# Water Treatment

Water treatment is used in many commercial operations, including food services, laundries, laboratories, pharmacies, and car washes. The type of treatment depends upon the application and the required water purity. Treatment ranges from simple cartridge filtration to sophisticated systems that produce extremely pure water. For example, ice machines often have cartridge sediment and carbon filters installed on the make-up water so the ice is free of particles and chlorine taste. Some laboratories and the pharmaceutical and electronics industries, however, require "ultrapure water," which has had all but a few parts per billion of minerals, organics, and other substances removed through a train of treatment, including filtration, carbon filtration, softening, reverse osmosis, and strong acid/base ion exchange, followed by microfiltration and ultraviolet-light disinfection. The following table compares various treatments found in commercial operations.

*Many commercial operations require some form of water treatment, either for use in processes or as a component of the end product.*

**Commercial Water Treatment Examples**

| | Treatment Process | | | | | | |
|---|---|---|---|---|---|---|---|
| | Sediment Filtration | Carbon Filtration | Softening and Ion Exchange | Membrane Process | Distillation | Disinfection | Other |
| **All Food Service** | x | x | x | x | | | x |
| **All Laundry & Dry Cleaning** | x | | x | | | | |
| **Hospital & Laboratory** | x | x | x | x | x | x | x |
| **Car Wash** | x | | x | x | | | |
| **Beverage Manufacturing** | x | x | x | x | | x | |
| **Metal Plating** | x | x | x | x | | | x |
| **Cooling Tower & Boiler** | x | | x | x | | x | x |
| **Pool, Spa, & Water Feature** | x | | | | | x | |
| **Office & Non-process** | x | x | x | | | x | x |

## Description of End Use

Each treatment technology offers unique opportunities for water conservation, as described below:

***Sediment filtration*** is one of the most common treatment techniques. Swimming pools, water feeds to commercial ice machines, cooling-tower side-streams, drinking-water, and water-using medical equipment are but a few examples where sediment filters are found. They remove particles down to a few microns in size. The two basic designs use disposable cartridges or granular filter media.

By their nature, cartridge filters are usually not designed for very large flows. Sample uses include pre-filters for ice machines, smaller medical equipment, and smaller swimming pools and spas. Filter material varies from tightly wound fibers to ceramics, fused powdered-metals, or other materials. Such filters are left in place until the sediment buildup causes a predetermined increased pressure drop across the filter, at which time the filter is replaced, backwashed, or removed and cleaned for reuse.

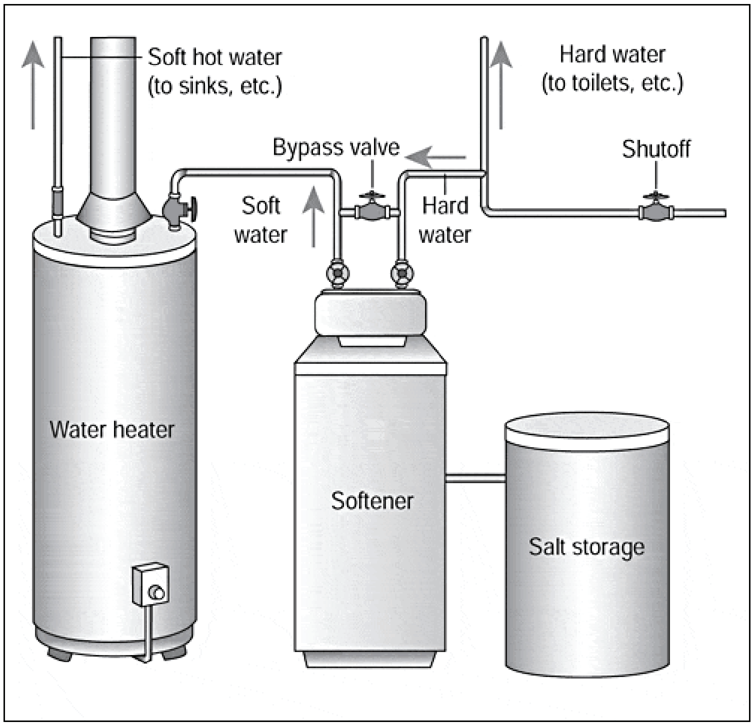
**Culligan heavy-duty whole house filter**

The second type of sediment filter is often found where larger volumes of water must be processed or higher levels of sediment must be removed. These include granular media such as sand, coated media (DE, cellulose, and perlite), and mixed-bed filters. All of these must be backwashed. The backwash water is generally discharged to the sanitary sewer. In some larger applications, however, the sediment can be allowed to settle out and the clarified water can be reintroduced at the head of the filtration process. Common applications include swimming pools, industrial water treatment, and side-stream filtration for cooling towers.

