinct odor

73

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CHLORINE SAFETY

Safety Precautions for Chlorine Gas

- Compressed air
  - 30 minute capacity
- Annually inspected
- Trained/fit tested
- PPE
  - Rubber gloves
  - Apron
  - Goggles
  - Safety shower, eyewash

74

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CHLORINE SAFETY

Where Chlorine Gas Is Used:

- Separate room for chlorine, with window to view inside
- Ventilation provided for one complete air change per minute
- Air outlet located near the floor
- Air inlet near the ceiling
- Temperature controlled room, 60ºF
- Switches for lights and fans located outside of room, crash-bar on door inside of chlorine room
- Vents from feeders and storage shall discharge to the outside atmosphere, above grade

75

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CHLORINE SAFETY

Where Chlorine Gas Is Used (cont'd):

- Must have a chlorine gas detection device connected to an alarm that can be heard throughout the treatment plant
- All gaseous feed chlorine installations shall be equipped with appropriate leak repair kits
- A fusible plug, designed to melt at 158º to 165ºF (70-74ºC), is located in the valve on a 150-lb cylinder and on the head of a ton container
  - It is designed to relieve pressure in the cylinder or container when exposed to high heat
- Leak detection – an ammonia solution produces white "smoke" in the presence of chlorine
  - A sensor type leak detector is the best means of detecting small leaks, less than 1ppm

76

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CHLORINE GAS CONTAINERS

- 3 types of Containers
  - 150 lb cylinder – Emergency repair kit A
  - Ton cylinder – Emergency repair kit B
  - Railroad cars – Emergency repair kit C

77

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CHLORINE SAFETY

Calcium Hypochlorite (HTH)

- Dry, white or yellow granular material
- Strong oxidizer
- Reacts with organics and can start fires
- Gives off lots of heat when mixed with water
- Will give off chlorine gas when it reacts
- Always add HTH to water when mixing
  - **NEVER add water to HTH!!**

78

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CHLORINE SAFETY

Calcium Hypochlorite (HTH)

- Granular HTH is safer to work with than tablet or liquid form
- HTH should be stored in a cool dry place away from acids, reducing agents, paints, oils, and grease
- Use a carbon dioxide extinguisher to put out fires started by HTH

79

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CHLORINE SAFETY

Calcium Hypochlorite (HTH)

- If a small amount of calcium hypochlorite is spilled, the chemical should be disposed of by dissolving it in a large amount of water

80

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CHLORINE SAFETY

Calcium Hypochlorite (HTH) – PPE

- Eye protection, protective clothing
- Rubber gloves
  - It will react with leather
- Rubber boots
  - It will react with leather
- SCBA

81

Safety Quiz

Lockout / Tagout

True or False

1. The term “lockout” means to block the flow of energy to equipment and keep it blocked by placing a lock to prevent accidental start-up.

   True False

2. The term “tagout” means to place a tag on the power source to identify yourself and the purpose of the lockout, and to warn others not to turn the power back on.

   True False

3. If someone else has already applied a lock and tag to a piece of machinery you need to work on, you should not add another one.

   True False

4. After locking and tagging out the equipment, you should test the equipment to make sure it won’t start.

   True False

5. You don’t need to use the lockout / tagout procedure if a machine has a built-in safety shut-off.

   True False

Confined Spaces

Fill in the blank:

6. A _____ is a form designed to make sure workers can safely enter a confined space by establishing procedures that must be followed.

7. The acceptable range for oxygen level in a confined space is _____ %.

8. List some activities that can reduce the level of oxygen in a confined space:

   _____

9. Entry-level permits should be kept on file for at least _____ year(s).

Multiple Choice

10. Which of these are examples of confined spaces? (Circle all that apply)
    a) Storage tanks
    b) Automobiles
    c) Meter pits
    d) Manholes
    e) Meeting rooms

11. When must the atmosphere of a confined space be tested?
    a) Only before a worker enters
    b) Never, if adequate ventilation exists
    c) Continuously
    d) Only if welding or painting is being performed

12. Some gases in a confined space can be:
    a) Colorless
    b) Odorless
    c) Deadly
    d) All of the above

True or False

13. If dangerous conditions exist, you do not have to wait for trained rescue personnel to perform a rescue.

True False

14. Carbon monoxide and hydrogen sulfide are two common dangerous gases found in confined spaces.

True False

Calcium Hypochlorite

Multiple Choice

15. Calcium hypochlorite:
    a) Is an oxidizer
    b) May cause a fire if contaminated
    c) Can release hazardous chlorine gas if stored improperly
    d) All of the above

16. Which form of calcium hypochlorite is the safest?
    a) Granular
    b) Tablet
    c) Liquid

17. Calcium hypochlorite should be stored away from:
    a) Acids
    b) Paint
    c) Reducing agents
    d) Oils and greases
    e) All of the above

18. What should be used to extinguish a fire involving calcium hypochlorite?
    a) Water
    b) Carbon dioxide
    c) Chemical smothering agents
    d) All of the above

19. When cleaning up a small spill, you should dispose of the calcium hypochlorite by:
    a) Burying it
    b) Placing it in the trash can
    c) Putting it back in the container
    d) Neutralizing it with acid or ammonia
    e) Dissolving it in a large amount of water

Fill in the blank

20. What personal protective equipment should you wear when handling calcium hypochlorite?

    _____

21. Why should smoking be prohibited in calcium hypochlorite storage areas?

    _____

22. Why must you never dispose of calcium hypochlorite in the trashcan?

    _____

Answers:

1. True
2. True
3. False
4. True
5. False
6. Confined space permit
7. 19.5% - 23.5%
8. Poor ventilation, welding, absorption, chemical consumption
9. One
10. A and D
11. C
12. D
13. False
14. True
15. D
16. A
17. E
18. B
19. E
20. Wear self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes (rubber gloves and rubber boots)
21. Fire hazard
22. Can react with organic material and cause a flash fire

TOSHA Standards Requiring Annual Training

Class	Regulation	Who should attend?
Medical & Exposure Records	1910.20(g)(1)	All employees (inform-existence, person responsible, location, right of access
Emergency Action	1910.38(a)(5) 1910.38(b)(4)	All employees – based upon other standards and requirements
Noise	1910.95(k)	All employees exposed to an 8 hour TWA or greater of 85dBA
Emergency Response	1910.120(q)	Employees who respond to spills of hazardous chemicals
Personal Protective Equipment	1910.132(f)	Employees who wear PPE
Permit-Required Confined Space	1910.146(g)	Employees who enter, attend or supervise P.R. confined spaces
Lock-Out/Tag-Out	1910.147(c)(7)	Employees who work on machinery
First Aid	1910.151(b)	At least one employee on each shift, annual as required by other standards
Fire Brigade	1910.156(c)	All fire brigade members (quarterly and annually)
Portable Fire Extinguishers	1910.157(g)	All employees expected to use fire extinguishers
Fork Lift Trucks	1910.178(1)	Fork lift truck operators
Mechanical Power Presses	1910.217(f)(2)	Operators
Asbestos	1910.1001(j)(1)	All employees exposures at or above PEL or excursion limit
Lead	1910.1025(1)	Anyone with a potential for exposure at any level – copy of appendix A&B. If exposed at or above action level, must be trained
Bloodborne Pathogens	1910.1030(g)(2)	Employees who render first aid
Hazard Communication	1910.1200(h) TDL 800-1-9-.07	Employees exposed or potentially exposed to any type of chemicals
Hazardous Chemicals in Laboratories	1910.1450(f)(2)	Employees exposed to chemicals

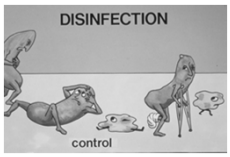
DISINFECTION

California State University: Sacramento

Water Treatment Plant Operation Vol. I

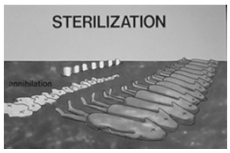
DISINFECTION VS. STERILIZATION

- Disinfection – the destruction of **pathogenic organisms**
  - To prevent waterborne disease outbreaks
  - Destroys only disease-causing organisms



- Sterilization – the destruction of **all organisms** in the water

Not all microorganisms are bad!



SAFE DRINKING WATER LAWS

- USEPA (US Environmental Protection Agency)
  - Responsible for setting drinking water standards
- SDWA (Safe Drinking Water Act)
  - Sets MCLs (maximum contaminant levels)for substances known to be hazardous to human health
- SWTR (Surface Water Treatment Rule)
  - Requires disinfection for all surface water supply systems to protect against exposure to viruses, bacteria, and *Giardia*

SAFE DRINKING WATER LAWS

- IESWTR (Interim Enhanced Surface Water Treatment Rule)
  - Increase public protection form illness caused by *Cryptosporidium*
- DPBR (Disinfection By-Products Rule)
  - Limits amount of certain potentially harmful disinfection by-products that may remain in drinking water after treatment
- LT2ESWTR (Long Term to Enhanced Surface Water Treatment Rule)
  - Builds upon earlier rules to reduce illness linked with *Cryptosporidium*

FACTORS INFLUENCING DISINFECTION

FACTORS INFLUENCING DISINFECTION

- pH
  - Chlorine disinfects faster at pH of 7 than at pH > 8
  - Hypochlorous acid disassociates at a higher pH
- Temperature
  - Higher temperature means more efficient disinfection
  - Longer contact time required at lower temperatures
  - Chlorine will dissipate faster in warmer waters
- Microorganisms
  - Number and type greatly influence disinfection effectiveness
  - Cysts and viruses can be very resistant to disinfection

FACTORS INFLUENCING DISINFECTION

- Turbidity
  - Excessive turbidity greatly reduces disinfection efficiency
  - Organic Matter
    - Organics can consume great amounts of disinfectants while forming unwanted compounds such as disinfection by-products
    - Reactions with organics and other reducing agents will significantly reduce the amount chemical available for disinfection
  - Inorganic matter
    - Ammonia can combine with disinfectant chemical to form side compounds

FACTORS INFLUENCING DISINFECTION

- Reducing Agents
  - Any substance that will readily donate electrons
  - Demand for chlorine by reducing agents must be met before chlorine becomes available to accomplish disinfection
  - Inorganic reducing agents
    - Hydrogen sulfide gas (H_2S)
    - Ferrous ion (Fe^{2+})
    - Manganous ion (Mn^{2+})
    - Ammonia (NH_3)
    - Nitrite ion (NO_2^-)

PROCESS OF DISINFECTION

PURPOSE OF PROCESS

- To destroy harmful organisms
- Physical
  - Removes the organisms from the water, or
  - Introduces motion that will disrupt the cells' biological activity and kill or inactivate them
- Chemical
  - Alter the cell chemistry causing microorganism to die
  - Most widely used is chlorine because it is easily obtained and leaves a measurable residual chlorine

AGENTS OF DISINFECTION

- Physical Means of Disinfection
  - Ultraviolet Rays (UV)
    - Rays must come in contact with each microorganism
    - Lack of measureable residual
  - Heat
    - Rolling boil for 5 minutes
  - Ultrasonic Waves
    - Sonic waves destroy microorganisms by vibration

AGENTS OF DISINFECTION

- Chemical Disinfectants
  - Iodine
    - Limited to emergency use due to high cost and negative health effects
  - Bromine
    - Very limited due to handling difficulties
  - Bases (sodium hydroxide and lime)
    - High pH leaves a bitter taste in water
  - Ozone
    - High costs, lack of residual, difficult to store, high maintenance requirements

AGENTS OF DISINFECTION

- Chemical Disinfectants
  - Chlorine -- Cl_2
    - 100% pure
    - gas
  - Calcium hypochlorite -- $Ca(Ocl)_2$
    - 65% pure
    - solid
    - HTH – high test hypochlorite
  - Sodium hypochorite -- NaOCl
    - 5-15% pure
    - Liquid
    - Bleach

CHLORINE (Cl_2)

- Properties of Chlorine
  - Greenish-yellow gas
  - 2.5 times heavier than air
  - Volume of gas will increase by almost 90% when temperatures rise
  - Liquid expands to 460 times the volume as a gas
  - Can support combustion

CHLORINE (Cl_2)

- Reaction with Water

Lowers pH

$$Cl_2 + H_2O \rightarrow \underset{\text{hypochlorous acid}}{HOCl} + \underset{\text{hydrochloric acid}}{HCl}$$

  - Free chlorine combines with water to form hypochlorous acid
    - Most effective disinfectant
    - Dissociates at higher pH (greater than 7)

$$\underset{\text{hypochlorous acid}}{HOCl} \rightarrow H^+ + \underset{\text{hypochlorite ion}}{OCl^-}$$

  - Hypochlorous acid has a much higher disinfection potential than hypochlorite ion
  - At pH = 7.5, of the chlorine present 50% will be HOCl and 50% will be OCl^-

CHLORINE (Cl_2)

- Hydrogen sulfide and ammonia are inorganic reducing agents
  - Hydrogen sulfide reacts with chlorine to form sulfuric acid and elemental sulfur
    - Causes odor problems
  - Ammonia reacts with chlorine to form chloramines
    - As ammonia concentration increases, the disinfectant power of chlorine decreases
  - Organics react with chlorine to form trihalomethanes (carcinogens)

HYPOCHLORITE (OCl^-)

- Reactions with Water
  - May be applied in the form of calcium hypochlorite ($Ca(OCl)_2$) or sodium hypochlorite (NaOCl)

$$Ca(OCl)_2 + H_2O \rightarrow \underset{\text{hypochlorous acid}}{HOCl} + \underset{\text{calcium hydroxide}}{Ca(OH)_2}$$

$$NaOCl + H_2O \rightarrow \underset{\text{hypochlorous acid}}{HOCl} + \underset{\text{sodium hydroxide}}{NaOH}$$

