WaterSense® Notice of Intent (NOI) to Develop a Draft Specification for Point-of-Use Reverse Osmosis (RO) Systems

I. Introduction

Reverse osmosis (RO) systems are water filtration systems that use the process of RO to remove contaminants from an incoming water supply. RO is the process by which pressure forces water through a semi-permeable membrane, creating a stream of treated water, called "permeate," and a stream of reject water, called "concentrate" or "brine," consisting of water with more concentrated contaminants that were unable to pass through the membrane.

RO systems can significantly reduce total dissolved solids (TDS), heavy metals, and inorganic and organic contaminants. There are different types of RO systems that vary in size and application. Point-of-use (POU) systems are connected to and provide treated water from a single faucet or appliance. Point-of-entry (POE) systems are connected to the water supply as it enters a house or building, and therefore treat water supplied to most or all end uses in the building. Both POU and POE systems can be used for residential and commercial settings. There are also larger RO systems used for applications such as desalinating seawater or treating industrial or municipal water and wastewater. These larger systems have specific considerations and requirements based on their intended applications and are not the focus of this notice. For the remainder of this document the term RO system refers to POU and POE RO systems, unless either type is specifically identified.

While RO systems can improve water quality, these systems also can generate a significant amount of water waste during operation. For example, a typical residential POU RO system will operate at an efficiency of 20 percent,[1] which means about four gallons of concentrate are generated for every gallon of permeate produced. Some inefficient units will generate 10 gallons or more of concentrate for every gallon of permeate produced. In recent years, membrane technology has improved, and some POU RO systems have been designed to operate more efficiently, with some manufacturers advertising systems that send just one gallon of concentrate down the drain for every one gallon of permeate produced (equivalent to an efficiency rating of 50 percent). POE RO systems tend to be more efficient than POU systems because they often include electric booster pumps and/or recirculate some of the concentrate water to improve efficiency. Therefore, POE RO systems can achieve efficiencies between 50 and 75 percent.

There are no current federal requirements that regulate water use of RO systems. However, as summarized in Section II Technical Background below, there are a number of applicable industry standards that outline requirements for RO systems, some of which include water efficiency criteria. The NSF International/American National Standard Institute (ANSI) 58 *Reverse Osmosis Drinking Water Treatment Systems* standard establishes minimum requirements for materials, design and construction, and performance of POU RO drinking water treatment systems, including procedures for testing claims of product efficiency. More

[1] Palkon, Tom A., 2021. "A Perfect Fit for ASSE's Mission". *Working Pressure*. January 14, 2021. www.workingpressuremag.com/a-perfect-fit-for-asses-mission/

recently ASSE[2] 1086 *Performance Requirements for Reverse Osmosis Water Efficiency—Drinking Water* (ASSE 1086), published in 2020, establishes criteria for designating high-efficiency POU RO systems.

To date, the U.S. Environmental Protection Agency (EPA) has not identified any products that are certified to ASSE 1086; however, based on discussions with various industry stakeholders, meeting the criteria identified in ASSE 1086 (discussed in more detail in Section IV Water Efficiency and Section V Performance and Product Testing) is achievable using more advanced membrane technology and other readily available design elements, such as automatic shutoff valves, flow restrictors, and permeate pumps.

EPA would like to build upon these existing standards to help further transform the market by encouraging the production of and—where the installation and use of the technology is appropriate—the adoption of more efficient RO systems. To that end, EPA's WaterSense program intends to develop a specification for labeling high-efficiency RO systems. With this notice of intent (NOI), EPA has preliminarily identified the water efficiency and performance criteria that it is considering, as well as outstanding issues that need to be addressed as the program moves forward in developing a draft specification for RO systems.

Because even the most efficient RO systems are water-intensive, WaterSense does not intend to promote their installation in all homes/applications or their use over other water treatment technologies. However, WaterSense recognizes that RO systems may be appropriate in certain applications depending on the desired water quality, characteristics of the incoming water supply, and consumer perception and preferences. In these instances, WaterSense wants to help consumers identify and purchase more water-efficient models.

II. Technical Background

EPA has long recognized the utility of RO systems as a treatment option for small drinking water systems,[3] and recent studies have shown their effectiveness in removing emerging contaminants such as per- and polyfluoroalkyl substances (PFAS).[4] RO systems work by applying pressure to reverse the flow of water in the natural process of osmosis so that water passes from a more concentrated solution to a more dilute solution through a semi-permeable membrane. Treated water (permeate), typically only a small proportion of the incoming feedwater, is delivered to the end user. The concentrated waste stream (concentrate), consisting of water and contaminants that were unable to pass through the membrane, is typically sent to the drain as wastewater. This process is illustrated in Figure 1 on page 3.

[2] From ASSE International, formerly known as the American Society of Sanitary Engineering.
[3] EPA, 2006. *Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems*. April 2006. www.epa.gov/sites/default/files/2015-09/documents/guide_smallsystems_pou-poe_june6-2006.pdf
[4] EPA, 2020. "EPA Researchers Investigate the Effectiveness of Point-of-use/Point-of-entry Systems to Remove Per- and Polyfluoroalkyl Substances from Drinking Water." January 22, 2020. www.epa.gov/sciencematters/epa-researchers-investigate-effectiveness-point-usepoint-entry-systems-remove-and.

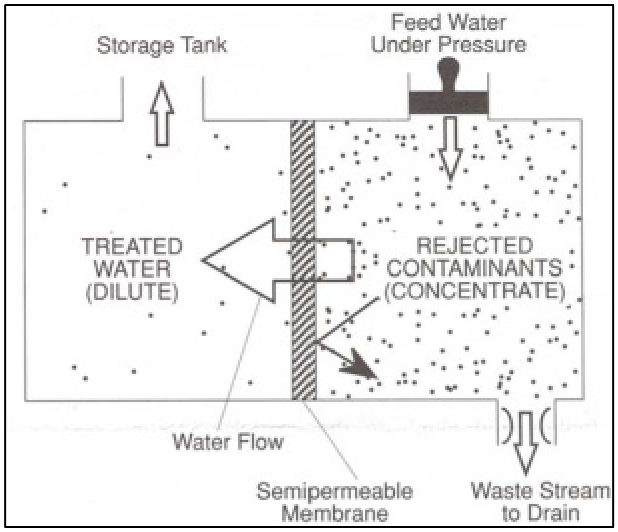

Figure 1. Diagram of Reverse Osmosis Water Treatment[5]

As mentioned in the introduction, RO systems can be characterized as POU or POE, both of which can be applied in residential or commercial applications.

