Triangularwave Technologies, Inc. (TWT®)

Explore Innovative Solutions

TWT Offers A Bold Series Of Reverse Osmosis Systems Designed To Meet The Demanding Challenge in Fluid Management!

Triangularwave Technologies, Inc. provides the right combination of value, components and features required for any R.O. application.

Let TWT, Inc. design a fluid management system to meet your industry specific application.

TWT RO water treatment systems are ruggedly constructed for exceptional performance. The rugged self-contained design of these systems ensure that the system will enjoy a long and reliable lifecycle when properly cared for.

TRIANGULAR WAVE TECHNOLOGIES, INC.
FLUID MANAGEMENT SOLUTIONS
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TA199

REVERSE OSMOSIS REVERSE OSMOSIS REVERSE OSMOSIS

Our World Is Changing:

Contaminations of water supplies all over the world has caused regulating agencies in different countries to rewrite the rules for the supply of safe water. Also, many industries now require a completely salt free water for their processes; and last, the scarcity of clean water has sent water treatment technicians to look for alternatives in feed water supplies. The need for contaminant free water has developed a totally new industry, now about a quarter century old, and the advances in technology created many alternatives in water treatment.

Whenever there is a chance of microbial contamination from waterborne pathogens such as cryptosporidium, giardia, coliforms, or viruses, new requirements in quality from special industries and bottling, have led water distributors towards the preferred technology - a membrane barrier purification system.

In the municipal side, both the United States and European regulations have had a significant impact on the treatment. Membranes can also remove dissolved solids such as arsenic, boron and nitrates and treat seawater and brackish water in coastal areas.

Membrane technology is the most reliable method of meeting the new requirements when compared to traditional techniques - conventional clarification/filtration, diatomaceous earth, and slow sand filtration.

Reverse Osmosis can meet or exceed today's regulations and planned changes for the future.

Why Membranes

Membrane separation systems provide clarification, softening, disinfection, & organic removal in compact automated modular units. They are superior to conventional filtration plants because they provide a positive physical barrier between contaminants in the feedwater and the purified product water. Membranes can meet new municipal water requirements with few chemical additives and no sludge disposal. Better yet, they can be installed in small facilities throughout the service area, even in residential neighborhoods.

But all membranes are not the same. The TWT engineering staff will select the best membrane for your water source. At times this may require more than one type of membrane for which TWT, Inc. is your single source supplier. We are in a unique position to design, build and integrate systems which can be combined with other processes for multiple barriers. Not only are we one of the leading equipment manufacturers of the four types of membrane; microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO), but we offer our equipment in three cartridge/element configurations; hollow fiber, tubes and spiral-wound. TWT, Inc. and it's suppliers will provide the best system for your needs.

Safe, Certified, Proven

For over two decades TWT, Inc. engineers, staff and technicians have lead the way in manufacturing filtration systems. With membrane systems installed in over 15 countries - including hundreds of industrial systems - we've demonstrated that we can help virtually everybody meet their water production requirements and wastewater reclamation needs safely and reliably.

TWT can help you decide which membrane will work best, Whether your water source is a river, lake, well, reservoir, spring, stream, snowmelt, brackish water, wastewater or seawater. Our manufacturer then designs, builds and delivers a rugged system based on the selected membrane. Our systems have been certified as meeting all pertinent requirements by regulating authorities in many countries as well as the United States.

Economics Favor Membranes

Advances in technology have brought membrane costs significantly down. Construction costs are lower because systems don't require large buildings or as much land as conventional systems.

Operating costs are reduced since today's membranes produce more water and remove more impurities while using less energy. Systems can be fully automated and systems include programmable logic controllers, and we'll show you how to do it in the most cost effective and reliable way.

All products and systems are shipped with easy to follow application, installation and maintenance manuals.

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What is Reverse Osmosis:

Reverse Osmosis?

Reverse Osmosis (RO) is a modern process technology to purify water for a wide range of applications, including semiconductors, food processing, biotechnology, pharmaceuticals, power generation, seawater desalting, and municipal drinking water. From initial experiments conducted in the 1950's which produced a few drops per hour, the reverse osmosis industry has today resulted in combined worldwide production in excess of 1.7 billion gallons per day. With demand for pure water ever-increasing, the growth of the reverse osmosis industry is poised to continue growing well into the next century. This section will provide historical background on the development of RO, and introduce the reader to the concepts of osmosis and semi-permeable membranes. A simple illustration to show how RO works to purify water is provided.

Historical Background

Research on Reverse Osmosis began in the 1950's at the University of Florida where Reid and Breton were able to demonstrate desalination properties of cellulose acetate membrane. Loeb and Sourirajan continued the development of the RO technology with the creation of the first asymmetric cellulose acetate membrane.

Research on these promising developments spawned new and better configurations of RO elements; today the industry produces predominately spiral wound elements, or in some cases, hollow fiber elements. In the early 1980's, research in US Government Labs resulted in the first Composite PolyAmide membrane. This membrane had significantly higher permeate flow and salt rejection than cellulosic membranes. Today, with the introduction of the ultra low pressure membranes, the industry has attained a 20-times increase in flow per pressure over original cellulosic membranes, with an order of magnitude decrease in salt passage.

What is Semi-permeable?

Semi-permeable refers to a membrane that selectively allows certain species to pass through it while retaining others. In actuality, many species will pass through the membrane, but at significantly different rates. In RO, the solvent (water) passes through the membrane at a much faster rate than the dissolved solids (salts). The net effect is that a solute-solvent separation occurs, with pure water being the product. (In some cases, dewatering is desired to concentrate the salts).

What is Osmosis?

Osmosis is a natural process involving the flow of a concentrated solution across a semi-permeable membrane barrier. Consider a tank of pure water with a semi-permeable membrane dividing it into two sides. “Pure water in contact with both sides of an ideal semi-permeable membrane at equal pressure and temperature has no net flow across the membrane because the chemical potential is equal on both sides.

If a soluble salt is added on one side, the chemical potential of this salt solution is reduced. Osmotic flow from the pure water side across the membrane to the salt solution side will occur until the equilibrium of chemical potential is restored. In scientific terms, the two sides of the tank have a difference in their "chemical potentials," and the solution equalizes, by osmosis, its chemical potential throughout the system. Equilibrium occurs when the hydrostatic pressure differential resulting from the volume changes on both sides is equal to the osmotic pressure. The osmotic pressure is a solution property proportional to the salt concentration and independent of the membrane.

Desalination Technologies and Filtration Processes

Reverse osmosis (RO) and nanofiltration (NF) membrane technologies are widely recognized to offer the most effective and economical process options currently available. From small scale systems, through to very large scale desalination, RO and NF can handle most naturally occurring sources of brackish and sea waters. Permeate waters produced satisfy most currently applicable standards for the quality of drinking waters.

RO and NF can reduce regeneration costs and waste when used independently, in combination or with other processes, such as ion exchange. They can also produce very high quality water, or, when paired with thermal distillation processes, can improve asset utilization in power generation and water production against demand.

