ANSI/AWWA B114-16
(First Edition)

American Water Works Association

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AWWA Standard

Reverse Osmosis and Nanofiltration Systems for Water Treatment

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Contents

All AWWA standards follow the general format indicated subsequently. Some variations from this format may be found in a particular standard.

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA B114.*

I. Introduction.

I.A. *Background.* The purpose of ANSI/AWWA B114-16 is to provide purchasers with a standard for the purchase and installation of membrane treatment systems using reverse osmosis (RO) and nanofiltration (NF) membranes.

A wealth of information about RO/NF membrane systems and their design is available from various sources, including *Journal AWWA*, *Water Treatment Plant Design*,† *Water Quality and Treatment*,‡ and other references listed in appendix A.

I.B. *History.* RO membranes have been used to purify water since the late 1960s§ and NF since the 1980s. RO and NF technologies have been and continue to be developed, improved, and widely applied in a myriad of water purification applications, including producing potable water from seawater, brackish water, groundwater, and surface water sources. Today, potable water production with RO and NF technology is widely accepted and practiced worldwide.

RO/NF membranes are made from a variety of polymeric and inorganic materials, although polymeric varieties currently predominate. Improvements to existing products and development of new types of RO/NF membrane materials, structures, and surface treatments are ongoing topics of research activities. For comparisons of performance between different membranes to be meaningful, test conditions should be carefully considered, since they can have a marked effect on results. RO/NF membrane separation performance can be described by a variety of measures, including salt rejection or passage, specific solute rejection or passage, and molecular weight cutoff, all within the context of specific test conditions, such as concentration, pH, recovery, pressure, temperature, flux, and flow rate or velocity. Measurement of RO/NF membrane performance including separation and output is not standardized by regulatory agencies. However, some standards groups have published standardized measurement methods and the industry has developed common and accepted approaches. This is one of the purposes of the testing requirements outlined in USEPA's *Membrane Filtration Guidance Manual* (USEPA 2005) associated with the Long Term 2 Enhanced

* American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.
† AWWA and ASCE, *Water Treatment Plant Design*, 5th Ed., McGraw-Hill (2012).
‡ AWWA, *Water Quality and Treatment*, 5th Ed., McGraw-Hill (2011).
§ *Water Desalting Planning Guide for Water Utilities*. John Wiley & Sons Inc. (2004).

Surface Water Treatment Rule (USEPA 2006) and various ASTM standards, including D4194-03, Standard Test Methods for Operating Characteristics for Reverse Osmosis and Nanofiltration Devices; D4472-08, Standard Guide for Recordkeeping for Reverse Osmosis and Nanofiltration Systems; and D4516-00, Standard Practice for Standardizing Reverse Osmosis Performance Data.

Regulatory concerns may or may not be the primary drivers for the use of RO/NF membranes by a municipality, but in all cases the regulations must be assessed for applicability. At present, US federal drinking water standards covering RO/NF membrane treatment deal mainly with how much removal credit can be received from their use as a microbial barrier. Other regulatory requirements may also apply, such as acceptable water contact materials, meeting the primary and secondary contaminant levels in the finished water, frequency of monitoring certain performance parameters, staffing, and isolation during clean-in-place (CIP) (e.g., possible requirements for isolating block and bleed valves).

This standard is intended to aid in the selection and procurement of RO and NF systems and in the regulatory permitting process. This standard should be considered as a list of minimum requirements for planning, procurement, selection, construction, and commissioning of an RO or NF treatment system. However, its proper application requires it be coupled with a thorough professional review of the specific water treatment case and site-specific conditions.

This first edition of this new standard ANSI/AWWA B114-16—Reverse Osmosis and Nanofiltration Systems for Water Treatment, was approved by the AWWA Board of Directors on Jan. 16, 2016. The standard was approved and promulgated in the course of the activities of the AWWA Standards Committee on Membrane Standards.

In 2010, the decision was made by the AWWA Standards Council to partition ANSI/AWWA B110-09—Membrane Systems (first edition) into three standards that cover specific membrane technologies. The AWWA Standards Council then assigned the task of development of three separate standards to the AWWA Standards Committee on Membrane Standards. This standard, ANSI/AWWA B114-16—Reverse Osmosis and Nanofiltration Systems for Water Treatment, is one of the three standards that were developed.

A guide to the AWWA membrane systems standards is presented in the table on the following page.

I.C. *Acceptance.* In May 1985, the US Environmental Protection Agency (USEPA) entered into a cooperative agreement with a consortium led by NSF

Guide to AWWA membrane standards and typical membrane characteristics

Membrane Type	Applicable AWWA Standard	Nominal Pore Size (µm)	≥3-µm Particle or Surrogate Organism Removal	Virus (MS2 Phage) Removal	Typical Molecular Weight Cutoff (daltons)	Salt (NaCl) Rejection (%)*
Microfiltration (MF)	B112-15	0.1 to 0.5	≥99.9% (≥3 log)	< 90% (<1 log)	≥200,000	None
Ultrafiltration (UF)	B112-15	0.005 to 0.1	≥99.9% (≥3 log)	≥ 90% (≥1 log)	10,000 to 200,000	None
Nanofiltration (NF)† and	B114-16	0.001 (approximate conceptual value)	Same as UF	Same as UF	200 to 1,000	0% to 95%
Reverse Osmosis(RO)†	B114-16	0.001 (approximate conceptual value)	Same as UF	Same as UF	150 to 300	>95%
Electrodialysis/ Ion-Exchange Membranes (IEM)	B116-15	Not applicable	Not applicable: demineralized product does not pass through a membrane barrier	Not applicable: demineralized product does not pass through a membrane barrier	Not applicable	>45%
Membrane Bioreactors (MBR)	B130-13	‡	‡	‡	‡	‡

Abbreviations: Less than <; Greater than >; Greater than or equal to ≥; Approximately ~; micron µ

* NF is similar to RO with the key difference being that NF has lower sodium chloride rejection than RO and NF exhibits greater selectivity in the types of ions that are removed, such that NF allows a comparatively higher percentage of monovalent ions to pass to the permeate than multivalent ions.