POU RO systems are typically installed at a single water connection (e.g., a faucet or coffee machine) and thus have smaller capacities based on the demand for treated water from that connection. Market research indicates POU systems are generally advertised to produce 50 to 100 gallons per day (gpd) of treated water based on the RO membrane's rating, although actual production and use once installed is generally much less than this quantity.[6] POU RO systems come in two main configurations, including:

- **Under-sink models**. These are the most common type of POU RO system, typically installed under a kitchen sink and plumbed in, drawing water from the supply line before it enters the faucet. Most under-sink models direct treated permeate to a storage tank where it can be stored and drawn from at any point, though some may be tankless models, providing treated water in real time (on demand) with the assistance of a booster pump.[7]
- **Countertop models**. These are less common, not plumbed in, and may be more appropriate for certain applications such as for temporary residents or areas with spatial limitations. Some countertop systems are fitted directly to the kitchen faucet outlet and draw water from the faucet via a diverter, while other models can be self-contained units that draw water from a reservoir that must be filled by the user. Unlike under-sink

[5] Kneen, Barbara, Ann Lemley, and Linda Wagenet, 2005. "Water Treatment Notes: Reverse Osmosis Treatment of Drinking Water." Cornell Cooperative Extensive. Updated November 2005.
[6] Often, manufacturers will advertise a system's water production per day based on the rated capacity of the RO membrane alone. However, NSF/ANSI 58 requires the entire system to be evaluated when testing for daily production rate. This introduces inefficiencies, such as back pressure from the storage tank. While the daily production rating, as determined by NSF/ANSI 58, can be significantly lower than is advertised as the RO system's capacity, it is likely to be more representative of a system's performance once installed.
[7] IntecAmerica, (n.d). "Reverse Osmosis." www.intec-america.com/residential-water-treatments/reverse-osmosis/.

systems, countertop systems typically provide treated water in real time and do not utilize a storage tank.

POE systems are connected to the water supply entry of a house, building, or facility and are designed to provide hundreds to thousands of gallons of treated water per day for most or all end uses. Depending upon the demand, POE systems can be larger free-standing or smaller wall-mounted units.

RO systems incorporate a variety of treatment steps to purify water, including sediment filtration, carbon filtration, and reverse osmosis. Some also incorporate a carbon post-filter or re-mineralizer to improve taste and odor and reintroduce healthy minerals that were removed during treatment. Each step within the treatment process is called a stage. While the number of stages can vary, a review of products on the market reveals that the typical under-sink RO system has five stages, made up of three pre-filters (one sediment filter and two carbon filters), the RO membrane, and one carbon post-filter. Figure 2 shows the typical configuration of an under-sink RO system.

Although there is some variety in the apparatus, treatment steps, and/or storage between different types of RO systems, the general components and treatment process are the same.

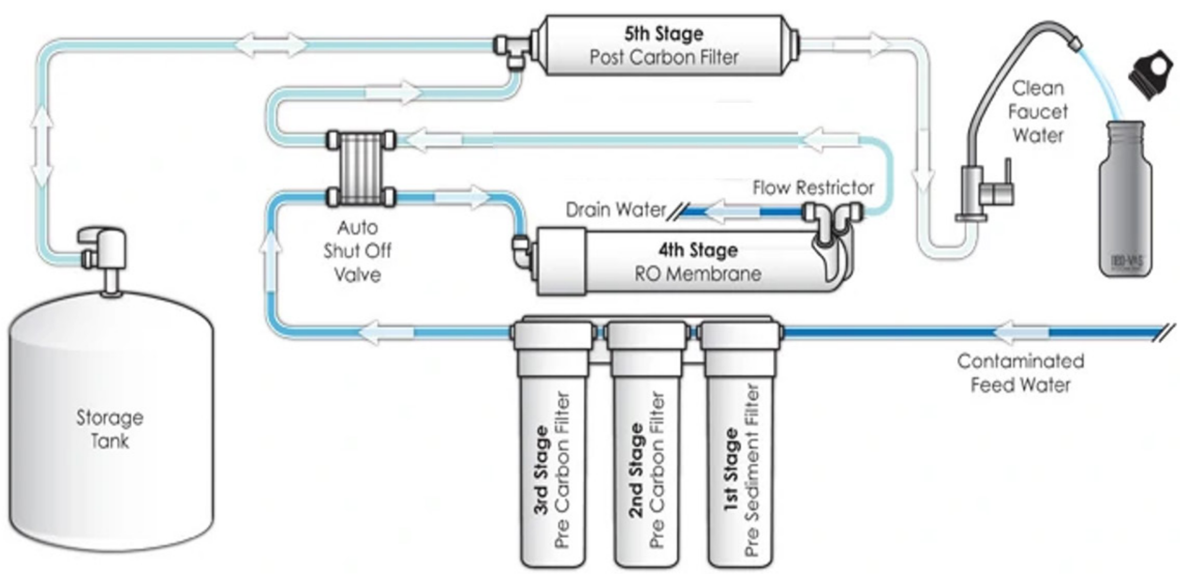

Figure 2. Diagram of a Typical Under-Sink POU RO System[8]

Each component within the system is described below:

[8] Modified from AquaTek Pro, 2019. "The Best Drinking Water by Using Reverse Osmosis." www.aquatekpro.com/5-stage-ro-filtration-system.html.