  - Raises pH due to OH^- ion
  - If is $Ca(OCl)_2$ injected at the same point of as sodium fluoride, a severe crust can form at injection point

CHLORINE DIOXIDE (ClO_2)

- May be used as a primary disinfectant
  - Not affected by ammonia
  - Very effective disinfectant at higher pH levels
  - Reacts with sulfide compounds to help remove and eliminate their characteristic odors
  - Can control phenolic tastes and odors
  - Effective oxidizing agent with iron and manganese
  - Does not form carcinogenic compounds from treating organics

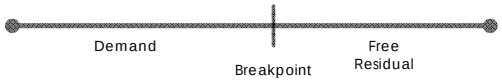
CHLORINATION

- Disinfection Action
  - Chlorine demand - the point where the reaction with organic and inorganic materials (aka reducing agents) stops
  - Chlorine residual – the total of all the compounds with disinfecting properties plus any remaining free chlorine
  - Chlorine dose – the amount of chlorine needed to satisfy the chlorine demand and the amount of chlorine residual needed for disinfection

Dose = Demand + Residual

BREAKPOINT CHLORINATION

- The process of adding chlorine to water until the chlorine demand has been satisfied
  - Further additions of chlorine will result in a chlorine residual that is directly proportional to the amount of chlorine added beyond the breakpoint



- Total chlorine dose = residual + demand

BREAKPOINT CHLORINATION

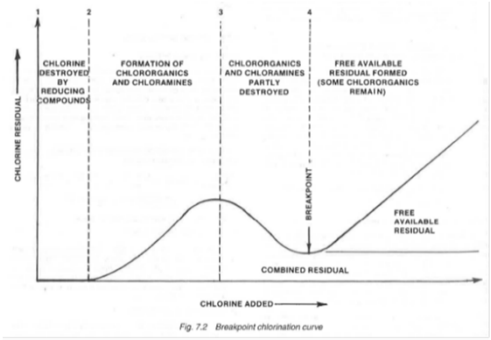


Fig. 7.2 Breakpoint chlorination curve

CHLORAMINATION

- Chloramines have been used as an alternative disinfectant for over 70 years
- An operator's decision to use chloramines depends on several factors
- However, chloramination alone is not an approved method of disinfection in the state of Tennessee

CHLORINE RESIDUAL TESTING

- Chlorine is effective in control biological agents and eliminating coliform bacteria
- To ensure adequate control of coliform aftergrowth, a chlorine residual of 0.2 mg/L in the distribution system can be a good indicator
  - A lack of this residual could indicate the presence of a heavy contamination

CHLORINE RESIDUAL TESTING

- Critical Factors
  - Effectiveness of upstream treatment processes
  - Injection point and method of mixing
  - Temperature
    - The higher temp, the more rapid the disinfection
  - Dosage and type of chemical
    - The higher the dose, the faster the disinfection
  - pH
    - The lower the pH, the better the disinfection
  - Contact time
    - Longer contact time has better disinfection
  - Concentration
    - Chlorine residual

CT VALUES

"kill" is proportional to C x T

- Destruction of organisms depends on the concentration of chlorine added (C) and the amount of time the chlorine is in contact with the organisms (T)
- Inversely proportional
  - If one is decreased, the other must be increased to ensure that "kill" remains the same

POINTS OF CHLORINE APPLICATION

- Prechlorination
  - Application of chlorine ahead of any other treatment processes
  - Benefits
    - Control of algal and slime growths
    - Control of mudball formation
    - Improved coagulation
    - Reduction of tastes and odors
    - Increased chlorine contact time
    - Increased safety factor in disinfection of heavily contaminated waters

POINTS OF CHLORINE APPLICATION

- Postchlorination
  - Application of chlorine after the water has been treated but before it enters the distribution system
  - Primary point of disinfection
- Rechlorination
  - Practice of adding chlorine in the distribution system
  - Common when distribution system is long or complex
- Wells
  - Good practice whenever wells are used for public water supplies

POINTS OF CHLORINE APPLICATION

- Mains
  - After initial installation and any repairs
- Tanks and Reservoirs
  - To resolve specific problems
  - After initial installation, repairs, maintenance, repainting, and cleaning
- Water Supply Systems
  - i.e. Small water systems

OPERATION OF CHLORINATION EQUIPMENT

HYPOCHLORINATORS

- A piece of equipment used to feed liquid chlorine solutions (bleach)
- Consists of chemical solution tank, diaphragm-type pump, power supply, water pump, pressure switch, water storage tank

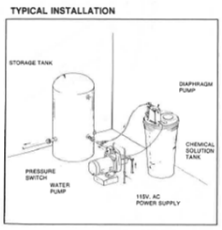
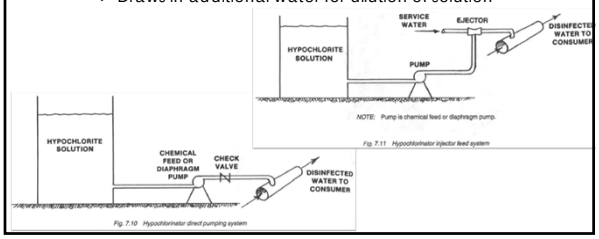


Fig. 7.7 Typical hypochlorinator installation
(Permission of Wallace & Tiernan Division, Pennwalt Corporation)

HYPOCHLORINATORS

- 2 methods of feeding
  - Directly pumped into water
  - Pump through an ejector (injector)
    - Draws in additional water for dilution of solution



CHLORINATORS

- Chlorine gas may be removed from chlorine containers by a valve and piping arrangement
- Chlorine gas is controlled, metered, and introduced into a stream of injector water, and then is conducted as a solution to the point of application
- Safety
  - Protective clothing: gloves and rubber suit
  - Self-contained pressure-demand air supply system (SCBA)
  - Chlorine leak detector set at floor level
    - Warning device located outside chlorine room

CHLORINATORS PARTS

- Ejector – creates the vacuum that moves the chlorine gas (also called injector or eductor)
  - Fitted with Venturi valve
- Check valve assembly – prevents water from back-feeding as the water moves through ejector
- Rate valve – controls the flow rate at which chlorine gas enters the chlorinator
- Diaphragm assembly – connects directly to the inlet valve of the vacuum regulator

CHLORINE CONTAINERS

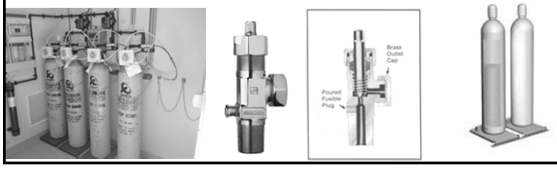
- Plastic
  - Commonly used for storage of hypochlorite solution
  - Should be large enough to hold 2-3 days' supply
    - Fresh solution should be prepared every 2-4 days
    - Sodium hypochlorite will lose 2-4% concentration per month at room temperature
    - Recommended shelf life of 60-90 days

CHLORINE CONTAINERS

- Steel Cylinders
  - Safety for handling and storing
    - Move cylinders with a properly balanced hand truck
    - Can be rolled in a vertical position
    - Always replace the protective cap when moving a cylinder
    - Keep cylinders away from direct heat and direct sun
    - Transport and store cylinders in an upright position
    - Store empty cylinders separate from full cylinders
      - Never store near turpentine, ether, anhydrous ammonia, finely divided metals, hydrocarbons, or other materials that are flammable
    - Remove outlet cap from cylinder and inspect outlet threads
    - Test chlorine cylinders at 800 psi every 5 years

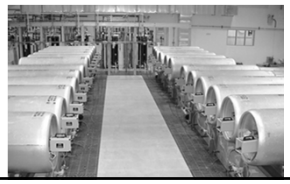
CHLORINE CONTAINERS

- Steel Cylinders
  - Contain 100 to 150 pounds
  - Fusible plug is placed in the valve below the valve seat
    - Safety device to prevent buildup of excessive pressures
    - Melts at 158°-165°F (70°-74°C)



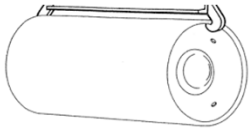
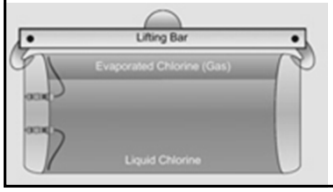
CHLORINE CONTAINERS

- Ton Tanks
  - Loaded weight of about 3,700 pounds
  - Openings for fusible plugs and valves
    - 2 operating valves
    - 6 fusible plugs (3 on each end)


CHLORINE CONTAINERS

- Ship ton tanks by rail in multiunit cars, truck or semitrailer
- Handle ton tanks with a suitable lift clamp or in conjunction with a hoist or crane
- Lay ton tanks on their sides
- Do not stack
- Separate tanks by 30 inches for access in case of leaks
- Place ton tanks on trunnions that are equipped with rollers
  - In case of a leak, tank can be rolled so that the leaking chlorine escapes as a gas not a liquid
- Use locking devices to prevent ton tanks from rolling while connected

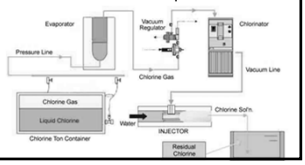




REMOVING CHLORINE FROM CONTAINERS

- Whenever performing any work or maintenance on chlorine cylinders, a self-contained breathing apparatus (SCBA)should be worn or at least readily available
- Greater than maximum feed rate will result in freezing and a decreased rate of delivery
  - 50 lb cylinder = 40 lbs/day
  - Ton cylinder = 400 lb/day
    - With evaporator = 9,600 lb/day
- Frosting may cause gas to condense to liquid which could plug the chlorine supply lines

REMOVING CHLORINE FROM CONTAINERS

- Ton Tanks
  - Must be placed on their sides with valves in vertical positions to allow either chlorine gas or liquid to be removed
    - Top valve to remove chlorine gas
    - Bottom valve to remove liquid chlorine
    - Must use an evaporator – used to convert liquid chlorine to gaseous chlorine

MAINTENANCE

CHLORINE LEAKS

- Chlorine leak can be smelled at concentrations as low as 3 ppm
  - Detectors can detect 1ppm or less
- Always work in pairs when looking for and repairing leaks
- If leak is large, all persons in adjacent areas should be warned and evacuated

CHLORINE LEAKS

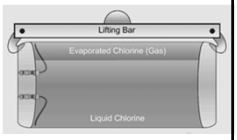
- Any new or repaired system should be cleaned, dried, and tested for leaks
- Ammonia solution on a piece of cloth held near a chlorine leak will produce a white vapor
  - Use concentrated ammonia solution of 28-30% ammonia
  - A squeeze bottle filled with ammonia water to dispense vapor may also be used
- If leak is in the equipment, close the valves at once

CHLORINE LEAKS

- If leak is in cylinder, use emergency repair kit
  - For 150 lb cylinder, Emergency Repair kit A
  - For ton cylinder, Emergency Repair kit B
  - For railroad car, Emergency Repair kit C

CHLORINE LEAKS

- If chlorine leaking as a liquid, rotate cylinder so leak is on top
  - Chlorine is escaping only as a gas
- If prolonged or unstoppable leak, emergency disposal should be provided
  - Chlorine may be absorbed into solutions of caustic soda, soda ash, or agitated hydrated lime
- Never put water on a chlorine leak
  - By-product (sulfuric acid) will make the leak larger
- Leak around valve stem can be stopped by closing the valve or tightening the packing gland nut



CHLORINE LEAKS

- Leaks at valve discharge outlet can often be stopped by replacing the gasket or adapter connection
- Leaks at fusible plugs and cylinder valves usually require special handling and emergency equipment
- Pinhole leaks in the walls of cylinders can be stopped by using a clamping pressure saddle with a turnbuckle available in repair kits
  - Temporary fix
- A leaking container must not be shipped
- Do not accept delivery of containers showing evidence of leaking, stripped threads, etc.

