Getting Smart With

REVERSE OSMOSIS SYSTEMS:

Best Practices for Industry Professionals & Tips for Consumers

Water Quality Association

Prepared on behalf of the water quality improvement industry by the Water Quality Association

The Water Quality Association provides technical information as a service to its members, policymakers and the general public. WQA's intent is to promote discussion on key water quality related issues through reliable, verifiable facts and data.

This booklet contains information appropriate for those who manufacture, sell, install, and maintain residential reverse osmosis (RO) treatment systems. Homeowners, regulators and legislators may also find it useful. In producing this guidebook, the Water Quality Association (WQA) leveraged the advice of respected industry professionals and the latest in scientific research.

WQA encourages industry professionals and consumers to:

- Be aware of pre-treatment requirements for optimum performance;
- Choose efficient system design and configuration;
    - Efficiency and recovery ratings can be evaluated under NSF/ANSI Standard 58 – Reverse Osmosis Drinking Water Treatment Systems.

- According to NSF/ANSI Standard 58, systems equipped with both an automatic shut-off device and either a pressurized or a non-pressurized storage tank shall report an efficiency rating and may report a recovery rating as an option. All other systems may report a recovery rating, but no efficiency rating shall be determined or reported.
- For more information, see the recovery versus efficiency section of this booklet.

- Connect customers to the right products for the right purpose; and
- Observe water conservation practices and encourage RO reject water reuse applications.

To read more about RO treatment efficacies, please visit the technical pages on **www.wqa.org**!

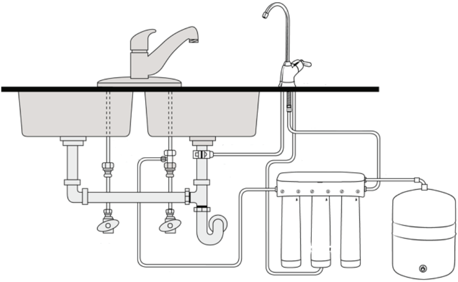


Figure 1: Typical design for under-the-sink reverse osmosis drinking water treatment unit. (diagram used with permission from Paragon Water Systems).

All Industry Professionals:

1. Proactively educate consumers about the benefits of replacing older systems with newer, more efficient technology.
2. Promote technologies and processes that use less water; such as atmospheric tanks, automatic shut-off mechanisms, water/water, booster pump, permeate pump, and direct flow (without storage tank).
3. Encourage systems with the highest practical efficiency rate.
4. Provide the consumer with the proper maintenance to reduce water waste and maintain performance and sanitation.

Best Design Practices for Manufacturers:

1. Carefully balance membrane durability and contaminant removal performance, with system efficiency.
2. Optimize system efficiency with automatic shut-off mechanism and flow restriction on the reject line.
3. When making claims for zero discharge, provide adequate instructions for installers regarding how to re-route reject line for reuse applications in accordance with local plumbing codes.
4. Provide proper air gap design.
5. Include documentation such as owner's manual, maintenance instructions, and contaminant removal performance specifications.
6. Offer RO treatment systems that are certified by an accredited third-party certification body.

Best Practices for Equipment Installers & Service Technicians:

1. Prior to installation, remediate any pretreatment needs and determine the homeowner's water conditions that can affect production and quality. Such as

influent (feed-water) TDS, temperature, pressure, and daily use patterns.

2. Whenever appropriate, size the equipment (by GPD capacity rating) and adjust its settings to optimize water consumption per manufacturer recommendations.
3. Consider using the reject water line for appropriate reuse applications in accordance to manufacturer specifications and local regulations.
4. Replace pre- and post-filters in a timely manner per the manufacturer's instructions, including sanitization.
5. Be aware that increased efficiency can decrease membrane life.
6. Ensure the protection of public health by installation with a proper air-gap.
7. Ensure that plumbing following an RO unit is made of plastic material and approved for use with drinking water in compliance with the local plumbing codes. Copper or metal pipe and fixtures downstream of a RO unit would not be advisable.

What is reverse osmosis?

Reverse osmosis (RO) is a cross-flow filtration water treatment process that removes undesirable materials from water by using pressure to force water molecules through a semipermeable membrane. This process is called "reverse" osmosis because the pressure forces the water to flow in the reverse direction (from the concentrated solution to the dilute solution) to the flow direction in the process of natural osmosis (from the dilute to the concentrated) [WQA Knowledge Base].

Efficiency versus Recovery

RO systems are rated with either an efficiency rating or a recovery rating. Following the conventions established in the American National Standard, NSF/ANSI 58, Efficiency is defined as the percentage of water entering the RO unit that is available as treated (product) water under normal use conditions. This efficiency rating is influenced by any back pressure created by automatic shut-off devices used in combination with a storage tank. Recovery is defined as the percentage of water entering the RO unit that is available as treated water when the system is operated without a storage tank (e.g., gravity and tankless RO systems), or when the storage tank is bypassed, meaning there are no impacts of back pressure on the membrane.