- **Pre-membrane filters**. Before entering the RO membrane, water is directed through pre-membrane filters to remove contaminants such as rust, sand, and chlorine that can damage the RO membrane and reduce its efficiency and longevity. Most RO systems have two or three pre-filters.[9]
- **RO membrane**. The RO membrane is where the RO treatment process takes place. From here, water is separated into two streams: concentrate and permeate. Some systems will incorporate a recirculation loop that directs concentrate back into the RO membrane for further treatment. However, in the Figure 2 diagram on page 4, concentrate is sent directly to the drain.
- **Flow restrictor**. The flow restrictor helps maintain a working flow rate and pressure to ensure proper RO treatment.
- **Storage tank**. The storage tank, if present, collects the permeate. This allows users to draw treated water on demand without having to wait for the water to pass through the RO system in real time. Storage tanks are common in most under-sink and POE RO systems. However, they are less common in countertop RO systems.
- **Automatic shutoff valve**. As the storage tank fills up, the pressure from the storage tank increases and approaches the pressure of the incoming water. This is called "back pressure."[10] An automatic shutoff valve is designed to automatically close when the back pressure from the tank reaches approximately two-thirds of the pressure of the incoming water.[11] This stops the treatment process and prevents the storage tank from overflowing and treated water from flowing down the drain. The shutoff valve is an important component for reducing water waste and maintaining system longevity. The shutoff valve operates solely based on water pressure and does not require electricity.[12]
- **Post-filters**. Some RO systems also have one or two post-filters that refine the taste, color, and odor of the treated water.[13] Alkaline or pH post-filters are intended to add healthy minerals such as calcium, potassium, and magnesium back into the water. These filters are placed after the storage tank, right before the water reaches the RO faucet and is collected by the user.
- **RO faucet**. This is the component through which the user draws the treated water. The RO faucet is often sold with the RO system and will typically require the user to drill a hole into their countertop for installation. POE systems do not have this component because treated water is sent into the building's entire plumbing network and delivered to all points of use. Some POU systems, such as the reservoir-type countertop systems, also do not have a separate RO faucet.

There are multiple existing consensus-based industry standards that are used to certify RO systems based on performance, design and construction, and more recently water efficiency, as summarized in Table 1 on page 6. These standards provide a framework from which EPA

---

[9] ESP Water Products, (n.d.). "How to Change Reverse Osmosis Water Filter." www.espwaterproducts.com/how-to-change-an-ro-filter-and-membranes/.
[10] Water Quality Association (WQA), 2019. "Getting Smart With Reverse Osmosis Systems: Best Practices for Industry Professionals & Tips for Consumers." www.wqa.org/Portals/0/Publications/Getting%20Smart%20with%20RO_Electronic.pdf.
[11] Fresh Water Systems, 2019. "What is a Reverse Osmosis Tank and How Does it Work?" www.freshwatersystems.com/blogs/blog/what-is-a-reverse-osmosis-tank-and-how-does-it-work.
[12] Water Technology, 2018. "Understanding reverse osmosis functionality." www.watertechonline.com/wastewater/article/15550715/understanding-reverse-osmosis-valve-functionality.
[13] WQA, 2020. Water Treatment for Dummies, 2nd WQA Special Edition. www.wqa.org/dummies.

intends to define the scope, as well as the water efficiency and performance test methods and requirements of a potential WaterSense specification.

Table 1. Overview of Industry Standards for RO Systems

Standard	Scope/Application	Attributes Addressed
NSF/ANSI 58-2020 *Reverse Osmosis Drinking Water Treatment Systems*	Point-of-use RO drinking water treatment systems designed to be used for the reduction of specific substances that may be present in drinking water (public or private) considered to be microbiologically safe and of known quality.	• Materials • Structural performance • Performance, including flow control, connections, and storage capacity • TDS reduction by 75 percent • Verification of other chemical and mechanical filtration claims • Verification of recovery and efficiency rating claims
ASSE 1086-2020 *Performance Requirements for Reverse Osmosis Water Efficiency—Drinking Water*	Residential RO systems used to treat drinking water. RO water treatment equipment reduces total dissolved solids, heavy metals, inorganics, and organics water contaminants. Through reference to NSF/ANSI 58, this standard is intended for residential POU locations, not POE.	• Compliance with NSF/ANSI 58 • Membrane life test for high-efficiency membrane systems • Minimum system efficiency (water efficiency) of 40 percent, tested in accordance with NSF/ANSI 58
ASSE 1087-2018 *Commercial and Food Service Water Treatment Equipment Utilizing Drinking Water*	Commercial water treatment equipment used in POE and POU applications connected to building plumbing to improve the water quality characteristics of potable water. This standard applies to a variety of water treatment equipment, including deionizers, filters, softeners, RO assemblies, ultraviolet systems, ozone systems, and distillers. It is not specific to RO systems, though commercial POU and POE RO systems are included in the scope.	• Service flow capacity • Pressure loss • Pressure shock • Structural integrity • Materials • Compliance with NSF/ANSI 58 for POU devices
ASSE *Listing Evaluation Criteria (LEC) for Point of Entry Reverse Osmosis Systems* (ASSE LEC 2006)	POE RO system used to treat drinking water with a permeate flow of two gallons per minute (gpm) or greater. POE ROs are typically installed after the water meter in residences or businesses.	• Chemical reduction claims • Materials safety and performance

The above standards include references to additional industry standards that establish requirements for drinking water systems related to aesthetic and health effects. These standards apply but are not specific to RO systems and include:

- NSF/ANSI 42, *Drinking Water Treatment Units—Aesthetic Effects*
- NSF/ANSI 53, *Drinking Water Treatment Units—Health Effects*

III. Scope

As shown in Table 1 on page 6, the industry standards use a variety of RO system types to define their scope, including POU, POE, residential, and commercial. However, none of the standards specifically defines these types of systems. All of the standards instead reference NSF/ANSI 330 *Glossary of drinking water treatment unit terminology*. Key definitions from NSF/ANSI 330, including definitions for POU and POE systems, are provided below.[14]

- **Reverse osmosis**: A process that reverses, by the application of pressure, the flow of water in a natural process of osmosis so that water passes from a more concentrated solution to a more dilute solution through a semi-permeable membrane.
- **Point-of-use system**: A plumbed-in or faucet-mounted drinking water treatment unit used to treat the drinking and/or cooking water at a single tap or multiple taps, but not used to treat the majority of water used for washing and flushing or other non-consumption purposes at a building or facility. Any batch system or device not connected to the plumbing system is considered a point-of-use system.
- **Point-of-entry system**: A drinking water treatment unit used to treat the water supply at the entry of a building or facility for drinking and for washing, flushing, or other non-consumption use. A POE system has a minimum initial clean-system flow rate of not less than 15 liters per minute at 103 kilopascals pressure drop and 18 ± 5 °C water temperature (not less than four gallons per minute at 15 psig pressure drop and 65 ± 10 °F water temperature).