† For NF and RO, rejection is generally based on test conditions for a single element, but there is some variation between membrane manufacturers and membrane models. In general, test conditions tend to vary as follows: (1) feed solutions: 500 to 700 mg/L sodium chloride, magnesium chloride, calcium chloride, or mixed solute solutions for NF; 1,500 to 2,000 mg/L sodium chloride for brackish water RO membranes; 32,000 to 38,000 mg/L sodium chloride for seawater RO membranes; (2) 25°C temperature or corrected to that temperature; (3) 6 to 8 pH; (4) 8 to 20 percent recovery per element.

‡ For a description of typical MBR characteristics, please refer to AWWA Standard B-130-13.

International* (NSF) to develop voluntary third-party consensus standards and a certification program for direct and indirect drinking water additives. Other members of the original consortium included the Water Research Foundation (formerly AwwaRF) and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association (AWWA) and the Association of State Drinking Water Administrators (ASDWA) joined later.

In the United States, authority to regulate products for use in, or in contact with, drinking water rests with individual states.† Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health effects of products and drinking water additives from such products, state and local agencies may use various references, including the following:

1. Specific policies of the state or local agency.

2. USEPA's *Membrane Filtration Guidance Manual* (EPA 815-R-06-009, USEPA 2005).

3. Two standards developed under the direction of NSF: NSF/ANSI‡ 60, Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI 61, Drinking Water System Components—Health Effects.

4. Other references, including AWWA standards, *Food Chemicals Codex*, *Water Chemicals Codex*,§ and other standards considered appropriate by the state or local agency.

Various certification organizations may be involved in certifying products in accordance with NSF/ANSI 60 and 61. Individual states or local agencies have authority to accept or accredit certification organizations within their jurisdictions. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

II. Special Issues. There is no consensus of opinion among academic, scientific, applied engineering, and regulatory practitioners for the precise definitions of RO and NF. The definitions and typical membrane characteristics of the membrane types shown in this standard are considered applicable to this standard and its use.

III. Use of This Standard. It is the responsibility of the user of an AWWA standard to determine that the products described in that standard are suitable for use in the particular application being considered.

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* NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105.

† Persons outside the United States should contact the appropriate authority having jurisdiction.

‡ American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

§ Both publications available from National Academy of Sciences, 500 Fifth Street, NW, Washington, DC 20001.

III.A. *Purchaser Options and Alternatives.* The following items should be covered by the purchaser:

1. Standard used, that is, ANSI/AWWA B114-16, Reverse Osmosis and Nanofiltration Membrane Systems, latest revision.
2. Details of other federal, state, local, and provincial requirements (Sec. 4.1.1).
3. Required equipment (Sec. 4.2.1).
4. Excluded systems and facilities (Sec. 4.2.2).
5. Required net production rate (Sec. 4.3.1.b).
6. Required documents for permitting (Sec. 4.3.1.u and Sec. 4.3.3.e).
7. Record drawings format (Sec. 4.3.4).
8. Whether compliance with NSF/ANSI 60 or NSF/ANSI 61 or other standards, rules, or regulations in addition to the requirements of the Safe Drinking Water Act are required (Sec. 4.6.4, 4.6.4.1, 4.6.4.2).
9. Element shipment requirements (Sec. 4.6.6.2).
10. Spare part requirements (Sec. 4.6.7.1).
11. Interface coordination requirements on project drawings (Sec. 4.6.8.1).
12. Electrical coordination requirements on project drawings (Sec. 4.6.8.4).
13. Instrumentation and control requirements on project drawings (Sec. 4.6.8.5).
14. Pneumatic requirements on project drawings (Sec. 4.6.8.6).
15. Flushing requirements (Sec. 5.1.2).
16. Installation requirements (Sec. 5.1.2).
17. Requirements for field testing (Sec. 5.4).
18. Demonstration testing requirements (Sec. 5.4.3).
19. Performance testing requirements (Sec. 5.4.4 and Sec. 5.4.5).
20. Basis for rejection (Sec. 5.5).
21. Affidavit of compliance (Sec. 6.3).

III.B. *Modification to Standard.* Any modification to the provisions, definitions, or terminology in this standard must be provided by the purchaser.

IV. Major Revisions. This is the first edition of this standard.

V. Comments. If you have any comments or questions about this standard, please call the AWWA Engineering and Technical Services at 303.794.7711, FAX at 303.795.7603; write to the department at 6666 West Quincy Avenue, Denver, CO 80235-3098; or email at standards@awwa.org.

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AWWA Standard

Reverse Osmosis and Nanofiltration Systems for Water Treatment

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard sets minimum requirements for reverse osmosis (RO) and nanofiltration (NF) membrane systems for water and reclaimed water treatment systems.

Sec. 1.2 Purpose

The purpose of this standard is to provide a minimum set of requirements for RO and NF membrane systems used for water and reclaimed water treatment systems. This standard is intended to assist with the design, procurement, installation, and commissioning of RO and NF membrane systems.

Sec. 1.3 Application

This standard can be referenced for design, procurement, installation, and commissioning of RO and NF membrane systems used for water purification and reclaimed water treatment systems.