

# Water and Wastewater Conveyance

**Pumping, Hydraulics,  
Piping, and Valves**



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Piping, and Valves**

**Frank R. Spellman**



**CRC Press**

Taylor & Francis Group

Boca Raton London New York

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CRC Press is an imprint of the  
Taylor & Francis Group, an **informa** business

CRC Press  
Taylor & Francis Group  
6000 Broken Sound Parkway NW, Suite 300  
Boca Raton, FL 33487-2742

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CRC Press is an imprint of Taylor & Francis Group, an Informa business

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Printed by CPI on sustainably sourced paper  
Version Date: 20160411

International Standard Book Number-13: 978-1-4987-7172-6 (Hardback)

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#### Library of Congress Cataloging-in-Publication Data

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Names: Spellman, Frank R., author.  
Title: Water and wastewater conveyance : pumping, hydraulics, piping, and valves / author, Frank R. Spellman.  
Other titles: Water and wastewater conveyance  
Description: Boca Raton : Taylor & Francis, CRC Press, 2016. | Includes bibliographical references and index.  
Identifiers: LCCN 2016002529 | ISBN 9781498771726 (alk. paper)  
Subjects: LCSH: Waterworks. | Hydraulics. | Pumping machinery.  
Classification: LCC TD485 .S6635 2016 | DDC 628.1--dc23  
LC record available at <https://lccn.loc.gov/2016002529>

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# Preface

Designing pumping and conveying equipment and systems is a science; maintaining and operating them can be considered an art. This is not a pump design book; it discusses limited conveyance engineering aspects, but it is not an engineering text. This book does not focus on the higher mathematics and science involved with pump design and pump engineering. This book focuses on the components related to the conveyance of water and wastewater; moreover, it discusses the art of operating and maintaining pumping and ancillary equipment. Thus, this book is for pump, pipe, and valve operators and maintenance personnel. Again, specifically, this book deals with the conveyance of water and wastewater. Anyone who has worked in various water utilities, including water or wastewater facilities, knows that piping and valves are the major conduits and critical controls, respectively, that enable the proper collection, treatment, and distribution of water and the proper treatment and discharging (outfalling) of wastewater.

The intent of *Water and Wastewater Conveyance: Pumping, Hydraulics, Piping, and Valves* is to provide fundamental, basic information on the means of conveying water and wastewater. The material presented in this text provides the information necessary for water or wastewater operators to develop a better understanding of pump operation fundamentals, applications, and maintenance procedures, as well as proper preventative maintenance and troubleshooting procedures.

Nearly everyone in the water or wastewater treatment industry can tell you flat out that times are changing. Some of the changes are dramatic—privatization, for example. Other changes are more subtle and affect plant maintenance activities in less profound but still important ways. Consider just one small example of these recent changes. In the past, plant electric motor controllers contained many electro-mechanical control devices. Today, these antiquated devices have been replaced by more compact and efficient microelectronic solid-state devices that reduce electrical maintenance requirements. Some changes are more apparent; for example, many treatment plants have replaced routine operator sampling functions (including the operators, in some cases) with automatic samplers. Moreover, the computer-assisted or managed process operations now being employed are managed and monitored by supervisory control and data acquisition (SCADA) systems. The management information age has had a dramatic impact on the industry, and continues to do so. Think about it. Turning a valve on some plant unit process used to be done manually, but today many of these same valves are operated by electromechanical valve operators—either automatically by electronically sensing various parameters or through initiation of the correct computer-initiated and -controlled operation.

Change is both inevitable and ongoing; however, in water and wastewater work, I see one fundamental tool that I predict will stay the same. The heart that creates the pulse (literally) of both water and wastewater operations remains the simple hydraulic machine—that is, the pump. Because the hydraulic pump is so perfectly suited to the tasks it performs, and because the principles that make the pump work are so profoundly fundamental, the idea that any new device could ever replace the

pump is almost incomprehensible and difficult to imagine. The hydraulic pump is the workhorse of water and wastewater operations and is unlikely to be replaced any time soon or in the foreseeable future.

But, one observation I have made in facility after facility puzzles me. If the pump, the hydraulic heart of water and wastewater treatment, is so basic and so widely accepted throughout the industry, why is this critical machine so frequently and blatantly ignored, abused, or disregarded—until it breaks down? When the heart in the human body malfunctions, the entire body is affected, and this is true for pumps in any critical application. When they fail, they can affect the entire water and wastewater process.