Again, following the conventions set forth in the established American National Standard, systems equipped with both an automatic shut-off device and either a pressurized or a non-pressurized storage tank should report an efficiency rating, because recovery would be misleading to the consumer since it does not take into account the effect of backpressure and would therefore under estimate the water usage that will be experienced by the consumer. All other systems should report a recovery rating instead of an efficiency rating.

Regardless of which term is used, **water-usage estimates reported to the customer need to accurately reflect the amount of RO water produced for every gallon of raw water sent to waste under normal use conditions** (i.e., taking into account any backpressure created by the system design).

Is RO Reject Water Safe for Reuse?

Rerouting the RO reject water for use in other applications is the surest way to achieve 100% efficiency. A common misconception is that the reject water from a point-of-use RO system is highly concentrated with contaminants and not safe for reuse. This is not necessarily true. Two examples below demonstrate scenarios where point-of-use RO systems are being used to treat drinking water that contains lead at a concentration equal to or near the US EPA Action Level (15 µg/L).

If the water source being treated contains 15 µg/L of lead, and the RO operates at 15% efficiency, the RO reject water will contain 17.6 µg/L of lead. Every 10 liters of influent water containing 15 µg/L lead contains 150 µg of lead. Operating at a 15% efficiency, the RO system will produce 1.5 liters of treated product water and 8.5 liters of reject water. If we assume that no lead ends up in the treated product water, which would be a "worst case" assumption for the purpose of evaluating whether the reject water is safe for reuse applications, then all 150 µg of lead would end up in the reject water. In this example, the concentration of the reject water is therefore 150 µg divided by 8.5 L, or 17.6 µg/L.

If the water source contains 14 µg/L of lead and the RO operates at 35% efficiency, the RO reject water will contain 21.5 µg/L of lead. Every 10 liters, the RO system will produce 3.5 liters treated water and 6.5 liters reject water. Again, assuming no lead ends up in the treated product water, the 6.5 liters reject will contain 140 µg/L of lead. The concentration of the reject water is 140 µg/L divided by 6.5L, which equals 21.5 µg/L.

These examples show that, depending on the purpose, it is certainly possible for RO reject water to be appropriate for reuse. The needs and limits of the application should be carefully considered in light of the math that must be done, as shown above, for the RO's rejection and efficiency levels.

RO Advances in Module Design

Improvements in the design of the RO membrane material or module can lead to improvements in RO system efficiency by improving the flux of water through the membrane or by reducing scaling or fouling potential.

Types of RO Systems: See definitions in Appendix A

Type of RO System	Tank Type	Pros	Cons
Gravity	Atmospheric tank	No backpressure effects	Requires tank to be mounted above dispensing point
Permeate Pump	Traditional storage tank with pump	No backpressure effects	Added cost and complexity
Tankless	No storage tank	No backpressure effects	Potential for high TDS creep
Traditional	Captive air storage tank	Simple, low cost design	Backpressure of storage tank negatively affects water efficiency
Water/Water	Water/water storage tank	No backpressure effects	Added complexity in valving/controls

Key:

Look for these easy icons, which indicate that a practice is a:

SMART UPGRADE
A way to save a lot while spending a little.

QUICK FIX
A no-cost solution that works for any budget.

GREAT INVESTMENT
A larger investment that can yield a larger reward.

Tips for Consumers

WQA encourages consumers to conserve water in and around the home by taking the following steps:

Whole House

1. Choose low-flow shower heads, sink faucet aerators, and high-efficiency washing machines, toilets, and other appliances.
2. Choose showers over baths whenever possible. When taking a bath, make sure the drain stopper is working properly to avoid having to refill the tub.
3. Pay attention to your water bill, an unanticipated increase could indicate a leak.
4. Don't ignore damp water spots on ceilings and walls. These leaks not only waste water but also can cause structural damage to your home. If you suspect a leak, consult with a plumber.
5. Leaks can hide, easily unnoticed, underneath the sink behind

supplies or under appliances. Pay special attention to musty odors, dampness or mold under sinks and appliances.

6. Be aware of any dripping faucets, this can waste hundreds of gallons of water per month. Sink and shower faucet repairs are simple and cost effective.

In the Kitchen

1. If you wash dishes in the sink, use a stopper to allow dishes to soak rather than running the faucet continuously.
2. Instead of letting the faucet run until the water becomes cold, simply keep a container of water in the refrigerator.

In the Bathroom

1. Do not leave the water running while brushing your teeth, shaving or washing your face.
2. Shorten your time in the shower by just five minutes. Over time, this

small change can save hundreds of gallons of water.

3. Make sure water from your toilet tank is not continuously leaking into the bowl. You can check by dropping some food coloring into the tank. Avoid flushing the toilet for one hour and then see if the water in the bowl has become tinted.

In the Basement

1. Avoid running the washing machine or dishwasher at less-than-full capacity or adjust the water usage settings for smaller loads.
2. Upgrade existing water softeners and filters to achieve water and salt usage savings.
3. Replace existing water softeners with efficient demand-initiated water softeners that regenerate only when needed using optimum salt and water settings.
4. The hoses bringing water to and from your washing machine can

burst. Avoid potential flooding issues by turning off both the hot and cold-water sources when not using the machine. Consider upgrading to "no-burst" hoses and inspect the connections regularly for leaks.

