Wisconsin Department of Natural Resources
Municipal Waterworks Operator Certification

Surface Water Study Guide

Subclass S

December 2006 Edition (Revised February 2016)

Wisconsin Department of Natural Resources
Operator Certification Program
P.O. Box 7921, Madison, WI 53707

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Preface

This operator's study guide represents the results of an ambitious program. Operators of water supply facilities, regulators, educators and local officials, jointly prepared the objectives and exam questions for this subclass.

February 2016: Objectives 1.1.10, 3.1.1, and 3.1.9 were updated to reflect the revised total coliform rule that takes effect April 1, 2016.

February 2015: Objective 2.2.5 was added. The reference list was also updated.

January 2013 Revisions: The December 2006 edition of this study guide has been updated to reflect recent changes in bacteriological sampling requirements and fluoride concentration targets. The following objectives have been updated: 3.1.1, 3.1.3, 3.1.4, 3.1.8, 3.1.9, and 3.1.15.

How to Use This Study Guide with References In preparation for the exam you should:

1. Read all the objectives and write down the answers to the objectives that readily come to mind.

2. Use the resources at the end of the study guide to look up those answers you are not sure of.

3. Write down the answers found in the resources to those objectives you could not answer from memory.

4. Review all answered objectives until you can answer each from memory.

It is advisable that the operator take classroom or online training in this process before attempting the certification exam.

Choosing a Test Date

Before you choose a test date, consider the training opportunities available in your area. A listing of training opportunities and exam dates is available on the internet at DNR website, keyword search "operator certification".

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Chapter 1 - Principle, Structure, and Function

Section 1.1 - Principles of Surface Water Treatment

1.1.1 Define an Ion, Anion, and a Cation.

1.1.2 Define surface water and give examples of the various forms.

1.1.3 Define the term watershed.

1.1.4 Describe the movement of water through the hydrologic cycle.

1.1.5 Discuss lake turnover and its effect on surface water quality.

1.1.6 Explain the circulation and stagnation zones of surface waters and reservoirs.

1.1.7 List the factors controlling runoff volume/rates.

1.1.8 Describe the term surface water quality.

1.1.9 List various types of unwanted chemicals found in surface water and sources of the contamination.

1.1.10 List various harmful waterborne microbiological organisms and the diseases they cause.

1.1.11 Define the following terms associated with surface water treatment:

A. Raw Water
B. Colloidal
C. Sedimentation
D. Sludge Blanket
E. Turbidity
F. Finished Water
G. Sludge

1.1.12 Describe the characteristics of primary and secondary drinking water standards.

1.1.13 Define the differences between the following:

A. An Exemption
B. A Conditional Waiver
C. A Compliance Agreement

1.1.14 Explain why the disinfection by-products trihalomethanes (TTHMs) and haloacetic acids (HAA5s) are a problem in drinking water.

1.1.15 Describe how trihalomethanes (TTHMs) and haloacetic acids (HAA5s) are formed.

Section 1.2 - Structure and Function

1.2.1 Explain how submerged lights placed at the outlet of a mixing basin can aid the operator.

1.2.2 List the controls and gauges which should be on a typical filter console.

1.2.3 Describe the following valves used in water treatment plants.

A. Gate Valve
B. Butterfly Valve
C. Check Valve
D. Ball Valve
E. Globe Valve
F. Plug Valve
G. Pressure Regulating Valve

1.2.4 Explain how a reduced pressure principle backflow preventer is used at a water treatment plant.

1.2.5 List the most common types of positive displacement pumps and explain how they work.

1.2.6 List the most common types of centrifugal pumps.

1.2.7 Discuss how a centrifugal pump works and the function of the following components:

A. Impeller
B. Shaft
C. Shaft Sleeve
D. Bearings
E. Lantern Ring
F. Mechanical Seal
G. Pump Casing
H. Packing Gland
I. Volute

1.2.8 Describe gravimetric and volumetric chemical feeders.

1.2.9 Describe the operation and following components of a solution-feed vacuum-type gas chlorination system.

A. Chlorine Gas Cylinder
B. Yoke Unit
C. Control Unit (Chlorinator)
D. Gas Vacuum Line

E. Booster Pump and Piping

F. Ejector

G. Exhaust Fan

1.2.10 List two types and applications of filtration in use at water treatment plants and identify some materials used for filter media.

