

RO8600

Reverse Osmosis

Water Purification Systems



Edstrom INDUSTRIES, INC.

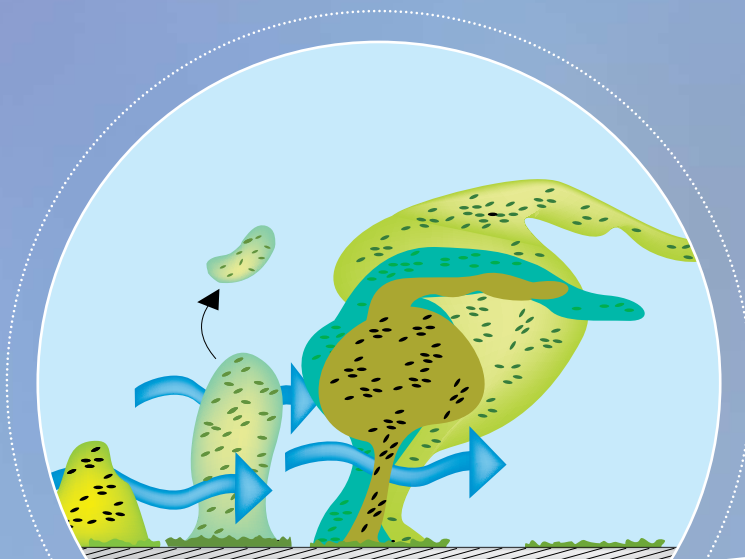
The Importance of Pure Water for Laboratory Animals

Current animal research trends demand control of as many variables as possible, including water quality. Contaminant concentrations in municipal water supplies have wide seasonal fluctuations. Therefore, simply filtering and disinfecting municipal water may not provide water of a reliable and controlled quality necessary for laboratory animals, particularly animals developed for highly refined applications such as specific-pathogen-free, immunocompromised, transgenic, and knock out animals.

Using reverse osmosis (RO), the animal facility can remove contaminants from animal drinking water. Reverse osmosis is a water purification process that removes 95-99% of most contaminants including microorganisms, organic compounds, dissolved inorganic compounds, microbial by-products such as endotoxins and pyrogens, and many carcinogenic compounds. These contaminants add uncontrolled variables to research involving laboratory animals, and can adversely affect animal health. RO water provides standardized water quality that is less dependent on a facility's location or water source. Reverse osmosis gives you control over the water quality being consumed by your animals. It prevents a compromised municipal supply from introducing a variable into laboratory animal studies.

RO machines are also key in managing biofilm development in watering systems. Biofilm is a collection of bacteria surrounded by slime. These slime cities thrive wherever there is water. Biofilm bacteria have sticky polymers that hold it together and cement it to a pipe wall. A biofilm can mature in several hours or weeks. These bacteria can cause infection and disease in laboratory animals. *Pseudomonas aeruginosa* is one such bacteria that can infect animals with suppressed immune systems. Biofilm is also responsible for corroding pipes, clogging water filters, and the rejection of medical implants. Almost all free-floating (planktonic) bacteria have detached from biofilm. Unfortunately biofilm cannot be prevented or eliminated, but it can be managed. Water purification can help. Reverse osmosis provides nutrient-poor water, which supports less biofilm than regular tap water, resulting in a thinner, less harmful biofilm.

*Biofilms form on piping surfaces when bacteria attach and secrete an extra cellular polymeric substance – slime!
(Costerton 1995)*





Contaminants Removed From Water by Reverse Osmosis

Reverse osmosis water treatment removes the contaminants shown in the table to the left. Performance is given as percent rejection or the percentage of the contaminants removed from a given water supply.

What does Reverse Osmosis Remove from Water?