In the Yard

1. Avoid watering your lawn and garden during midday or when it is raining and take care not to overwater.
2. Use drip irrigation systems for watering yards and gardens. They can save 30-50% of the water sprinklers lose from evaporation and runoff.
3. If you have an automatic watering system, make sure no water is wasted on paved areas. Always remember to shut off the automatic system during a rainfall.
4. Choose drought-resistant flowers and plants, rather than those requiring large amounts of water

for your garden.

5. Collect water in a rain barrel and use it for watering lawns and plants.
6. Add a top layer of organic mulch, or plant with a compost pile, to help your garden retain moisture.
7. Check outdoor faucets, pools, and spas on a regular basis for leaks too.

Appendix A: Definitions

Booster pump: An auxiliary pump which is used to boost incoming line pressure to the membrane in an RO system to increase or maintain the pressure in the system.

Daily production rate (DPR): The volume of product water produced by a system per day [NSF/ANSI 58 – 2017 Reverse Osmosis Drinking Water Treatment Systems].

Efficiency rating: The percentage of the influent water to the system that is available to the user as reverse osmosis treated water under operating conditions that approximate typical daily use [NSF/ANSI 58 – 2017 Reverse Osmosis Drinking Water Treatment Systems]. See recovery rating.

Feed Water Pumped Systems: An RO system that includes a pump that increases the feed pressure of the water to the system.

Gravity storage tank system: An RO system with a gravity dispensing action from an atmospheric storage tank to the glass. Water from the membrane empties into the tank until a sensor or a float valve turns the system off.

RO system with a permeate pump: An RO system with a permeate pump is a device that uses the pressure of the waste or feed line to add pressure to the permeate going to the tank. The additional pressure from the pump minimizes the effect of the backpressure on the permeate flow rate and water efficiency of a traditional captive air system.

Pressurized storage tank/captive air systems: The pressurized storage tank uses a tank with two adjacent chambers separated by a flexible diaphragm or bladder. One chamber contains product water and the other chamber is pre-charged with approximately 5psi of air. A valve senses pressure at a pre-described percentage of feed pressure and shuts off the waste when full. When RO water is dispensed, the air chamber applies pressure to the diaphragm forcing water out of the dispenser (e.g. faucet, icemaker or bottleless cooler). Pressurized storage tank RO systems are the most common type of RO systems in the United States. A typical system is depicted earlier in the article.

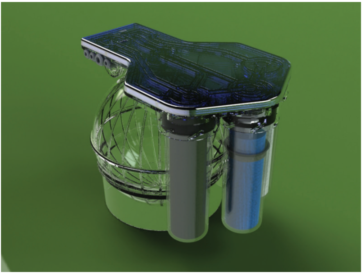
Recovery rating: The percentage of the influent water to the membrane portion of the system that is available to the user as reverse osmosis treated water when the system is operated without a storage tank or when the storage tank is bypassed [NSF/ANSI 58 – 2017 Reverse Osmosis Drinking Water Treatment Systems]. See efficiency rating.

Reject water: A term used in distillation, electro dialysis, reverse osmosis, nanofiltration, and ultrafiltration to describe the portion of the incoming influent that has passed across the membrane but has not been converted to treated product water and is being sent to drain [WQA Glossary of Terms, Fourth Edition].

Tankless RO Systems: An RO system with either a single large membrane or multiple membranes that can deliver water to the faucet continuously without the need of a storage tank.

TDS Creep: The increase in the total dissolved solids (TDS) of permeate water during stagnation due to ions moving from the waste side to the permeate side of the membrane.

Water/water RO System: The water/water design uses a tank with two adjacent chambers separated by a flexible diaphragm or bladder. One chamber is product water, and the other chamber is squeeze water which comes from the reject water from the membrane. RO product water then gradually fills the chamber, displacing the accumulated reject water to the drain until it occupies all of the tank's volume. When RO water is dispensed, reject water under line pressure squeezes the diaphragm forcing the RO product water out. This type of design offers efficient water usage due to zero back pressure on the membrane.



Web Resources:

General information about water treatment products and professionals

1. Water Quality Association (WQA) website: www.wqa.org
   a. "Find a Certified Product" search tool
   b. Gold Seal Product Certification Program
   c. "Find a Water Treatment Professional" search tool
   d. NSF International: www.nsf.org

Water conservation

1. U.S. Environmental Protection Agency: www.epa.gov
   a. EPA WaterSense Program
   b. Water conserving products & information
   c. Water conservation tips
   d. Tips for watering wisely
   e. Tips for smart landscaping

2. Alliance for Water Effiency: www.allianceforwaterefficiency.org
   a. Water conservation practices for process water, including food & beverage, auto repair & service, paper manufacturing, and metal finishing

Calculated water usage

1. Water Footprint Network: www.waterfootprint.org

Water Quality ASSOCIATION®

Published by the
Water Quality Association
4151 Naperville Road
Lisle, Illinois 60532-3696

Visit www.wqa.org
or call 630-505-0160