***Carbon filtration*** removes chlorine, taste, odor, and a variety of organic and heavy-metal compounds from water by adsorption. Activated carbon, which has an enormous surface area per unit volume, attaches to the unwanted materials and holds them on its surfaces. Restaurants and food service providers for hospitals and other institutional operations often use activated carbon for drinking water and ice-machine feed water. It is also used in the beverage industry for taste and odor control.

Activated carbon is also used to remove pollutants in the metal-finishing industry and other operations where pretreatment to remove metals or organics is needed. These systems can employ either disposable cartridges or packed columns, where the activated carbon can be removed and sent for recharge. With both cartridge and packed-column systems, water simply passes through the carbon medium until its adsorptive capacity is used up.

***Water softening*** employs zeolites or ion exchange resins, where calcium and magnesium ions are exchanged for sodium or potassium ions. Softening removes hardness to control scale, improves water for washing, and prevents “hard water” spots. Recharge is done with a salt solution containing sodium or potassium cations, the most common being sodium chloride (table salt). Water is used in the recharging process to make up the brine solutions and to purge the softener of brine prior to being returned to service. All softener systems should be equipped with controllers that are activated based upon the volume treated, not on timers. They should either be adjusted for the hardness of the water supply or be equipped with a hardness controller that actually measures the hardness and volume treated, if the hardness of the feed water varies.




**Water Softener System**

www.bobvila.com/howto_library

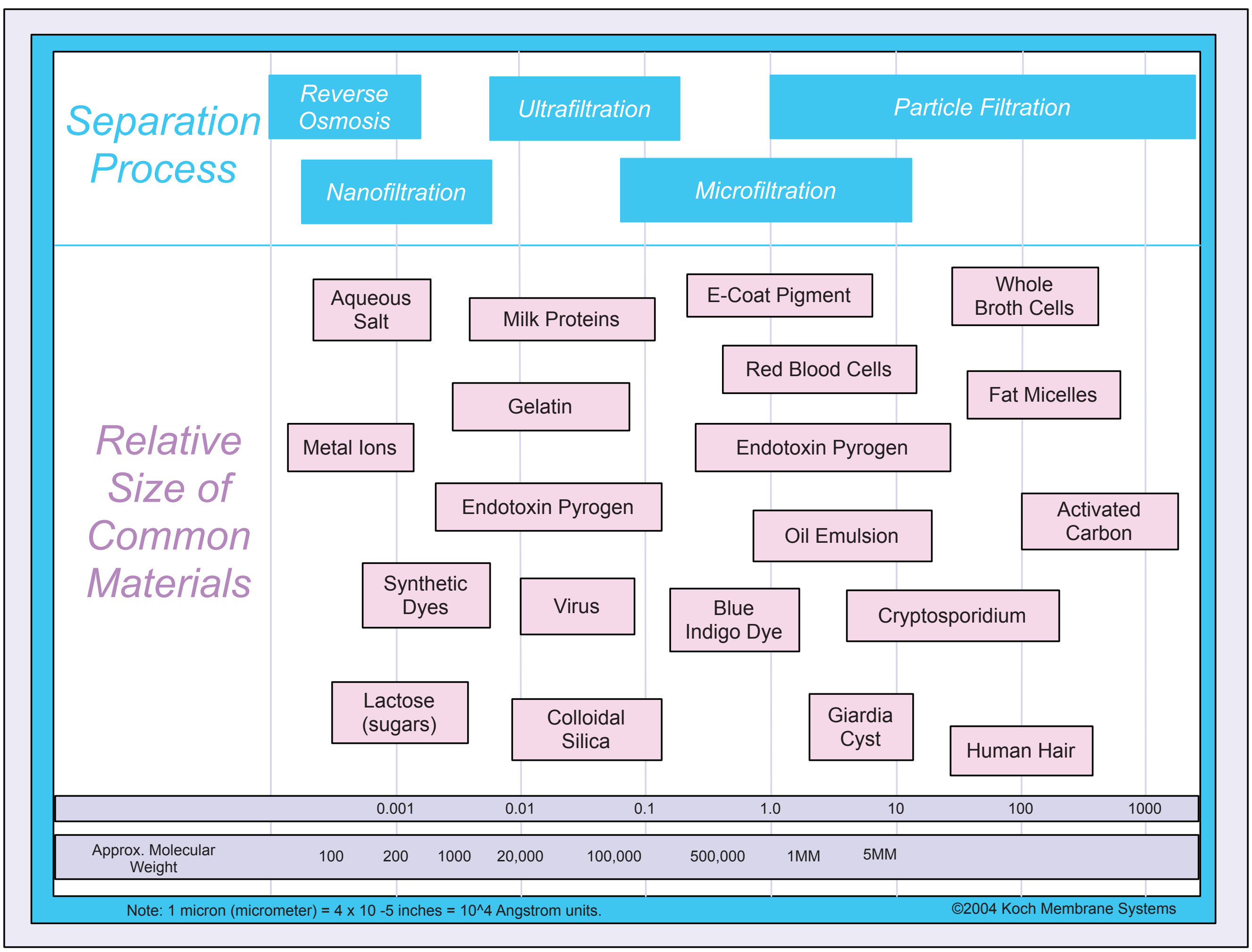
Softeners are commonly found where hardness interferes with water use or where scale formed by hard water could be detrimental. Laundries, car washes, boiler feed-water, laboratory water, hot-water systems for restaurants and food-service establishments, and metal-plating operations commonly employ softening. It is used occasionally for cooling-tower feed-water or in a process called side-stream softening, which helps extend the usefulness of cooling-tower water. *(See "Thermodynamic Processes.")*