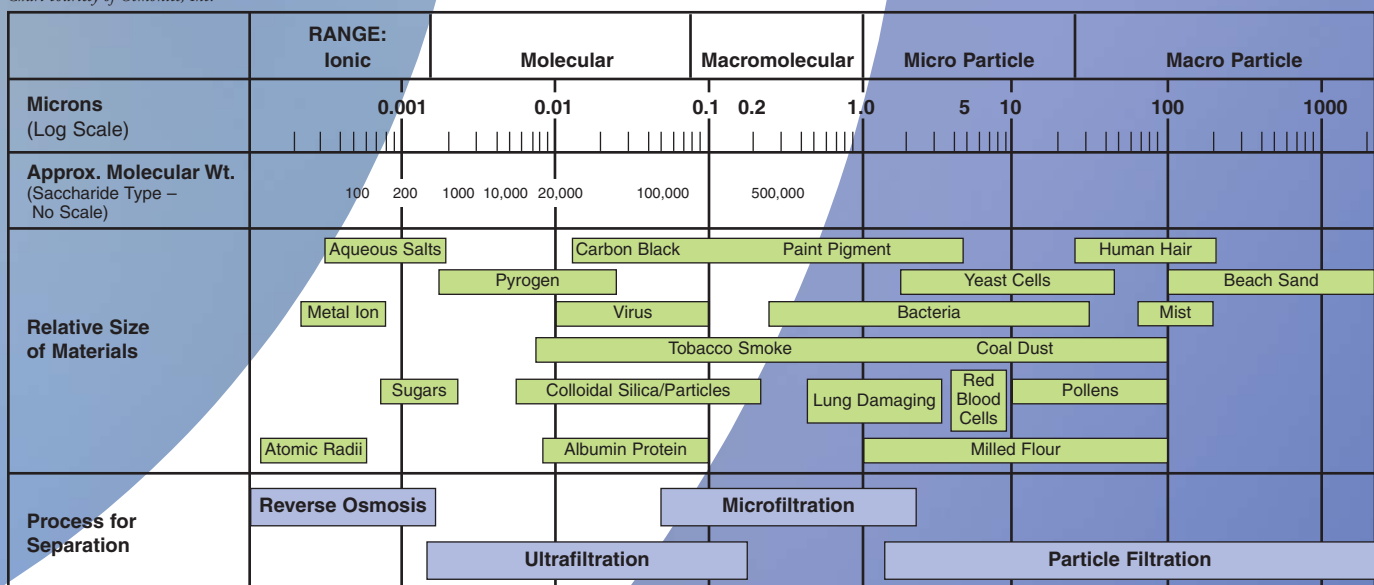
Contaminant	Standard CA Membrane	Optional PA Membrane
Dissolved Ions	>93%	>95%
Organics	99% >200MW	99% >150 MW
Particles	>99%	>99%
Bacteria	>99%	>99%
Pyrogens	>99%	>99%

MW=Molecular weight. The molecular weight cut-off is based on the pore size of the membrane. Organic contaminants smaller than the cut-off size can pass through the RO membrane. To remove smaller organic contaminants, carbon filtration pretreatment can be used.

Reverse osmosis removes some contaminants more effectively than others. Contact Edstrom Industries for more information about the removal of a particular impurity.

The Filtration Spectrum

Chart courtesy of Osmonics, Inc.



This chart shows the relationship of contaminant size to filtration process. Reverse osmosis removes materials in the ionic size range and larger.

How Does Reverse Osmosis Work?

Reverse osmosis is a water purification process in which water is forced by pressure through a semi-permeable membrane.

In normal osmosis, water flows from a less concentrated solution through a semi-permeable membrane to a more concentrated solution (see Figure 1). Reverse osmosis uses pressure to reverse normal osmotic flow. Water flows from a more concentrated solution through a semi-permeable membrane to a less concentrated solution (see Figure 2).

The feedwater to the reverse osmosis system flows over the surface of the membrane and a percentage of the water is forced through by pressure. This is purified water or **permeate**. The remaining water, **concentrate**, retains the rejected contaminants and is drained (see Figure 3).

The percentage of feedwater that is recovered as permeate, called **percent recovery**, is typically 50 percent. The other 50 percent is drained.

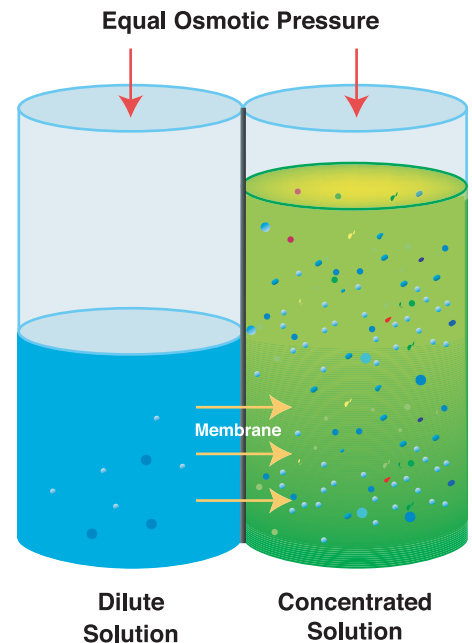


Figure 1: Osmosis

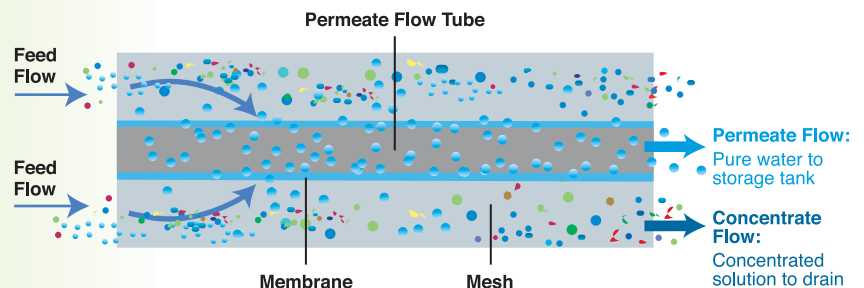


Figure 3: Permeate and Concentrate Flows

Purified Water Treatment Comparisons

Distillation, like reverse osmosis, is a water purification method which will remove a wide range of contaminants (see table below). Because they are more energy intensive,

distillation units are more expensive to operate than reverse osmosis systems. Scale formation can also be a problem with distillation units.

