Principles and Practices of Water Supply Operations

Water Transmission and Distribution



Student Workbook

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Water Transmission and Distribution Student Workbook
Principles and Practices of Water Supply Operations Series

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Foreword

This workbook is designed for use with the text *Water Transmission and Distribution* in the series *Principles and Practices of Water Supply Operations*, fourth edition. This edition provides detailed information on the technology and information of commonly used practices for potable water treatment.

Other volumes in the series are

- *Water Sources*
- *Water Treatment*
- *Water Quality*
- *Basic Science Concepts and Applications*

The workbook provides assignments, review questions, and a convenient method for keeping organized notes of important points as the text is reviewed. It is designed for use in either classroom or independent study.

Basic Science Concepts and Applications is a reference handbook that is a companion to all the other text books. It contains basic reviews of mathematics, hydraulics, chemistry, and electricity fundamental to water utility operation, as well as explanations and examples of many specific water system operating problems.

A special thanks to Nancy McTigue for the revision of this workbook.

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Acknowledgments

The student workbooks have been added to the WSO series in conjunction with the fourth edition updating of the WSO texts. The author of this Student Workbook is Nancy McTigue. Special thanks to Larry Mays, author of the revision of the text book, and Bill Lauer, AWWA Senior Technical Manager, for their review of this workbook.

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Introduction: Using Your Student Workbook

This Student Workbook is provided to assist you in studying the basic principles of water distribution systems. If you carefully maintain your own personal workbook with notes and supplemental information, you will likely reference it throughout your water utility career.

FORMAT

This workbook provides the following sections for each chapter of the text:

- *Objectives.* This is a listing of some of the major concepts that you should be able to identify and explain when you have completed study of the chapter. You should preview the list at the beginning of study to assess what will be covered. You should then review it again when you have completed study of the chapter to see if you adequately understand the listed concepts.
- *Reading Assignments.* A list is provided indicating the chapters and sections from *Water Transmission and Distribution* and other texts that should be read in conjunction with the study of the chapter.
- *Other Assignments.* If you are attending a class, this space can be used to make a record of additional reading and study assignments made by the instructor. If you are using this workbook for self-study, you can make notes for future reference on additional sources of information.
- *Class Notes.* Space has been provided for you to keep notes of points you feel are important as you read the text or of points made by the instructor during class discussions.
- *Review Questions.* The review questions are intended to emphasize some of the important concepts in the chapter.
- *Study Problems.* A few problems are provided to be used for additional study.
- *Additional Notes.* Each chapter concludes with an extra page for note taking.

TEXTS AND REFERENCES

It will be necessary for you to have copies of both *Water Transmission and Distribution* and *Basic Science Concepts and Applications* available while studying the subject. You should also have access to the other volumes in the series Principles and Practices of Water Supply Operations because there are some references to them in the reading assignments. If the copies you are using belong to your water utility or someone else, it is best not to mark or highlight in the books. Your notes on important points can instead be made in the workbook.

A list of supplementary sources of information is provided at the end of each chapter in the text. You should try to make use of some of them, particularly if you have a special interest in certain subjects. For example, if you are presently working at a water treatment

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facility, you will probably want to know more about the particular types of treatment or operating problems experienced by your utility.

The supplementary reading list is, of course, current only as of the publication of the text. Many additional handbooks, manuals, and articles are published yearly. If you have a special interest in obtaining the latest information on a subject, you may contact the American Water Works Association (AWWA) and some of the other publishers and information sources for their current publications list. If you have access to a file of back issues of the *Journal AWWA* and *Opflow*, you will find that an index of all articles for the previous year is listed in each December issue. The "Water Library" section of the www.awwa.org website also has a searchable database of Journal of the *American Water Works Association* and *Opflow* articles, conference proceedings and AWWA Standards.

If you are presently working for a water utility, you probably have access to old editions and copies of some texts that are no longer in print. You will find it is helpful to look through these books and read about subjects you are studying, using this workbook. Sometimes, there may be more detail, or subjects may be presented in a different way in another text. You must be aware, though, that water treatment technology and state and federal regulations have changed greatly in recent years, so some information in an older text will no longer be valid.