The various filtration technologies which currently exist can be categorized on the basis of the size of particles removed from a feed stream. Conventional macrofiltration of suspended solids is accomplished by passing a feed solution through the filter media in a perpendicular direction. The entire solution passes through the media, creating only one exit stream. Examples of such filtration devices include cartridge filters, bag filters, sand filters, and multimedia filters. Macrofiltration separation capabilities are generally limited to undissolved particles greater than 1 micron. For the removal of small particles and dissolved salts, cross flow membrane filtration is used. Cross flow membrane filtration uses a pressurized feed stream which flows parallel to the membrane surface. A portion of this stream passes through the membrane, leaving behind the rejected particles in the concentrated remainder of the stream. Since there is a continuous flow across the membrane surface, the rejected particles do not accumulate but instead are swept away by the concentrate stream.

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There are four general categories of cross flow membrane filtration: microfiltration, ultrafiltration, nanofiltration, and reverse osmosis.

Microfiltration (MF)

Microfiltration removes particles in the range of approximately 0.1 to 1 micron. In general, suspended particles and large colloids are rejected while macromolecules and dissolved solids pass through the MF membrane. Applications include removal of bacteria, flocculated materials, or TSS (total suspended solids). Transmembrane pressures are typically 10 psi (0.7 bar).

Ultrafiltration (UF)

Ultrafiltration provides macro-molecular separation for particles in the 20 to 1,000 Angstrom range (up to 0.1 micron). All dissolved salts and smaller molecules pass through the membrane. Items rejected by the membrane include colloids, proteins, microbiological contaminants, and large organic molecules. Most UF membranes have molecular weight cut-off values between 1,000 and 100,000. Transmembrane pressures are typically 15 to 100 psi (1 to 7 bar).

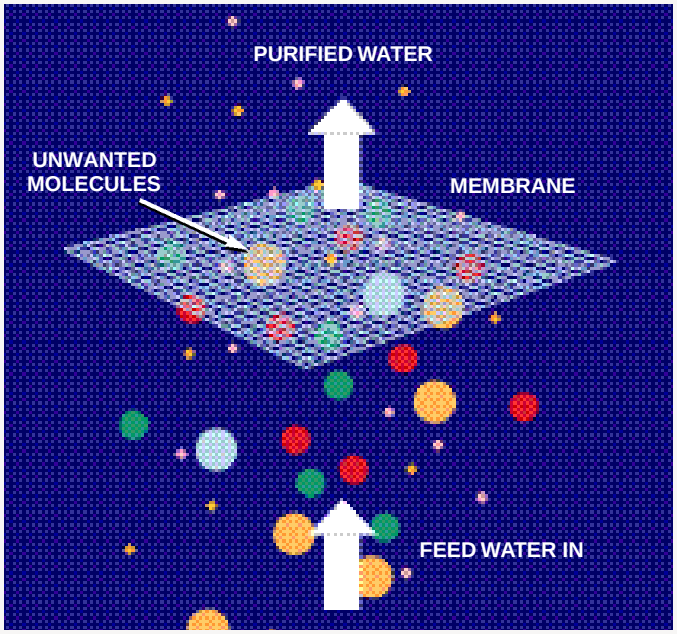
Nanofiltration (NF)

Nanofiltration refers to a speciality membrane process which rejects particles in the approximate size of 1 nanometer (10 Angstroms), hence the term “nanofiltration.” NF operates in the realm between UF and reverse osmosis. Organic molecules with molecular weights greater than 200-400 are rejected. Also, dissolved salts are rejected in the range of 20-98%. Salts which have monovalent anions (e.g. sodium chloride or calcium chloride) have rejections of 20-80%, whereas salts with divalent anions (e.g. magnesium sulfate) have higher rejections of 90-98%. Typical applications include removal of color and total organic carbon (TOC) from surface water, removal of hardness or radium from well water, overall reduction of total dissolved solids (TDS), and the separation of organic from inorganic matter in specialty food and wastewater applications. Transmembrane pressures are typically 50 to 225 psi (3.5 to 16 bar).

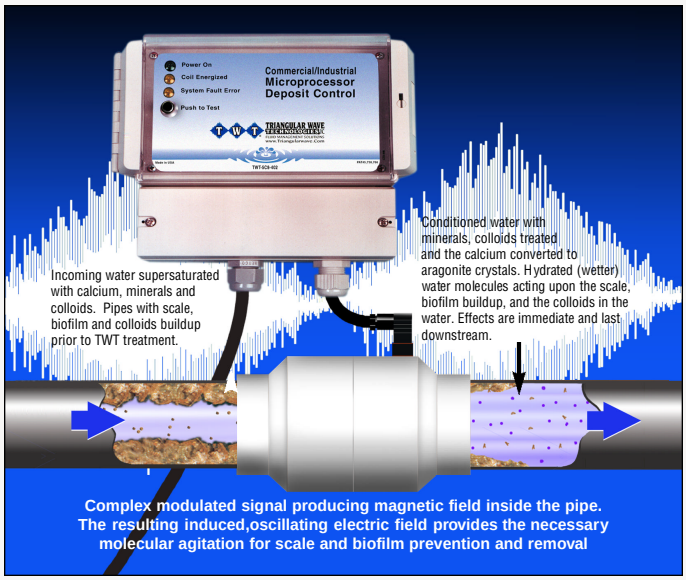
Reverse Osmosis (RO)

Reverse osmosis is the finest level of filtration available. The RO membrane acts as a barrier to all dissolved salts and inorganic molecules, as well as organic molecules with a molecular weight greater than approximately 100. Water molecules, on the other hand, pass freely through the membrane creating a purified product stream. Rejection of dissolved salts is typically 95% to greater than 99%.

The applications for RO are numerous and varied, and include desalination of seawater or brackish water for drinking purposes, wastewater recovery, food and beverage processing, biomedical separations, purification of home drinking water and industrial process water. Also, RO is often used in the production of ultrapure water for use in the semiconductor industry, power industry (boiler feed water), and medical/laboratory applications. Utilizing RO prior to ion exchange (IX) dramatically reduces operating costs and regeneration frequency of the IX system. Transmembrane pressures for RO typically range from 75 psig (5 bar) for brackish water to greater than 1,200 psig (84 bar) for seawater.



TWT Deposit Control System Controls Scale Buildup in Reverse Osmosis Water Treatment System, Reduces Operating Costs.

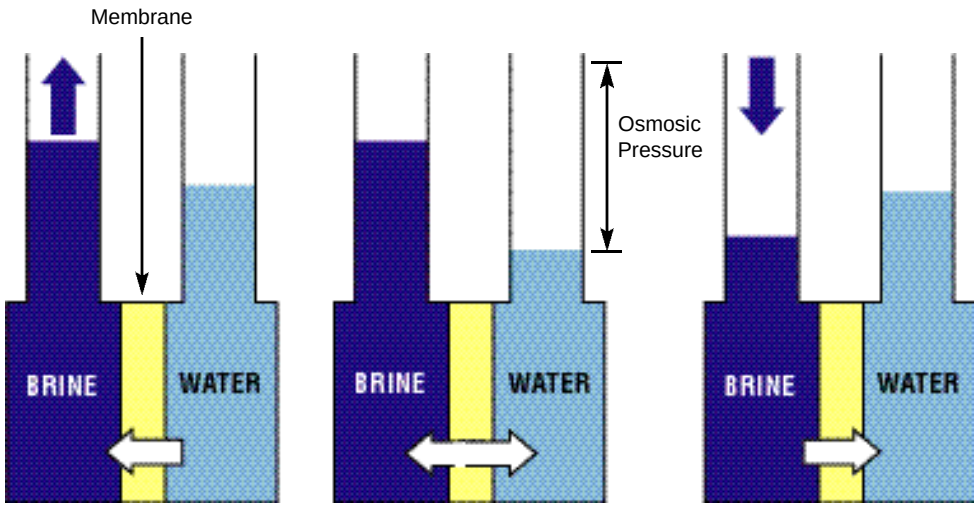


Using modern integrated circuitry and signal processing techniques, the patented TWT Deposit Control Technology works by producing a complex frequency-modulated waveform. This creates a deionizing effect, induced by physical means, which increases the solubility of the minerals, and colloids in the liquid and changes the shape, size and texture of the calcium carbonate crystals. By this reaction, the minerals, colloids and crystals lose their adhesive properties and remain in suspension in the liquid. Pre-existing scale is taken back into solution and in the same way. The result is clean corrosion-free pipes, tubing and delivery system with no biofilm and reduced bacterial contamination.