NSF/ANSI 330 does not provide definitions specific to RO systems. However, EPA has modified the NSF/ANSI 330 definitions above to define the following terms:

- **RO system**: A system that incorporates a water treatment process that removes undesirable materials from water by using pressure to force the water molecules through a semipermeable membrane.
- **POU RO system**: A plumbed-in or faucet-mounted RO system used to treat the drinking and/or cooking water at a single tap or multiple taps, but not used to treat the majority of water used for washing and flushing or other non-consumption purposes at a building or facility. Any batch RO system or device not connected to the plumbing system is considered a point-of-use RO system.
- **POE RO system:** An RO system used to treat the water supply at the entry of a building or facility for drinking and for washing, flushing, or other non-consumption use. A POE RO system has a minimum initial clean-system flow rate of not less than 15 liters per

[14] NSF/ANSI 330-2020 *Glossary of Drinking Water Treatment Unit Terminology.*

minute at 103 kilopascals pressure drop and 18 ± 5 °C water temperature (not less than four gallons per minute at 15 psig pressure drop and 65 ± 10 °F water temperature).

These definitions will be used for the purposes of this NOI and to inform future specification development related to this product category. EPA does not intend to differentiate between commercial and residential RO systems in its specification and therefore did not propose definitions for these terms. **EPA is seeking input on these definitions and would also be interested in other accepted industry definitions.**

EPA intends to limit the scope of a potential WaterSense specification to POU RO systems, as defined above, consistent with the applicability of NSF/ANSI 58. NSF/ANSI 58 does not differentiate among POU RO systems that are intended for residential or commercial applications; therefore, its scope is slightly broader than the ASSE 1086 standard, which is limited to residential POU systems. Further ASSE 1086 specifies compliance with NSF/ANSI 58, including the test method for system efficiency, thus it does not appear that the application of the product (residential or commercial) has a bearing on its ability to be tested to the efficiency or performance requirements of either standard. At this point in time, EPA does not see the need to limit a specification to residential POU RO systems and exclude POU products that may be used in commercial applications. Within the POU category, WaterSense also does not intend to distinguish among the different types of POU RO systems (e.g., countertop, under-sink) in terms of the water efficiency or performance requirements. Overall, WaterSense's goal is to reduce water wasted by POU RO systems by decreasing the amount of concentrate produced for every gallon of water treated, which can be achieved across a wide range of available technologies.

Based on research and conversations with stakeholders, EPA intends to exclude POE RO systems from the scope of a potential WaterSense specification. Not all end uses of water require or even benefit from the quality of water generated from an RO system (e.g., water used for toilet flushes, clothes washing, or bathing). While POE RO systems are generally more efficient due to their tendency to include electric booster pumps and/or recirculate some of the concentrate water, POE RO systems treat, and subsequently waste, more water on the whole than POU systems. WaterSense, therefore, does not want to encourage the use of oversized systems that subsequently generate significant water waste during the treatment process. **WaterSense is seeking input on the intended scope of a potential specification that includes POU RO systems, as defined above, and excludes POE systems.**

WaterSense is considering whether to include high-efficiency RO membranes in the scope of its specification to help distinguish them from typical membranes. This would help consumers identify appropriate high-efficiency replacement membranes for their system to ensure it continues to perform at its rated water efficiency. Additionally, it may encourage consumers with less efficient systems to purchase compatible high-efficiency membranes to increase the efficiency. As discussed in more detail in Section V Performance and Product Testing, ASSE 1086 includes test procedures to evaluate a high-efficiency membrane separate from an RO system, at least with respect to life span and performance. **WaterSense is seeking feedback on whether labeling RO membranes would be beneficial to consumers and whether it is feasible to swap out the membrane in a typical RO system for a higher efficiency membrane to increase the system's water efficiency.**

Beyond potential consideration for labeling RO membranes, WaterSense does not intend for the specification to apply to other accessories or “add-on” devices intended to improve product efficiency, production rate, or otherwise impact the operation of an RO system. These products include a permeate pump, which is a non-electric device that can be used to retrofit a POU RO system to reduce the back pressure from the storage tank and therefore improve the system’s water efficiency and performance. Other companion products include retrofit recirculation kits (used to recirculate the concentrate water as feed water) and any systems that divert RO reject water for other uses. If a POU RO system requires the use of a companion product to meet the requirements of a future specification, then WaterSense intends to require the companion product to be tested, packaged, and sold along with the system in order for the system to bear the WaterSense label. **WaterSense is seeking feedback on its intent to exclude add-on/aftermarket companion products from the scope of the specification.**

There are also a variety of hybrid RO systems within the marketplace that combine various methods of water treatment, including filtration and even ultraviolet (UV) disinfection. The additional treatment technologies may fall within the scope of other NSF/ANSI standards. For example, filters are tested and certified according to NSF/ANSI 42 *Drinking Water Treatment Units—Aesthetic Effects* and/or NSF/ANSI 53 *Drinking Water Treatment Units—Health Effects.* UV systems are tested and certified according to NSF/ANSI 55 *Ultraviolet Microbiological Water Treatment Systems.* The scope of NSF/ANSI 58 requires that systems with manufacturer claims that include components or functions covered under other NSF or NSF/ANSI standards must conform to those applicable requirements; therefore, EPA’s understanding is that any RO system certified to NSF/ANSI 58 would also be required to have filters and other components certified to applicable standards. WaterSense intends to permit hybrid systems to earn the WaterSense label, provided the RO portion of the system meets the scope and all water efficiency and performance requirements of a future specification. **WaterSense is seeking input on its intent to include hybrid systems within the scope of a specification. Further, WaterSense seeks feedback on whether it should require that components of hybrid systems be tested and certified to other applicable standards (e.g., NSF/ANSI 42 for filtration, NSF/ANSI 55 for UV).**

IV. Water Efficiency

Historically, RO systems provide only a small proportion of the incoming feedwater as permeate; a majority ends up as concentrate. In recent years, manufacturers have made strides to improve the efficiency of RO systems, reducing the amount of concentrate produced for every gallon of water treated.

Product research indicates that manufacturers often advertise the efficiency of RO systems using simple terms such as “pure-to-waste ratio.” Pure-to-waste ratios vary among products on the market. A commonly advertised pure-to-waste ratio is 1:4, meaning that for every gallon of permeate it produces, the system discards four gallons of concentrate. A review of products online indicates more efficient systems have advertised pure-to-waste ratios of 1:1.