You might be thinking, “Not in my facility! Everyone there fully understands the importance of pumps in the day-in, day-out operation of our water/wastewater treatment operations. So what is your point?” The answer goes to the heart (you might say) of my supposition that this text is badly needed to ensure proper operations in water and wastewater treatment. Based on my experience and observations, many treatment facilities are unable to meet their water treatment or distribution requirements or wastewater effluent limits for one of three reasons:

1. Untrained operation and maintenance staff
2. Poor plant maintenance
3. Improper plant design

This text is designed to address the first two of these three problems. It provides plant operators and maintenance operators, utility managers, and general readers with a basic knowledge of the principles of operation of each type of centrifugal and positive displacement pump commonly associated with water and wastewater treatment, along with an introduction to water hydraulics, piping systems, and their ancillaries, such as valves. It also addresses the maintenance requirements of each, common operational problems, appropriate corrective actions, and specific maintenance procedures, such as, for example, packing and changing a mechanical seal on a pump.

This text is not meant to replace the hands-on experience and training required by those intending to perform maintenance on centrifugal and positive displacement pumps. However, applying the information presented in this text, combined with in-plant experience in basic pump, piping, and valve maintenance procedures, should achieve the desired result: better performance through maintenance of plant flexibility and a reduction in unscheduled shutdowns of critical plant pumping and conveying devices.

The technology associated with pumping and conveying water and wastewater is easier to learn than most might think. The subject matter in this text is presented in plain English, with as little emphasis on technical jargon as possible; avoidance of technical mumbo jumbo is the rule. Consistent with modern practices and design, illustrative problems involving commonly used pumping, conveying, and hydraulic terms and parameters (e.g., head, capacity, work power) are presented. These example problems cover typical pumping types and ancillary equipment found in today's water and wastewater systems, no matter the size of the plant.

Each chapter ends with a chapter review quiz to help readers evaluate their mastery of the concepts presented. Before going on to the next chapter, take the chapter review quiz, compare your answers to the key, and review the pertinent information for any problems you missed. If you miss many items, review the entire chapter. The final chapter presents a comprehensive practice examination for water and wastewater operators who may be preparing for state licensure examinations. Many of the questions included in the practice examination are the types of questions typically presented in licensure exams.

This text is accessible to those who have no experience with pumping systems; however, an understanding of basic mathematical principles is a plus. If you work through the text systematically, you will be surprised at how easily you acquire an understanding of the basics of pumping systems. The book includes numerous illustrations, as well as definitions of key terms for easy comprehension of the concepts and processes and for quick reference. The reader is also advised that this book is presented in the author's typical conversational style, format, and tone. As with all of my other technical works to date, I simplify content because my intent is to ensure that there is no failure to communicate with the reader. Failure to communicate with anyone is not an option.





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# Author



**Frank R. Spellman, PhD**, is a retired adjunct assistant professor of environmental health at Old Dominion University, Norfolk, Virginia, and the author of more than 100 books covering topics ranging from concentrated animal feeding operations (CAFOs) to all areas of environmental science and occupational health. Many of his texts are readily available online, and several have been adopted for classroom use at

major universities throughout the United States, Canada, Europe, and Russia; two have been translated into Spanish for South American markets. Dr. Spellman has been cited in more than 850 publications. He serves as a professional expert witness for three law groups and as an incident/accident investigator for the U.S. Department of Justice and a northern Virginia law firm. In addition, he consults on homeland security vulnerability assessments for critical infrastructures, including water/wastewater facilities, and conducts pre-Occupational Safety and Health Administration and Environmental Protection Agency audits throughout the country. Dr. Spellman receives frequent requests to co-author with well-recognized experts in several scientific fields; for example, he is a contributing author to the prestigious text *The Engineering Handbook*, 2nd ed. Dr. Spellman lectures on wastewater treatment, water treatment, and homeland security, as well as on safety topics, throughout the country and teaches water/wastewater operator short courses at Virginia Tech in Blacksburg. In 2011, he traced and documented the ancient water distribution system at Machu Picchu, Peru, and surveyed several drinking water resources in Amazonia, Ecuador. He has also studied and surveyed two separate potable water supplies in the Galapagos Islands, in addition to studying Darwin's finches while there. Dr. Spellman earned a BA in public administration, a BS in business management, an MBA, and both an MS and a PhD in environmental engineering.



