ENVIRONMENTAL
Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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Reverse Osmosis Treatment for Drinking Water

Other fact sheets in this series identify reverse osmosis, commonly called RO, as a treatment process for removing many different contaminants. RO is more generally used for small volumes of drinking water. This document provides greater detail concerning RO treatment.

WHAT IS REVERSE OSMOSIS TREATMENT?

Many decades ago, scientists noted that water molecules would spontaneously migrate through certain membranes that were separating a dilute solution from a concentrated solution. This phenomenon is called osmosis. They also noted that if pressure was added to the higher contaminant solution, this natural flow could be reversed. This reversal allows the contaminant solution to be concentrated further and allows purified water to be produced.

AMOUNT OF WATER TO BE TREATED

Where only a small volume of treated water is needed, approximately 0-10 gallons per day (gpd), RO is typically the most flexible and cost efficient treatment process available for private home use.

Devices treating small volumes of water are often called "under-the-sink" or "point-of-use" (POU) sized treatment devices. Treatment devices which purify all water used in a home are commonly called "whole house" or "point-of-entry" sized water treatment devices.

CONTAMINANTS APPROPRIATE FOR RO TREATMENT

Certain contaminants in drinking water do not need to be fully removed from all of the water used in the home, but only from that water which will be consumed or used in food preparation. Some of these contaminants suitable for POU include arsenic, beryllium, fluoride, radium/uranium, sodium/chloride, pesticides, and herbicides.

Other contaminants need treatment for **all** water used within the home, including radon, hydrogen sulfide, iron/manganese, and some volatile organic chemicals.

The above breakdown is generic and assumes only modest levels of contaminants in the water supply. Where contaminants are very high, whole house treatment is likely required for all contaminants.

THE RO TREATMENT DEVICE

An RO device typically consists of the membrane housing and "pre" and "post" filters. The stainless steel **housing** containing the membrane, would be at a minimum, approximately 3 inches in diameter by 10 inches long and the pre and post filters would be of similar size. The membrane would likely be of the spiral wound type. The housing would have three connection ports to accommodate the three flows regimes of a RO device.

1. A raw water "feed-in" port.
2. A treated water "outlet" port.
3. A reject water "outlet" port.

Operationally, an RO device functions as follows. Raw water from the source is fed onto one side of this membrane. Some water migrates through the membrane and accumulates in a small water storage tank on the "treated water" side of the device. This pure water is called the **permeate** water. Impurities and the remaining raw water stay on the raw water side of the membrane. This water, called the **reject water**, is not further used and is discharged from the device continuously when the device is producing treated water. Typically this reject wastewater is discharged to a sewer, leach field, or dry well. The reject water has a higher concentration of contaminants than the raw water had. Disposal (wasting) of the reject water is a major concern in arid areas.

EFFICIENCY OF THE RO PROCESS

The efficiency of the RO process can be measured in two ways; using both purity and volume based measurement.

1. **Efficiency based on the purity of the treated water.** RO can typically remove 80 to 99 percent of most mineral contaminants. For example, if the concentration of contaminants in the raw water was 1.0 milligram per liter (mg/L) and the efficiency of the treatment device was 90 percent for that contaminant; the treated water contaminant concentration would be approximately 0.1 mg/L. **Treated water quality is the most important measure of the efficiency of an RO device.**

2. **Efficiency based on a volume of treated water.** In New Hampshire, treatment efficiency based on the volume of water produced is poor, typically in the range of 20 to 30 percent. This is due to the typically cool temperatures of the state's groundwater. For example, assuming the volumetric efficiency of an RO treatment device was 25 percent, if 10 gallons of raw water is fed into the device daily, only 2.5 gallons of water will migrate through the membrane to become treated pure water. The contaminants and the remaining 7.5 gallons of water will become reject water and will be discharged to a sewer, leach field, or drywell. Typical New Hampshire groundwater temperature is 40 to 45 degrees Fahrenheit. This temperature is fairly constant year round. RO devices are often rated at an operational temperature of 77 F at 60 pounds per square inch (psi) applied pressure. The technical condition causing this low rate of production is the viscosity (stickiness) of the water when cold.

The amount of water wasted in the "under-the-sink" size is a relatively small amount (7.5 gpd in the above example) when compared to the total average household usage of over 200 gpd for a family of four.

WATER QUALITY CONSTRAINTS FOR RO DEVICES

RO treatment can be negatively affected by some common water quality factors.