The principal publications that are frequently referenced and will be particularly useful to have on hand during study of *Water Transmission and Distribution* include:

- *Water Quality and Treatment.* 6th ed. 2010. New York: McGraw-Hill and American Water Works Association (available from AWWA).
- *Manual of Water Utility Operations.* 8th ed. 1988. Austin, Texas: Texas Water Utilities.
- *Manual of Instruction for Water Treatment Plant Operators.* 1975. Albany, N.Y.: New York State Department of Health.
- Back copies of the *Journal AWWA* and *Opflow.*

USE OF THE WORKBOOK

If you are using this workbook in conjunction with class instruction, you are urged to keep a loose-leaf notebook for supplementary sheets distributed by the instructor, filed in the order in which the subjects are studied. When your notes are carefully kept in order, they provide an excellent personal information source for later review and reference.

The review questions are designed to highlight some of the major points of each chapter. You should reread sections covered by the review questions until you can completely answer the questions. The instructor will then review the answers during a class period to make sure everyone understands the subject and has provided the correct answers.

Your instructor usually will also provide supplemental assignments and furnish handout material for each chapter. When the length of class meetings is limited, some chapters will be broken into segments and covered during two or more meetings.

The workbook can also be used for individual study. Notes should be made of important points as the text and references are read, and the review questions should be answered completely to ensure that the full significance of important points is understood.

STATE AND FEDERAL REGULATIONS

Many aspects of water treatment and distribution system operation are now directed and regulated by federal regulations. A review of federal regulations in effect at the time the second edition of this volume was published is provided in *Water Quality* (another volume in this series). But many changes are expected within coming years.

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Although the states are generally required to enact regulations that are as stringent as the federal requirements, they may, at times, vary, be more stringent, or include additional requirements. It is therefore important that you obtain a reference copy of the latest state drinking water regulations for the state in which you are working. Applicable sections of the regulations should then be reviewed in conjunction with your study of each chapter.

QUIZZES AND EXAMINATIONS

If you are attending training classes, the instructor will probably give you a few quizzes during the course. These are important to you in indicating whether you are adequately learning the material being presented; they are also important to the instructor to determine if the material is being properly presented.

If you are studying this subject in preparation for taking a state certification examination, it is particularly important that you become comfortable in taking exams of the type used by the state. If you would like more review and practice in answering questions of the type used on certification exams, it is suggested that you obtain the AWWA publication *Operator Certification Study Guide,* 6th ed., Denver, Colo.: American Water Works Association.

Good Luck in Your Water Utility Career!

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CHAPTER 1

Introduction to Water Distribution Systems

OBJECTIVES

After completing study of this chapter, you should be able to understand:

- the purpose of drinking water distribution systems
- the types of public water systems, categorized by water source
- the components of distribution systems

READING ASSIGNMENTS

1. *Water Transmission and Distribution*: Read chapter 1, Introduction to Water Distribution Systems.
2. State public water supply regulations: Read sections relating to required state approval of plans and specifications for water distribution system construction.

OTHER ASSIGNMENTS

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CLASS NOTES

1. System purpose:

2. Types of systems:

3. System planning issues:

4. Supply and distribution system components:

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REVIEW QUESTIONS

1. What are two purposes of drinking water distribution systems?

2. What is a "well field" and why is it sometimes installed?

3. Why are increasing numbers of public water systems purchasing their water from another utility?

4. What special features are typically included in a purchased water source system?

5. What is a rural water system?

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6. How do local conditions affect the design of distribution systems? Name two of these local considerations:

7. What kind of local policy decisions could affect new system development or expansion?

8. Name six functional components of a conventional water supply system :

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9. Name three components of a distribution system:

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STUDY PROBLEMS

1. You work for a public water system that uses surface water as a source. A housing development near your distribution system would like you to extend your distribution system to accommodate the houses in the development. Currently, the houses use a communal well for their water supply. The home owners have asked if their distribution system can be directly connected to your public water system. For your manager, put together a list of issues that would need to be resolved before the decision could be made.