How Reverse Osmosis Works

The phenomenon of osmosis occurs when pure water flows from a dilute saline solution through a membrane into a higher concentrated saline solution. The phenomenon of osmosis is illustrated in Figure 1. A semi-permeable membrane is placed between two compartments. "Semi-permeable" means that the membrane is permeable to some species, and not permeable to others. Assume that this membrane is permeable to water, but not to salt. Then, place a salt solution in one compartment and pure water in the other compartment. The membrane will allow water to permeate through it to either side. But salt cannot pass through the membrane. As a fundamental rule of nature, this system will try to reach equilibrium. That is, it will try to reach the same concentration on both sides of the membrane. The only possible way to reach equilibrium is for water to pass from the pure water compartment to the salt-containing compartment, to dilute the salt solution. Above schematic shows that osmosis can cause a rise in the height of the salt solution. This height will increase until the pressure of the sure against the membrane is called osmotic column of water (salt solution) is so high that the force of this water column stops the water flow. The equilibrium point of this water column height in terms of water pressure. If a force is applied to this column of water, the direction of water flow through the membrane can be reversed. This is the basis of the term reverse osmosis. Note that this reversed flow produces a pure water from the salt solution, since the membrane is not permeable to salt. pressure plays a minor role if the salt permeability is high.

Figure1: Overview of osmosis



Osmosis

Water diffuses through a semi-permeable membrane toward region of higher concentration to equalize solution strength. Ultimate height difference between columns is "osmotic" pressure.

Equilibrium

Osmotic pressure is the pressure required to stop water flow and reach equilibrium.

Reverse Osmosis

Applied pressure in excess of osmotic pressure,

reverses water flow direction. Hence the term

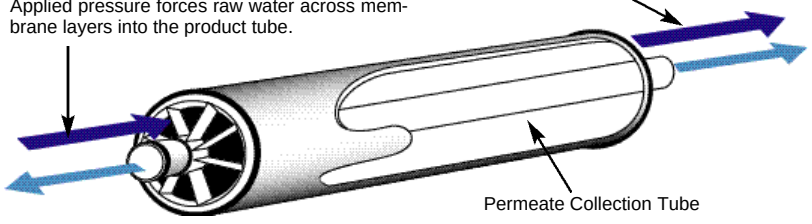
Microfiltration/Ultrafiltration

Microfiltration (MF) and ultrafiltration (UF) can remove microorganisms and especially algae that are sometimes very difficult to remove by standard techniques. The MF/UF membranes should be made from a chlorine-resistant material to withstand periodic treatment with biocides. MF/UF membranes, however, do not remove the low molecular weight fractions of organic matter and other compounds that are nutrients for microorganisms. Pretreatment with MF/UF membranes helps to retard and to control the onset of biofouling, but it is no safeguard by itself.

THE REVERSE OSMOSIS MEMBRANE ELEMENT

CONCENTRATE WATER containing salts is rejected by the membrane and does not enter the product tube. The concentrate water exits the side of the element opposite of the feed.

RAW WATER FEED enters into membrane layers. Applied pressure forces raw water across membrane layers into the product tube.



PRODUCT WATER collects in the product tube and can be output from either end of the membrane element.

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How Nanofiltration Works

The nanofiltration membrane is not a complete barrier to dissolved salts. Depending on the type of salt and the type of membrane, the salt permeability may be low or high. If the salt permeability is low, the osmotic pressure difference between the two compartments may become almost as high as in reverse osmosis. On the other hand, a high salt permeability of the membrane would not allow the salt concentrations in the two compartments to remain very different. Therefore the osmotic pressure plays a minor role if the salt permeability is high.

ElementConstruction

Membranes are thin film composite membranes packed in a spiral wound configuration. Spiral wound designs offer many advantages compared to other module designs, such as tubular, plate and frame and hollow fiber module design for most of the reverse osmosis applications in water treatment. Typically, a spiral wound configuration offers significantly lower replacement costs, simpler plumbing systems, easier maintenance and greater design freedom than other configurations, making it the industry standard for reverse osmosis and nanofiltration membranes in water treatment.

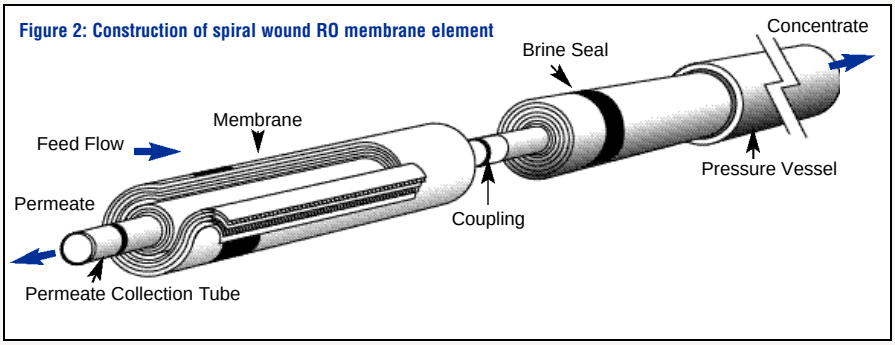


Figure 2: Construction of spiral wound RO membrane element

The construction of a spiral wound membrane element as well as its installation in a pressure vessel is schematically shown (figure 2-next page). A element contains from one, to more than 30 membrane leafs, depending on the element diameter and element type. Using our unique automated manufacturing process, each leaf is made of two membrane sheets glued together back-to-back with a permeate spacer in-between them. Automated process produces consistent glue lines about 1.5 in (4 cm) wide that seal the inner (permeate) side of the leaf against the outer (feed/concentrate) side. There is a side glue line at the feed end and at the concentrate end of the element, and a closing glue line at the outer diameter of the element. The open side of the leaf is connected to and sealed against the perforated central part of the product water tube, which collects the permeate from all leaves. The leaves are rolled up with a sheet of feed spacer between each of them, which provides the channel for the feed and concentrate flow. In operation, the feed water enters the face of the element through the feed spacer channels and exits on the opposite end as concentrate.

A part of the feed water – typically 10-20 % – permeates through the membrane into the leaves and exits the permeate water tube. When elements are used for high permeate production rates, the pressure drop of the permeate flow inside the leaves reduces the efficiency of the element. Therefore, elements have been optimized with a higher number of shorter membrane leaves and thin and consistent glue lines.