WATER TREATMENT GUIDE						
	Particulates	Ions/Metals	Organics	Volatile Organics	Microorganisms	Pyrogens
Reverse Osmosis (RO)	●	●	● ¹		●	●
Distillation	●	●	●		●	●
Deionization (DI)		●			○	
Ultrafiltration	●		● ²		●	●
Filtration, 5 micron	●				○	
Filtration, 0.2 micron	●				●	
Carbon Filtration			●	●	○	
Chlorination					●	
Acidification					●	
Ozonation					●	
Ultraviolet Disinfection					●	

This table shows how reverse osmosis compares with other water treatment and purification methods in the ability to remove a variety of contaminants. Many of the treatment methods for microorganisms can be used for post-treatment of RO water.

● = Effective removal or treatment

○ = Detrimental effect

¹ Organics > 200 molecular weight

² Organics > 1000 + molecular weight

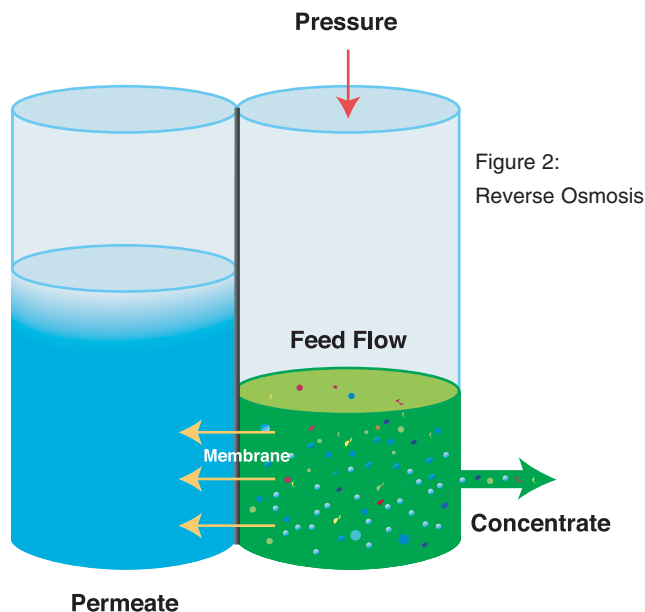


Figure 2:
Reverse Osmosis

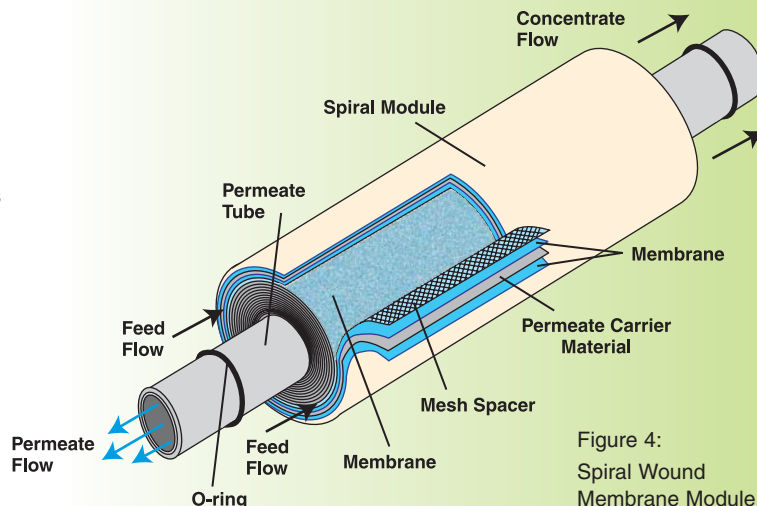


Figure 4:
Spiral Wound
Membrane Module

Two membrane materials are available:

- **Cellulose Acetate (CA or CTA) Membrane** – CA/CTA membranes can tolerate chlorine. Dissolved chlorine will pass through the CA membrane into the purified water. Systems using CA membranes include pretreatment to chlorinate feedwater to 0.3-2.0 ppm.
- **Polyamide (PA) Membrane** – PA membranes have slightly higher ionic rejection and permeate flow rates than CA membranes. They have zero chlorine tolerance, so chlorine must be removed from RO feedwater when using PA membranes.

CA membranes are standard. For animal drinking water, CA membranes are preferred over PA despite lower ion rejections. They pass dissolved chlorine which tends to keep permeated water bactericidal. Very high chemical rejections are unnecessary in most laboratory animal applications, but organism content is of paramount concern.