Pure-to-waste ratio is not a metric that is verified through testing to industry standards. Instead, industry standards, including NSF/ANSI 58, define and assess RO system water efficiency based on “recovery rating” and “efficiency rating” (explained further below). EPA intends to use these terms and associated test methods to establish the water efficiency criteria for an RO system specification.

EPA has also identified the presence of an automatic shutoff valve as a key parameter that can be used to address the water efficiency of an RO system.

Recovery Rating and Efficiency Rating

NSF/ANSI 58 defines and sets the testing procedures for "efficiency rating" and "recovery rating," metrics used to convey an RO system's water efficiency. These metrics express the percentage of intake water that ultimately becomes available to the user as permeate under specific testing conditions. Because systems with a storage tank have back pressure that slows permeate production as the tank fills up, the actual efficiency of such systems will be lower than systems without a tank. The efficiency and recovery rating metrics, defined below, are meant to provide a more comparable measure of efficiency for products with and without a storage tank, respectively. In all cases, if both metrics are provided, the efficiency rating will be lower than the recovery rating. In general, systems with higher efficiency ratings or recovery ratings, as applicable, are more water-efficient than those with lower ratings.

- **Efficiency rating**. The percentage of the influent water to the system that is available to the user as RO treated water under operating conditions that approximate typical daily usage. Only systems equipped with an automatic shutoff valve and a pressurized or non-pressurized tank will have an efficiency rating.
- **Recovery rating**. The percentage of the influent water to the membrane portion of the system that is available to the user as RO treated water when the system is operated without a storage tank, or when the storage tank is bypassed and the permeate is open to the atmosphere. All products can have a recovery rating. Systems without a shutoff valve and pressurize/non-pressurized tank will only have a recovery rating.

More detailed test methods and calculations for efficiency rating and recovery rating are included in NSF/ANSI 58. For the purposes of this notice of intent, the calculations from both efficiency rating and recover rating can be simplified as:

$$percent\ recovery\ or\ percent\ efficiency = \frac{permeate\ volume}{(concentrate\ volume + permeate\ volume)} * 100\% \qquad \textit{Equation 1}$$

NSF/ANSI 58 also establishes testing procedures for the RO system "daily production rate," which is a metric that quantifies the estimated amount of permeate the system can produce in a day under specific conditions. The recovery rating, efficiency rating, and daily production rate are all influenced by the configuration of the RO system, including the presence of a storage tank or automatic shutoff valve. Therefore, these metrics are tested together under specific configurations described in Table 2 on page 11. The testing requirements differ for each RO system configuration. Most notably, systems without a storage tank will not have an efficiency rating.

Table 2. NSF/ANSI 58 Daily Production Rate, Recovery Rating, and Efficiency Rating Testing Configurations

Testing Configuration	EPA's Understood Applicability	Efficiency Metrics Evaluated
Systems with storage tank and automatic shutoff	Includes most under-sink models. The automatic shutoff valve is an important water-saving device because it prevents the tank from overflowing and sending permeate down the drain.	• Recovery rating • Efficiency rating • Daily production rate
Countertop systems with storage tanks or reservoirs	Includes reservoir-type countertop systems. Most faucet-mounted countertop systems do not have a storage tank.	• Recovery rating • Efficiency rating • Daily production rate
Systems without storage tanks	Includes tankless under-sink systems and most faucet-mounted countertop systems, which typically do not have a storage tank.	• Recovery rating • Daily production rate
Systems with no shutoff provisions	Meant for systems with a storage tank but no shutoff device.	• Recovery rating • Daily production rate

The NSF/ANSI 58 standard does not establish specific criteria for designating water-efficient RO systems. Instead, the efficiency and recovery ratings are included in the standard as a means to verify manufacturers' claims with regard to efficiency. ASSE 1086, which is intended to aid water conservation efforts by providing manufacturers an efficiency target for their RO system designs, references the test methods in NSF/ANSI 58 and further establishes a minimum system efficiency of 40 percent or the manufacturer's claimed efficiency, whichever is greater. This efficiency criteria applies regardless of whether the RO system has a tank (i.e., the results of recovery rating and efficiency rating, as applicable, must be at least 40 percent).

A review of existing products on the market and discussions with industry stakeholders revealed that the typical efficiency rating for POU products is about 10 to 20 percent, which would result in four to nine gallons of concentrate for every one gallon of permeate produced. The typical recovery rating is about 33 percent. WaterSense is currently unaware of any products that have been certified to ASSE 1086; however, some manufacturers advertise pure-to-waste ratios as low as 1:1. This equates to a 50 percent efficient/recovery rating, suggesting that there may be products on the market that can meet/exceed the 40 percent threshold established in ASSE 1086 but have not yet been certified. ASSE 1086 was published in 2020 and is a relatively new standard; therefore, market uptake has not had much time to occur.

WaterSense intends to adopt the NSF/ANSI 58 testing procedures for recovery rating and efficiency rating. **WaterSense is seeking feedback from stakeholders regarding the viability of using the NSF/ANSI 58 recovery rating and efficiency rating test methods to evaluate RO system water efficiency.** WaterSense is also considering adopting criteria to require RO systems to achieve a recovery rating of at least 40 percent and an efficiency rating (as applicable) of at least 40 percent. These criteria align with the requirements of ASSE 1086. **WaterSense is seeking feedback from stakeholders on this proposed water efficiency criteria for POU RO systems.**

Automatic Shutoff Devices

Automatic shutoff devices are an important water-saving component applicable to RO systems. This device shuts off the flow of incoming water when the storage tank fills to a certain capacity, thereby stopping the treatment process, preventing the tank from overflowing, and preventing reject water when the system is not actively treating. This is a requirement included within ASSE 1086. Similarly, WaterSense intends to require that all RO systems be equipped with an automatic shutoff device. **WaterSense is seeking input on whether requiring an automatic shutoff valve is a reasonable expectation for a water-efficient RO system.**