The element construction also optimizes the actual active membrane area (the area inside the glue lines) and the thickness of the feed spacer. Element productivity is enhanced by a high active area while a thick feed spacer reduces fouling and increases cleaning success. Such precision in element manufacture can only be achieved by using advanced automated precision manufacturing equipment. In membrane systems the elements are placed in series inside of a pressure vessel. The concentrate of the first element becomes the feed to the second element and so on. The permeate tubes are connected with interconnectors (also called couplers), and the combined total permeate exits the pressure vessel at one side (sometimes at both sides) of the vessel.

Pretreatment Membrane Fouling Considerations

The feed water, depending on its source, may contain various concentrations of suspended solids and dissolved matter. Suspended solids may consist of inorganic particles, colloids and biological debris such as microorganisms and algae. Dissolved matter may consists of highly soluble salts, such as chlorides, and sparingly soluble salts, such as carbonates, sulfates, and silica. During the RO process, the volume of feed water decreases, and the concentration of suspended particles and dissolved ions increases. Suspended particles may settle on the membrane surface, thus blocking feed channels and increasing friction losses (pressure drop) across the system. Sparingly soluble salts may precipitate from the concentrate stream, create scale on the membrane surface, and result in lower water permeability through the RO membranes (flux decline). This process of formation of a deposited layer on a membrane surface is called membrane fouling and results in performance decline of the RO system.

The objective of the feed water pretreatment process is to improve the quality of the feed water to the level which would result in reliable operation of the RO membranes.

The quality of the feed water is defined in terms of concentration of suspended particles and saturation levels of the sparingly soluble salts. The common indicators of suspended particles used in the RO industry are turbidity and Silt Density Index (SDI). The maximum limits are: turbidity of 1 NTU and SDI of 4. Continuous operation of an RO system

with feed water which has turbidity or SDI values near the limits of these values may result in significant membrane fouling. For long-term, reliable operation of the RO unit, the average values of turbidity and SDI in the feed water should not exceed 0.5 NTU and 2.5 SDI units, respectively.

The indicators of saturation levels of sparingly soluble salts in the concentrate stream are the Langelier Saturation Index (LSI) and the saturation ratios. The LSI provides an indication of the calcium carbonate saturation. Negative values of LSI indicate that the water is aggressive and that it will have a tendency to dissolve calcium carbonate. Positive values of LSI indicate the possibility of calcium carbonate precipitation. The LSI was originally developed by Langelier for potable water of a low salinity. For high salinity water encountered in RO applications, the LSI is an approximate indicator only.

The saturation ratio is the ratio of the product of the actual concentration of the ions in the concentrate stream to the theoretical solubilities of the salts at a given conditions of temperature and ionic strength. These ratios are applicable mainly to sparingly soluble sulfates of calcium, barium and strontium. Silica could be also a potential scale forming constituent. Other potential scale forming salts, such as calcium.fluoride or phosphate which may be present in RO feed, seldom represent a problem. Depending on the raw water quality, the pretreatment process may consist of all or some of the following treatment steps:

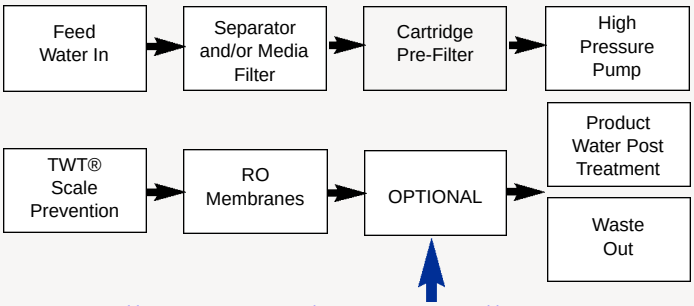
- **Removal of large particles using a coarse strainer.**
- **Clarification with or without flocculation.**
- **Clarification and hardness reduction using lime treatment.**
- **Media filtration.**
- **Reduction of alkalinity by pH adjustment.**
- **Addition of scale inhibitor.**
- **Water sterilization using UV radiation.**
- **Final removal of suspended particles using cartridge filters.**

The initial removal of large particles from the feed water is accomplished using mesh strainers or traveling screens. Mesh strainers are used in well water supply systems to stop and remove sand particles which may be pumped from the well. Traveling screens are used mainly for surface water sources, which typically have large concentrations of biological debris. It is common practice to disinfect surface feed water in order to control biological activity. Biological activity in a well water is usually very low, and in majority of cases, well water does not require chlorination. In some cases, chlorination is used to oxidize iron and manganese in the well water before filtration. Well water containing hydrogen sulfide should not be chlorinated or exposed to air. In presence of an oxidant, the sulfide ion can oxidize to elemental sulfur which eventually may plug membrane elements.

Settling of surface water in a detention tank results in some reduction of suspended particles. Addition of flocculants, such as iron or aluminum salts, results in formation of corresponding hydroxides; these hydroxides neutralize surface charges of colloidal particles, aggregate, and adsorb to floating particles before settling at the lower part of the clarifier. To increase the size and strength of the flock, a long chain organic polymer can be added to the water to bind flock particles together. Use of lime results in increase of pH, formation of calcium carbonate and magnesium hydroxide particles. Lime clarification results in reduction of hardness and alkalinity, and the clarification of treated water. Well water usually contains low concentrations of suspended particles, due to the filtration effect of the aquifer. The pretreatment of well water is usually limited to screening of sand, addition of scale inhibitor to the feed water, and cartridge filtration. Surface water may contain various concentrations of suspended particles, which are either of inorganic or biological origin. Surface water usually requires disinfection to control biological activity and removal of suspended particles by media filtration. The efficiency of filtration process can be increased by adding filtration aids, such as flocculants and organic polymers. Some surface water may contain high concentrations of dissolved organics. Those can be removed by passing feed water water through an activated carbon filter. Depending on composition of the water, acidification and addition scale inhibitor may be required.

Cartridge filters, almost universally used in all RO systems prior to the high pressure pump, serve as the final barrier to water born particles. The nominal rating commonly used in RO applications is in the range of 5 - 15 microns. Some systems use cartridges with micron ratings as low as 1 micron. There seems to be little benefit from lower micron rated filters as such filters require a high replacement rate with relatively small improvement in the final feed water quality. Recently, new pretreatment equipment has been introduced to the RO market. It consists of backwashable capillary microfiltration and ultrafiltration membrane modules. This new equipment can operate reliably at a very high recovery rates and low feed pressure. The new capillary systems can provide better feed water quality than a number of conventional filtration steps operating in series. The cost of this new equipment is still very high compared to the cost of an RO unit.

Suggested RO Process Diagram



TWT®-All-In-One: Multi-Process All-In-One Systems:

TWT All-In-One Fluid management systems are unique, compact, self-contained units for the treatment of water. Filtration, deposit control, UV purification combined for maximum effectiveness. ***"The Competitive Edge"***

TWT® Reverse Osmosis (RO) Systems

Custom Orders: Larger volume applications are available upon request. Check requested RO volume.

Sea Water RO Systems:

Gallons per Day

- ☐ Sea Water RO at 150 GPD
- ☐ Sea Water RO at 300 GPD
- ☐ Sea Water RO at 600 GPD
- ☐ Sea Water RO at 1200 GPD
- ☐ Sea Water RO at 3000 GPD
- ☐ Sea Water RO at 5000 GPD

Gallons per Minute

- ☐ Sea Water RO at 5 GPM
- ☐ Sea Water RO at 10 GPM

For additional information about reverse osmosis (RO) systems from 15 GPM to 110 GPM and higher, contact your dealer or Triangularwave Technologies, Inc.