Chapter 2 - Operation and Maintenance

Section 2.1 - Operation

2.1.1 Explain how to predict disinfection by-product formation and list the appropriate analytical methods.

2.1.2 Discuss why fluoridation is practiced and identify common fluoride compounds used in surface water treatment.

2.1.3 List the function of the following chemicals used at surface water facilities:

1. Carbon
2. Chlorine
3. Potassium Permanganate
4. Alum
5. Ferric Chloride
6. Polymers
7. Hydrofluosilicic Acid
8. Activated Silica
9. Lime
10. Phosphates
11. Caustic Soda
12. Ozone

2.1.4 Describe the metal commonly used as an expendable auxiliary anode for corrosion control in steel tanks.

2.1.5 Identify the following terms used to express concentrations.

A. ppm
B. lbs/mg
C. mg/L
D. ug/L
E. ppb

2.1.6 Explain total dynamic head.

2.1.7 Define pretreatment and list the common processes in surface water pretreatment.

2.1.8 Explain what changes need to be performed to control the effects of lake turnover on surface water quality.

2.1.9 Define T10 and how it is determined.

2.1.10 Explain post-chlorination and why it is done.

2.1.11 Explain the process of chemical disinfection for the following:

A. To the Water Supply
B. To the Tanks and Pipes

2.1.12 Explain the various forms of chlorine used for water disinfection.

2.1.13 List the disinfectants available for cyst and virus inactivation.

2.1.14 Discuss the following terms related to chlorination:

A. Chlorine Demand
B. Free Chlorine
C. Combined Chlorine
D. Total Chlorine Residual
E. Gas (Chlorine)
F. Solid (Calcium Hypochlorite)
G. Liquid (Sodium Hypochlorite)

2.1.15 Sketch a flow diagram of a conventional surface water treatment plant identifying the major processes.

2.1.16 Explain how the chlorine cylinder is connected to the chlorine feed equipment.

2.1.17 Describe coagulation and flocculation.

2.1.18 List the common chemical coagulants used in surface water treatment.

2.1.19 Discuss the use of coagulant aids and identify several types.

2.1.20 Describe how the following may affect coagulation:

A. Temperature
B. pH
C. Concentration of Dissolved Solids
D. Concentration of Suspended Solids
E. Mixing Conditions
F. Concentration of Coagulant

2.1.21 Describe enhanced coagulation and how it reduces disinfection by-product (DBP) precursor levels.

2.1.22 Describe flocculation basins.

2.1.23 Describe rate-of-flow controllers.

2.1.24 Explain the limiting factors which govern the rate-of-flow in a filter.

2.1.25 Identify typical design rates for filtering and backwashing in gpm/square feet for the following filters:

A. Rapid Sand Filter

B. Dual Media (Anthracite/Sand) Filter

C. Multi-Media (Anthracite/Sand/Garnet) Filter

2.1.26 Discuss the gel-like material (Schmutzdecke) commonly found on filter surfaces.

2.1.27 Identify factors determining when filter media should be replaced.

2.1.28 Identify the factors which indicate the need and duration for backwashing.

2.1.29 Describe the steps in backwashing a filter.

2.1.30 Indicate the valve position (open or closed) for the following operational valves during both filtering and backwashing.

A. Influent Valve

B. Effluent Valve

C. Washwater Valve

D. Surface Wash Valve

E. Waste or Drain Valve

F. Backwash Valve

2.1.31 Explain the operation and maintenance of sedimentation basins.

2.1.32 Discuss suitable means of sludge disposal.

2.1.33 Identify control strategies for trihalomethanes (TTHMs) and haloacetic acids (HAA5s).

2.1.34 Discuss disinfection by-product precursors, precursor sources, and how to control them.

2.1.35 Describe treatment process modifications capable of controlling trihalomethanes (TTHMs) and haloacetic acids (HAA5s).

2.1.36 Describe the disinfection by-product bromate, its precursor, how it forms, and how it can be controlled.

Section 2.2 - Maintenance

2.2.1 Describe the maintenance of a positive displacement pump.

2.2.2 Describe the maintenance of a centrifugal pump with regard to the following:

A. Priming
B. Packing
C. Bearings
D. Alignment

2.2.3 Describe problems associated with pump packing.

2.2.4 Explain the importance of a surface wash in the filter cleaning process.

2.2.5 Per Wisconsin Administrative Code NR810.13, describe the requirements for exercising emergency power generators and engines and keeping records of these activities.

Chapter 3 - Monitoring and Troubleshooting

Section 3.1 - Monitoring

3.1.1 Describe the Maximum Contaminant Level (MCL) for E. coli and the total coliform treatment technique trigger.

3.1.2 List the Maximum Contaminant Levels (MCL) or treatment technique for the following:

1. Fluoride
2. Nitrate
3. Sodium
4. Corrosivity
5. Total Trihalomethanes (TTHM)
6. Turbidity

3.1.3 List the monitoring requirements for the following:

1. Inorganic Chemicals
2. Corrosivity
3. Organic Chemicals
4. Turbidity

3.1.4 Describe the bacteriological monitoring requirements for surface water suppliers.

3.1.5 Define CT Value and list the variables needed to determine a required CT Value for free chlorine.

3.1.6 List the total inactivation/removal for Giardia Lambia cysts and viruses required by the EPA surface water treatment rule.