MEASUREMENT OF CHLORINE RESIDUAL

METHODS OF MEASURING CHLORINE RESIDUAL

- Amperometric titration
- DPD tests
- All subpart H systems (surface water systems and groundwater systems under the influence of surface water) must provide disinfection
- Must collect residual chlorine sample at the same frequency and location as total coliform samples

METHODS OF MEASURING CHLORINE RESIDUAL

- Amperometric titration
  - A means of measuring concentrations of certain substances in water based on the electric current that flows during a chemical reaction
  - 1. place a 200 mL sample of water in titrator
  - 2. Start the agitator
  - 3. Add 1 mL of pH 7 buffer
  - 4. Titrate with phenylarsene oxide solution (PAO)
  - 5. End point is reached when one drop will cause a deflection on the microammeter and the deflection will remain
  - 6. mL of PAO used in titration is equal to mg/L of free chlorine residual

METHODS OF MEASURING CHLORINE RESIDUAL

- DPD tests
  - A method of measuring the chlorine residual in water
  - N,N-diethyl-p-phenylene-diamine
  - The residual may be determined by either titrating or comparing a developed color with color standards
    1. Collect a sample
       - Typically 10 mL or 25 mL
    2. Zero instrument with sample blank
    3. Add color reagent
    4. Read colored sample in spectrophotomer or colorimeter
  - "False positive" can occur when sample contains a combined chlorine residual

CHLORINE SAFETY PROGRAM

CHLORINE HAZARDS

- Chlorine gas is 2.5 times heavier than air
  - Extremely toxic
  - Corrosive in moist atmospheres
  - Very irritating to mucous membranes of the nose, throat, and lungs

Effect	Cl_2 concentration (ppm)
Slight symptoms after several hours' exposure	1
Detectable odor	0.3-3.5
Noxiousness (harmful)	5
Throat irritation	15
Coughing	30
Dangerous from ½ to 1 hour	40
Death after a few deep breaths	1,000

CHLORINE PPE

- Every person should be trained in the use of self-containing breathing apparatus (SCBA), methods of detecting hazards, and should know what to do in case of emergencies
- Clothing exposed to chlorine can be saturated with chlorine, which will irritate the skin if exposed to moisture or sweat
- Self-contained air supply and positive pressure breathing equipment must fit and be used properly
- Wear protective clothing to enter an area containing a chlorine leak
  - Chemical suit will prevent chlorine from contacting the sweat on the body and forming hydrochloric acid

FIRST-AID MEASURES

- Mild chlorine exposure
  - Leave contaminated area
  - Move slowly, breathe lightly without exertion, remain calm, keep warm, and resist coughing
  - If clothing has been contaminated, remove as soon as possible
  - If slight irritation, immediate relief can come from drinking milk

FIRST-AID MEASURES

- Extreme Chlorine Exposure
  - Follow established emergency procedures
  - Always use proper safety equipment; do not enter area without self-contained breathing apparatus
  - Remove patient from affected area immediately
  - First-aid
    - Remove contaminated clothes
    - Keep patient warm and cover with blankets
    - Place patient in comfortable position on back
    - Administer oxygen if breathing is difficult
    - Perform mouth-to-mouth resuscitation if breathing seems to have stopped
    - If chlorine has got in eyes, flush with large amounts of water immediately (at least 15 minutes)

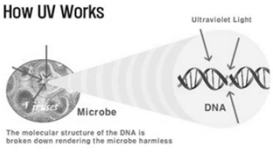
HYPOCHLORITE SAFETY

- Wash spills with large volumes of water
- Hypochlorite can damage eyes and skin upon contact
  - Immediately wash affected are thoroughly with water
- Nonflammable, however can cause a fire when comes in contact with organics

DISINFECTION USING ULTRAVIOLET (UV) SYSTEMS

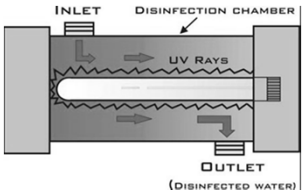
USES OF UV SYSTEMS

- Ultraviolet light – band of electromagnetic radiation just beyond the visible light spectrum
  - UV light absorbed by cells of microorganisms damages the genetic material to cease growth or reproduction



TYPES OF UV LAMPS

- Based on internal operating design
  - Low-pressure, low-intensity
  - Low-pressure, high-intensity
  - Medium-pressure, high-intensity



LOW PRESSURE UV LAMPS

- Source of UV energy in majority of systems
- Last between 8,000 and 10,000 hours
- Operate between 40° and 60°F
- Generate light by transforming electrical energy into UV radiations
- Emits light at wavelength 253.7 nm
- Each lamp protected by quartz sleeve with watertight electrical connections

LOW PRESSURE UV LAMPS

- Lamp assemblies mounted in a rack(s) that are immersed in flowing water
- Can be enclosed in a vessel or in an open channel
  - Enclosed in vessels in pressure systems
- Placed either horizontal and parallel to flow or vertical and perpendicular to flow
- Number of lamps determines water depth in channel

SAFETY

- UV lamp can burn eyes
- Never look into uncovered parts of the UV chamber without protective glasses
- Lamps contain mercury vapor that will be released of lamp breaks

OPERATION

- Water level over lamps must be maintained to ensure all microorganisms are exposed and to prevent short circuiting
- Water level control device must be regulated by the operator to:
  - Minimize variation of the channel's water level
  - Maintain the channel's water level at a defined level
  - Keep the UV lamps submerged at all times
  - Prevent excessive water layer thickness above the top lamp row

OPERATION

- Light must be intense enough to penetrate pathogens' cell walls
  - Intensity affected by the condition of the UV lamps and the quality of the water
  - An old or dirty lamp has a reduced UV light intensity
  - High turbidity inhibits light transmission, reducing the disinfecting power in proportion to its distance from the light source
  - High TSS inhibits light transmission and shields bacteria protecting them from disinfection
- Low UV light intensity will produce a low level of disinfection

OPERATION

- UV Dose Calculation
  - Intensity of UV radiation and contact time determine the UV dose and, therefore, the effectiveness
  - Expressed as mJ/sq cm (milli-joules per square centimeter)
  - Use worse case intensity for calculation (farthest point from UV)
- Channel Volume Calculation
  - Refers to the irradiated volume of the UV reactor
    - Volume of bacteria exposed to UV radiation
  - Fixed calculation

OPERATION

- Routine Operations Tasks
  - Check UV monitors for UV transmission
  - Routinely clean the UV lamps
- Wiping Systems
  - Should be observed to ensure proper operation of the wiping action of a bank and the proper wiping cycle
- Monitoring Lamp Output Intensity
  - Lamp output declines with use
  - Lamps should be replaced with output no longer meets standards or burn out

OPERATION

- Monitoring Influent and Effluent Characteristics
  - Must maintain velocities and low turbidity levels
    - Suspended particles shield microorganisms from UV light
    - Flows should be somewhat turbulent to ensure exposure to all microorganisms, but controlled so that water is exposed for long enough for disinfection to occur
  - Bacteriological tests must be performed frequently since there is no residual left by UV
- Emergency Alarms
  - UV systems require extensive alarm systems to ensure complete disinfection

MAINTENANCE

- Routine Maintenance
  - Check UV monitor for reduction in lamp output
  - Monitor process for major changes
  - Check for fouling of the quartz sleeves
  - Check that all UV lamps are energized
  - Monitor reports to determine UV lamp replacement interval
  - Check quartz sleeves for discoloration
  - Dewater and hose down UV channel if algae and other attached biological growths form on walls and floor

MAINTENANCE

- Quartz Sleeve Fouling
  - Occurs when cations attach to protein and colloidal matter that crystallizes on the quartz sleeves
  - This will decrease the intensity of the UV light
- Sleeve Cleaning
  - Frequency depends on the quality of water being treated and treatment chemicals used
  - Best done by dipping bulbs an inorganic acid solution for 5 minutes
    - i.e. Nitric acid (50%) or phosphoric acid (5-10%)

MAINTENANCE

- UV lamps
  - Service life ranges from 7,500 – 20,000 hours
  - Depends on
    - Level of suspended solids
    - Frequency of on/off cycles
    - Operating temperature of lamp electrodes
  - Lamp output drops 30-40% in first 7,500 hours
  - Lamp electrode failure is most common cause of lamp failure
  - Do not throw used lamps in garbage can
    - Must be disposed properly due to mercury content

OZONE

Introduction to Water Treatment

OZONE (O_3)

- Bluish toxic gas with pungent odor
- Alternative disinfectant
- Very strong oxidant and virucide (kills viruses)
- Must be generated on site
- Generated by passing an electrical current through pure oxygen

$$O_2 + \text{Energy} \rightarrow O + O$$

$$O + O_2 \rightarrow O_3$$

OZONE (O_3)

- Effectiveness of disinfection depends on
  - Susceptibility of the target organisms
  - Contact time
  - Concentration of the ozone
- Because ozone is consumed quickly, it must be exposed to the water uniformly
- Residual ozone measured by the iodometric method
- Dissolved ozone measured by Indigo test

EQUIPMENT

- Consists of 4 major parts
  - Air preparation unit
  - Electrical power unit
  - Ozone generator
  - Contactor

EQUIPMENT

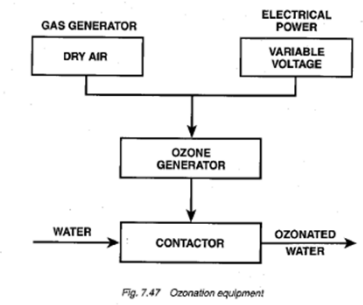


Fig. 7.47 Ozonation equipment

EQUIPMENT

Air preparation

- When air is used as the feed gas for an ozone generator, it must be extremely dry
- The preparation unit usually consists of a commercial air dryer with a dew point monitoring system
  - This is the most critical part of the system
- Air should be clean and dry with a dew point below -51°C (-60°F)

EQUIPMENT

Electrical Power Units

- Usually a very special electrical control system
- Most common unit provides low frequency, variable voltage
- For large installations, medium frequency, variable voltage is used
  - Reduces power costs
  - Allows for higher ozone output

EQUIPMENT

Ozone Generator

- Consists of a pair of electrodes separated by a gas space and a layer of glass insulation
- Air passes through the empty space
- Electrical discharge occurs across the gas space and ozone is formed

Oxygen from air + Electrical voltage → Ionized oxygen + Heat
O_2 + electricity → 2(O)

Ionized oxygen + Non-ionized oxygen → Ozone
2(O) + 2(O_2) → 2 (O_3)

EQUIPMENT

Ozone Contactor

- Mixing chamber for the ozone rich material and the water
- Ozone has a very short life
- Must be evenly and efficiently introduced to the water to be treated
  - Critical to the success of the system

EQUIPMENT

Types of Ozone Contactors

- Turbine mixers
- Injectors
- Packed columns
- Spray chambers
- Fine-bubble diffusion
  - Most common
  - Small bubbles rise through the tank transferring the ozone to the water

OZONE ADVANTAGES

- More effective than chlorine in destroying viruses
- No harmful residuals after ozonation
- No regrowth of microorganisms
- Removes color, tastes, and odors
- Oxidizes iron, manganese, sulfides and organics

OZONE LIMITATIONS

- Low dosage may not effectively inactivate some viruses, spores, and cysts
- Complex technology requiring complicated equipment
- Ozone if very reactive and corrosive require corrosion resistant materials
- Ozone is very irritating and possibly toxic
- The cost of treatment can be relatively high in capital and power costs
- Cannot be used as sole means of disinfectant in Tennessee due to Cl_2 residual requirements
- Can combine with bromide to form bromate
  - A carcinogen

APPLICATIONS OF OZONE

- Ozone may be used for more than just disinfection or viral inactivation
  - When used prior to coagulation
    - Treats Fe and Mn, helps flocculation, and removes algae
  - If applied before filtration
    - Oxidizes organics, removes color, and treats tastes and odors

MAINTENANCE

- Inspect electrical equipment and pressure vessels monthly
- Conduct a yearly preventive maintenance program
  - Should be done by a factory representative or an operator trained by the manufacturer
- Lubricate moving parts according to manufacturer's recommendations

SAFETY

- Ozone is a toxic gas and is a hazard to plants and animals
- When ozone breaks down in the atmosphere, the resulting pollutants can be very harmful
- Ozone contactors must have a system to collect ozone off-gas.
  - Ozone generating installations must include a thermal or catalytic ozone destroyer

Fleming Training Center

Pipe Disinfection Formulas for 50 mg/L of HTH

If a pipe is of size not listed below, the following formula will give the calculations needed to find the amount of HTH needed, if the length of line is given:

Calculation Formula = $0.000026007(X)^2(L)$

L= the length of the line in feet,
X = the diameter in inches

Or, Use the following Chart, if Pipe Diameter is listed

DIAMETER (INCHES)	LBS OF HTH
6	0.000935(L)
8	0.00166(L)
10	0.0026(L)
12	0.00374(L)
14	0.00509(L)
16	0.00665(L)
20	0.01038(L)
C24	0.01495(L)

Contact Amanda Carter At Fleming Training Center

(615) 898-6507

Disinfection Vocabulary

A. Amperometric Titration
B. Bacteria
C. Breakpoint Chlorination
D. Carcinogen
E. Chlorination
F. Chlorine Demand
G. Chlorine Requirement
H. Chlorine Residual
I. Chlororganic
J. Colorimetric Measurement
K. Combined Available Chlorine
L. Combined Available Chlorine Residual
M. Combined Chlorine
N. Combined Residual Chlorination
O. DPD
P. Dew Point
Q. Disinfection
R. Eductor
S. Enteric
T. Free Available Residual Chlorine
U. HTH
V. Hydrolysis
W. Hypochlorination
X. Hypochlorite
Y. IDLH
Z. MPN
AA. Oxidation
BB. Oxidizing Agent
CC. Pathogenic Organisms
DD. Postchlorination
EE. Potable Water
FF. Prechlorination
GG. Precursor, THM
HH. Reagent
II. Reducing Agent
JJ. Reliquefaction
KK. Sterilization
LL. Titrate
MM. Total Chlorine
NN. Total Chlorine Residual
OO. Trihalomethanes
PP. Turbidity
QQ. Ultraviolet

_____ 1. The Most Probable Number of coliform group organisms per unit volume of sample water

_____ 2. Any substance which tends to produce cancer in an organism

_____ 3. A chemical reaction in which a compound is converted into another compound by taking up water.

_____ 4. Any substance that will readily donate electrons

_____ 5. The application of chlorine to water to produce combined available chlorine residual

_____ 6. A hydraulic devise used to create a negative pressure by forcing a liquid through a restriction, such as a Venturi.