System Maintenance and Modifications

During discussions with stakeholders, some indicated that it may be possible for consumers to make modifications or changes to the system after purchase that would decrease product efficiency. For example, a customer could replace the RO membrane within a high-efficiency RO system with a less efficient membrane, either by accident or to save on maintenance costs. It is also possible that the consumer could replace the storage tank with a different size. **WaterSense is seeking feedback on the likelihood of these post-purchase modifications and the magnitude of their effect on the RO system's water efficiency. WaterSense is also seeking suggestions on how to encourage and inform consumers to purchase appropriate replacement parts to maintain their system's water efficiency.**

Estimated Water Savings

WaterSense has not identified field studies to date that assess actual water savings associated with more efficient RO systems compared to inefficient systems. Further, while EPA has anecdotally heard that an estimated one million POU RO systems are sold annually, the exact product market is unknown. **WaterSense is seeking RO system market data and usage data to assess the impact of a potential WaterSense specification on potential water savings.**

However, WaterSense is able to estimate per-unit savings of high-efficiency RO systems based on expected operating conditions. Based on conversations with stakeholders and the approximate usage prescribed per the ASSE 1086 testing criteria, WaterSense assumes that the average person will withdraw one gallon of permeate per day from their RO system for drinking and cooking. According to the U.S. Census Bureau, the average number of persons per household is 2.6.[15] This translates to approximately 950 gallons of water per household per year for drinking and cooking. As mentioned previously, WaterSense identified typical efficiency ratings between 10 percent and 20 percent for RO systems with storage tanks (common in residential settings) based on a review of products available online. Therefore, WaterSense is assuming an average efficiency rating of 15 percent for typical POU RO systems, which translates to 5,400 gallons of concentrate generated per household per year. Assuming a suggested efficiency rating criteria of 40 percent, a high-efficiency RO system can reduce water use by approximately 4,000 gallons per household per year. Table 3 on page 13 summarizes these calculations.

---

[15] U.S. Census Bureau, 2019. Households and Families. https://data.census.gov/cedsci/table?q=Families%20and%20Household%20Characteristics&tid=ACSST1Y2019.S1101.

Table 3. Water Savings Potential for a High-Efficiency POU RO System

System Type	Consumption (gallons) per Person per Day	Persons per Household	Gallons of Permeate Required per Household per Year	Efficiency Rating	Total Concentrate Generated per Household per Year (gallons)
	A	B	C=A*B*365	D	E=(C/D)-C
Typical RO system	1	2.61	953	15%	5,400
High-efficiency RO system				40%	1,430
Water Savings per Year (Gallons)					**3,970**

V. Performance and Product Testing

From a consumer's perspective, the ideal residential RO system significantly reduces drinking water contaminants, provides permeate at a sufficient volume, and is easy to maintain. These qualities provide convenience for the consumer and assurance that their drinking water is adequately treated. Beyond recovery rating, efficiency rating, daily production rate, and presence of an automatic shutoff valve, performance metrics that can be used to measure these qualities include TDS and contaminant reduction and membrane and filter longevity.

TDS and Contaminant Reduction

TDS, which refers to the total amount of dissolved solids such as minerals, salts, metals, and organic matter in the water, is a common indicator used to determine the general quality of drinking water. NSF/ANSI 58 evaluates and specifies criteria for TDS percent reduction, which is a helpful metric that can quantify the RO system's ability to reduce drinking water contaminants. The NSF/ANSI 58 standard also allows for and provides testing methods and requirements for the removal of other more specific contaminants to verify manufacturer reduction claims.

WaterSense is considering requiring that all labeled products conform to the applicable requirements of NSF/ANSI 58 to ensure adequate contaminant reduction performance criteria are met. NSF/ANSI 58 only requires the system to meet a minimum of 75 percent TDS reduction. Beyond this, any contaminant reduction claims made by the manufacturer must be verified by test data generated under the requirements of NSF/ANSI 58. **WaterSense is seeking feedback from stakeholders regarding the viability of requiring that WaterSense labeled RO systems meet all of the requirements of NSF/ANSI 58, including the 75 percent TDS reduction requirement.**

Membrane and Filter Lifespan

Membrane and filter life is an important performance attribute for consumers. Based on a review of products on the market, in most cases an RO system will require pre-filter replacement every six months and RO membrane replacement every one to three years. Consumers may find it costly, burdensome, or difficult to keep up with regular maintenance if the filters and membrane need to be replaced more frequently. However, filter replacement is important to ensure that the membrane and filters will perform adequately and maintain efficiency throughout their prescribed lifespan.

ASSE 1086 includes testing procedures and requirements for the membrane life of high efficiency membranes and systems. The procedure calls for the membrane or system to be evaluated under specific testing conditions for a minimum of 20 days to produce a total product volume of at least 1,000 gallons. This test is meant to be representative of a year of treatment under challenge conditions.[16] To satisfy the requirements of the standard, the following criteria must be met:

- The percent TDS reduction shall be a minimum of 75 percent each day.
- The flow rate shall not decrease by more than 50 percent of the Day 1 reading throughout the test.
- The system recovery shall be on average a minimum of 40 percent. One tenth of the sample readings may be less than 40 percent but no less than 30 percent. The final recovery measurement shall be a minimum of 40 percent.

WaterSense is considering incorporating the ASSE 1086 membrane life test procedures and criteria into a potential specification to ensure the RO membrane will have adequate resistance to fouling and maintain its water efficiency and performance over time. **WaterSense is seeking feedback from stakeholders regarding the viability of using the ASSE 1086 membrane life test methods to evaluate membrane lifespan and RO system performance.**

VI. Product Marking, Documentation, and Marketing

WaterSense specifications typically include requirements for marking and product documentation to aid consumers in understanding the efficiency and performance of WaterSense labeled products.

NSF/ANSI 58 prescribes requirements pertaining to product instructions and performance data sheets, which include communication of the efficiency rating (or recovery rating as applicable), model numbers for replacement membranes and filters, and daily production rate. However, based on EPA's review of products, this information is not always readily available.

ASSE 1086 requires that certified products be packaged with installation instructions that adhere to the NSF/ANSI 58 requirements. The product must also have a specification sheet that includes the system recovery and efficiency rating. In addition, the system itself must be marked with the rated water efficiency in a place that is visible after installation. Further, ASSE 1086 specifies that detailed instructions on how to change pre-filters, post-filters, and membranes and the recommended frequency of changing these components be provided.

