American Water Works Association

Manual of Water Supply Practices

M46

Third Edition



Nanofiltration and Reverse Osmosis

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Nanofiltration and Reverse Osmosis

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Preface

Nanofiltration (NF) and reverse osmosis (RO) are membrane technologies that can treat various water sources for a wide range of concerns to produce drinking water or high-quality industrial water supplies. These membrane technologies can remove organic and inorganic substances from water and can be adjuncts to such traditional treatment methods as sand filtration, primary disinfection, lime and soda softening, ion exchange, and evaporative processes to improve the reliability and quality of a finished water. NF and RO are both pressure-driven membrane processes with similar process configurations and equipment. The main differences between the processes are primary treatment focused in terms of removal performance (hardness and/or organics removal for NF and demineralization or salt reduction for RO) and the degree of necessary applied pressure (higher for RO). However, the two membrane processes exhibit far more similarities than differences, thus their inclusion in the same manual.

RO was commercialized in the United States in the 1960s and has been used for water desalting applications ever since. Through research and development, NF was shown to be a membrane process with lower operating costs for softening water and removing organic substances (color, disinfection byproduct precursors, and synthetic organics) for waters not requiring demineralization/desalination.

Membrane technology of all types became particularly applicable to drinking water production in the late 1980s when the amendments to the US Environmental Protection Agency's Safe Drinking Water Act (SDWA) required higher-quality drinking water. The amendments were based on the latest research on health effects and the ability to detect contaminants at increasingly lower detection limits using sensitive analytical techniques. Because of their ability to remove or reduce many of the substances regulated by SDWA, membranes play an increasingly important role in enabling water utilities to meet these regulations.

This manual was developed to provide an overview of NF and RO technology for operators, administrators, engineers, scientists, educators, and anyone seeking an introduction to these processes. An introductory chapter, which discusses an overview of NF and RO processes and applications, is followed by chapters discussing NF and RO process design, facility design, residuals management, and operations and maintenance. The information contained in these chapters includes history, regulations, theory, terminology, water resources, pretreatment, process technology, posttreatment, concentrate disposal, and membrane and system components, configuration, maintenance, chemistry, cost, and safety. The final chapters provide case studies of existing NF and RO facilities, as well as market trends that offer insights into the future of NF and RO technology and applications.

As this is the third edition of AWWA Manual M46, *Nanofiltration and Reverse Osmosis*, the Membrane Processes and Research Committee and AWWA welcome comments and suggestions for improving future editions. Please send an email to the Engineering & Technical Services Department at etssupport@awwa.org or in hard copy to 6666 West Quincy Avenue, Denver, CO 80235, attention Water Quality Engineer.

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Chapter 1

Introduction

This manual provides an overview of membrane separation processes using semipermeable nanofiltration (NF) and reverse osmosis (RO). The manual provides general information about the fundamental processes and practical application of NF and RO membranes to separate an aqueous solution with dissolved constituents (e.g., total dissolved solids) into a permeate stream with lower concentrations of dissolved constituents and a residual stream with the concentrated constituents.

The information contained in this manual should be used in conjunction with the most recent instructions provided by the system integrator or manufacturer, membrane element manufacturer, and warranty requirements. The specific instructions and warranty must take precedence to confirm that the operating conditions are compatible with the equipment and element to ensure the membranes are not damaged or the warranty is not voided. In addition, NF/RO is a rapidly changing field; therefore, some of the information in this manual may not be applicable to new products or applications.

The manual is divided into the following seven chapters.

Chapter 1: Introduction. This section describes the fundamental principles of NF and RO membranes and how the membranes are configured in a typical treatment system. A brief history of the technology is provided to explain how the technology has evolved from a specialty treatment process that required high pressure, extensive source water pretreatment, and frequent membrane replacement to the current situation—a mature technology that is reliable and cost effective for production of municipal potable water and a mainstay of industrial treatment systems requiring water with low concentrations of dissolved constituents.

Chapter 2: Process Design. This chapter describes how NF and RO elements are assembled into systems with a few elements to thousands of elements to cost-effectively produce permeate for municipal and industrial use. The chapter describes how source water quality impacts the percentage of permeate that can be recovered and the potential for mineral scaling and fouling of the membranes. Design considerations for pretreatment, pumping, flow control, and posttreatment ancillary system are presented.

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