_____ 7. Organic compounds combined with chlorine

_____ 8. Organisms capable of causing diseases in a host

_____ 9. The total concentration of chlorine in water, including the combined chlorine and the free available chlorine

_____ 10. Pertaining to a band of electromagnetic radiation just beyond the visible light spectrum; used to disinfect water

_____ 11. Addition of chlorine to water until the chlorine demand has been satisfied; additional chlorine beyond this point will result in a free chlorine residual

_____ 12. Immediately Dangerous to Life or Health; the atmospheric concentration of any toxic, corrosive or asphyxiant substance that poses and immediate threat to life or would cause irreversible or delayed adverse health effects

_____ 13. The amount of chlorine that is needed for a particular purpose

_____ 14. The addition of oxygen, removal of hydrogen, or the removal of electrons from an element or compound

_____ 15. The removal or destruction of all microorganisms

_____ 16. The cloudy appearance of water caused by the presence of suspended and colloidal matter

_____ 17. A pure chemical substance that is used to make new products or is used in chemical tests to measure, detect, or examine other substances

_____ 18. The application of hypochlorite compounds to water for the purpose of disinfection.

_____ 19. The sum of the chlorine species composed of free chlorine and ammonia

_____ 20. The total chlorine, present as chloramine or other derivatives, that is present in a water and is still available for disinfection and for oxidation of organic matter

_____ 21. The application of chlorine to water generally for the purpose of disinfection

_____ 22. The addition of chlorine at the headworks of the plant prior to other treatment processes mainly for disinfection and control of tastes, odors, and aquatic growths

_____ 23. That portion of the total available residual chlorine composed of dissolved chlorine gas, hypochlorous acid, and or hypochlorite ion remaining in water after chlorination.

_____ 24. A method of measuring the chlorine residual in water

_____ 25. An substance, such as oxygen or chlorine, that will readily add electrons

_____ 26. The return of a gas to the liquid state e.g. a condensation of chlorine gas to return it to its liquid form by cooling

_____ 27. The concentration of residual chlorine that is combined with ammonia, organic nitrogen, or both in water as a chloramine and is still available to oxidize organic matter and kill bacteria

_____ 28. The difference between the amount of chlorine added to water and the amount of residual chlorine remaining after a given contact time

_____ 29. Living organisms, microscopic in size, which usually consist of a single cell

_____ 30. The addition of chlorine to the plant effluent, following plant treatment, for disinfection purposes

_____ 31. The total amount of chlorine residual present in a water sample after a given contact time

_____ 32. Of intestinal origin, especially applied to wastes or bacterias

_____ 33. Water that does not contain objectionable pollution, contamination, minerals, or infective agents and is considered satisfactory for drinking

_____ 34. The temperature to which air with a given quantity of water vapor must be cooled to cause condensation of the vapor in the air

_____ 35. A means of measuring unknown chemical concentrations in water by measuring a sample's color intensity

_____ 36. A means of measuring concentrations of certain substances in water based on the electric current that flows during a chemical reaction

_____ 37. A chemical solution of known strength is added drop by drop until a certain color change, precipitate, or pH change in the sample is observed (end point)

_____ 38. Natural organic compounds found in all surface and groundwaters that may react with halogens such as chlorine

_____ 39. Calcium hypochlorite. $Ca(OCl)_2$

_____ 40. The process designed to kill or inactivate most microorganisms in water, including essentially all pathogenic bacteria

_____ 41. The concentration of chlorine present in water after chlorine demand has been satisfied

_____ 45. Derivatives of methane in which three halogen atoms are substituted for three of the hydrogen atoms

_____ 43. Chemical compounds containing available chlorine

Answers

1. Z	12. Y	23. T	34. P
2. D	13. G	24. O	35. J
3. V	14. AA	25. BB	36. A
4. II	15. KK	26. JJ	37. LL
5. N	16. PP	27. L	38. GG
6. R	17. HH	28. F	39. U
7. I	18. W	29. B	40. Q
8. CC	19. M	30. DD	41. H
9. MM	20. K	31. NN	42. OO
10. QQ	21. E	32. S	43. X
11. C	22. FF	33. EE	

Disinfection
Review Questions

1. What are pathogenic organisms?

2. What is disinfection?

3. Drinking water standards are established by what agency of the United States government?

4. MCL stands for what words?

5. How does pH influence the effectiveness of disinfection?

6. How does the temperature of the water influence disinfection?

7. What two factors influence the effectiveness of disinfection on microorganisms?

8. List the physical agents that have been used for disinfection (chlorine is not a physical agent).

9. List the chemical agents other than chlorine that have been used for disinfection.

10. What is a major limitation to the use of ozone?

11. How is the chlorine dosage determined?

12. List two organic reducing chemicals with which chlorine reacts rapidly.

13. What does chlorine produce when it reacts with organic matter?

14. How do chlorine gas and hypochlorite influence pH?

15. How does pH influence the relationship between HOCl and OCl^-?

16. What is breakpoint chlorination?

17. List the two most common points of chlorination in a water treatment plant.

18. Under what conditions should waters not be prechlorinated?

19. What are the benefits of prechlorination?

20. List the major parts of a typical hypochlorinator system.

21. What are the two common methods of feeding hypochlorite to the water being disinfected?

22. What type of container is commonly used to store hypochlorite?

23. How large a supply of hypochlorite should be available?

24. What is the purpose of the fusible plug?

25. What is removed by the upper and lower valves of ton chlorine tanks?

26. Why are one-ton tanks placed on their sides with the valves in a vertical position?

27. If chlorine is escaping from a cylinder, what would you do?

28. How can chlorine leaks around valve stems be stopped?

29. How can chlorine leaks at the valve discharge outlet be stopped?

30. What properties make chlorine gas so hazardous?

31. What type of breathing apparatus is recommended when repairing chlorine leaks?

32. What first-aid measures should be taken if a person comes in contact with chlorine gas?

33. The UV light intensity that reaches the pathogens in the water is affected by what factors?

34. Routine maintenance of UV disinfection systems includes which tasks?

35. How often should quartz sleeves be cleaned?

36. The service life of UV lamps depends on which factors?

37. How can operators determine the proper way to dispose of used UV lamps?

38. Why is ozone generated on site?

39. The effectiveness of ozone disinfection depends on which factors?

Disinfection
Review Questions

1. Pathogenic organisms are disease-producing organisms
2. Disinfection is the selective destruction or inactivation of pathogenic organisms.
3. The US Environmental Protection Agency establishes drinking water standards.
4. MCL stands for Maximum Contaminant Level.
5. Most disinfectants are more effective in water with a pH around 7.0 than at a pH over 8.0.
6. Relatively cold water requires longer disinfection time or greater quantities of disinfectants.
7. The number and type of organisms present in water influence the effectiveness of disinfection on microorganisms.
8. (1) Ultraviolet rays (2) heat, and (3) ultrasonic waves
9. (1) Iodine (2) bromine (3) bases (sodium hydroxide and lime) (4) ozone
10. The inability of ozone to provide a residual in the distribution system
11. Dose = demand + residual
12. Hydrogen sulfide and ammonia
13. Suspected carcinogenic compounds (trihalomethanes)
14. Chlorine gas lowers the pH; hypochlorite increases the pH
15. The higher the pH the greater the percent of OCl^-
16. The addition of chlorine to water until the chlorine demand has been satisfied and further additions of chlorine result in a free available residual chlorine that is directly proportional to the amount of chlorine added beyond the breakpoint.
17. Prechlorination ahead of any other treatment processes and postchlorination after the water has been treated and before it enters the distribution system
18. When the raw waters contain organic compounds
19. (1) Control of algal and slime growths (2) control of mudball formation (3) improved coagulation (4) reduction of tastes and odors (5) increased chlorine

contact time (6) increased safety factor in disinfection of heavily contaminated water

20. Chemical solution tank for the hypochlorite, diaphragm-type pump, power supply, water pump, pressure switch, and water storage tank
21. (1) Pumping directly into the water (2) pumping through an ejector which draws in additional water for dilution of the hypochlorite solution
22. Plastic containers
23. A week's supply of hypochlorite should be available
24. The fusible is a safety device. The fusible metal softens or melts at 158-165^{o}F to prevent buildup of excessive pressures and the possibility of rupture due to fire or high surrounding temperatures.
25. The upper valve discharges chlorine gas, and the lower valve discharges liquid chlorine from ton chlorine tanks.
26. In this position, either chlorine gas or liquid chlorine may be removed.
27. Turn the cylinder so that the leak is on top and the chlorine will escape as a gas.
28. By closing the valve or tightening the packing gland nut. Tighten the nut or stem by turning it clockwise.
29. By replacing the gasket or adapter connection.
30. Chlorine gas is extremely toxic and corrosive in moist atmospheres.
31. A properly fitting self-contained air or oxygen supply type of breathing apparatus, positive/demand breathing equipment, or rebreather kits are used when repairing a chlorine leak
32. First aid measures depend on the severity of the contact. Move the victim away from the gas area, remove the contaminated clothes and keep the victim warm and quiet. Call a doctor and fire department immediately. Keep the patient breathing.
33. The UV light intensity that reaches the pathogens in the water is affected by the condition of the UV lamps and the quality of the water.
34. (1) Checking the UV monitor for significant reduction in lamp output (2) monitoring the process changes in normal flow conditions (3) checking for fouling of the quartz sleeves and the UV intensity monitor probes (4) checking the indicator light display to ensure that all of the UV lamps are energized (5)

monitoring the elapsed time meter, microbiological results, and lamp log sheet (6) checking the quartz sleeves for discoloration

35. Depends on the quality of the water being treated and the treatment chemicals used prior to disinfection
36. Depends on (1) the level of suspended solids in the water to be disinfected and the fecal coliform level to be achieved (2) the frequency of the on/off cycles (3) the operating temperature of the lamp electrodes
37. Contact the appropriate regulatory agency. Do not throw UV bulbs in trash because they contain mercury.
38. It is unstable and decomposes to elemental oxygen in a short time after generation.

Laboratory Practices

Water Quality

- Process control monitoring
  - All public water systems that provide some type of treatment must monitor water quality
- Monitored to ensure safety and integrity
- Monitored to meet state and federal requirements
- Monitor raw, finished, and where you expect a physical/chemical change in your plant
- Monitor in distribution system also
  - Quality can degrade due to contamination or growth of organisms

Water Quality

Degradation

- Treated water is disinfected, not sterilized
- Disinfection kills or inactivates harmful organisms (pathogens)
- Organisms can grow in distribution system if conditions are right
- To prevent growth of organisms
  - Keep chlorine residuals up
  - Keep excess nutrients out
  - Prevent stagnation
  - Prevent cross-connections

Water Quality

Analysis

- The first step in water quality analysis is collecting samples which accurately represent the water
  - Representative sample
    - sample which contains basically the same constituents as the body of water from which it was taken
  - Improper sampling is one of the most common causes of error in water quality
- All chemical analysis must be kept for 10 years

Sampling

Types of Samples

- Grab sample
  - Single volume of water
  - Representative of water quality at exact time and place of sampling
  - Coliform bacteria, residual chlorine, temperature, pH, dissolved gases
- Composite samples
  - Representative of average water quality of location over a period of time
  - Series of grab samples mixed together
  - Determines average concentration
  - Not suitable for all tests

Composite Samples

- Time composite - equal volumes at different times
- Flow-proportional composite - volume varies depending on flow rate

Sampling

Sample Volume and Storage

- Volume depends on test requirements
- Use proper sampling container
- Follow recommended holding times and preservation methods
  - If bottle already has preservative or dechlorinator in it, don't over fill or rinse out

❖ If you have questions regarding volume, container or holding times, check *Standard Methods* or contact the lab if you have an outside lab do you analysis

7

Sampling

Sample Labeling

- Specific location (address)
- Date and time sampled
- Chlorine residual
- pH and temperature
- Sample type
- Name or initials of person taking sample

8

Sampling

Sample Type

- D – distribution
- R – repeat
  - S – same
  - A – upstream
  - B - downstream
- F – fixed/repaired line in service
- N – new line NOT in service
- S – special sample

9

Sampling

Sample Labeling

Site 196 E. Main Street Billieville, TN

Date / Time August 15, 2005 8:15 AM

Sampled by Billy Joe Smith

Comments grab sample, monthly BacT

pH Residual, SO_4, and strength 4°C

10

Sampling

Selecting Sampling Points

- Raw-water supply
- Treatment plant
- Distribution system

11

Sampling

Raw-water Sampling Points

- Install valve or sample cock on raw-water transmission lines or well discharge pipe

12

Sampling

Treatment Plant Sampling Points

- Sampling from various points helps determine efficiency of processes
- Sample at every point where a change in water quality is expected
- Finished water sample point usually at point of discharge from clearwell

13

Sampling

Distribution Sampling Points

- Distribution sampling is the best indicator of system water quality
- Water quality changes in the distribution system:
  - Corrosion
    - increase in color, turbidity, taste and odor
  - Microbiological growth
    - slime
  - Cross-connections

14

Sampling

Distribution Samples

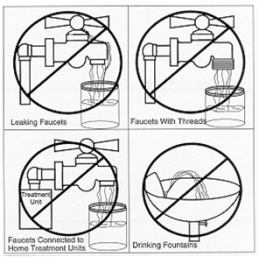
- Determine water quality at customers' taps
- Most common tests are chlorine residual and coliform bacteria
- Number of samples depends on population served or water source

15

Sampling

Monthly Distribution System Bacteriological Samples

- Samples should never be taken from a hydrant or hose
- Only collect samples from approved faucets
- Don't collect samples from swivel faucets
- Only use cold water tap
- Front yard faucets on homes with short service lines



16

Sampling

Monthly Distribution System Bacteriological Samples

- Do not flame faucet with torch
  - Use alcohol or bleach solution to clean
- Turn on faucet to steady flow and flush service line (2-5 min) – getting water from the main line
- Fill bottle to proper level
- Label bottle with pertinent information
- Refrigerate to proper temperature, 4°C
- Test as soon as possible – within 30 hours