Brackish Water RO Systems:

Gallons per Day

- ☐ Brackish Water RO at 100 GPD
- ☐ Brackish Water RO at 200 GPD
- ☐ Brackish Water RO at 400 GPD
- ☐ Brackish Water RO at 500 GPD
- ☐ Brackish Water RO at 1000 GPD
- ☐ Brackish Water RO at 2000 GPD

Gallons per Minute

- ☐ Brackish Water RO at 2 GPM
- ☐ Brackish Water RO at 4 GPM
- ☐ Brackish Water RO at 5 GPM
- ☐ Brackish Water RO at 10 GPM

Water temperature

Product water quality and production of any RO system is dependent on pressure and temperature. Watts™ RO systems are rated at standard conditions of 77°F (25°C), 60 psi (4.2 bar) inlet pressure and 1,000 TDS feed water quality. Higher temperatures will result in more water passing through the membranes and increased water production. As a rule, at given pressures and TDS levels, for each one-degree change in water temperature the change in water production is approximately 2%.

Water temperature		Production Factor*
°F	°C	(Using thin film membranes)
40	4	0.48
50	10	0.60
60	16	0.73
70	21	0.88
77	25	1.00
80	27	1.06
90	32	1.26

*Percent of rated production.

Water pressure

Commercial RO systems require a minimum of 10 psi feed pressure to function properly. The maximum pressure is 90 psi, and a pressure regulator must be utilized over 90 psi to reduce feed water pressure.0

Feed / source water inlet requirements

The source water requirements shown below are essential for proper operation:

Inlet feed water requirements	
Factor	**Requirement**
Hardness	<1 grain per gallon
Free chlorine	0 ppm
T.D.S.	<1,000 ppm
S.D.I.	<5
pH	3-11
Iron	<0.01 ppm
Silica	<25 ppm
Manganese	<0.05 ppm
Turbidity	<1 NTU
Temperature	40°F - 95°F (4°C - 32°C)
Pressure	0 - 90 psi (2.8 - 5.6 bar)

Plumbing

The high-pressure pumps used require a continuous flow of water to the system. Minimum feed pressure is 10 psi. Please see table, below for minimum flow rates.

Electrical

The customer must provide a properly sized electrical service.

Custom System Quote: Industry specific fluid treatment needs and up grades.

Custom installation & pricing: To be established based upon proposal submitted at time of sale based on foot print and materials cost at time of purchase.

Note: Above systems are fully integrated and factory assembled and mounted, offering end to end fluid management and treatment solutions.

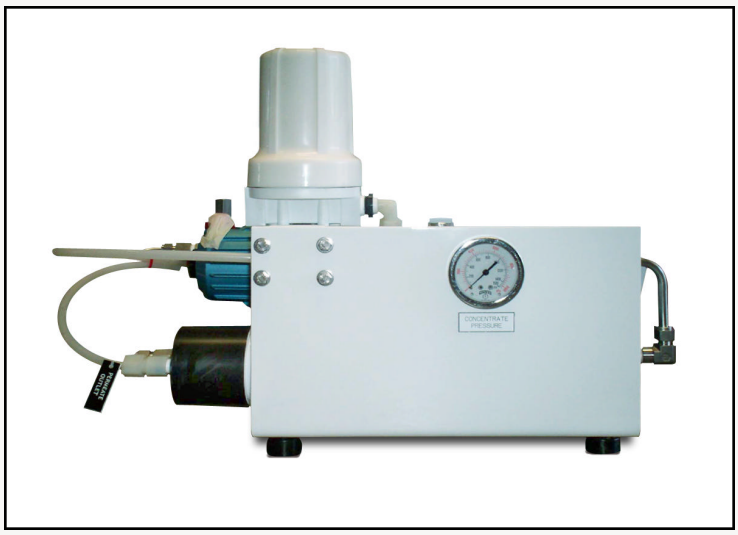
TBD: Carriers, shipping and handling costs for products are constantly changing. For that reason, it is difficult for TWTto determine the exact shipping method and weight for products before TWT has a confirmed and accepted purchase order in-house.

Quotes are meant to ensure proper use, application and installation.
Quotes based on price of material at time of purchase.

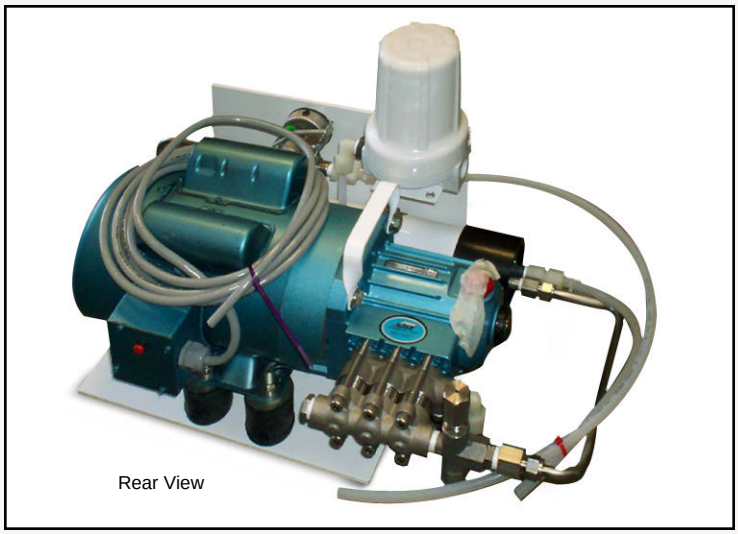
Onsite tech support available upon request • Fee to be determined at time of purchase

E-mail: info@triangularwave.com • triwaveinc@aol.com • Fax: 201-750-1096

Reverse Osmosis (RO) Systems



TWT-SWRO-100 – 100 GPD System



Rear View

Drinking Water from Sea Water

The RO filtration system is ideal for use on board boats, yachts and vessels of all types. Compact and dependable, this sea water desalination system is able to provide up to 100 GPD (400 LPD) of drinking water from sea water source.

This system may be used as a stand alone unit or in combination with with TWT deposit control and/or ultra violet disinfection systems to provide an extra measure of protection by killing all potentially harmful bacterial and viral pathogens which may be present in the water. Rugged and well constructed, the SWRO-100 will ensure many years of dependable service.

System location

The RO system should be located on a level surface in an area sheltered from sun, wind and rain. The temperature in this area should be maintained, and should not fall below 35°F, If these limits are exceeded, damage to components may result and the warranty may be considered void. It is important to allow sufficient space around the unit(s) so maintenance can easily be performed.

Consumables and replacement parts list for RO system will be provided at time of purchase.

RO systems are shipped with easy to follow application, installation and maintenance manual.

The TWT-SWRO-100 Reverse Osmosis System Specifications

- Output max. 100 gallons per day
- For Feed Water Containing up to 36,000 mg/L TDS (36,000 ppm) at 25 C, SDI < 3
- 316L Stainless Steel Pump
- 24 Volt DC Motor (1 HP), Running at 1800 RPM
- High Rejection Sea Water Membrane
- Flow Meter Installed on the Permeate Line
- 5 Micron Sediment Pre-Filter
- Frame: Bent aluminum panel, with anti-vibration support
- Motor: 120 or 220V 50/60 Hz, 1Ph, 1.0 HP, 1470 RPM (60 Hz) or 1450 RPM (50 Hz)
- Pump: Cat 2SF15 (brass) or 2SF15Sell (316SS-optional)
- Membrane: FILMTEC or SIMILAR 2.5"D x 14"L
- Pressure Vessel: Own Manufacturing (OSMO-2514-1000)
- Flowmeter: 0 to .25 GPM (or 0 to 15 GPH), Acrylic Block (optional)

RO systems are shipped with easy to follow application, installation and maintenance manual.