Spiral Wound Membrane Module

Edstrom Industries uses a spiral wound membrane module which is, basically, a membrane envelope sealed to a center tube and then rolled up like a scroll. Spiral wound modules have several advantages over other designs. They have a very high membrane area per unit volume, and the flat sheet can't break and cause permeate contamination. Spacers between membrane layers promote turbulent flow to ensure low fouling and longer life (Figure 4 above).

Ion Exchange (Deionized or DI) water is purified by passing water through ion-exchange resins which remove only dissolved ionized chemicals. Deionization does not remove organic chemicals, bacteria, and other microorganisms (see table at left). A big problem with DI water is that colonies of microorganisms can become established and proliferate on the nutrient-rich surfaces of the resin. When not regularly sanitized or regenerated, ion-exchange resins can contaminate drinking water with bacteria.

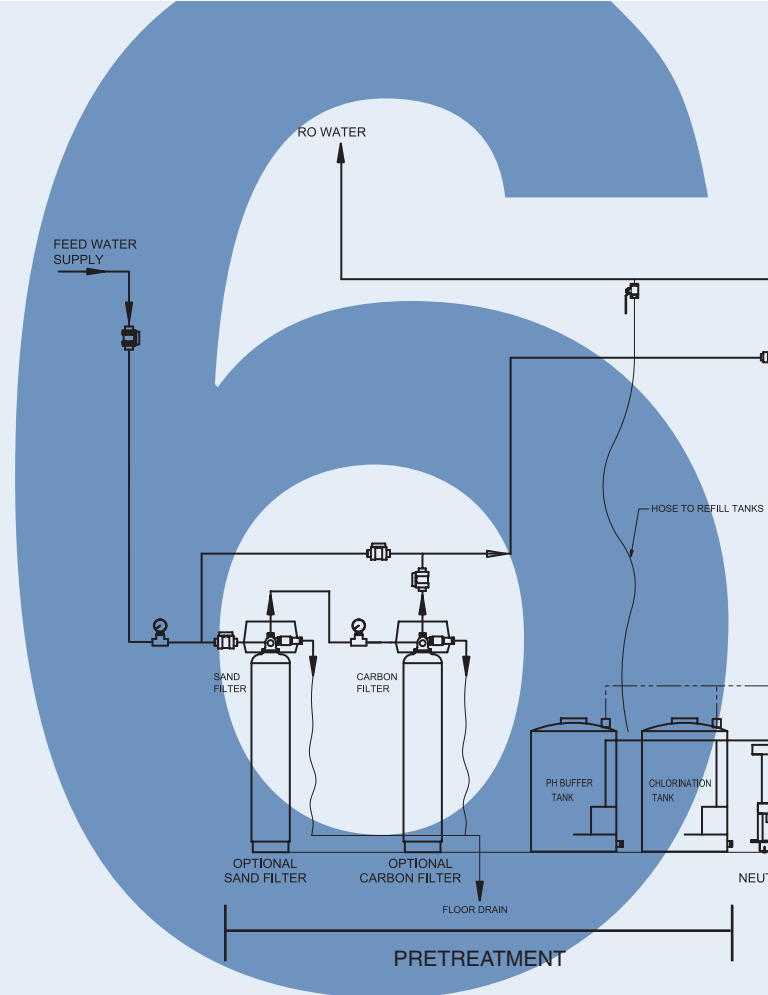
Ultraviolet disinfection could best be described as invisible radiation that kills microorganisms by striking the cell. UV energy penetrates the outer cell membrane, passes through the cell body, and disrupts its DNA, preventing reproduction. UV treatment does not alter water chemically; nothing is added except energy. Under ideal conditions, UV can provide greater than 99% reduction of all bacteria. However, UV does not remove dissolved organics, inorganics, or particles in the water. UV units only kill bacteria at one point in a watering system and do not provide any residual germicidal effect downstream. Bacteria cells are not removed in a UV unit, but are converted into pyrogens. The killed microorganisms and any other contaminants in the water are a food source for any bacteria that do survive downstream of the UV unit.

Ultrapure Water contains very low amounts of chemical impurities and has a resistance of 1 to 18 megohm-cm. In the laboratory, ultrapure water usually refers to Type 1 reagent grade water. RO drinking water is not ultrapure. Reverse osmosis removes approximately 93-97 percent of dissolved ionized chemicals from the feedwater which means that 3 to 7 percent of minerals pass through the membrane into the drinking water. Depending on the feedwater quality, the conductivity of RO drinking water is typically 5-50 micromho/cm (resistance = 0.2-0.02 megohm-cm). The purity of ultrapure water is about 100 or more times greater than RO drinking water.