17

Collection of Samples

- Only approved containers should be used
  - 125 mL volume
  - Pre-sterilized bottles recommended
  - Other bottles sterilized at 121°C for 15 min
  - Should contain sodium thiosulfate

18

Collection of Samples

- Remove aerator or screen
- Collect sample from cold water tap
- Sample from homes with short service lines
  - same side of street as water main

19

Collection of Samples

- Disinfect faucet with sodium hypochlorite
- Flush service line
- Adjust flow so that no splashing will occur

20

Collection of Samples

- Do not touch inside of lid of sample bottle
- Do not set lid down or put it in your pocket
- Do not rinse bottle or allow it to overflow

21

Microbiological Indicator Organism

- Always present in contaminated water
- Always absent when no contamination
- Survives longer in water than other pathogens
- Is easily identified
- Water treatment indicator organism
  - coliform group (total coliforms)

22

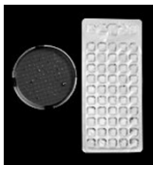
EPA Approved Methods

- Multiple-Tube Fermentation
- Presence-Absence Test
- MMO-MUG
- Membrane Filter Method
- Enzyme (chromogenic/fluorogenic) Substrate Tests

23

Bacteriological Samples

- The MCL for coliform bacteria is based on presence or absence
- Finished and distributed water should be Zero (absent)
- Must keep results for 5 years



24

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State Regulations

- 0400-45-1-.06(4) Microbiological
  - (a)1. If you collect 40 samples/month, no more than 5% can be positive to be in compliance
  - (a)2. If you collect less than 40 samples/month, no more than 1 sample can be positive to be in compliance
  - (c) If any routine or repeat sample test (+) for total coliform, it must be analyzed for fecal or *E. coli*

25

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State Regulations

- 0400-45-1-.07(2) Repeat Monitoring
  - (a) If a routine sample is total coliform positive, the system must collect a set of repeat samples within 24 hours of being notified of the positive result
  - (b) The system must collect one at original site, at least one repeat within five service connections upstream and at least one repeat within five service connections downstream

26

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Testing

Enzyme Substrate Testing

- Colilert (P/A)
- Colilert Quanti-Tray
- Colilert-18 (P/A)
- Colilert-18 Quanti-Tray
- E*Colite
- Colisure
- Readycult ® Coliforms 100 (P/A) and Fluorocult LMX Broth
- Colitag

27

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Testing

Colilert/Colilert 18 for P/A

- Equipment needed:
  - Incubator
  - UV lamp
  - Comparator
  - pH meter to check tryptic soy broth
- Sample bottle is used in the testing procedure
- Tests for total coliforms and *E. coli* in one step
  - Sample turns yellow if positive for total coliforms
  - Sample turns fluoresces if positive for *E. coli*

28

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Testing

Colilert/Colilert 18 for P/A cont'd

- Detects a single viable coliform per sample
- For Colilert 18, samples need to be pre-warmed to 35°C before incubation period starts
- Colilert 18 can lift boil water notices 6 hours earlier than other methods
- Shelf life is 12 months for media packet

29

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Testing

Colisure

- Step 1
  - Add reagent (shelf life is 12 months) to sample
  - Incubate for 24 hours
    - if samples are not room temperature, they need to be pre-warmed before incubating
- Step 2
  - Read results
    - yellow = negative
    - magenta = total coliform positive
    - magenta/fluorescent = *E. coli* positive

30

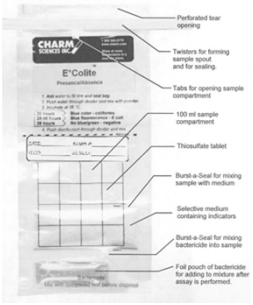
Testing

Colitag

- Detects 1 CFU of total coliform or *E. coli* bacteria per 100 mL sample
- Acid-resuscitation technology
  - With self adjusting pH level
  - Detects chlorine-injured cells

31

Testing



E*Colite™

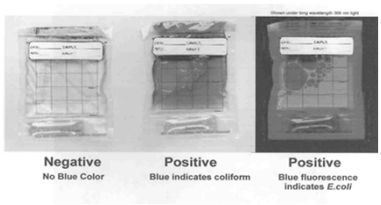
- Add water sample to bag
- Push water into the medium compartment
- Incubate at 35°C for 28 hours
- Info at www.charm.com

32

Testing

E*Colite™

- Interpretation
  - If a blue sample does not fluoresce, continue incubating an additional 20 hours



33

Testing

Readycult® 100

- Add Readycult® snap packet (3 year shelf life) to 100 mL sample
  - Incubate at 35.5°C for 24 hours
- Any color change to blue-green (even if only at the upper section of sample) confirms the presence of total coliforms
  - Don't need a color comparator

Negative Positive Coliforms 34

Testing

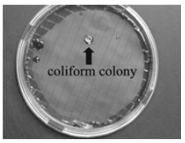
Readycult® 100

- A light blue fluorscence indicates the presence of *E. coli* (94-96% *E. coli* specific)
- If confirmation of *E. coli* is desired, the indole test can be performed directly in the same broth by adding Kovac's reagent (or Bactident® Indole)
  - If a red ring appears immediately, you have positive confirmation

35

Testing

Membrane Filter Technique



- 100 mL sample is filtered through a membrane filter under a vacuum
- Filter placed on sterile Petri-dish containing M-Endo broth (food source for bacteria) for Total Coliforms
- Petri-dish labeled, turned upside down, placed in incubator at 35° +/- 0.5°C for 24 hours
- A coliform bacteria colony will grow at each point on filter where a viable bacterium was left during filtering
- The colonies will appear red with a green-gold metallic sheen

36

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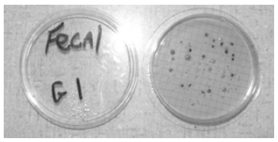
Testing

Fecal Coliform Determination

- Membrane filtration test
- More reliably indicates the potential presence of pathogenic organisms
- Same procedure as Total Coliform, 100 mL sample is filtered through a membrane filter under a vacuum
- Filter placed on sterile Petri-dish containing mFC broth
- Incubation at 44.50 +/- 0.2°C for 24 hrs
- Bacterial colonies appear blue
- Looks for heat tolerant bacteria



37

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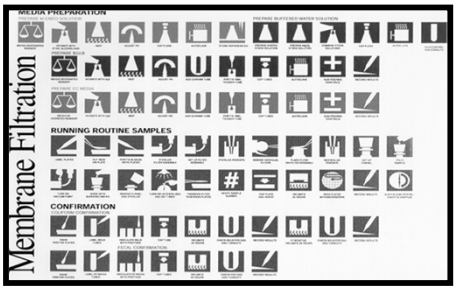
Testing

Membrane Filtration Pictorial



38

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Testing

Colilert Method Pictorial

39

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Chlorine Residual

- Free chlorine residual must be tested and recorded when bacteriological samples are collected
- Two most common tests:
  - Amperometric titration
    - less interferences as color and/or turbidity
  - DPD (N,N-diethyl-*p*-phenylenediamine)
- Analysis should be performed ASAP
- Exposure to sunlight or agitation of the sample will cause a reduction in the chlorine residual

40

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Chlorine Free Residual

- DPD colorimetric method most commonly used
  - Match color sample to a standard
  - ***Swirl sample for 20 seconds*** to mix
  - Within ***one minute*** of adding reagent, place it into colorimeter
    - Different than Total Residual
- Must maintain a free residual of 0.2 mg/L throughout entire distribution system
  - Chlorine residual must not be less than 0.2 mg/L in more that 5% of samples each month for any two consecutive months

41

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pH

- Power of hydrogen
  - Measurement of the hydrogen concentration
  - Each decrease in pH unit equals 10x increase in acid
- Indicates the intensity of its acidity or basicity
- Scale runs from 0 to 14, with 7 being neutral
- pH probe measures milivolts, then converts into pH units
  - Temperature affects milivolts generated, therefore you need a temperature probe as well for corrections

42

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pH

- Calibrate daily with **fresh buffers**
  - Use at least two buffers
- Gel filled probes are not recommended for water industry
  - Water is too clean for probe to make an accurate measurement
- Store probe in slightly acidic solution
- Replace probes yearly

43

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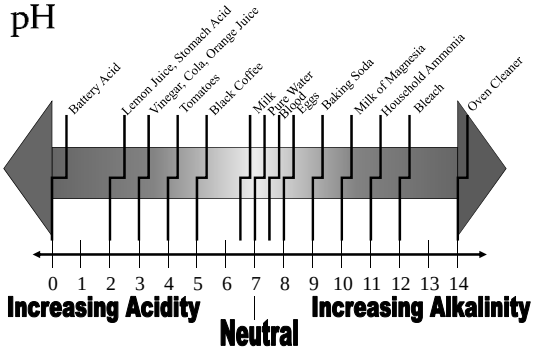
pH



44

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Fluoride

- Added to drinking water for the reduction of dental caries (cavities)
- Interferences
- Primary MCL = 4.0 mg/L
- Secondary MCL = 2.0 mg/L
- State of Tennessee recommends 0.7 mg/L
  - Fluoridation of drinking water in the state of Tennessee is not required

45

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Fluoride

- Methods
  - SPADNS
    - interferences are more common with this test
    - alum or aluminum complexes can interfere
  - Electrode
    - TISAB removes most of the aluminum interferences
      - Total Ionic Strength Adjustment Buffer
      - Contains CDTA – used to tie up interferences
    - store probe in a standard, the higher the better
    - probes can last 3-5 years
    - can clean with toothpaste

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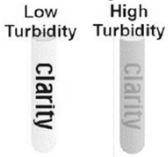
Turbidity

- Physical cloudiness of water
  - Due to suspended silt, finely divided organic and inorganic matter, and algae
- Nephelometric method measures scattered light
  - unit - NTU
- SDWA stipulates monitoring requirements



47

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Turbidity

- Measure samples ASAP
- Keep sample tubes clean and scratch free
- Gently mix samples prior to reading
- Calibrate meter at least quarterly
- Records must be kept until next sanitary survey

48

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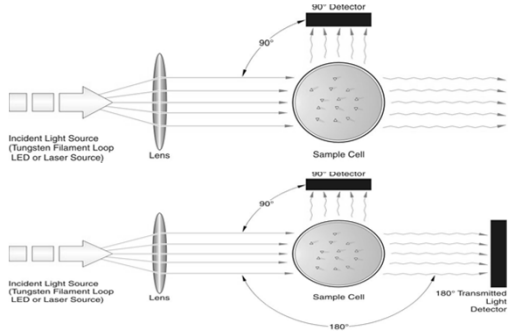
Turbidimeter



49

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Alkalinity

- Capacity of water to neutralize acids
- Due to presence of hydroxides, carbonates, and bicarbonates
- Many water treatment chemicals (alum, chlorine, lime) alter water quality
- Titration using H_2SO_4 to pH endpoint or color change of indicator

50

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Alkalinity

- Expressed as mg/L $CaCO_3$
- Methyl orange or bromcresol green-methyl red measures alkalinity
  - *Standard Methods* makes no mention of methyl orange
  - End point color change may be difficult to see with methyl orange
  - If using bromcresol green-methyl red and water is chlorinated, use sodium thiosulfate to remove chlorine that interferes with the color change

51

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Hardness

- Mainly due to calcium and magnesium ions in solution
- Can cause scale when water evaporates or when heated in water heaters and pipes
- Test involves titration with 0.02 N EDTA standard from a red to a blue endpoint
- Precautions
  - Metal ions may interfere, so an inhibitor may be needed
- Measured as $CaCO_3$, in mg/L

52

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Iron and Manganese

- Can precipitate out in distribution system
- Elevated levels in water can cause staining of plumbing fixtures and laundry
- sMCL for iron is 0.3 mg/L
- sMCL for manganese is 0.05 mg/L

53

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Lead and Copper Rule

- Established by EPA in 1991
- All community and non-community water systems must monitor for lead and copper at customers' taps
- If aggressive water is dissolving these metals, system must take action to reduce corrosivity
- Samples must be take at high risk locations
  - homes with lead service lines
- Water must sit in lines for at least 6 hours
  - first draw
- One liter of sample collected from cold water tap in kitchen or bathroom
- Test results must be maintained for 12 years

54

Lead and Copper Rule

- Action levels
  - Lead - 0.015 mg/L
  - Copper - 1.3 mg/L
- If action level is exceeded in more than 10% of samples, steps must be taken to control corrosion
  - Corrosion control program
  - Source water treatment
  - Public Education
  - and/or Lead service line replacement

Phosphates

- Orthophosphates work well for lead and copper protection
- Polyphosphates work as *sequestering agents* – tie up iron and manganese to prevent color and taste complaints
  - Tie up calcium carbonate as a catalyst
  - Calcium (from alkalinity) is required as a catalyst
  - If low alkalinity, need a blend of polyphosphate and orthophosphate
  - Orthophosphate coats pipe; polyphosphate sequesters

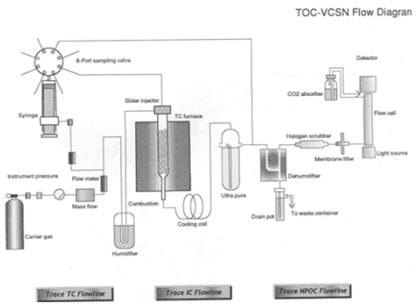
Phosphates

- Common tests
  - Total phosphates
    - need to be digested before they can be analyzed
  - Ortho-phosphates
    - colorimetric test
    - easily done with Hach test kit
      - reactive phosphates
    - 48 hour hold time

Total Organic Carbon (TOC)