Please Note:
System engineering design, weight, size and system component assembly may vary based on TWT engineering review, water conditions, application, industry and /or customer specific needs.
Pumps, piping, fittings, valves,and other material needed to and from system owners responsibility.

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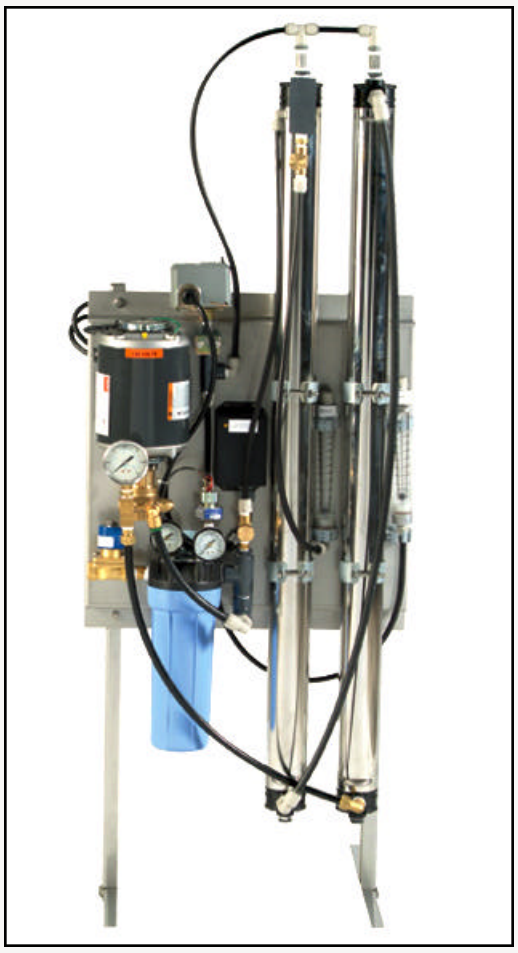
Reverse Osmosis (RO) Systems



TWT-R12-0150 –150 GPD Wall Mounted System
with Optional Legs
Sea water membranes available

Consumables and replacement parts list for RO system will be provided at time of purchase.

RO systems are shipped with easy to follow application, installation and maintenance manual.

R-12 Wall Mounted Systems

Four models for flow rates to 1200 GPD

Standard features package #1

- Stainless steel frame
- Automatic inlet valve
- Pre-filter housing and cartridge, 10"
- Procon pump (brass)
- 1/2 HP motor
- Liquid filled pump pressure gauge (2-1/2")
- Stainless steel pressure vessels
- Needle valve for concentrate line
- Needle valve for recycle line
- Check valve for product water (stainless steel)
- Product pressure switch with Auto/Off
- Low-pressure shut-off with automatic restart

Additional features included in package #2

- Pre-filter pressure gauges
- Product water flow meter
- Reject water flow meter

Additional features included in package #3

- Automatic fast flush for concentrate

Specifications

- Product water & reject water connection (tubing) 3/8"
- Feed water requirement (maximum) 2.4 GPM
- Feed water pressure requirement (minimum) 10 PSIG
- Drain requirement (maximum) 2.4 GPM
- Electrical requirement 120v/60hz
- Amps 8
- Pump 1/2 HP

Options

Part Number	Description
R2864	Stainless steel leg kit
R2353-SD	Product water float switch
R2288	Whole house option*

Models

Model Number	Package	GPD	Recovery (Adjustable)	Membrane Size	Number Of Membranes	Feed Water Connection	Typical Rejection	Dimensions	Ship Wt.
R12-0150-1	1	150	15%-75%	2-1/2"x14"	1	1/2" NPT	98%	22"x32"x12"	50
R12-0150-2	2	150	15%-75%	2-1/2"x14"	1	1/2" NPT	98%	22"x32"x12"	50
R12-0150-3	3	150	15%-75%	2-1/2"x14"	1	1/2" NPT	98%	22"x32"x12"	50
R12-0250-1	1	250	15%-75%	2-1/2"x21"	1	1/2" NPT	98%	22"x32"x12"	50
R12-0250-2	2	250	15%-75%	2-1/2"x21"	1	1/2" NPT	98%	22"x32"x12"	50
R12-0250-3	3	250	15%-75%	2-1/2"x21"	1	1/2" NPT	98%	22"x32"x12"	50
R12-0600-1	1	600	15%-75%	2-1/2"x40"	1	1/2" NPT	98%	22"x52"x12"	60
R12-0600-2	2	600	15%-75%	2-1/2"x40"	1	1/2" NPT	98%	22"x52"x12"	60
R12-0600-3	3	600	15%-75%	2-1/2"x40"	1	1/2" NPT	98%	22"x52"x12"	60
R12-1200-1	1	1200	25%-75%	2-1/2"x40"	2	1/2" NPT	98%	22"x52"x12"	70
R12-1200-2	2	1200	25%-75%	2-1/2"x40"	2	1/2" NPT	98%	22"x52"x12"	70
R12-1200-3	3	1200	25%-75%	2-1/2"x40"	2	1/2" NPT	98%	22"x52"x12"	70

*Includes 300 gallon tank, product water float switch and repressurization pump with built-in controls.

Performance specifications are based on 77°F feed water, 3 SDI or less, TDS below 1000 and pH of 8. Please see water temperature conversion charts to determine actual production rate for each installation. Chlorine reduction and other pretreatment may be required. Membrane rejection rates are based on membrane manufacturer's specifications. Pre-filter is FPMB5-978 melt blown cartridge. Systems are designed for use with municipal and well water.

Please Note:
System engineering design, weight, size and system component assembly may vary based on TWT engineering review, water conditions, application, industry and/or customer specific needs.

Pumps, piping, fittings, valves,and other material needed to and from system owners responsibility.

Reverse Osmosis (RO) Systems

TWT-R13-0250 – 250 GPD Compact Wall Mounted System

Consumables and replacement parts list for RO system will be provided at time of purchase.

RO systems are shipped with easy to follow application, installation and maintenance manual.