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# Contents

|              |      |
|--------------|------|
| Preface..... | xvii |
| Author ..... | xxi  |

## **SECTION I    *Water and Wastewater Sources and Characteristics***

|                      |   |        |
|----------------------|---|--------|
| <b>Chapter 1</b>     | Potable Water Sources.....                                    | 3      |
|                      | Comparative Conveyance.....                                   | 3      |
|                      | Introduction.....   | 4      |
|                      | Key Terms and Definitions.....                                | 4      |
|                      | Hydrologic Cycle.....   | 6      |
|                      | Sources of Water .....  | 7      |
|                      | Surface Water .....   | 8      |
|                      | Advantages and Disadvantages of Surface Water .....           | 8      |
|                      | Surface Water Hydrology .....                                 | 8      |
|                      | Raw Water Storage .....                                       | 10     |
|                      | Surface Water Intakes.....                                    | 10     |
|                      | Surface Water Screens.....                                    | 11     |
|                      | Surface Water Quality .....                                   | 11     |
|                      | Groundwater.....  | 11     |
|                      | Groundwater Quality.....                                      | 13     |
|                      | Groundwater under the Direct Influence of Surface Water ..... | 14     |
|                      | Surface Water Quality and Treatment Requirements .....        | 14     |
|                      | Public Water System Quality Requirements .....                | 15     |
|                      | Chapter Review Questions .....                                | 15     |
|                      | References and Recommended Reading.....                       | 16     |
| <br><b>Chapter 2</b> | <br>Wastewater Sources and Characteristics.....               | <br>17 |
|                      | Wastewater Sources.....                                       | 18     |
|                      | Generation of Wastewater.....                                 | 18     |
|                      | Classification of Wastewater.....                             | 18     |
|                      | Wastewater Characteristics .....                              | 19     |
|                      | Physical Characteristics.....                                 | 19     |
|                      | Chemical Characteristics.....                                 | 20     |
|                      | Biological Characteristics and Processes .....                | 21     |
|                      | Wastewater Collection Systems.....                            | 22     |
|                      | Gravity Collection System.....                                | 22     |
|                      | Force Main Collection System .....                            | 22     |

|   |    |
|---|----|
| Vacuum System .....                         | 23 |
| Pumping Stations.....                       | 23 |
| Pumping Station Wet Well Calculations ..... | 24 |
| Chapter Review Questions .....              | 25 |

## **SECTION II *Pumping***

|                  |   |    |
|------------------|---|----|
| <b>Chapter 3</b> | Pumping: Setting the Stage .....                        | 29 |
|                  | Introduction .....                                      | 29 |
|                  | Archimedes' Screw .....                                 | 29 |
|                  | Thought-Provoking Question .....                        | 32 |
|                  | References and Recommended Reading .....                | 32 |
| <b>Chapter 4</b> | Basic Pumping Definitions and Calculations .....        | 33 |
|                  | Introduction .....                                      | 33 |
|                  | Definitions and Key Terms .....                         | 33 |
|                  | Basic Pumping Hydraulics .....                          | 39 |
|                  | Weight of Air .....                                     | 39 |
|                  | Weight of Water .....                                   | 39 |
|                  | Weight of Water Related to the Weight of Air .....      | 40 |
|                  | Water at Rest .....                                     | 40 |
|                  | Gauge Pressure .....                                    | 41 |
|                  | Water in Motion .....                                   | 41 |
|                  | Pipe Friction .....                                     | 44 |
|                  | Basic Pumping Calculations .....                        | 45 |
|                  | Pumping Rates .....                                     | 45 |
|                  | Calculating Head Loss .....                             | 46 |
|                  | Calculating Head .....                                  | 46 |
|                  | Calculating Horsepower and Efficiency .....             | 47 |
|                  | Pump Performance Curves .....                           | 51 |
|                  | Head–Capacity Curve .....                               | 52 |
|                  | Power–Capacity Curve .....                              | 52 |
|                  | Efficiency–Capacity Curve .....                         | 53 |
|                  | Pumps in Series and Parallel .....                      | 53 |
|                  | Considerations for Pumping Wastewater .....             | 54 |
|                  | Types of Pumps Used in Water/Wastewater Treatment ..... | 55 |
|                  | Chapter Review Questions .....                          | 58 |
|                  | References and Recommended Reading .....                | 59 |
| <b>Chapter 5</b> | Centrifugal Pumps .....                                 | 61 |
|                  | Introduction .....                                      | 61 |
|                  | Key Terms and Definitions .....                         | 61 |
|                  | Centrifugal Pump Description .....                      | 63 |