- High temperature combustion at 950°C
- Sample is injected into a heated reaction chamber packed with oxidative catalyst such as cobalt oxide
- Water is vaporized and the organic carbon is oxidized to CO_2 and H_2O
- CO_2 is transported in the carrier-gas streams and is measured by means of a nondispersive infrared analyzer (NDIR)
- Samples are preserved with sulfuric or phosphoric acid and cooled to 4°C

Total Organic Carbon (TOC)



THM

- Trihalomethane
  - Chloroform
  - Dibromochloromethane
  - Bromodichloromethane
  - Tribromomethane
- MCL = 0.080 mg/L

HAA5

- Haloacetic acids
  - Monochloracetic acid
  - Dichloroaecitic acid
  - Trichloroacetic acid
  - Monobromoacetic acid
  - Dibromoacetic acid
- MCL = 0.060 mg/L

61

LT2ESWTR

- Long Term 2 Enhanced Surface Water
  - Treatment Rule (LT2ESWTR) requires Public Water Systems (PWS) that use surface water or ground water under the direct influence of surface water to monitor their source water for *Cryptosporidium*, *E. coli*, or turbidity for a limited period
  - Based on the results additional treatment techniques may be required for some systems

62

LT2

- *Crypto*
  - Methods 1623 or 1622
  - 10L in bulk or filtered
  - Matrix spike samples
- *E. coli*
  - Enumeration, not presence/absence
- Turbidity

63

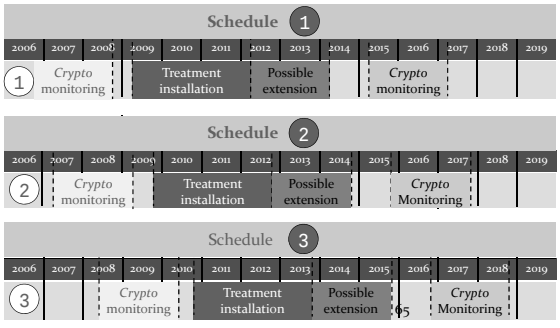
Cryptosporidium (Crypto)

- Protozoan parasite
- Common in surface water
- Resistant to traditional disinfectants
- Can pass through filters
- Causes cryptosporidiosis
- Filtration and alternative disinfectants can remove and/or inactivate

Cryptosporidium Oocyst

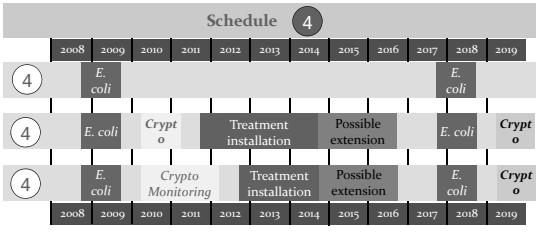
64

Implementation Time line



65

Implementation Time line



66

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Lab Safety

- Read SDS for all chemicals used in lab
- Store chemicals properly
- Know where safety equipment is stored
- Never pour water into acid
- CPR and First Aid Training (TOSHA requirement)
- Clean chemical spills immediately
- Follow published lab procedures (*Standard Methods*)
- Read and become familiar with Safety SOP

67

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Lab Safety

Safety Data Sheets (SDS)

- Keep on file for all chemicals purchased
  - According to the Americans with Disabilities Act of 1990, MSDS's should be kept for a minimum of 30 years
- Includes all information shown on chemical label and more

68

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Lab Safety

Safety Data Sheets (SDS)

- Must be readily available for employee review at all times you are in the work place
  - The can't be locked in an office or filing cabinet to which you don't have access to
  - If they are on a computer, everyone must know how to access them
- If you request to see an SDS for a product you use at work and your employer can't show it to you, after one working day you have the right refuse to work with that product until you are shown the correct SDS

69

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Lab Safety

Safety Data Sheets (SDS)

- Information provided:
  - Identification
  - Hazards identification
  - Composition
  - First aid measures
  - Fire-fighting measures
  - Accidental release measures
  - Exposure controls/personal protection
  - Physical & chemical properties
  - Stability and reactivity
  - Toxicological information
  - Other information, including date of SDS preparation or last revision

70

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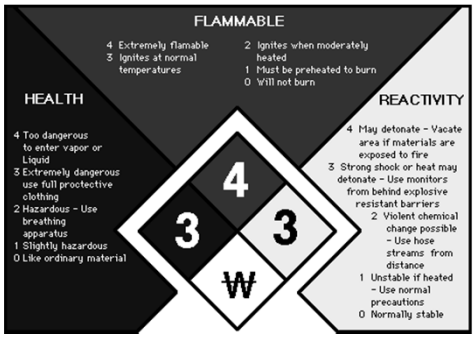
Lab Safety – Chemical Label



71

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QA/QC Program

- A QA/QC program consists of procedures that ensure the precision and accuracy of tests performed on a daily basis
- Precision - repeatability
  - Shooting at a target and hitting the same spot repeatedly
- Accuracy – closeness of test results to the correct (known) value
  - Shooting at a target and hitting the bull's eye

72

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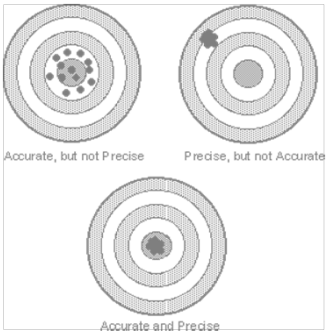
QA/QC Program



73

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QA/QC Program

Three Phases

- Keeping records
- Documenting that equipment is regularly calibrated and temperatures are correct
- Perform QC tests to demonstrate precision and accuracy

74

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QA/QC Program

Record Keeping

- Maintain a complete and accurate list of exact locations of all sampling sites
- Maintain a complete and accurate list of all test procedures used
  - Record method numbers on bench sheets
- Write in pen
- Initial your entries
- Use a notebook

75

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QA/QC Program

Quality Control Tests

- Duplicates
- Blanks
- Lab standards
- Unknown lab standards
- Spikes

76

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QA/QC Program

Duplicates

- Simplest form of QC test
- Run two tests on one sample
  - This shows how precise the analyst's procedure is
  - Sample results should yield very close results
    - goal is to have no difference
- General recommendation is to run a duplicate every 10 samples

77

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QA/QC Program

Common Source of Errors for Duplicates

- Sample size
  - Should be same size
- Insufficient mixing
- Dirty glassware
- Calculation errors
- Reagents
- Titration
  - Misreading burette
- Weighing
- Calibration
- Reagent water

78

QA/QC Program

Blanks

- Can show test interference
- Should be treated as a sample
  - Take through all procedures
  - Add all reagents or incubate along with other samples
- Target value for a blank is zero

79

QA/QC Program

Blanks

- Positive blanks show a problem
  - Bad reagents
  - Bad technique
  - Unclean glassware
  - Bad distilled water

80

QA/QC Program

Blanks

- Coliform tests
  - A blank should never be positive
  - Blanks should be run before you filter samples and when you are done filtering samples
    - if the pre-sample blank has colony growth, the equipment was not properly sterilized
    - if the post-sample blank has colony growth, the equipment was not cleaned well enough between samples

81

QA/QC Program

Laboratory Standards

- Determines accuracy
- If the test value agrees with the true value, the test has been performed accurately
- Mix onsite or purchased from supplier
  - Purchased standards should be the preference because this can reduce the possibility of having mixing errors
  - They also come with a certificate of analysis
- Perform along with duplicates
  - One every 10 samples

82

QA/QC Program

Unknown Laboratory Samples

- EPA quality control unknowns
- Commercially available
- Gives confidence to analyst
- Can show deficiencies in the testing procedure

83

QA/QC Program

Spikes

- Determine accuracy
- A known amount of standard is added to a sample
- The results should equal the sample value plus the added known amount
- Goal is to have 100% recovery of spike and sample
- If you use Hach methods, most have directions on how to spike a sample

84

QA/QC Program

Spikes

- If your sample result was 100 mg/L and you added 50 mg/L into the sample
  - you should yield 150 mg/L

85

QA/QC Program

Other Samples

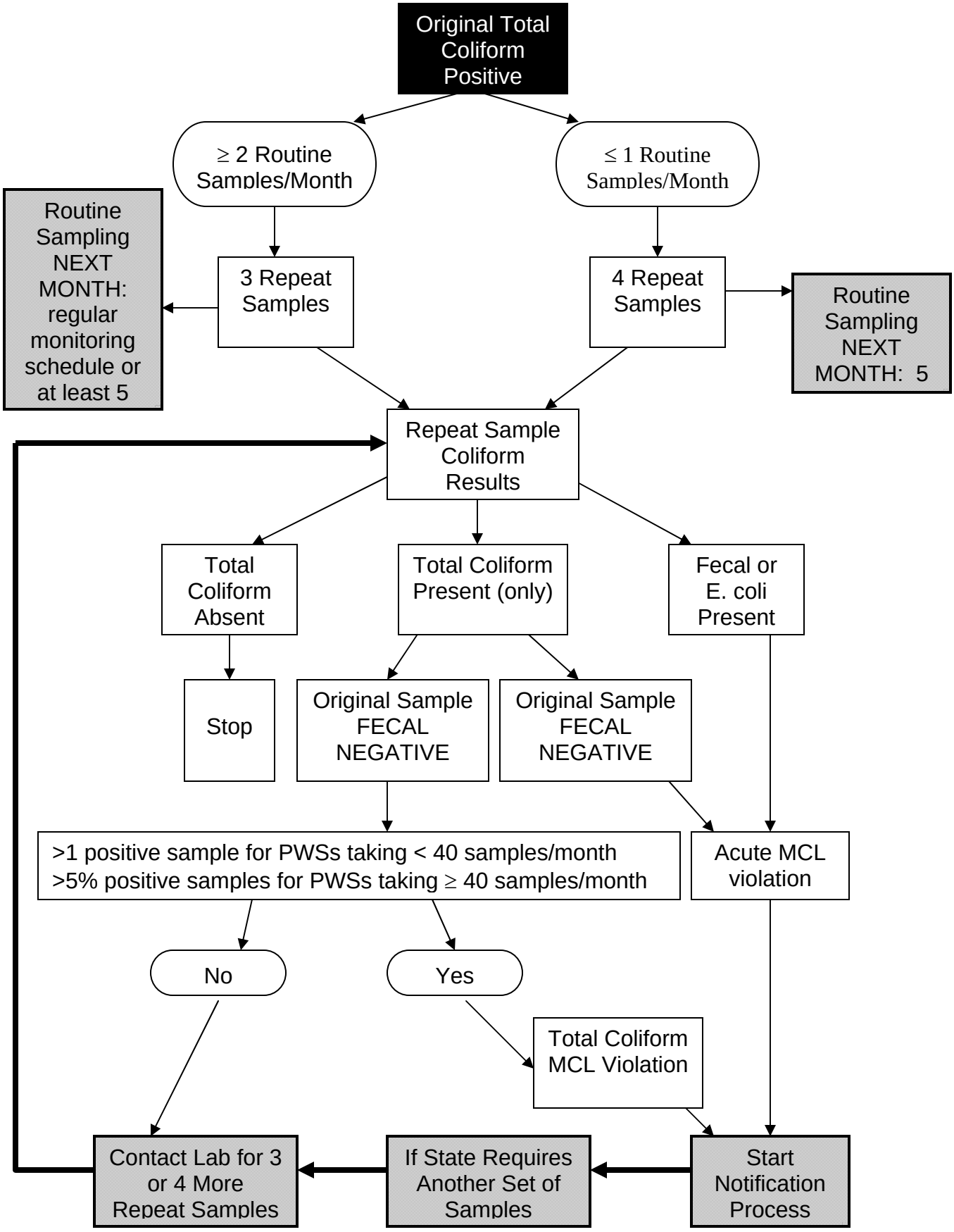
- Some labs split samples with other labs to check the accuracy of the testing procedure
- If you are concerned that your contract lab is getting wrong values, send in a known standard as a sample
  - This does double your cost, but you can see how close they are to the known value
  - Don't tell the contracted lab that the second sample is a known

86

Total Coliform Monitoring Frequency for Community Water Systems

Population Served	Minimum Number of Samples Per Month
25 to 1,000	1
1,001 to 2,500	2
2,501 to 3,300	3
3,301 to 4,100	4
4,101 to 4,900	5
4,901 to 5,800	6
5,801 to 6,700	7
6,701 to 7,600	8
7,601 to 8,500	9
8,501 to 12,900	10
12,901 to 17,200	15
17,201 to 21,500	20
21,501 to 25,000	25
25,001 to 33,000	30
33,001 to 41,000	40
41,001 to 50,000	50
50,001 to 59,000	60
59,001 to 70,000	70
70,001 to 83,000	80
83,001 to 96,000	90
96,001 to 130,000	100
130,001 to 220,000	120
220,001 to 320,000	150
320,001 to 450,000	180
450,001 to 600,000	210
600,001 to 780,000	240
780,001 to 970,000	270
970,001 to 1,230,000	300
1,230,001 to 1,520,000	330
1,520,001 to 1,850,000	360
1,850,001 to 2,270,000	390
2,270,001 to 3,020,000	420
3,020,001 to 3,960,000	450
3,960,001 or more	480

Total Coliform Action Flow Chart



Water Treatment and Distribution
Laboratory Practice Quiz

1. The MCL for total coliform bacteria is based on their _____ .
   a. Concentration in mg/L
   b. Concentration in colonies per 100 mL
   c. Presence or absence
   d. All of the above
   e. None of the above