WaterSense is considering whether to require that the efficiency rating (for systems with a storage tank) or recovery rating (for systems without a storage tank) be displayed on the product, product packaging, and associated specification sheet. Because efficiency rating and recovery rating are technical terms with detailed testing procedures and somewhat similar

[16] ASSE 1086-2020. *op. cit.*

definitions, the distinction between the two values may not be clear to consumers. WaterSense is also concerned that presenting the efficiency/recovery rating as a percentage may be confusing to consumers and may not effectively convey the water efficiency of the device. As discussed earlier, many manufacturers advertise a "pure-to-waste" ratio in addition to or instead of efficiency/recovery rating, which may be more comprehensible but does not appear to be a standardized metric. There are no specific testing procedures for determining pure-to-waste ratio, and the term is sometimes used synonymously with recovery rating, efficiency rating, or neither. For this reason, WaterSense is considering defining the term "treated-to-waste ratio" as the ratio equivalent of the efficiency rating (for systems with a storage tank) or recovery rating (for systems without a storage tank), as applicable, of a given RO system. For example, using Equation 1 on page 10, an RO system with an efficiency rating of 40 percent would have a 1:1.5 treated-to-waste ratio. WaterSense is considering requiring the treated-to-waste ratio on product packaging and documentation to more easily convey the RO system water efficiency to consumers. **WaterSense is seeking input on the proposed "treated-to-waste ratio" definition and any other reasonable ways to mark products, product packaging, and specification sheets that would be easy for the consumer to understand.**

For hybrid systems that use additional treatment technologies (e.g., UV), product marking should specify that the WaterSense label and criteria apply solely to the RO portion of the treatment process. If WaterSense decides not to require certifications or criteria pertaining to the additional treatment technology(ies), **WaterSense is seeking input on how to incorporate packaging/labeling requirements that clarify which treatment technology is certified under the WaterSense label.**

WaterSense's goal is to promote the adoption of water-efficient products. In many cases, RO systems are not the most water-efficient drinking water treatment solution for a given application. EPA intends to use careful and considerate messaging so as not to promote the use of RO systems over other water treatment technologies that may be equally or more appropriate. Instead, the intent of the WaterSense POU RO system specification is to help consumers who already intend to purchase an RO system identify the most water-efficient options. **WaterSense is seeking input on messaging that can be used so as not to promote the purchase of RO systems when they are not necessary.**

VII. System Impacts and Other Considerations

Cost to Consumer

Anecdotally, EPA has observed that more efficient RO systems tend to be more expensive than average systems. Similarly, based on a review of available products online, higher efficiency RO systems sometimes have more expensive membranes than average systems, with relatively similar lifespans. However, during conversations with EPA, some manufacturers have stated that it is possible to produce and sell high-efficiency systems, filters, and membranes at similar costs to standard systems and components. WaterSense is unclear whether some high-efficiency membranes require more frequent replacement, which would increase maintenance costs. **WaterSense is seeking input on the impact of high-efficiency systems on product and maintenance costs.**

Energy Consumption

Most POU RO systems (particularly under-sink models) do not use energy. However, some more efficient RO systems use electric pumps to achieve greater efficiency/recovery ratings. These systems may have an energy tradeoff to consider. WaterSense is interested in understanding the current market for RO systems that use energy, particularly as it relates to improving efficiency; whether a WaterSense specification would increase the use of electric pumps to achieve greater efficiencies; and how much energy these types of systems typically consume. This information will help the program assess and convey the potential water/energy tradeoffs to consumers. **WaterSense is seeking input on the efficiency gains possible from incorporating an electric pump in a system and how much energy these systems tend to use. Should WaterSense consider including a maximum energy or minimum pump efficiency requirement for electric RO systems in its specification? If so, are there data available that could help establish these criteria?**

Wastewater Quantity and Quality

EPA has not identified any data suggesting there are potential impacts of concern with respect to the discharge of a concentrated waste stream from RO systems. High-efficiency RO systems will produce more concentrated reject water; however, this reject water is blended with other wastewater from a residence or business, and any resulting increase in contaminants is expected to be negligible.

EPA does not have data on specific impacts to onsite septic systems. The amount of wastewater generated from a POU RO system is minimal when compared to other typical residential water uses, such as from toilets, bathing, and clothes washing. Further, an RO system does not add any additional minerals or contaminants to the wastewater (but rather concentrates contaminants from the incoming water supply). If anything, WaterSense expects a potential specification will promote RO systems that reduce the wastewater being directed to the septic system compared to typical RO systems. However, it is possible a septic system could be impacted depending on a variety of factors.

WaterSense is seeking input on whether RO systems contribute any negative impacts to wastewater and wastewater treatment systems, including septic systems, and whether those impacts are exacerbated with high-efficiency systems. If there are negative impacts, what best practices can be used to mitigate those impacts?

Use of POU and POE RO Systems to Meet Drinking Water Regulations

EPA allows small public water systems (PWS) to use POU and POE treatment systems to meet the requirements of the National Primary Drinking Water Regulations (NPDWRs). These systems, which include residential RO systems, may be a more affordable option for PWSs than traditional, centralized treatment. The PWS is responsible for installation and maintenance of the treatment systems and cannot delegate operation and maintenance tasks to homeowners.[17]

A similar regulation was passed in California as part of the Safe and Affordable Funding for Equity and Resilience (SAFER) program, which aims to minimize disproportionate

[17] EPA, 2006. *op. cit.*

environmental burdens to disadvantaged communities by ensuring access to safe, clean, and affordable drinking water. In 2018, the California State Water Resources Control Board adopted regulations allowing for PWSs with less than 200 service connections to use POU and POE treatment systems to fulfill the requirements of the Safe Drinking Water Act where centralized treatment is not immediately economically feasible.[18]

If WaterSense moves forward with development of a specification to label higher efficiency POU RO systems, PWSs that are currently using or considering RO systems under these EPA and California allowances may benefit from greater system-wide efficiency.

VIII. Summary of Information Requests

WaterSense is requesting feedback on all aspects of this notice; summarized below are the specific outstanding issues, questions, and concerns about which WaterSense is seeking input prior to drafting its specification for POU RO systems. All interested parties are encouraged to submit information and comments to watersense-products@erg.com.