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ADDITIONAL NOTES

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CHAPTER 2

Pipe Systems and Piping

OBJECTIVES

After completing study of this chapter, you should be able to understand:

- the common configurations used in distribution system design
- the principal considerations involved in sizing water mains
- considerations that must be made when piping materials are selected
- the purpose of AWWA and ANSI/NSF standards
- the four general types of piping used in water systems
- general characteristics of commonly used pipe materials
- principal advantages and disadvantages of each type of pipe
- types of joints and fittings primarily used with each type of pipe

READING ASSIGNMENTS

1. *Water Transmission and Distribution*:
   - Read chapter 2, Pipe Systems and Piping.
   - Read appendix A, Specifications and Approval of Treatment Chemicals and System Components.
2. State public water supply regulations: Read sections relating to required state approval of plans and specifications for water distribution system construction.

OTHER ASSIGNMENTS

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CLASS NOTES

1. System planning:

2. System layout:

3. Sizing mains:

4. Fire flow requirements:

5. Material selection:

6. Pipe uses:

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7. Gray cast-iron pipe:

8. Ductile-iron pipe:

9. Steel pipe:

10. Asbestos–cement pipe:

11. PVC and other plastic pipe:

12. Concrete pipe:

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REVIEW QUESTIONS

1. What type of distribution system configuration is not recommended? Why?

2. Explain what determines the selection of main sizes.

3. What is the minimum main size recommended by the fire insurance underwriters?

4. What is a network analysis?

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5. What do AWWA standards define? What materials are covered by ANSI/NSF 61?

6. Explain what is meant by the *C* value of a pipe.

7. List seven unusual pipe installation conditions that might have a bearing on the type of pipe used for a particular installation.

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8. What are transmission lines?

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9. Identify five types of piping material commonly installed today in water distribution systems.

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10. List some advantages and disadvantages of ductile-iron pipe.

11. List six common types of joints used with ductile-iron pipe, and describe the conditions under which each may be used.

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12. List some advantages and disadvantages of PVC pipe.

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STUDY PROBLEMS

1. Suppose your utility serves a population of 10,000 people. To meet increased demand in a new service area, a main extension program is being considered. The soil in the area ranges from hardpan to cobbles. Prepare statements supporting your recommendations for

   - the selection of the best type of pipe to use
   - the minimum size of main that should be installed

2. The present water source for your community (population 50,000) is no longer adequate. You are considering running a main to a point 5 mi (8 km) away where a new well field can be established. Assume this main would not have to go through any other communities. Contact contractors in your area for the approximate cost per foot of installing a main for various types of pipe, assuming soil and terrain conditions for your part of the country. Prepare a brief report of the considerations that must be made and your recommendations for the pipeline.

3. Contact distribution system operators at several public water systems in the area and determine the following information:

   - If there are old water mains in the system:

     —How old are the oldest mains?

     —What type of pipe is it?

     —What problems have there been with the pipes?

   - For mains installed in recent years:

     —What type of pipe is presently being installed?

     —If the type is different than the old pipe, why was a change made?

     —If a different type of pipe is now being used, what have the advantages and disadvantages been?

   From this information, compile some conclusions for your area on the following:

   - the effect of local water quality and weather conditions on the selection of pipe materials
   - the changes being made by water systems in the type of pipe that is being used
   - reasons the water systems are changing or not changing the type of pipe being used

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CHAPTER 3

Water Storage

OBJECTIVES

After completing study of this chapter, you should be able to understand:

- the principal reasons for storing water in the distribution system
- the difference between operating storage and emergency storage requirements
- common construction features and accessory devices for water storage tanks
- key factors that must be considered to select the proper size and location for a water reservoir
- important points in the operation and maintenance of water storage facilities

READING ASSIGNMENTS

1. *Water Transmission and Distribution*: Read chapter 3, Water Storage.
2. State drinking water regulations: Read sections relating to requirements for the type and amount of storage that must be provided.