2. The sample volume to be used when running a membrane filter test for coliform bacteria is _____ .
   a. 20 mL
   b. 40 mL
   c. 60 mL
   d. 80 mL
   e. 100 mL

3. Records of bacteriological analyses must be kept at least _____ .
   a. Until the next sanitary survey
   b. Three years or until the next sanitary survey
   c. Five years
   d. Ten years
   e. Twelve years

4. Analysis of samples for determining bacteriological quality of the water must be started within _____ hours of collection.
   a. 24
   b. 30
   c. 36
   d. 42
   e. 48

5. A bacteriological bottle contains a white powder which is placed in the bottle in order to _____ .
   a. Keep the bottle clean
   b. Kill any bacteria present
   c. Remove any chlorine residual
   d. All of the above
   e. None of the above

6. When the membrane filter method for coliform analysis is used, a typical coliform colony will be pink to dark red with a distinctive _____ .
   a. Greenish metallic sheen
   b. Dull bluish coating
   c. Shape
   d. All of the above
   e. None of the above

7. Any sample that contains coliform bacteria is a _____ sample.
   a. Grab
   b. Negative
   c. Positive
   d. Representative
   e. Routine

8. Any sample that does not contain coliform bacteria is a _____ sample.
   a. Grab
   b. Negative
   c. Positive
   d. Representative
   e. Routine

9. For bacteriological sample to be useful, it must contain essentially the same constituents as the body of water from which it was taken. This type of sample is called a _____ sample.
   a. Grab
   b. Flow-proportional time composite
   c. Representative
   d. Time composite

10. To remove any stagnant water from the customer's service line, and to make certain that water from the distribution main is being sampled, flush the faucet for _____ minutes.
    a. 1 – 3
    b. 2 – 5
    c. 5 – 7
    d. 7 – 9
    e. 10 – 15

11. Bottles for collecting samples for bacteriological analyses should _____ .
    a. Not be rinsed before use
    b. Be rinsed before use
    c. Be completely filled
    d. All of the above
    e. None of the above

12. Bottles for collecting samples for bacteriological analyses contain _____, which destroys any chorine residual in the sample.
    a. Sodium arsenite
    b. Sodium chloride
    c. Sodium fluoride
    d. Sodium hydroxide
    e. Sodium thiosulfate

13. Samples for bacteriological analysis should not be taken from _____.
    a. Swivel faucets
    b. Leaking faucets
    c. Faucets with aerators, strainers or hose attachments
    d. All of the above
    e. None of the above

14. A sample which consists of a number of grab samples taken from the same sampling point at different times and mixed together before analysis is called a _____ sample.
    a. Composite
    b. Grab
    c. Flow-proportional time composite
    d. Representative
    e. Time composite

15. High fluoride readings can result from all of the following causes except _____.
    a. Polyphosphates can interfere with the SPADNS method, resulting in high fluoride readings
    b. Not accounting for natural fluoride in the water
    c. Dilution of water which has been fluoridated with unfluoridated water in storage tanks
    d. All of the above
    e. None of the above

16. What is the secondary maximum contaminant level for fluoride?
    a. 0.2 mg/L
    b. 0.4 mg/L
    c. 2.0 mg/L
    d. 4.0 mg/L

17. The maximum permissible level of a contaminant in water as specified in the regulations of the Safe Drinking Water Act is the _____ .
    e. Maximum contaminant level
    f. Saturation point
    g. Zeta potential
    h. All of the above
    i. None of the above

18. _____ is an indicator used when measuring the total alkalinity concentration on a water sample.
    j. EDTA
    k. Eriochrome black-T
    l. Bromcresol Green Methyl Red
    m. Phenolphthalein
    n. Sodium thiosulfate

19. A(n) _____ is a device that sterilizes laboratory equipment by using pressurized steam.
    a. Autoclave
    b. Beaker
    c. Buret
    d. Nepholometer
    e. Pipet

1. C
2. E
3. C
4. B
5. C
6. A
7. C
8. B
9. C
10. B
11. A
12. E
13. D
14. E
15. C
16. C
17. A
18. C
19. A

TDEC - Fleming Training Center 1

STORAGE TANKS

Disinfection
Rules and Regulations

TDEC - Fleming Training Center 2

Objectives

- Reasons for storing water
- Operating storage and emergency storage
- Size and location for storage tanks
- Operation and maintenance
- Rules and regulations

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Water Storage

Purpose

- Equalizing supply and demand
- Increasing operating convenience
- Leveling out pumping requirements
- Decreasing power costs

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Water Storage

Purpose

- Providing water during power or pump failure
- Providing adequate water for fire fighting
- Providing surge relief
- Increasing detention times
- Blending water sources
- Decrease pumping costs

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Water Storage

Capacity Requirements

- Based on maximum water demands in different parts of the system
- Too much storage can cause stagnant water and taste & odor problems
  - 20 % turnover rate to prevent it from becoming septic
    - less sediment

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Water Storage

Type of Service

- Operating storage
  - Tank directly connected to distribution piping
  - Fills and empties based on system pressure
- Emergency storage
  - Used for emergency, i.e. fire protection
  - Not suitable for potable use
  - Subject to freezing due to lack of circulation

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Storage Tanks

- Elevated tanks
- Ground-level reservoirs
- Standpipes
- Hydropneumatic system

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Storage Tanks

Elevated Tanks

- Supported by steel or concrete tower
- Maintains adequate and uniform pressure
- Minimizes variations in pressure due to turning pumps on or off
- May require altitude valve to prevent overflow
  - One-way are best
- More expensive than ground tanks

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Storage Tanks

Standpipes

- Tank rests on ground
  - Has greater height than diameter
- Stores volumes at low pressure
- Water must be turned over frequently to avoid stagination
  - 20% is bare minimum
- Located at high points in land elevation

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Storage Tanks

Ground-Level Reservoirs

- For raw water - lakes, ponds, basins
- For finished water - ground level or underground tanks
  - Lower initial cost than elevated tank, but requires pumps to move water
  - Main disadvantage is cost of booster pump station that must be used with the tank

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Storage Tanks

Ground-Level Reservoirs

- This is an old open-topped reservoir that has been converted with a liner-cover

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Storage Tanks

Hydropneumatic System

- Partially filled with water; partially filled with compressed air
  - 2/3 water to 1/3 air
- Air helps maintain pressure in tank
- Usually for very small water systems

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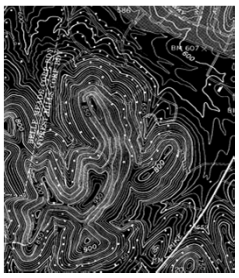
Storage Tanks

Selection and Location of Storage

- Determined by hydraulics, water demand, elevation of terrain, purpose of tank, etc
- Type of storage depends on purpose of tank



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Tank Equipment

Monitoring Devices

- Pressure sensor at base of tank
  - Altitude valve
- Level sensor inside tank
- Data transmitted to central location
  - Alarms can alert operator of high or low levels

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Tank Equipment

Air Vents

- Allow air to enter and escape as water level rises
- Require screens to keep out birds & other contaminants
- Mesh should be #24 and stainless steel

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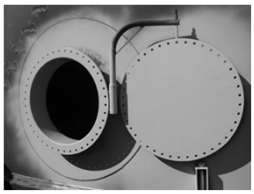
Tank Equipment

Access Hatches

- For entry and ventilation during maintenance
- Hatch on roof requires rim to prevent runoff from entering tank
- Hatch at bottom of tank must withstand tank pressure
- Must be secured to prevent vandalism
  - Locks must be in place since 9/11



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Tank Equipment

Ladders

- Most ladders begin about 8 ft from ground to deter unauthorized use
- May extend to ground if heavy metal shield is locked in place to prevent unauthorized entry
- All ladders must meet OSHA regs, including safety cage

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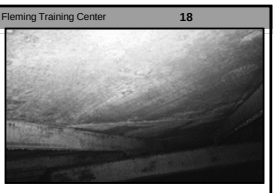
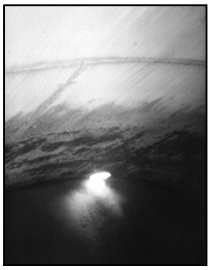
Tank Equipment





Coatings

- Protect interior and exterior of tank from corrosion without causing taste & odor problems
- Coatings must meet the requirements of NSF (ANSI Standard 61)

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Tank Equipment

Cathodic Protection

- Can assist in corrosion control
- Electrodes placed in tank which corrode instead of tank and appurtenances
- Inspect annually

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Maintenance

TDEC - Fleming Training Center 21

Tank Inspections

- Must be professionally inspected every 5 years in accordance with state requirements (Rule 33)
  - Inspection by draining or by using a diver

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Tank Inspections

- Inspection reports must be on file and available for review by State Sanitary Inspectors
- Visual inspections recommended annually

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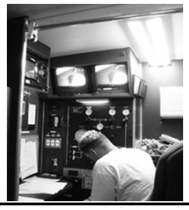
Tank Inspections

- Requires draining the tank or using divers
- Check vents, overflows, paint, altitude valves, etc
- Check for corrosion inside & outside
- Considered confined space; get permit



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Storage Tank Collapse

- Caused by massive leak in 42 inch water main which quickly drained the tank
  - 50,000 gallons per minute
- Vacuum formed sucking the roof in

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Security

- Fencing, locks on access to manholes and other necessary precautions shall be provided to prevent trespassing, vandalism, and sabotage

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Security

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Records

- Every tank in your system should have a historical record file containing, as a minimum, the most current inspection report
- Location, type of maintenance or repair performed, all contract documents and specifications for repair, paint and equipment submittals, etc

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Storage Tank Safety

- Follow regulations for confined spaces
- Inspect ladders and safety cages for damage
- Use protective equipment
- Provide ventilation inside tank when inspecting
- Provide adequate lighting with proper wiring to prevent shock hazard

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AWWA Standard for Disinfection of Water Storage Facilities

- Before placing into service, all storage tanks shall be disinfected
- There are standards for disinfecting storage tanks covered by ***AWWA C652***
  - Covers materials, tank preparation, disinfectant application and sampling for coliform bacteria

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Chlorine Disinfection

- Chlorine gas
  - 100% available chlorine
- Calcium hypochlorite
  - 65% available chlorine
- Sodium hypochlorite
  - 5-15% available chlorine

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Methods of Chlorination

Method 1

- Water tank shall be filled to overflow level with enough chlorine added to maintain at least 10ppm residual for 24 hour period

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Methods of Chlorination

Method 2

- A solution of 200 ppm available chlorine is applied directly to the entire surface of the storage tank that comes in contact with water when it is full for at least 30 minutes
- Applied by brushing or spraying on
- Tank should be flushed with potable water before put back into service
- WARNING – experienced operators only
  - Hazardous to attempt


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Methods of Chlorination

Method 3

- Water and chlorine are added to the storage tank to make a 50 ppm available chlorine that fills about 5% of the total storage volume
- This is held in the tank for no less than 6 hours
- The tank is then filled up to the overflow level and held for at least 24 hours
- There should be a 2 ppm residual chlorine remaining after a 24 hour period
- All highly chlorinated water needs to be drained

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Methods of Chlorination

Bacteriological Sampling and Testing

- Storage tanks must be tested for coliform bacteria after chlorination procedure and before it is put back into service
- "If the … facility yields positive bacterial samples, additional flushing, disinfection and bacteriological sampling shall be repeated until the water is coliform free." - 0400-45-01-.17(8)(a) & (b)

Differs from AWWA standards

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Rules and Regulations

- From Community Public Water Systems Design Criteria
  Division of Water Resources
  Tennessee Department of Environment and Conservation, 1997; Part 8

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Rules and Regulations

- 8.0.2 Protection – All new finished water storage structures shall have suitable watertight roofs or covers which exclude birds, animals, insects, and excessive dust.


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Rules and Regulations

- 8.0.3 Protection from Trespassers – Fencing, locks on access to manholes, and other necessary precautions shall be provided to prevent trespassing, vandalism, and sabotage.

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Rules and Regulations

- 8.0.4 Drains – No drain on a water storage structure may have a direct connection to sewer or storm drain. Splash pad and drainway shall be provided to prevent erosion.

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Rules and Regulations

- 8.0.5 Overflow – The overflow pipe of a water storage structure should be brought down near the ground. No overflow may be connected directly to a sewer or storm drain.
  - c. The overflow shall be protected with a 24 mesh non-corrodible screen with a flap valve.

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Rules and Regulations

- 8.0.5 Overflow cont'd

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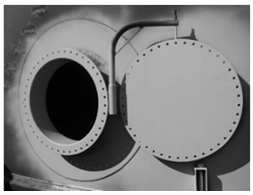
Rules and Regulations

- 8.0.6 Access – Manholes on scuttles above waterlines
  - a. shall be…on ground-level structures manholes should be elevated 24 to 36 inches above the top or covering sod.



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Rules and Regulations

- 8.0.7 Vents – Finished water storage structures shall be vented by special vent structures
  - a. shall prevent the entrance of surface water
  - b. shall exclude birds and animals
  - c. shall…be covered with 24-mesh non-corrodible screen cloth.

Rules and Regulations

- 8.0.10 Safety – Safety shall be considered…
  - a. ladders, ladder guards, balcony railings, and safe location of entrance hatches shall be provided where applicable.