Deionization also employs exchange resins, but it is different from softening. Strong acid/base ion-exchange resins, known as deionization resins, are used to produce extremely pure water for laboratory analysis, kidney dialysis, and feed-water for a number of industrial processes. Water use is similar to that for recharging softening systems, but the discharge water can be much more corrosive. Controls should be based upon the chemistry of the feed water and volume treated, not on timers.

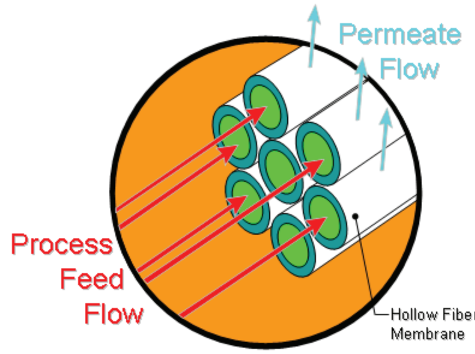
Ion-removal systems operate similarly to ion-exchange systems and have similar water-use patterns. Ion-exchange resins can also remove a variety of ionic contaminants, such as arsenic or fluoride.

***Membrane processes*** include several water-treatment methods. A membrane, usually composed of a polymer material, is used to remove contaminates. All membrane processes have three things in common: there is a feed stream, a retentate or waste stream, and a product called permeate. The type of membrane process used depends upon the size or type of contaminant one wishes to remove, as illustrated by the following diagram.

The example following is for an ultrafiltration membrane, but could represent any of the four membrane processes:



- Microfiltration employs membranes that remove particles of 0.1 to 10 microns in size or larger. It is used in municipal water treatment to remove bacterial and *Giardia lamblia* cysts, and *Cryptosporidium* oocysts. Water is forced through the membrane until the pressure drop reaches a set point. The filter is then backwashed. The membranes also require periodic chemical cleaning. Both the backwash and cleaning processes use water. Retentate or waste volumes are usually a small percentage of the total feed volume. The retentate is often recirculated and only a small stream of "bleed water" is discharged as wastewater. Some ceramic filters can also filter in this range.




**Permeate/Feed-Stream/ Retentate Diagram**

**Koch Membrane Systems**
**www.kochmembrane.com**

- Ultrafiltration operates at higher pressures than microfiltration and removes materials that are much smaller, including viruses and proteins. It is often used to separate milk and whey. These filters must be backwashed and cleaned in a manner similar to microfiltration membranes.
- Nanofiltration membranes have pore sizes midway between those of ultrafiltration and reverse osmosis. Nanofilters are often referred to as "softening" filters, since they are effective in removing multivalent cations such as calcium and magnesium.
- Reverse osmosis (RO) removes salts from a water stream. It finds use wherever very pure water is needed, such as laboratories, medical uses including kidney dialysis, metal plating, boiler feed-water, and a number of related applications. Typically, RO will reject 90 to 95 percent of the salts. RO is also used before strong acid/base deionization for the production of ultrapure water for laboratory, pharmaceutical, and microelectronics manufacturing operations.

***Distillation,*** a process once in common use to make water for laboratory applications, is still found in many laboratories. Electric or gas stills are used. Production quantity depends upon the size of the still. Smaller stills often use once-through condenser water and can waste huge volumes of water to produce a single gallon of distillate. Small and medium size stills use air to cool the coils and have no discharge. These are the most water-efficient stills. Some larger stills have reject streams to prevent scale buildup. These typically dump 15 to 25 percent of the water entering the still.