R-13 Compact Wall Mount RO

Three models for flow rates to 1200 GPD

Standard features

- Powder coated steel frames
- Inlet solenoid valve
- Pre-filter
- 1/2 HP motor
- Brass pump
- Liquid filled pre-filter pressure gauge
- 2 1/2" liquid filled pump pressure gauge
- Product water & reject water flow meters
- High pressure, non-metallic membrane housings
- SS needle valves for concentrate and recycle lines
- Stainless steel product water check valve
- On / off toggle switch
- Low-pressure shut-off with auto restart
- Feed water and product water TDS monitor

Applications

- Whole house
- Ice makers
- Labs
- Beverages
- Coffee shops
- Restaurants

Specifications

• Feed water connection	3/4" NPTF
• Product water connection	3/8" Tubing OD
• Reject water connection	3/8" Tubing OD
• Feed water required (max.)	2.4 GPM
• Feed water pressure (min.)	10 PSI
• Drain required (max.)	2.4 GPM
• Electrical requirements	120 VAC 60 Hz
• Amps	8
• Pump (H.P.)	1/2

Options

Part Number	Description
R2868	Leg Kit
R2353-SD	Product float switch
R2288	Whole house option*

Models

	R13-0250	R13-0600	R13-1200
Maximum production (gallons per day)	250	600	1200
Average membrane rejection rate	98 %	98 %	98 %
Recovery (adjustable)	8 - 75 %	17 –75%	34 - 75 %
Membrane size	3" x 10"	3" x 20"	3" x 20"
Number of membranes	1 (P/N R96310)	1 (P/N R96320)	2 (P/N R96320)
Pre-filter (system ships with one 5 micron cartridge)	10"	20"	20"
Dimensions, approximate (W x H x D)	26" x 26" x 9"	26" x 36" x 9"	26" x 36" x 9"
Shipping Weight, estimated (lbs.)	50	60	75

Performance specifications are based on 77° feed water, SDI < 3, TDS below 1000 ppm and pH of 8. Individual membrane productivity and rejection rates are based on manufactures specifications. Please see water temperature conversion charts for production factor. Chlorine reduction and other pretreatment may be required. Systems are designed for use with municipal and well water.
*Includes 300 gal tank, product float switch and repressurization pump with built in controls.

Please Note:
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Reverse Osmosis (RO) Systems

TWT-RX40-1 – 2200 GPD RO System

Consumables and replacement parts list for RO system will be provided at time of purchase.

RO systems are shipped with easy to follow application, installation and maintenance manual.

R4X40 RO System

Model for flow rate to 2200 GPD

Standard Features

- Powder coated steel frame
- Inlet solenoid valve
- 20” prefilter
- Prefilter pressure gauge
- Multistage centrifugal pump
- Low-pressure protection with microprocessor auto reset
- 2 1/” liquid filled pump pressure gauge
- Stainless steel pressure vessel(s)
- Product flow meter
- Reject flow meter
- Concentrate needle valve
- Non metallic recycle needle valve
- On / off toggle switch
- Feed water and product water TDS monitor

Applications

- Whole house
- Boiler feed water
- Humidifiers
- Greenhouses
- Process water
- Electronics

Specifications

• Membrane Size	4” x 40”
• Average membrane rejection	98 %
• Feed Water Connection	3/4" NPTF
• Prefilter	20”
• Product Water Connection	5/8"tubing OD
• Reject Water Connection	5/8"tubing OD
• Feed Water Pressure (minimum)	10 psi
• Electrical Requirement	120 VAC 60 Hz*

Options

Part Number	Description
R2288	Whole House Option*
R4X40	RO Series

Models

	R4X40-1	R4X40-2	R4X40-3
Maximum Productivity (gallons per day)	2200	4400	6600
Recovery (user adjustable)	15 - 75 %	25 – 75%	32 - 75 %
Number Of Membranes	1	2	3
Feed Water Required (maximum)	10gpm	12 gpm	14 gpm
Drain Required (maximum)	10gpm	12 gpm	14 gpm
Motor Horse Power	3/4	1	1 1/2
Electrical Requirement	15 amps	20 amps	25 amps
Dimensions W x D x H	20 x 20 x 50	20 x 20 x 50	20 x 26 x 50
Shipping Weight (estimated lbs)	120	150	180

Maximum production based on a feed water of 77°F, SDI < 1, 1000 ppm TDS, and pH 7. Individual membrane productivity may vary (± 15%). May be operated on other feed waters with reduced capacity. Percent Rejection is based on membrane manufactures specifications; overall system percent rejection may be less.

*Also available in 230 volts single phase.

**Includes 300 gal tank, product float switch, and repressure pump with built in controls

Please Note:
System engineering design, weight, size and system component assembly may vary based on TWT engineering review, water conditions, application, industry and/or customer specific needs.

Pumps, piping, fittings, valves,and other material needed to and from system owners responsibility.

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Reverse Osmosis (RO) Systems

TWT-R14-02-1WM – 3600 GPD Wall Mounted System
Sea water membrane available

Consumables and replacement parts list for RO system will be provided at time of purchase.

RO systems are shipped with easy to follow application, installation and maintenance manual.

R-14 wall-mounted systems

Models for flow rate to 5400 GPD,
Stainless steel fittings, fully assembled and ready for installation.

Standard features

- Stainless steel frame
- Stainless steel pressure vessels
- Pre-filter housing and cartridge, 10" Full-Flow
- Webtrol® multi-stage centrifugal pump
- Automatic inlet valve
- Low-pressure shut-off with automatic restart
- Tank level input
- Pretreatment interlock input
- Adjustable recycle line
- Pre-filter pressure gauges
- Pump discharge pressure gauge (liquid filled)
- Flow meter for product water
- Flow meter for reject water
- Check valve for product water
- Sample valve for product water
- On / off switch

Specifications

• Feed water connection	1" FNPT
• Product water connection (1800 & 3600 GPD)	1/2" tube
• Product water connection (5400 GPD)	5/8" tube
• Reject water connection (all R14 models)	1/2" tube
• Feed water pressure requirement (minimum)	10 PSIG
• Drain requirement (maximum)	10 GPM
• Electrical requirement	230v/60hz
• Amps (1800 & 3600 GPD)	6
• Amps (5400 GPD)	9

Options

Part Number	Description
R2353-SD	Product water float switch
R2288	Whole house option*

Models

Model Number	Fittings & Valves	GPD	Pump (H.P.)	Recovery (Adjustable)	Membrane Size	Membranes	Feed Water Required** (GPM)	Typical Rejection	Dimensions	Ship Wt. (Lbs.)
R14-02-1WM	SS	3600	1	25%-75%	4" x 40"	2	5	98%	41"x51"x18"	250

Performance specifications are based on 77°F feed water, 3 SDI or less, TDS below 1000 and pH of 8. Please see water temperature conversion charts to determine actual production rate for each installation. Chlorine reduction and other pretreatment may be required.Membrane rejection rates are based on membrane manufacturer's specifications. Pre-filter is FPMB-BB5-10 melt blown cartridge.Systems are designed for use with municipal and well water.
*Includes 300 gallon tank, product water float switch and repressurization pump with built-in controls. **At 50% recovery.

Please Note:
System engineering design, weight, size and system component assembly may vary based on TWT engineering review, water conditions, application, industry and /or customer specific needs.