The advantages of RO water over ultrapure water:

1. Less "aggressive". RO Water will not dissolve piping materials as fast as ultrapure water. (RO water is more aggressive than tap water so only stainless steel and plastic piping are used, not brass or copper.)
2. Less expensive. An ultrapure water system might start with RO quality water and purify it further with distillation or deionization.

Basic Features of the RO Machine



PRETREATMENT

Pretreatment of the feedwater is a key factor for the successful long-term operation of an RO system.

Filtration: 5 Micron Prefilter mounted on the RO machine removes suspended particles from the feedwater to prevent membrane plugging.

Optional Multi-media Sand Filter: Feedwaters high in suspended solids or turbidity may require a sand filter in addition to the 5 micron prefilter. Automatic backflush periodically flushes the captured solids to drain.

Optional Activated Carbon Filter: Filter may be needed to:

1. Remove small organic contaminants (less than 200 molecular weight) not removed by reverse osmosis.
2. Remove feedwater chlorine (PA membranes only). A multi-media sand filter placed upstream will keep the carbon filter free of solids.

pH Adjustment: Soluble salts in natural water supplies are concentrated in the RO process and may precipitate to form a scale deposit on the membrane surface. To keep these salts dissolved, the pH of the feedwater is adjusted to 5.8-6.2 by injecting acid. The pH buffer system includes an acid storage tank, chemical feed pump, and in-line pH probe with analyzer for monitoring and control.

Chlorination (CA/CTA Membrane only): Microorganisms can grow on most surfaces that are immersed in water with no biocides. To prevent bacterial growth in the RO system, feedwater

is chlorinated to 0.3-2.0 ppm. Some chlorine will pass into the RO water to protect against bacterial regrowth in the storage tank.

RO MACHINE

Frame: Floor standing frame of 304 stainless steel includes level adjusting feet, and a NEMA 12 water resistant control panel enclosure.

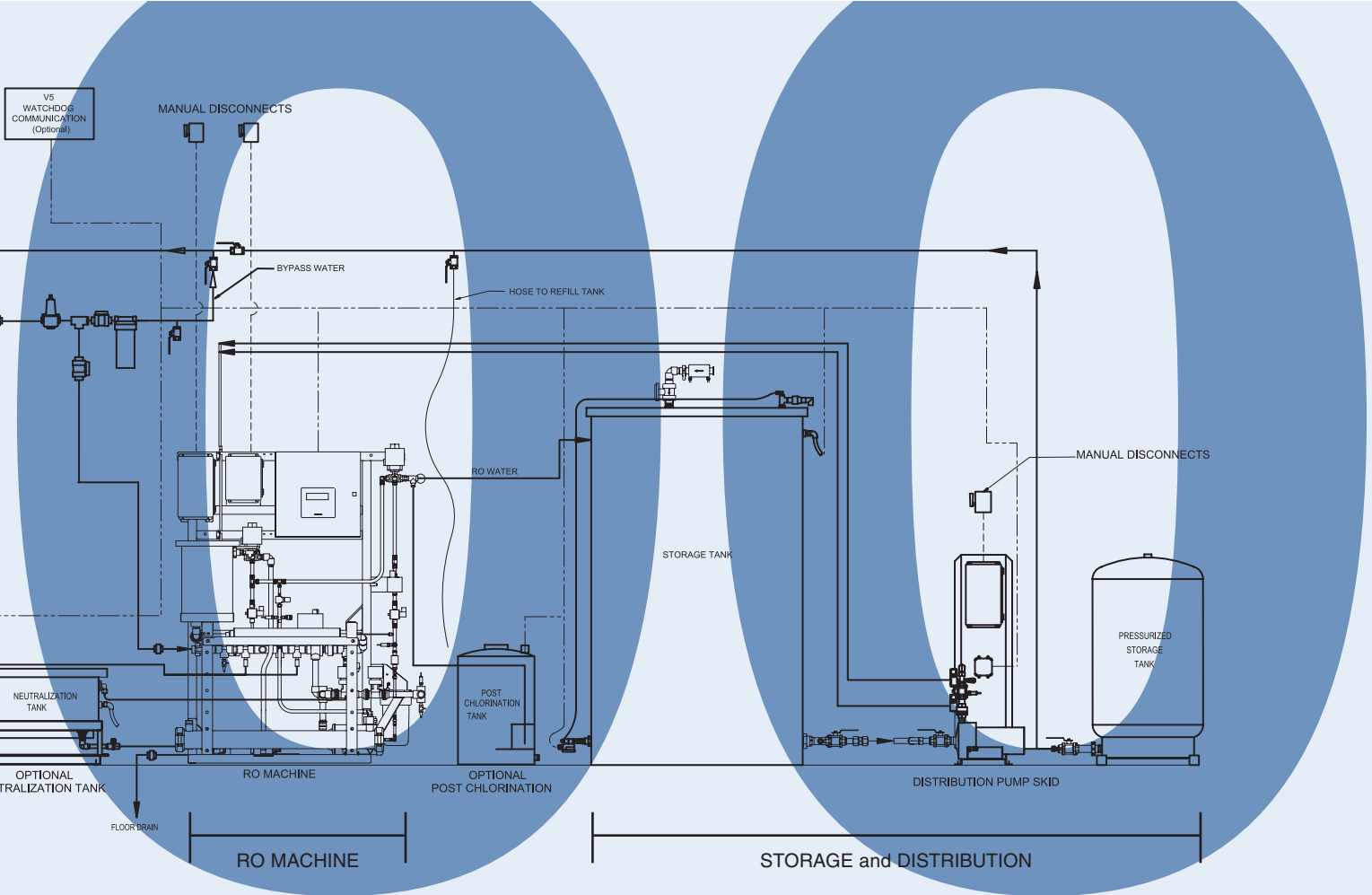
Pump: Reliable multistage centrifugal pumps achieve operating pressures of 200-225 psi.

