Wisconsin Department of Natural Resources
Municipal Waterworks Operator Certification

Lime Softening Study Guide

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Subclass L

Wisconsin Department of Natural Resources
Bureau of Science Services
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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 2013 update: Key knowledge 2.2.5 was added.

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 http://dnr.wi.gov, keyword search "operator certification". It can also be found in the annual DNR "Certified Operator" or by contacting your DNR regional operator certification coordinator.

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Chapter 1 - Principle, Structure, and Function

Section 1.1 - Principle of Lime Softening

1.1.1 Describe the lime softening process.

1.1.2 Define the term "water hardness".

1.1.3 List the problems associated with hard water.

1.1.4 Identify two principle elements (cations) which cause hard water.

1.1.5 Identify additional elements which contribute to water hardness other than calcium and magnesium.

1.1.6 Explain how elements find their way into groundwater.

1.1.7 Differentiate between carbonate and non-carbonate hardness.

Section 1.2 - Structure and Function

1.2.1 Sketch a drawing of a typical lime softening facility, identifying processes and points of chemical addition in the appropriate order for each of the following:
1. Straight lime
2. Split-lime
3. Lime-soda ash split
4. Lime-soda ash
5. Solids contract unit

1.2.2 Differentiate between gravimetric and volumetric dry feeders.

1.2.3 Describe the operation of a positive displacement pump.

1.2.4 Sketch a drawing of a cross-section of a filter, label weirs, troughs, surface wash, media, underdrains, and gravel.

1.2.5 Sketch a drawing of a filter showing valves; indicate which valve would be open or closed during filtering and backwashing.

Chapter 2 - Operation and Maintenance

Section 2.1 - Operation

2.1.1 Define the following terms:

A. Raw eater
B. Slaker
C. Flocculation
D. Coagulation
E. Colloid
F. Sedimentation
G. Sludge blanket
H. Clarifier
I. Turbidity
J. Recarbonation
K. Finished water
L. Sludge
M. Stabilization index.

2.1.2 Cite advantages and disadvantages of using lime softening to control water hardness.

2.1.3 Cite advantages and disadvantages of using lime softening for iron and manganese removal.

2.1.4 Differentiate between the terms "feeding" and "mixing" and their relation to coagulation.

2.1.5 Differentiate between split lime treatment and excess lime treatment.

2.1.6 Describe the solids contact process.

2.1.7 State whether each of the following will increase, decrease, or stay the same as a result of lime softening:

1. Calcium concentration
2. Alkalinity values
3. Magnesium concentrations
4. Total solids values
5. Hardness
6. Iron concentrations
7. Manganese concentrations
8. Bacteria levels
9. Turbidity
10. Sulfate values
11. Sodium values
12. Fluoride levels
13. Chloride values

2.1.8 State the purpose of each of the following chemicals:

1. Lime
2. Alum
3. Soda ash
4. Polymers
5. Carbon dioxide

2.1.9 Differentiate between quicklime and hydrated lime.

2.1.10 Differentiate between a primary coagulant and a coagulant aid.

2.1.11 Differentiate between anionic and cationic polymers.

2.1.12 Describe how polymer charge can affect coagulation.

2.1.13 Identify and describe situations where coagulant aids can help improve coagulation and flocculation.

2.1.14 Describe how the following situations affect coagulation.
A. Temperature
B. pH
C. Concentration of dissolved solids
D. Concentration of suspended solids
E. Mixing conditions
F. Concentration of coagulant

2.1.15 Identify factors affecting particle settling.

2.1.16 Describe the materials that can be used for filter media.

2.1.17 Explain the advantage multi-media filters have over sand filters.

2.1.18 Identify suitable rates in GPM/ft^2 for filtering and backwashing.

2.1.19 Describe the backwashing procedure.

2.1.20 Explain the benefits of expanding the bed during backwashing.

2.1.21 Identify the critical factors which must be considered in order to determine the duration of a backwash cycle.

Section 2.2 - Maintenance

2.2.1 Identify means to adjust chemical feed rates for the following:
A. Gravimetric feeder
B. Volumetric feeder
C. Positive displacement pump