3.1.7 List the removal credit given for a well operated conventional plant and resultant disinfection levels required.

3.1.8 Explain the sampling locations in the distribution system for the following:

A. Inorganic Chemicals (IOCs)
B. Corrosivity
C. Organic Chemicals (SOCs & VOCs)

3.1.9 Describe the procedure to follow when a bacteriological sample is positive.

3.1.10 List the circumstances where public notification is required.

3.1.11 Define minimum chlorination residuals for surface water systems.

3.1.12 Explain the frequency of testing disinfectant residual in a water distribution system.

3.1.13 Explain the term maximum residual disinfectant level (MRDL) and list the MRDL for chlorine and chloramines.

3.1.14 Explain the preparation of a bacteriological sampling bottle for testing of a chlorinated water supply.

3.1.15 Identify the acceptable range, and the optimum target level, for fluoride concentration in public drinking water.

3.1.16 Explain the preparation procedure for bottles used to collect fluoride samples.

3.1.17 Discuss monthly fluoride split samples and what to do with them.

3.1.18 Explain the frequency of testing for fluoride in a water distribution system.

3.1.19 Identify common laboratory tests for fluoride, and the procedures used to perform the test.

3.1.20 Describe the Jar Test and its function.

3.1.21 Define the following terms:

A. End Point
B. Acidic
C. Basic
D. NTU

3.1.22 State how many buffers should be used when calibrating a pH meter.

3.1.23 Explain the suitable buffers used to calibrate a pH meter prior to analyzing basic and acidic samples.

3.1.24 Explain how to read a water level meniscus.

3.1.25 Describe a colorimetric analysis and list which tests are commonly performed by this method.

3.1.26 Describe the following total chloride residual tests:

A. DPD Colorimetric
B. DPD Titrimetric
C. Amperometric Titrimetric

3.1.27 Describe a specific Ion Probe and list example tests that use this method.

3.1.28 Identify the tests used to establish corrosive and deposition potential of finished water.

3.1.29 Discuss the primary chemical parameters used to determine coagulation, disinfection, softening, and corrosion control.

3.1.30 List the steps in using the following to perform a bacteria analysis:

1. Using a membrane filter
2. Using the multiple tube fermentation method
3. Using the standard plate count
4. Using Colilert

3.1.31 Identify where samples are collected for trihalomethanes (TTHMs) and haloacetic acids (HAA5s) analysis and list the MCLs.

Section 3.2 - Troubleshooting

3.2.1 Discuss the importance, types, and operational concerns with the necessity for standby power.

3.2.2 List common pump problems and their possible cause.

3.2.3 Discuss how a sand detector might be of value in relation to filtration.

3.2.4 Discuss "negative head" and how it affects water filtration.

3.2.5 Explain how media size affects headloss and filter run.

Chapter 4 - Safety and Calculations

Section 4.1 - Safety

4.1.1 Identify the possible hazardous areas or situations that may be present at a surface water facility.

4.1.2 Describe proper safety procedures and/or equipment used in the following:

A. Confined spaces
B. Moving or rotating equipment
C. Condensation on floors
D. Laboratory
E. Stairs
F. Chlorine/Fluoride handling
G. Degradation of metal
H. Low piping
I. Electrical equipment

4.1.3 Discuss typical chemical feed room safety equipment needed for the following common surface water treatment chemicals.

A. Chlorine Gas
B. Alum/Fluoride
C. Carbon
D. Lime

4.1.4 Describe protective measures used to store and handle water treatment chemicals.

4.1.5 Identify various types of respiratory protection devices.

4.1.6 Describe a method of detecting chlorine gas leaks.

Section 4.2 - Calculations

4.2.1 Explain how to calculate theoretical hydraulic detention time in rectangular and circular sedimentation basins and reservoirs.

4.2.2 Explain how to calculate the backwash flow rate.

4.2.3 Explain how to calculate the percent of total water production used for backwashing.

4.2.4 Explain how to calculate chlorine feed rate.

4.2.5 Explain how to calculate filtration rate in gallons per minute (gpm) per square foot.

4.2.6 Explain how to calculate the pounds per gallon of a given solution if the specific gravity is known, or how to calculate the specific gravity if the weight per gallon is known.