Pump and Membrane Protection: Pressure, flow and temperature transducers continuously sense system vitals that are monitored by the Controller. The system will alarm and shut down if water pressure or flow is lost, or if water temperature rises above 100°F.

Product Water Monitoring: Conductivity and flow transducers continuously sense permeate water vitals. The Controller also monitors vitals. When poor water quality is detected, the Controller alarms and diverts permeate water to drain, to protect the quality of permeate in the storage tank.

Additional Components:

- **Autoflush System** provides automated high velocity membrane flushing at preset intervals to extend membrane life.
- **Flow Control Valves** can be adjusted to control operating pressure and to maximize permeate recovery.
- **Flowmeters** monitor permeate and concentrate rates.



Clean-In-Place System: Cleaning of the machine is vital because contaminants can build up on the membrane surfaces and reduce permeate quality and membrane life. The Clean-In-Place System includes a solution tank, 3-way automatic valves, cleaning solution injectors, and all necessary piping. Every 90 days, or sooner if performance parameters dictate, a detergent cleaning solution is mixed, recirculated through the machine, and flushed out. The cycle is automated, requiring no manual control.

Optional Cleaning Solution Neutralization Tank: This tank permits manual neutralization of cleaning solution when local code regulates disposal of solutions with low pH. The Neutralization tank catches and holds the cleaning solution until the solution is manually neutralized and drained.

Control Panel: For automated operation and quality assurance, a microprocessor-based control panel is used to control the entire system.

Features include:

- **Message Screen** displays printed messages of alarm conditions and operational status.
- **Local Alarms** include an audible buzzer and alarm light located on the control panel door.
- **Watchdog Integration:** Alarm warning messages are displayed on the control panel graphics display. When the RO is connected to the Watchdog system, alarms are reported via email, paging or callout.
- **Remote alarm, dry contact relay** is included for use with other alarm devices. A second dry contact relay is used for

the Power Loss remote alarm.

STORAGE and DISTRIBUTION

Storage Tank: The storage tank accommodates peak water usage (such as during flushing of watering system) and provides a reserve water supply to cover machine cleaning and repair periods while also protecting the RO water from contamination. Available in sizes from 50 to 1,000 US-gallons.

Features include:

- **Sealed Cover** with air vent filtration to 0.2 microns prevents airborne contamination.
- **Multi-level Monitoring** controls reverse osmosis filling cycle and alarms for low, empty, and overfull water levels.
- **Food Grade** polyethylene material.

Dual Purified Water Distribution Pumps: Two pumps operate alternately to repressurize stored RO water. This provides automatic backup operation with alarm if either pump fails. Centrifugal pumps are made from 316 passivated stainless steel for compatibility with RO water.

Pressure Tank: This tank stores repressurized RO water to minimize pump starts and stops. It can be filled directly by the RO machine for applications with low volume stored water requirements. It is not used in recirculating distribution systems.



RO8600

The Controller

The controller operates the entire RO system. The controller includes a graphic display that can support various languages by simply installing a new language chip. Daily log calculations are automated; the RO performs and stores daily log information for up to 90 days. Percent rejection, permeate conductivity, normalized differential pressure, post chlorine, and pH are some of the items included in the daily log. Information can be viewed from the front panel or uploaded to a laptop where it can be stored in CSV (comma separated value) format.

Watchdog Integration

The new controller also offers the option to connect the RO to the Edstrom Watchdog Vivarium Management System – version 5. Because Watchdog automates the daily log and notifies you of problems, staff normally assigned to checking the RO on a daily basis can be reassigned to other tasks. Watchdog will automatically store the daily log information. Daily log reports can be generated from Watchdog at any time for any date range. The Watchdog interface also supports the ability to monitor current RO operating parameters from any networked PC using the Web interface. Watchdog reports alarms using email, paging or callout, so if the machine shuts down you know right away. In addition to collecting daily log information, Watchdog will store events related to cleaning, configuration changes on the machine, and back flushing of pre-filters.