|   |        |
|---|--------|
| Theory .....  | 64     |
| Types of Centrifugal Pumps.....                                   | 65     |
| Radial-Flow Impeller Pumps .....                                  | 66     |
| Mixed-Flow Impeller Pumps .....                                   | 67     |
| Axial-Flow Impeller Pumps (Propeller Pumps).....                  | 67     |
| Centrifugal Pump Characteristics .....                            | 68     |
| Advantages and Disadvantages .....                                | 69     |
| Water/Wastewater Applications .....                               | 72     |
| Chapter Review Questions .....                                    | 72     |
| References and Recommended Reading .....                          | 74     |
| <br><b>Chapter 6</b> Centrifugal Pump Components.....             | <br>75 |
| Introduction .....  | 75     |
| Key Terms and Definitions .....                                   | 75     |
| Casing.....   | 76     |
| Solid Volute Casing .....   | 77     |
| Split Casing Pumps.....   | 77     |
| Impellers.....  | 78     |
| Semi-Open Impellers .....   | 78     |
| Open Impellers .....  | 79     |
| Closed Impellers.....   | 79     |
| Wear Rings .....  | 79     |
| Shafts, Sleeves, and Couplings.....                               | 81     |
| Shafting .....  | 81     |
| Sleeves .....   | 83     |
| Couplings.....  | 83     |
| Stuffing Box and Seals .....                                      | 86     |
| Stuffing Box Packing Assembly.....                                | 86     |
| Mechanical Seals.....   | 89     |
| Bearings.....   | 90     |
| Applications and Types of Pump Bearings .....                     | 91     |
| Bearing Installation, Maintenance, and Lubrication.....           | 95     |
| Chapter Review Questions .....                                    | 95     |
| References and Recommended Reading .....                          | 95     |
| <br><b>Chapter 7</b> Centrifugal Pump Operational Procedures..... | <br>97 |
| Introduction .....  | 97     |
| Key Terms and Definitions.....                                    | 97     |
| Centrifugal Pump Installation.....                                | 98     |
| Installation Procedure .....                                      | 98     |
| Startup .....   | 99     |
| Startup Procedure.....  | 100    |
| Normal Operation .....  | 100    |
| Shutdown.....   | 101    |

|  |     |
|--|-----|
| Priming.....                             | 101 |
| Priming Procedure .....                  | 102 |
| Backflushing .....                       | 103 |
| Backflushing Procedure.....              | 103 |
| Manual Removal Procedure .....           | 104 |
| Chapter Review Questions .....           | 104 |
| References and Recommended Reading ..... | 104 |

## **Chapter 8** Centrifugal Pump Maintenance and Troubleshooting Procedures ..... 105

|  |     |
|--|-----|
| Introduction .....                           | 105 |
| Key Terms and Definitions.....               | 105 |
| Pump and Motor Lubrication .....             | 106 |
| Purpose of Lubrication.....                  | 106 |
| Separates Surfaces.....                      | 106 |
| Prevents Wear.....                           | 107 |
| Cushions Shock .....                         | 107 |
| Transfers Heat.....                          | 107 |
| Protects against Corrosion.....              | 107 |
| Acts as a Seal.....                          | 108 |
| Lubrication Requirements .....               | 108 |
| Lubrication Procedures .....                 | 108 |
| Motor Bearing Lubrication.....               | 109 |
| Oil Lubrication of Pump Bearings .....       | 110 |
| Grease Lubrication of Pump Bearings .....    | 111 |
| Packing and Seal Replacement .....           | 112 |
| Packing Procedure.....                       | 113 |
| Mechanical Seal Installation Procedure.....  | 114 |
| Pump and Motor Bearing Inspection .....      | 114 |
| Shaft and Coupling Alignment .....           | 115 |
| Alignment Procedure .....                    | 115 |
| Removal of Obstructions .....                | 116 |
| Preventive Maintenance .....                 | 117 |
| Daily Maintenance .....                      | 118 |
| Weekly Maintenance .....                     | 118 |
| Monthly Maintenance .....                    | 119 |
| Quarterly Maintenance.....                   | 119 |
| Semiannual Maintenance .....                 | 119 |
| Troubleshooting.....                         | 120 |
| The Troubleshooter.....                      | 120 |
| Troubleshooting: What Is It? .....           | 121 |
| Goals of Troubleshooting .....               | 121 |
| Troubleshooting Process.....                 | 122 |
| Troubleshooting Centrifugal Pumps .....      | 123 |
| Pump Fails to Prime or Loses Its Prime ..... | 125 |
| Pump Does Not Discharge .....                | 126 |