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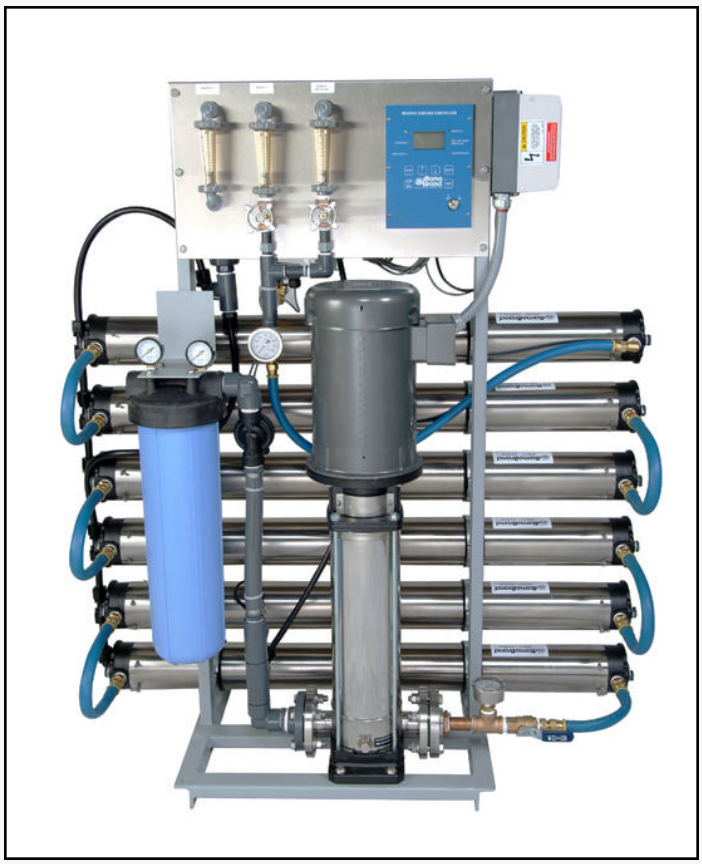
Reverse Osmosis (RO) Systems



TWT-R14-04-1111000 – 7200 & 9000 GPD Floors Mounted Systems
Sea water membrane available

Consumables and replacement parts list for RO system will be provided at time of purchase.

RO systems are shipped with easy to follow application, installation and maintenance manual.

R-14 floor-mounted systems

Two models for flow rates 7200 to 1900 GPD

Standard features

- Powder coated steel frame
- Stainless steel pressure vessels
- Pre-filter housing and cartridge (20" Full-Flow)
- Webtrol® heavy-duty multi-stage centrifugal pump
- Automatic inlet valve
- Low-pressure shut-off with automatic restart
- Tank level input
- Pretreatment interlock input
- Adjustable recycle line
- Pre-filter pressure gauges
- Pump discharge pressure gauge (liquid filled)
- Flow meter for product water
- Flow meter for reject water
- Flow meter for recycle water
- Check valve for product water
- On / off switch

Specifications

Feed water connection	1" FNPT
Product water connection	3/4" FNPT
Reject water connection	3/4" FNPT
Feed water pressure requirement (min.)	10 PSIG
Drain requirement (maximum)	15 GPM
Electrical requirement	230VAC/60hz
Phase	3
Amps	15

Models

Model Number	Package	GPD	Pump (H.P.)	Recovery (Adjustable)	Membrane Size	Membranes	Feed Water Required* (GPM)	Typical Rejection	Dimensions	Ship Wt. (Lbs.)
R14-04-1111000	1	7200	5	42%-75%	4" x 40"	4	10	98%	60"x18"x56"	600
R14-05-1111000	1	9000	5	46%-75%	4" x 40"	5	12.5	98%	60"x18"x56"	700

Performance specifications are based on 77°F feed water, 3 SDI or less, TDS below 1000 and pH of 8. Please see water temperature conversion charts to determine actual production rate for each installation. Chlorine reduction and other pretreatment may be required. Membrane rejection rates are based on membrane manufacturer's specifications. Pre-filter is FPMB-BB5-20 melt blown cartridge. Systems are designed for use with municipal and well water. *At 50% recovery.

Please Note:
System engineering design, weight, size and system component assembly may vary based on TWT engineering review, water conditions, application, industry and /or customer specific needs.

Pumps, piping, fittings, valves,and other material needed to and from system owners responsibility.

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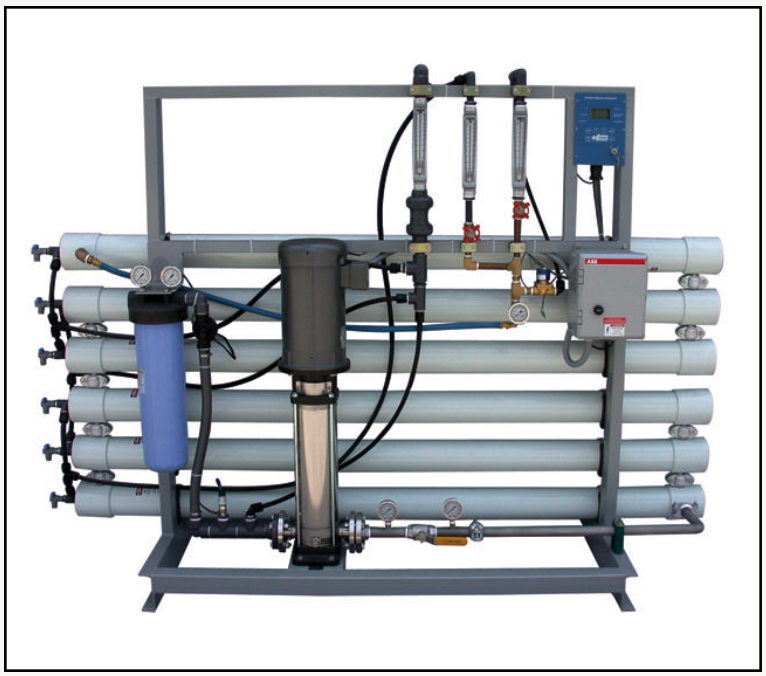
Reverse Osmosis (RO) Systems



TWT-R24-08-1111000 – 10 GPM RO System
Sea water membrane available

Consumables and replacement parts list for RO system will be provided at time of purchase.

RO systems are shipped with easy to follow application, installation and maintenance manual.

R-24 Model for flow rate 10 GPM

Standard features (package #1 shown)

- Powder coated steel frame
- FRP multi-port pressure vessels
- Pre-filter housing and cartridge (20” B-B)
- Webtrol® multi-stage centrifugal pump
- Automatic inlet valve
- Low-pressure shut-off with auto restart
- Tank level input
- Pretreatment interlock input
- Adjustable recycle line
- Pre-filter pressure gauges
- Pump discharge pressure gauge
- Flow meter for product water
- Flow meter for reject water
- Flow meter for recycle water
- Check valve for product water
- Sample valves for product water
- On / off switch

Specifications

Feed water connection	1" FNPT
Product water connection	1" FNPT
Reject water connection	3/4" FNPT
Feed water pressure requirement (min.)	10 PSIG
Drain requirement (maximum)	17, 21, 25 GPM
Electrical requirement	230VAC/60hz
Phase	3
Amps	20

Models

Model Number	GPM	Pump (H.P.)	Recovery (Adjustable)	Membrane Size	Membranes Array	Feed Water Required* (GPM)	Typical Rejection	Dimensions	Ship Wt. (Lbs.)
R24-08-1111000	10	7.5/TEFC	60%-75%	4" x 40"	2:1:1	17	98%	96"x24"x72"	800

Performance specifications are based on 77°F feed water, 3 SDI or less, TDS below 1000 and pH of 8. Please see water temperature conversion charts to determine actual production rate for each installation. Chlorine reduction and other pretreatment may be required. Membrane rejection rates are based on membrane manufacturer's specifications. Pre-filter is 20” Full-Flow plastic housing and FPMB-BB5-20 melt blown filter cartridge. Systems are designed for use with municipal and well water. *At 65% recovery.

Please Note:
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WHO WILL BE PLEASED TO WORK CLOSELY WITH YOU TO DETERMINE THE OPTIMAL INSTALLATION FOR YOUR INDUSTRY SPECIFIC NEEDS.

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