Scope

- Are the RO system, POU RO system, and POE RO system definitions acceptable, or are there any other accepted industry definitions for these terms?
- Should the scope of the specification be restricted to POU systems only and exclude POE systems?
- Should WaterSense label high-efficiency RO membranes to encourage consumers to purchase these as replacement membranes? Is it reasonable to expect these membranes to improve the efficiency of a typical RO system?
- Is it appropriate to exclude add-on/aftermarket companion products from the scope of the specification?
- Should hybrid/enhanced systems be included in the scope of the specification? Should WaterSense require that they be tested to applicable standards (e.g., NSF/ANSI 55 for UV systems)?

Water Efficiency

- Would it be viable to use the NSF/ANSI 58 efficiency rating and recovery rating test methods to evaluate RO system water efficiency?
- Are the proposed criteria for efficiency rating and recovery rating (≥ 40 percent), consistent with ASSE 1086, reasonable?
- Is it reasonable to require all RO systems that earn the WaterSense label to have an automatic shutoff device?
- How likely are consumers to modify their system after purchasing in a way that would decrease the system's water efficiency, and what is the potential magnitude of these effects?

---

[18] California State Water Resources Control Board, 2019. SWDDW-17-003 Point-of-Use/Point-of-Entry Treatment—Permanent Regulations. www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/regulations/.

- Are there any RO system market data and usage data that could be used to estimate potential water savings?

Performance and Product Testing

- Is it appropriate and viable to require that all WaterSense labeled RO systems meet the requirements of NSF/ANSI 58?
- Would it be viable to use the ASSE 1086 membrane life test methods to evaluate RO system performance?

Marking and Product Documentation

- Is the definition for "treated-to-waste ratio" sufficient, and are there any other reasonable ways to mark products, product packaging, and specification sheets that would be easy for the consumer to understand?
- How should WaterSense incorporate packaging/labeling requirements that clarify what is certified under the WaterSense label, especially in the case of hybrid systems?
- How should WaterSense market the POU RO system specification to avoid promoting the adoption of RO systems when they are not necessary or when alternative, more water-efficient treatment technologies would be sufficient?

System Impacts and Other Considerations

- What is the impact of more efficient RO systems on product and maintenance costs to the consumer? What is the impact of producing more efficient RO systems on the cost to the manufacturer?
- What efficiency gains are possible from incorporating an electric pump in a system, and how much energy do these systems tend to use? Should WaterSense consider including a maximum energy or minimum pump efficiency requirement for electric RO systems in its specification?
- Do RO systems contribute any negative impacts to wastewater and wastewater treatment systems, including septic systems, and are those impacts exacerbated with high-efficiency systems? If there are negative impacts, what best practices can be used to mitigate those impacts?

IX. Schedule and Next Steps

WaterSense is requesting input, supporting information, and data from all interested parties on topics discussed in this NOI and otherwise related to RO systems. Interested parties can provide input to WaterSense regarding any of the issues presented in this notice by submitting written comments to watersense-products@erg.com. Comments and information on the issues presented in this NOI are welcome and will be taken into consideration as WaterSense develops a draft specification for RO systems.

WaterSense will accept feedback on the information requested above and will consider all comments and information provided by stakeholders and the general public. In addition, WaterSense plans to hold a public meeting to discuss the information presented in this NOI and any stakeholder feedback received up to that point as part of the NOI review.

X. References

AquaTek Pro, 2019. "The Best Drinking Water by Using Reverse Osmosis." www.aquatekpro.com/5-stage-ro-filtration-system.html.

ASSE International (ASSE) Standard #1087-2018. *Commercial and Food Service Water Treatment Equipment Utilizing Drinking Water.*

ASSE LEC #2006-2019. *Listing Evaluation Criteria (LEC) for Point of Entry Reverse Osmosis Systems*.

ASSE #1086-2020. *Performance Requirements for Reverse Osmosis Water Efficiency—Drinking Water.*

California State Water Resources Control Board, 2019. SWDDW-17-003 Point-of-Use/Point-of-Entry Treatment—Permanent Regulations. www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/regulations/.

EPA, 2006. Point-of-Use or Point-of-Entry Treatment Options for Small Drinking Water Systems. www.epa.gov/sites/default/files/2015-09/documents/guide_smallsystems_pou-poe_june6-2006.pdf.

EPA, 2020. "EPA Researchers Investigate the Effectiveness of Point-of-use/Point-of-entry Systems to Remove Per- and Polyfluoroalkyl Substances from Drinking Water." www.epa.gov/sciencematters/epa-researchers-investigate-effectiveness-point-usepoint-entry-systems-remove-and.

ESP Water Products, (n.d.). "How to Change Reverse Osmosis Water Filter." www.espwaterproducts.com/how-to-change-an-ro-filter-and-membranes/.

Fresh Water Systems, 2019. "What is a Reverse Osmosis Tank and How Does it Work?" www.freshwatersystems.com/blogs/blog/what-is-a-reverse-osmosis-tank-and-how-does-it-work.

IntecAmerica, (n.d.). "Reverse Osmosis." https://www.intec-america.com/residential-water-treatments/reverse-osmosis/.

Kneen, Barbara, Ann Lemley, and Linda Wagenet, 2005. "Water Treatment Notes: Reverse Osmosis Treatment of Drinking Water." Cornell Cooperative Extensive. Updated November 2005.

NSF/ANSI Standard 58-2020. *Reverse Osmosis Drinking Water Treatment Systems.*

NSF/ANSI Standard 330-2020. *Glossary of Drinking Water Treatment Unit Terminology.*

Palkon, Tom A., 2021. "A Perfect Fit for ASSE's Mission". *Working Pressure*. January 14, 2021. www.workingpressuremag.com/a-perfect-fit-for-asses-mission/.

Water Quality Association (WQA), 2019. "Getting Smart With Reverse Osmosis Systems: Best Practice for Industry Professionals & Tips for Consumers." www.wqa.org/Portals/0/Publications/Getting%20Smart%20with%20RO_Electronic.pdf.

WQA, 2020. Water Treatment for Dummies®, 2nd WQA Special Edition. www.wqa.org/dummies.

Water Technology, 2018. "Understanding reverse osmosis functionality." www.watertechonline.com/wastewater/article/15550715/understanding-reverse-osmosis-valve-functionality.

U.S. Census Bureau, 2019. Households and Families. https://data.census.gov/cedsci/table?q=Families%20and%20Household%20Characteristics&tid=ACSST1Y2019.S1101.