|                   |   |            |
|-------------------|---|------------|
|                   | Pump Does Not Deliver Rated Capacity .....              | 127        |
|                   | Pump Does Not Deliver Sufficient Pressure .....         | 128        |
|                   | Pump Starts and Stops Pumping .....                     | 129        |
|                   | Pump Overloads Driver or Consumes Excessive Power ..... | 130        |
|                   | Pump Is Noisy or Has Extensive Vibration .....          | 131        |
|                   | Packing Has a Short Life .....                          | 132        |
|                   | Stuffing Box Leaks Excessively .....                    | 133        |
|                   | Mechanical Seal Has a Short Life .....                  | 133        |
|                   | Mechanical Seal Leaks Excessively .....                 | 133        |
|                   | Bearings Have a Short Life .....                        | 134        |
|                   | Pump Overheats and/or Seizes .....                      | 134        |
|                   | Chapter Review Questions .....                          | 135        |
|                   | References and Recommended Reading .....                | 136        |
| <b>Chapter 9</b>  | <b>Centrifugal Pump Modifications .....</b>             | <b>137</b> |
|                   | Introduction .....                                      | 137        |
|                   | Key Terms and Definitions .....                         | 137        |
|                   | Submersible Pumps .....                                 | 138        |
|                   | Applications .....                                      | 139        |
|                   | Advantages .....  | 139        |
|                   | Disadvantages .....                                     | 139        |
|                   | Recessed Impeller or Vortex Pumps .....                 | 139        |
|                   | Applications .....                                      | 139        |
|                   | Advantages .....  | 139        |
|                   | Disadvantages .....                                     | 140        |
|                   | Turbine Pumps .....                                     | 140        |
|                   | Application .....                                       | 141        |
|                   | Advantages .....  | 141        |
|                   | Disadvantages .....                                     | 142        |
|                   | Chapter Review Questions .....                          | 142        |
| <b>Chapter 10</b> | <b>Positive Displacement Pumps .....</b>                | <b>143</b> |
|                   | Introduction .....                                      | 143        |
|                   | Key Terms and Definitions .....                         | 143        |
|                   | Reciprocating Pumps .....                               | 144        |
|                   | Diaphragm Pumps .....                                   | 144        |
|                   | Metering Pumps .....                                    | 145        |
|                   | Rotary Pumps .....                                      | 147        |
|                   | Progressive Cavity Pump .....                           | 148        |
|                   | Peristaltic Pumps .....                                 | 148        |
|                   | Chapter Review Questions .....                          | 148        |
|                   | References and Recommended Reading .....                | 149        |



**SECTION III    *Water Hydraulics***

**Chapter 11** Well Systems and Pumps ..... 153

    Well Systems ..... 153

        Well Site Requirements ..... 154

        Types of Wells ..... 154

        Components of a Well ..... 156

    Well Hydraulics ..... 158

        Key Terms and Definitions ..... 158

    Well Evaluation ..... 160

    Well Pumps ..... 161

        Well Pump Water Contamination..... 161

    Routine Operation and Recordkeeping Requirements..... 162

    Well Maintenance..... 163

        Troubleshooting Well Problems ..... 163

    Well Abandonment..... 164

    Chapter Review Questions ..... 165

    References and Recommended Reading ..... 165

  

**Chapter 12** Water Hydraulics: What Is It? ..... 167

    Setting the Stage..... 167

    The Stage Is Set..... 168

        Key Terms and Definitions..... 168

    Basic Concepts ..... 169

        Stevin’s Law..... 171

    Units, Conversion Factors, and Formulas ..... 172

        Commonly Used Conversion Factors  
        (Water/Wastewater Operations)..... 172

        Commonly Used Basic Formulas  
        (Water/Wastewater Operations)..... 174

    Properties of Water..... 177

        Density and Specific Gravity..... 177

    Force and Pressure ..... 179

        Hydrostatic Pressure..... 180

        Effects of Water under Pressure ..... 181

    Head ..... 183

        Static Head..... 184

        Friction Head ..... 184

        Velocity Head ..... 184

        Total Dynamic Head (Total System Head)..... 185

        Pressure and Head ..... 185

        Head and Pressure ..... 185