Water Production Capacity: RO8600

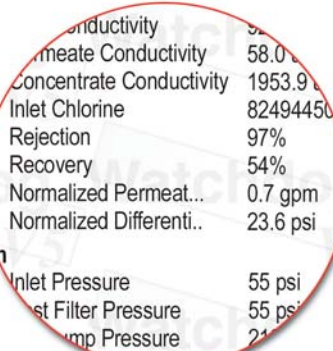
Permeate Production Range (Feed 60°F)¹

STANDARD CA/CTA Membrane	OPTIONAL PA Membrane
585-3510 US-gallons/day	1242-7452 US-gallons/day

¹ Permeate production is greater at higher temperatures. For 77°F feed, production increases by a factor of 1.28.

FEATURES:

- Local alarms •
- Low voltage control •
- Easy access for service •
- 86 US-gallon pressure tank •
- Optional neutralization tank •
- Contains Clean Joint fittings •
- Optional chlorine monitoring •
- Daily log calculations automated •
- Monitors quality of product water •
- Automated system control and monitoring •
- Water capacity of 585-3510 US-gallons/day •
- Generates daily log reports from Watchdog •
- Stainless steel plumbing •
- Automatic Clean-In-Place system •
- Integrates with Watchdog V5 System •
- Controller supports various languages •
- When connected to Watchdog, reports alarms via email, page, or callout •
- Current RO operating parameters can be monitored from any networked PC when using Watchdog Web •
- Monitors pH, flow, temperature, pressure, and conductivity •
- Removes 95-99% of water-borne contaminants •



Conductivity	58.0
Permeate Conductivity	1953.9
Concentrate Conductivity	82494450
Inlet Chlorine	97%
Rejection	54%
Recovery	0.7 gpm
Normalized Permeat...	23.6 psi
Normalized Differenti...	
Inlet Pressure	55 psi
Post Filter Pressure	55 psi
Pump Pressure	21

Watchdog Web allows you to check the current RO machine status and displays water quality information from any computer in the world that is connected to the Internet.



Clean Joint Fitting and Stainless Steel Plumbing

The RO machine utilizes all stainless steel plumbing to carry the permeate RO water to the storage tank and contains Edstrom Clean Joint Fittings. This clean system design minimizes the places biofilm can grow. The Clean Joint eliminates dead legs by drawing pipe ends together at an L-shaped rubber seal. This provides a smooth internal profile that is free of internal dead spaces that can harbor bacteria and biofilm.

Low Voltage Control

The RO8600 operates on 24-volt control. This low voltage power is utilized by control valves, transducers, and the Controller to provide additional safety.

Easy Access for Service

The RO8600 is designed for ease of service. Membrane replacement is fast and easy with membranes located horizontally on the front of the machine. Preventive maintenance sample ports and 5-micron filter are located for easy access.

Optional Chlorine Monitoring

Chlorine monitoring is available for pre or post membrane monitoring. The Controller interfaces with the monitor to provide on/off control of chlorine injection and out of range alarm.

RO8600 Benefits

- Removes nearly all contaminants from drinking water
- Prevents the introduction of a variable associated with water into your lab animal studies
- Gives immediate notification of problems
- Provides a standardized water quality
- Supports less biofilm
- Provides control over water quality
- Helps prevent disease in laboratory animals
- Saves valuable time and labor by automating the daily log so staff can be assigned to other tasks
- Helps keep watering systems in good condition – prevents the clogging of water filters and corrosion of pipes



Equipment Operation and Maintenance

Daily Operation

Reverse osmosis systems require regular attention and maintenance. This includes changing filters, refilling solution tanks, and documenting operating parameters. Your facility personnel will be trained in daily operational maintenance by an Edstrom representative.

Each RO system comes with a maintenance kit which includes:

- Clearly organized log sheets for units that are not connected to Watchdog for documenting system operating parameters
- Chlorine test kit and handheld conductivity meter for checking pretreatment and product water quality
- Solutions for calibrating in-line





Maintaining Water Quality

To maintain the purity of RO water until it reaches the animal's drinking valve, the following automated watering system design features should be incorporated into your system.

Wetted Materials:

Stainless steel (316) and plastics are acceptable storage and piping materials for RO water. Copper and brass components should not be used.

Piping Layout:

Piping should be laid out to ensure flow through the entire system. Stagnant dead-end lengths of pipe should be avoided. Serpentine distribution piping increases the effectiveness of flushing procedures. The Edstrom Clean Joint fitting elimi-

nates dead spaces that harbor bacteria and biofilm.

Flushing Systems:

In normal use, the flow of water through an automated watering system is low and intermittent. Regular high pressure flushing will exchange the water and help control bacteria. Edstrom Industries offers both manual and automated flushing systems for room distribution system and rack manifold piping. A residual disinfectant will help control bacteria, limiting biofilm thickness.