2.2.2 Describe the limiting factors which govern the rate of flow in a filter.

2.2.3 Identify means to prevent lime deposits on filter media.

2.2.4 Describe how to determine when to backwash a filter.

2.2.5 Describe the types of gravity filters and the design of media for these filters.

Chapter 3 - Monitoring and Troubleshooting

Section 3.1 - Monitoring

3.1.1 Identify the optimum pH for the precipitation of:
A. Calcium hardness
B. Magnesium hardness

3.1.2 Identify suitable ranges after treatment for each of the following:
A. pH
B. Alkalinity
C. Hardness
D. Turbidity

3.1.3 Discuss various methods used to determine stability of water, including the Langelier Index method. How might a calcium carbonate solubility curve (pH vs. alkalinity) be used to determine the corrosive or depositing properties of a particular water?

3.1.4 Discuss laboratory tests used for process control in a lime softening facility.

3.1.5 State how often the tests listed above should be run.

3.1.6 Describe a jar test and list applications for use.

3.1.7 Define the following terms:
A. End point
B. Phenolphthalein
C. P-alkalinity
D. M-alkalinity
E. Acidic
F. Basic
G. NTU

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

3.1.9 Given approximate pH values, identify suitable buffers for use in calibrating a pH meter.

3.1.10 Identify the titrant in each of the following tests:
A. Hardness
B. Alkalinity

3.1.11 Cite advantages and disadvantages of liquid and powder indicators used in the EDTA hardness test.

3.1.12 Describe the color changes at the endpoints of P- and M-alkalinity tests.

3.1.13 Identify the pH values for the P-alkalinity and M-alkalinity endpoints.

3.1.14 Determine carbon dioxide values given a pH versus alkalinity graph.

Section 3.2 - Troubleshooting

3.2.1 Given the following problems, pinpoint a cause and corrective action:
- A. Floc going over weirs
- B. Corrosive water
- C. High turbidity
- D. Air binding
- E. Media loss
- F. Media cracks

3.2.2 List suitable means of sludge disposal.

Chapter 4 - Safety and Calculations

Section 4.1 - Safety

4.1.1 Identify and describe protective measures used to store, transport and deliver alum and ferric chloride.

Section 4.2 - Calculations

4.2.1 Given necessary data, calculate:
1. Rate of flow through a filter
2. Filter backwash rate
3. Percent of total water used for backwashing

4.2.2 Give the necessary data formulas, calculate:
1. Lime dosage to remove carbonate hardness
2. Soda ash dosage to remove non-carbonate hardness
3. Polymer dosage in lbs/mg/L

4.2.3 Given pounds of lime used, gallons of water treated, and raw and finished water hardness, calculate parts per million hardness removed per pound of lime.

4.2.4 Given the formula and laboratory data, calculate the hardness in ppm.

4.2.5 Given the formula and laboratory data, calculate the alkalinity in ppm.

4.2.6 Given P- and M-alkalinity values, use a table of alkalinity relationships to determine bicarbonate, carbonate, and caustic alkalinity concentrations.

4.2.7 Given total and P-alkalinity data for either settled water or tap water, determine what corrective action, if any, should be taken.

References and Resources

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http://www.owp.csus.edu/

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2nd Edition (1989). Volumes 1 and 2. Kenneth D. Kerri. California State University, 6000 J Street, Sacramento, CA 95819-6025. Phone (916) 278-6142.

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Wisconsin Legislative Reference Bureau, One E Main St, Suite 200, Madison, WI 53701-2037 Reference Desk: 608-266-0341.

http://docs.legis.wisconsin.gov/code/admin_code/nr/800/809

5. WISCONSIN ADMINISTRATIVE CODE NR 811 REQUIREMENT FOR THE OPERATION AND DESIGN OF COMMUNITY WATER SYSTEMS.

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13. SAFE DRINKING WATER ACT SERIES:

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VOC'S AND UNREGULATED CONTAMINANTS. AWWA No. 70058 (1990).
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15. TREATMENT TECHNIQUES FOR CONTROLLING TRIHALOMETHANE IN DRINKING WATER.

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