4.2.7 Explain the dosage calculations necessary if powdered activated carbon is utilized for odor control.

4.2.8 Calculate the pounds of alum required per day based on desired concentration, a given flow rate, and the percent alum available.

4.2.9 Determine the amount of a concentrated solution required to achieve a diluted concentration in a larger volume.

References and Resources

- Water Treatment Plant Operation: A Field Study Training Program (Volumes 1 & 2)

Kerri, Kenneth D. Water Treatment Plant Operation: A Field Study Training Program. Volume I & II. 6th ed, 5th ed. Vol. 1, 2. Sacramento: California State U, Sacramento, 2008, 2006. Print.

Drinking Water Courses or available through inter-library loan at the Wisconsin Water Library

- WI Administrative Codes NR 809, NR 810 And NR 811

Wisconsin Legislative Reference Bureau Phone (608) 266-0341

Chapter NR 809: Safe drinking water
Chapter NR 810: Requirements for the operation and maintenance of public water systems
Chapter NR 811: Requirements for the operation and design of community water systems

- Safe Drinking Water Act

US EPA. EPA 816-F-04-030, (June 2004).

- Surface Water Treatment Rules

US EPA, 1989-2006. The Surface Water Treatment Rule was originally published in 1989 and has been modified several times since then.

Interim Enhanced Surface Water Treatment Rule (1998)

Long Term 1 Enhanced Surface Water Treatment Rule (2002)

Long Term 2 Enhanced Surface Water Treatment Rule (2006)

- Compliance Help for Surface Water Treatment Rules

Surface Water Treatment Rules: What do they mean to you? (October 2011)

Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources (March 1991) Both documents are linked in the "Guidance" section Complying with the Long Term 2 Enhanced Surface Water Treatment Rule: Small Entity Compliance Guide (April 2009) -- linked from the "Compliance Help" web site

- Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rules (December 1998 and January 2001)

Complying with the Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rule:

Basic Guide (March 2006)

- Water Treatment Operator Training Handbook

3rd edition, 2013: Nicholas G. Pizzi and William C. Lauer. Publisher: AWWA American Water Works Association or available through inter-library loan at Wisconsin Water Library

- Cross Connection Control Manual

US EPA. EPA 816-R-03-002, (February 2003).

- Water Quality and Treatment: A Handbook on Drinking Water

Edzwald, James K. Water Quality & Treatment: A Handbook on Drinking Water. 6th ed. New York: McGraw-Hill, 2011. Print.

Available from American Water Works Association

- Surface Water Treatment: The New Rules

von Huben, Harry. Surface Water Treatment: The New Rules. AWWA no. 20249 (1991). This is a good basic reference, although dated. It may be available through some libraries or used book dealers.

- Water Distribution System Monitoring: A Practical Approach for Evaluating Drinking Water Quality

Cantor, Abigail E. 2009. CRC Press, Boca Raton. 203 pp.

- Revised Guidance Manual for Selecting Lead and Copper Control Strategies (March 2003)

US EPA, EPA 816-R-03-001

Available from the Compliance Help section of EPA's web site on the Lead and Copper Rule

- Water Distribution System Monitoring: A Practical Approach for Evaluating Drinking Water Quality

Cantor, Abigail E. 2009. CRC Press, Boca Raton. 203 pp.

- Standard Methods for the Examination of Water & Wastewater

22nd Edition (2012). Joint Publication of: American Public Health Association, American Water Works Association, and Water Environment Federation

(Old WPCF). Publication Office: American Public Health Association, 1015 Fifteenth

Street NW, Washington, DC 20005.

Standard Methods or available through most libraries

- Basic Management Principles for Small Water Systems

AWWA No. 20222 (1982). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone: (303) 794-7711. Available from American Water Works Association

- Distribution System Maintenance Techniques

AWWA No. 20237 (1987). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone: (303) 794-7711. Available from American Water Works Association

- Leaks In Water Distribution Systems

AWWA No. 20236 (1987). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone: 303-794-7711. Available from American Water Works Association

- Maintaining Distribution-System Water Quality

AWWA No. 20231 (1985). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone: (303) 794-7711. Available from American Water Works Association

- Maintenance Management for Water Utilities

3rd Edition (2010). James K. Jordan. American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone: (303) 794-7711. Available from American Water Works Association

- Plain Talk About Drinking Water

5th Edition (2010/2009) James M. Symons. American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone: (303) 794-7711. Available from American Water Works Association

- Public Information - How to Build a Successful Public Information/Public Relations Program

AWWA No. 20242 (1989). American Water Works Association, Member Service Department. 6666 W. Quincy Avenue, Denver, CO 80235. Phone: (303) 794-7711. Available from American Water Works Association