Turbidity (cloudiness)

To accomplish separation of water from contaminants, the passageways in the membrane must be very small. Thus these membranes are very sensitive to clogging by small solid particles. Where there are any particles in the raw water, a sediment pre-filter must be installed. Sediment cartridge filters are so inexpensive that it is normally good practice to installed a sediment pre-filter before all RO units, regardless of the solids content of the raw water.

Where waters are very clear, the pre-filter size chosen is typically 5 microns. Where the raw water has more solids, the 5 micron filter could be preceded by a filter of larger pore size, approximately 25 or 50 microns.

Iron & Manganese
These naturally occurring contaminants often create particles which will clog RO membranes. A particle filter is critical where iron or manganese concentrations are high.

Hydrogen Sulfide
This material can create a gelatinous coating on the membrane. This may limit the life of an RO cartridge. Where hydrogen sulfide is high, other pretreatments may also be necessary.

Chlorine
Some RO membranes, called thin film composite (TFC), will be damaged by the presence of chlorine or other strong oxidizing compounds. Either a chlorine resistance membrane, such as cellose acetate (CA) must be used, or the chemical injection point for the chlorine should be placed after the RO unit.

OTHER RO APPURTENANCES

Conservation of Reject Water
To prevent the constant wasting of water from the reject port, an automatic valve is often added to the waste discharge line. This valve shuts off the raw water feed as the treated water pressure tank approaches near full capacity. This valve is available on more sophisticated RO designs.

Differential Pressure across the Membrane
The greater the pressure differential pressure across the RO membrane, the **higher** the purity of the treated water. When the small accumulation pressure tank is nearly full, the differential pressure across the RO membrane drops to near zero. This creates the potential for excessive level of contaminants to diffuse across the membrane and recontaminate the purified water. To prevent this recontamination, more sophisticated designs add two additional functions that activate when the device is not producing water. One turns off the feed water when the accumulation tank is near filled and the second purges the raw water side of the membrane, with treated water. These designs features are valuable but they also raise the cost of the RO device.

Pre and Post Activated Carbon Filters
We have already mentioned the importance of a sediment pre-filter before the RO unit. After the RO unit, the water conditioning industry normally advocates the installation of an activated carbon filter. The activated carbon targets taste and odor constituents that have escape prior treatment.

BACKUP AND REDUNDANCY
A very conservative design would provide a further treatment device down stream of the RO element to address the small concentration of contaminants that escaped through the main treatment device, particularly in point-of-use sized treatment. Such a device would address the possibility of rupture of the membrane or leakage of the internal membrane cartridge. Typically a media filter is used for this backup. The media type and associated contaminants are shown below.

Backup Media	Target Contaminant
Activated alumina	Arsenic, beryllium, and fluoride
Cartridge Ion exchange	Uranium, radium, other positive ions
	Sodium and chloride

PURCHASE AND INSTALLATION

If purchasing water treatment equipment, please refer to DES fact sheet: WD-DWGB-2-5, Considerations When Purchasing Water Treatment Equipment.

The purified water accumulated in the pressure tank. This water is typically dispensed by a special dedicated faucet mounted on the kitchen sink. This treated water can also be plumbed directly to the refrigerator ice maker.

The RO device can be installed in the basement or "under-the-sink" location. The basement location typically provides the greater ease of maintenance. Be sure to check the adequacy of the plumbing at both the water supply connection point and waste discharge connection point.

RO MAINTENANCE

In order to ensure proper operation, the home owner must establish and carry out a maintenance program for any treatment device. For RO systems, this program would consist of the following.

1. Periodic replacement of the particle pre-filter and or post filter.
2. Periodic water quality testing of the treated water.
3. Possible raw water testing.
4. Evaluation of RO membrane integrity.

The membrane would need to be replaced at some point. This can be estimated from the differential pressure build up on the membrane and results of the treated versus raw water quality tests. Your sales representative can provide an estimate of the membrane's longevity under specific operating conditions.

FOR MORE INFORMATION

Please contact the Drinking Water and Groundwater Bureau and the New Hampshire Water Well Board at (603) 271-2513 or dwgbinfo@des.nh.gov or visit our website at http://www.des.nh.gov/organization/divisions/water/dwgb/index.htm. All of the bureau's fact sheets are on-line at http://www.des.nh.gov/organization/commissioner/pip/factsheets/dwgb/index.htm.

Note: This fact sheet is accurate as of September 2009. Statutory or regulatory changes or the availability of additional information after this date may render this information inaccurate or incomplete.