OTHER ASSIGNMENTS

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CLASS NOTES

1. Water storage requirements:

2. Types of treated-water storage facilities:

3. Locations of distribution storage systems:

4. Water storage facility equipment:

5. Operation and maintenance of water storage facilities:

6. Water storage facility safety:

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REVIEW QUESTIONS

1. Identify nine reasons for providing water storage within a distribution system.

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2. What is the difference between operating storage and emergency storage?

3. What are the advantages and disadvantages of elevated tanks, standpipes, and ground-level tanks?

4. Describe the operation and intended application of hydropneumatic storage.

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5. Materials of construction used for drinking water reservoirs must be in compliance with which standards?

6. What is the benefit of having many smaller storage tanks in a distribution system instead of one large tank?

7. List three types of piping found in every water tank.

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8. After disinfection, what must be done before a water storage tank can be placed back in service?

9. List five safety precautions that must be observed during work inside storage tanks.

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STUDY PROBLEMS

1. Obtain a map of a local community and locate all water storage facilities on it. Prepare a report discussing the advantages and disadvantages of each of the locations regarding elevation, position in relation to population centers and sources of supply, hydraulics, and acceptability to the public.
2. Prepare a report discussing cold-weather problems that can be experienced with elevated storage tanks, as well as what should be done to minimize the problems.

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CHAPTER 4

Pumping Stations and Pumps

OBJECTIVES

After completing study of this chapter, you should be able to understand:

- the operating principles of common types of velocity and positive-displacement pumps
- general operating procedure for centrifugal pumps and the reasons for these procedures
- the regular preventive maintenance procedures required for centrifugal pumps
- the purpose and function of the principal parts of centrifugal pumps

READING ASSIGNMENTS

1. *Water Transmission and Distribution*: Read chapter 4, Pumping Stations and Pumps.

OTHER ASSIGNMENTS

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CLASS NOTES

1. Types of pump stations:

2. Pump curves for pump stations:

3. Types of pumps:

4. Operation of centrifugal pumps:

5. Centrifugal pump maintenance:

6. Record keeping:

7. Pump safety:

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REVIEW QUESTIONS

1. What is the purpose of a booster pump station?

2. What two types of piping are found in a pump station?

3. What is the purpose of surge (pressure) relief valves in the discharge piping of a pump station?

4. What are the two basic categories of pumps used in water supply operations? What are the principal water supply uses of each type?

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5. What is the basic operating principle of a velocity pump?

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6. Identify one unique safety feature that velocity pumps have over positive-displacement pumps.

7. What is a multistage centrifugal pump? What effect does the design have on discharge pressure and flow volume?

8. What are the two pump and motor arrangements commonly used for vertical turbine well pumps?

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9. What type of vertical turbine pump is commonly used as an in-line booster pump?

10. Describe the two main parts of a jet pump.

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11. What is the purpose of a foot valve installed on the suction pipe to a centrifugal pump?

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12. What is the function of the wear rings in the centrifugal pumps of the closed-impeller design? What is the function of lantern rings?

13. Describe the two common types of seals used to control leakage between the pump shaft and the casing.

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14. What are the four steps that should be followed in greasing pump bearings?

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STUDY PROBLEMS

1. Outline the basic steps that should be considered during installation of a vertical turbine pump that will pump from a wet well.
2. Visit the pump house at a local water system and record information on two or three different makes or models of pumps that are in use. If possible, obtain a copy of the manufacturer's pump curve for each pump.

   Obtain the following information for each unit:

   - pump data: design type, name of manufacturer, model number, date of installation, types of bearings, types of seals, and so on
   - driving motor horsepower rating
   - installation: inlet and outlet piping sizes, types of valves and valve operators, increases in pipe sizes near the unit, and so on
   - observations: suction and outlet pressures during operation, amount of water leaking from the gland, pump noise, relative bearing temperature (i.e., hot or cool), noticeable vibration, and so on

   From the collected data, prepare a brief report on each pump unit.

   - Refer to the pump curve. At what theoretical efficiency is the pump operating?
   - Does the pump appear to need repair or replacement?
   - Does the water system maintain good records of its equipment and of the maintenance and repair work performed?

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