Rules and Regulations

- 8.0.14 Painting and/or Cathodic Protection – Proper protection should be given to metal surfaces by paints or other protective coatings, by cathodic protective devices, or by both.
  - a. paint systems consistent with AWWA standards, or…all paints must be acceptable to FDA and EPA for contact with potable water
  - b. cathodic protection should be designed and installed by competent technical personnel

Rules and Regulations

- 8.0.15 Turnover of Water – If the storage reservoir is sized large than required for initial demand and there is more than 2 days storage, provisions shall be made for turnover of the water tank and/or booster chlorinator
- 8.0.17 Disinfection – Finished water storage structures shall be disinfected in accordance with AWWA Standard C652 before being put into service
- 8.2.5 (Pressure Tanks) Auxiliary Power – Auxiliary power with automatic takeover capability shall be provided when positive pressures are not available from system gravity flow

Rules and Regulations

- 8.0.16 Sampling – A suitable sampling tap should be provided on all storage structures and be protected from public access

Rules and Regulations

Distribution Storage

- 8.3.1 The purpose of system storage is to have sufficient water available to provide adequate flow and pressure at peak demand as well as to provide for fire flow when needed. For most water systems, a satisfactory rule-of-thumb to meet these needs it to provide at least the average 24-hour demand in elevated storage
- 8.3.4 Level Controls – Adequate controls shall be provided to maintain levels in distribution system storage structures
  - a. telemeter equipment should be used when pressure-type controls are employed and any appreciable head loss occurs in the distribution system
  - b. altitude valves or equivalent controls may be required for a second and subsequent structures on the system

Ground Storage Tank Inspection Report

Job No.: _____ Date: _____ Inspector: _____

Tank owner: _____ Owner's order #: _____

Owner's representative: _____ Title: _____

Mailing address: _____

Physical address: _____

City, State: _____ Zip: _____

County tank is located: _____ Seismic zone of county: _____

Telephone: _____ Fax: _____

Location of tank: _____

Original Contractor #: _____ Year built: _____

Original Manufacturer: _____ Capacity: _____

Date of last inspection: _____

Diameter: _____ Height: _____

Type of construction: Welded: _____ Riveted: _____

Who is customer's insurance carrier? _____

Storage Tank Vocabulary

A. Altitude Valve
B. Booster Disinfection
C. Cathodic Protection
D. Elevated Storage
E. Elevated Tank
F. Emergency Storage
G. Ground-level tank
H. Hydropneumatic System
I. Overflow Level
J. Reservoir
K. Riser
L. Standpipe
M. Tank

_____1. An electrical system for preventing corrosion to metals, particularly metallic pipes and tanks.
_____2. A system using an airtight tank in which air is compressed over water (separated from the air by a flexible diaphragm). The air imparts pressure to water in the tank and the attached distribution pipelines.
_____3. A structure used in a water system to contain large volumes of water or other liquids.
_____4. The maximum height that water or liquid will rise in a receptacle before it flows over the overflow rim.
_____5. A valve that automatically shuts off water flow when the water level in an elevated tank reaches a preset elevation then opens again when the pressure on the system side is less than that on the tank side.
_____6. Storage volume reserved for catastrophic situations, such as supply-line break or pump-station failure.
_____7. (a) Any tank or basin used for the storage of water. (b) A ground-level storage tank for which the diameter is greater than the height.
_____8. A ground-level water storage tank for which the height is greater than the diameter.
_____9. In the distribution system, storage of water in a tank whose bottom is at or below the surface of the ground.
_____10. In any distribution system, storage of water in a tank supported on a tower above the surface of the ground.
_____11. The vertical supply pipe to an elevated tank.
_____12. A water distribution storage tank that is raised above the ground and supported by posts or columns.
_____13. The practice of adding additional disinfectant in the distribution system.

Storage Tank Review Questions

1. List 9 reasons for providing water storage in a distribution system.
   -
   -
   -
   -
   -
   -
   -
   -
   -
2. List the 4 types of distribution storage tanks and a description of each.
   -
   -
   -
   -
3. What is the difference between operating storage and emergency storage?

4. Why should vent openings on storage tanks be screened?

5. What is the purpose of an altitude valve?

6. How often must storage tanks be inspected according to the Regulations for Public Water Systems and Drinking Water Quality for the State of Tennessee?

7. After disinfection, what must be done before a tank is put back in service?

8. Name four things that should be considered when determining the type and the site for a new storage tank.
   -
   -
   -
   -

9. Why should the overflow pipe on a storage tank never be directly connected to a sewer or storm drain?

10. How are storage tanks protected from corrosion?

Storage Tank Review Questions

1.
- Equalizing pressure and demand
- Increasing operating convenience
- Leveling out pumping requirements
- Decreasing power costs
- Providing water during source or power failure
- Providing adequate water for fire fighting
- Providing surge relief
- Increasing detention time
- Blending water source

2.
- Elevated – tank on tower, provides pressure, minimizes pressure variations
- Standpipe – tank on ground, taller than diameter, stores large volumes of water at low pressure, safer than elevated tank, may require pump
- Ground-level reservoir – diameter greater than height, requires pump
- Hydro-pneumatic – 2/3 water, 1/3 air; air helps maintain pressure, usually used with wells; small tanks

3. Emergency storage is not considered to be potable water – for emergencies only, e.g. fire protection.
   Operating storage is directly connected to distribution system, fills and empties by distribution pressure.

4. To keep out birds, insects, animals, etc.

5. To keep tank from overflowing

6. Professionally every 5 years

7. Bacteriological samples must be taken and must pass.

8. Water demand; Hydraulics, terrain; Purpose of tank; Public opinion

9. That would be a cross connection

10. Cathodic protection, coatings

Storage Tank Vocabulary

1. C
2. H
3. M
4. I
5. A
6. F
7. J
8. L
9. G
10. D
11. K
12. E
13. B

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Significance
Sampling
Methods of Determination
Methods of Removing

TASTE AND ODOR

1

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Taste and Odor

- There are few, if any, enforceable regulations worldwide regarding taste and odor compounds in drinking water
- They have the status of "Secondary Standards"

2

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Taste and Odor

- Customers expect their tap water to taste and smell good
- The problem is that if there is a taste or odor problem present, your customer associates this with unsafe drinking water

3

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Taste and Odor

- This lack of trust has resulted in dramatic increase in the use of bottled water

4

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Taste and Odor

- Aesthetic qualities of drinking water and their measures are dependent on human perception
- Difficult to measure
- Caused by a variety of substances
  - Organic matter
  - Dissolved gases
  - Industrial waste
  - Leached metals

5

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Taste and Odor

- The exact cause of taste and odor problems must be identified, whether it is source contamination, microbial metabolites, chemicals produced during treatment or chemicals produced in the distribution system, in order to minimize the problem

6

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Taste and Odor

- Since researchers have been able to identify causes of taste and odor problems, control methods can be used to improve the aesthetic quality of drinking water
- This means happier customers ☺

7

FIGURE 1 Wheel identifying distribution system–generated tastes and odors

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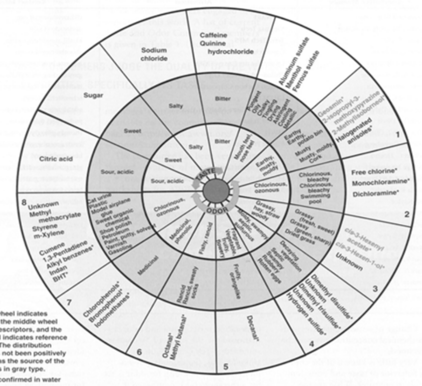

The inner wheel indicates categories, the middle wheel indicates descriptors, and the outer wheel indicates reference standards. The distribution system has not been positively confirmed as the source of the compounds in gray type.

*Presence confirmed in water

Source: D. Khiari et al, 2002. *Distribution Generated Taste-and-Odor Phenomena.* AwwaRF Report, AWWA Bookstore catalog no. 90897. AWWA, Denver.

8

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Taste

- Taste tests can only be run on water known to be safe for drinking
- Usefulness is limited
- Classifications
  - Sweet
  - Sour
  - Bitter
  - Salty

9

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Odors

- Human sense of smell is more sensitive than taste, so odor tests are run most commonly in water treatment plants

10

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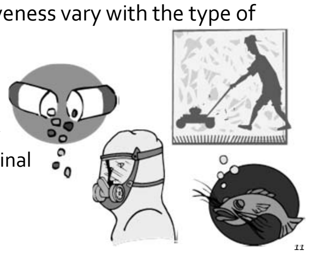
Odors

- Most frequently caused by algae or decaying organic matter
- Intensity and offensiveness vary with the type of organic matter
- Classifications

  Aromatic
  Grassy
  Septic
  Rotten egg
  Fishy
  Musty
  Medicinal



11

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Significance

- Odor tests can be used to evaluate how well a plant removes taste and odor causing organic materials
- Odor tests can also be used to detect problems in the distribution system
  - Odors in dead-end water mains may have a significant bacteriological buildup
  - Chlorine odor can indicate the loss of free chlorine caused by stagnation, slime buildup, and/or anaerobic conditions

12

Sampling

- Water samples should be taken from raw and finished waters
- Preferably, use glass containers because plastic may have their own odor
- Mixing of sample should be kept to a minimum until ready for analysis
  - Aeration may reduce odor causing compounds
- Odor tests should be run ASAP – within 24 hours

13

Common Taste & Odor Complaints

Customer Complaint	Possible Cause
Red water or reddish-brown staining of fixtures and laundry	Corrosion of iron pipes or presence of natural iron in raw water
Bluish stains on fixtures	Corrosion of copper lines
Black water	Sulfide corrosion of copper or iron lines OR precipitations of natural manganese
Foul tastes and/or odors	Byproducts from microbial acitvity
Loss of pressure	Excessive scaling, tubercule (buildup from pitting corrosion), leak in system from pitting or other type of corrosion
Lack of hot water	Buildup of mineral deposits in hot water system (can be reduced by setting thermostats to under 140°F)
Short service life of household plumbing	Rapid deterioration of pipes from pitting or other types of corrosion

14

Methods of Determination

Threshold Odor Test

- Measured in Threshold Odor Number (TON)
- Determined by diluting a sample with odor-free water until the least definitely perceptible odor is achieved
- More accurate with more people conducting test

$$TON = \frac{A + B}{A}$$

Where: A = mL sample
B = mL odor-free water

15

Methods of Determination

Flavor Profile Analysis

- Can be applied for both taste and odor causing compounds
- Panelists are trained in the proper methods of tasting and sniffing samples and are taught to identify and rate the attributes of both tastes and odors
- Standards can be made from sucrose for sweetness, citric acid for sourness, sodium chloride for saltiness, and coffee for bitterness
  - Geranium leaves may also be used for a standard geranium odor in a water sample

16

Methods of Determination

Quantitative Methods

- How much is present
  - Closed-loop Stripping Analysis
  - Solid Phase Microextraction (SPME) by GC/MS
  - Purge and Trap (dynamic headspace)
- Complaint calls can be received with Geosmin and MIB at 10 ppt (parts per trillion)

17

Treatment of Taste & Odor

- There are two different areas taste and odor problems can begin
  - Source water
    - can be treated in source water or at the treatment plant
  - Distribution system
    - can be caused by corrosive water leaching metals into water or low chlorine residuals resulting in bacterial growth in water

18

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Treatment

Source Water Treatment

- Early detection of an algal bloom is best
  - Usually have to have historical data to know when blooms occur
  - Data tracking
    - temperature
    - pH
    - turbidity
    - nutrient removal
  - Early detection by
    - underwater visual inspection
    - flavor profile analysis
    - algae collection and identification

19

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Treatment

Source Water Treatment

- Copper sulfate
  - Operations methods
    - aeration
    - blending treated water with non-treated water
    - selective withdrawal
  - Operational tools
    - alum
    - ferric salts
    - artificial circulation - prevents lake stratification
    - removal of fish - stir up sediments
    - dredging of lake/reservoir (extreme)

20

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Treatment

Treatment in Plants

- Most plants don't have the luxury of having protected reservoirs they can treat to prevent problems before the come into the plant
- Best way to prevent is to look at historical data
  - e.g. if algal blooms occur when water reaches certain temperature

21

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Treatment

Treatment in Plants

- Oxidizers
  - Ozone
    - removes 90% of Geosmin and MIB
  - Chlorine dioxide
    - removes phenolic and medicinal odors
  - Potassium permanganate
    - removes grassy and cucumber
- PAC
- Biological filtration

22

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Distribution System

- Look at historical data
  - What time of year are complaints made
  - Where there are breaks, repairs, or replacements on the water main
  - Was there a possibility of cross-connection and backflow
- Always remember, as temperature increases during the summer, chlorine residual drops
  - Chlorine can mask a taste or odor
  - Bacteria can grow with low/no residual chlorine
  - Either of these problems can cause taste and odor problems

23

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Distribution System

- Problems
  - Getting a good description from you customer
    - e.g. one person may say the water has a metallic taste and another may say it tastes like sewage
- Getting samples
  - Take at customer's house
  - Make sure customer checks sample to see if taste or odor problem is present in the sample you just collected
    - if not, no need to send to lab

24

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Distribution System

- Once a problem has been identified, work upstream from the customers tap to find the source of the problem
- Once you have solved a customer's problem, you learn more about your distribution system and you increase customer confidence
- Operational tools
  - Flushing mains
  - Reconfiguring mains
  - Cross-connection control

25

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Taste and Odor

- Some treatment methods may remove taste and odor problems, by doing so, they may add new taste and odors that are offensive
- For the treated water industry to move forward, more effort is need to:
  - Characterize taste and odors
  - Develop analytical procedures
  - Detect and identify causes of taste and odor problems
  - Develop economical solutions for minimizing taste and odor problems

26

Examples of Customer Complaints

Customer Complaint	Possible Cause
Red water or reddish-brown staining of fixtures and laundry	Corrosion of iron pipes or presence of natural iron in raw water
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