Recirculating Systems:

Constant water recirculation is another method of reducing water stagnation. Water flows from the storage tank, through an ultraviolet disinfection unit, to the room distribution system, and back to the tank.

Chlorination:

If possible, some chemical protection against bacterial regrowth is recommended. Using the CA membrane, reverse osmosis will pass up to approximately 1.5 ppm of chlorine into the purified water. If necessary, an optional Chlorine Injector Station can be used for additional chlorination of RO water.

System Sanitization:

Room distribution piping, rack manifold piping, and recoil hoses should be periodically sanitized to control bacteria growth. Edstrom Industries' Portable Sanitizer, Chlори-Flush, and Recoil Hose Flush Stations offer easy, effective means of sanitizing system components.

Preventive Maintenance

Additional maintenance and calibrations should be done every six months. Edstrom Industries' trained technicians can perform this maintenance.

Contact Edstrom Industries, Inc., at 800-558-5913 or by Fax 262-534-5184, for more information about our Preventive Maintenance Contracts. (EUROPE +44(0)1432 830 026)

UNIT SPECIFICATIONS*

Pretreatment

- Chlorine control
- pH control
- Prefiltration

Reverse Osmosis Machine

cabinets and frame – floor standing

- Overall size: 60"W x 38"D x 78"H
{1.52(m)W x 0.97(m)D x 1.98(m)H} max with membranes
(Six membrane model)
- Five or less membrane model: 60"W x 35"D x 78"H
{1.52(m)W x 0.89(m)D x 1.98(m)H} max with membranes
- Material: 300 series stainless steel
- Water capacity: 585-3510 US-gallons/day
(2214-13287 litres/day)
- Optional neutralization tank
(Separate floor standing assembly)

Reverse Osmosis Pump and Membranes

Pump/Motor

- Type: multistage centrifugal
- Pump material: stainless steel
- Motor: 208-230/460 VAC, 60Hz, 3 phase, 3HP**
- Control: automatic with manual on/off inlet valve

Membranes

- Type: spiral wound, 4.0" dia. x 40" length
{10(cm) dia. x 102(cm) length}
- Material: cellulose acetate (CA)
- Housing: 304 stainless steel; 4.5" dia. x 49"
{11.5(cm) dia x 124.5(cm)}

Sensors/Transmitters and Controls

- pH monitoring
- Flow monitoring
- Temperature monitoring
- Pressure monitoring
- Conductivity monitoring

Control Panel

- Microprocessor based controller
- Display: 64 x 240 character LCD graphics display
- Audible alarm with disable mode
- Input power: 24VAC, 50/60Hz, 1 phase isolated

Maintenance Equipment

Automatic Clean-in-Place

- Polyethylene, 18 US-gallon (68 litre) tank
- Stainless steel Fill Solenoid

Piping, Tubing, Fittings, Connections

PVC/CPVC/Polypropylene/316 stainless steel

Storage Tank Assembly

Capacity: sized to application (320-1000 US-gallons)
(1211-3785 litres)

- Material:
- Polyethylene tank and gasket
 - Polypropylene cover
 - 316 stainless steel hardware

Purified Water Distribution Dual Pump Skid

Type: centrifugal

Wetted material:

- Pump – 316 stainless steel passivated
- Piping/Fittings – 316 stainless steel passivated and electropolished
- Motor: 208-230/460 VAC, 50/60Hz, 3 phase**
(sized to application, 1.5-2.0 HP)
- Motor Starter: frame mounted and prewired to motors
- Floor standing frame: stainless steel
- Size: 30"D x 36"W x 49.5"H
{76(cm)D x 92(cm)W x 126(cm)H}

Pressure Tank

Provides pressurized storage of RO product water

Capacity: Size per application

- 86 US-gallon (325 litre) tank with 25.4 US-gallon (96 litre) working capacity at 40/55 psi (2.76/3.79 BAR) drawdown
- Optional 34 US-gallon (129 litre) tank with 10 US-gallon (38 litre) working capacity at 40/55 psi (2.76/3.79 BAR) drawdown
- Wetted material: polypropylene, butyl – FDA approved with stainless steel fitting
- Size: 26"D x 47.2"H – (86 US-gallon) or 22" dia x 29.5"H
(optional – 34 US-gallon)
66(cm)D x 120(cm)H – (325 litre) or
56(cm) dia x 75(cm)H (optional – 129 litre)
- Floor standing

Capabilities and Features

System performance:

CA Membrane

- Salt rejection 93-97%
- Organic rejection >200 MW
- Bacteria rejection >99%
- Pyrogen rejection >99%
- Particle rejection >99%

Automated System Control and Monitoring

*Specs subject to change without notice

**Kits available to adapt unit to power supplies that differ from listed

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