***Disinfection and other technologies*** can consume small amounts of water, if chemicals are fed in a liquid or slurry form. Chemical disinfection technologies include use of chlorine compounds, ozone, and hydrogen peroxide, as well as pH control with acids and bases and the addition of antiscalants and sequestrates such as sodium hexameta phosphate. Ultraviolet light, heat, and extreme mechanical sheer are among other technologies in use.

It is important to examine disinfection requirements. Ultraviolet light, heat, and mechanical sheer processes do not use water. Other processes use water to make up the solutions, but this becomes part of the product water and is not lost. However, cleaning chemical storage areas does consume water. The potential for water savings by choosing among disinfection technologies is not great; however, the potential to waste water in cleaning the equipment and storage vessels is a concern which use of waterless methods can lessen.

## Water-Savings Potential

The first water-saving possibility for water treatment is to question the need for additional treatment. If treatment is cost-effective, choose methods that need the least amount of cleaning and backwash or that have reject streams. All membrane processes produce a reject stream, which in the case of nanofiltration and reverse osmosis might be reusable.

## Cost-Effectiveness Analysis

Cost analysis depends upon many variables. Equipment costs for water treatment processes vary from tens to hundreds of thousands of dollars. For select industries, some level of purified water is essential to operation and is an unavoidable cost. Since many variables are involved in analyzing water-treatment alternatives, a cost-benefit analysis, including the cost of energy, should be conducted for each application to determine the most feasible water-treatment option.

## Recommendations

### *Proven Practices for Superior Performance*

- For all filtration processes, require pressure gauges to determine when to backwash or change cartridges.
- For all filtration processes, base backwash upon pressure differential.
- For all ion-exchange and softening processes, require recharge cycles to be set by volume of water treated or based upon conductivity controllers.
- Require that all softeners be recharged based upon the amount of water they process (demand-based) or by actual measurement of the grains of hardness removed.

### *Additional Practices That Achieve Significant Savings*

- Use water treatment only when necessary.
- Choose a reverse-osmosis or nanofiltration system with the lowest reject rate for its size.
- Choose distillation equipment that recovers at least 85 percent of the feed water.
- Evaluate opportunities to reuse backwash waste streams.

## References

APS Water Services Corporation. www.apswater.com/.

Barnstead International (2555 Kerper Boulevard, Dubuque, Iowa USA 52001-1478.). **Classic Electrically Heated Stills — Operations Manual**.

Doulton USA (19541 Cherry Hill Rd., Southfield, MI 48076). www.doultonusa.com/.

Gibbs, Eric L., Ph.D. July 2001. **Preparation of Reagent Water — Design of Laboratory Water Stills.** High = Q, Inc. www.high-q.com/articles.html.

Hoffman, H. W. (Bill), and Sutton, John T. 2003. **State Energy Conservation Office Suggested Water Efficiency Guidelines for Buildings and Equipment at State Facilities.** Texas State Energy Conservation Office. Austin, Texas.

Hoffman, H. W. (Bill). March 2006. **Building Reduced Water and Wastewater Cost into the Design.** Austin Water Utility. Austin, Texas.

Klenck, Thomas. **How Softeners Work.** Ahdorma Water Filters Purification and Treatment (320 Robling St., #401, Brooklyn, New York). www.thewatersite.com/how_they_work_water_softeners.htm.

Koch Membrane Systems. www.kochmembrane.com.

Loretitsch, Gary. **Guidelines for Managing Water in Cooling Systems: For Owners, Operators, and Environmental Engineers**. Puckorius & Associates. San Jose/Santa Clara Water Pollution Control Plant.

Makini, Byron. Fall 2005. **Achieving Zero Liquid Discharge in the Semiconductor Industry**. Columbia University, Department of Earth and Environmental Engineering. New York, New York.

McDermit, Kery. August 10, 2006. **RO System Helps Unilever Reduce Water Usage**. WaterandWastewater.com.

McIntyre, James P. August 1998. **Industrial Water Reuse and Wastewater Minimization**. BetzDearborne.

Neptune Benson, **Defender Automatic Regenerative Filter** (6 Jefferson Drive, Coventry, Rhode Island 02816)**.** Neptunebenson.com.

North Carolina Department of Environment and Natural Resources, Division of Pollution Prevention. August 1998. **Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities.**

Pacific Northwest Pollution Prevention Research Center. **Pollution Prevention Technology Profile: Conductivity Controls in Water Rinsing, Cooling.**

Thompson, Chris; and Lickteig, Edward. October 2008. ***Recycling High Purity Rinsewater at Samsung Austin Semiconductor.*** Ultrapure Water, Samsung Austin Semiconductor. Austin, Texas.

**Towers and Boilers.** February 2005. Seattle, Washington.

Wilcox, Daniel. 2005. **AMD Austin Water Conservation Summary**. Advanced Microdevices (AMD). Austin, Texas.