

**SIGNET Guide to Industrial and Municipal
Water Treatment Systems**

GEORGE FISCHER +GF+

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Introduction

“RO, DI, two-bed, mixed bed...”

Every industry has its own dictionary of specialized techniques and terminologies. With terms like RO, and mixed bed, the water and wastewater treatment industry is certainly no exception. This booklet is intended to provide an in-depth understanding of applications in both industrial and municipal water and wastewater treatment systems.

SIGNET: The Water Treatment Experts

The application information contained in this booklet was derived from actual SIGNET installations, and compiled by SIGNET's water treatment specialists.

Little Known Facts Regarding Water Usage . . .

- **97%** of the earth's water is in the form of salt water; another **2%** of the supply is in the form of ice. Less than **1/2 of 1%** of the world's water supply is available as fresh water.
- **Increasing contamination** of available fresh water, and rapid population growth into arid areas, is placing new demands on the suppliers and users of quality water. Regulations concerned with reducing water pollution are providing impetus for ever-increasing water treatment techniques and systems. In fact, virtually **all of the water which we use each day must be treated** both before and after use.
- The U.S. uses **1,300 gallons of water per person each day**. Many times more than most developing nations.
- Altogether, the U.S. withdraws **339 billion gallons of ground and surface water a day**. Although four trillion gallons of water falls on

us daily in the form of precipitation, much of that disappears in evaporation and runoff. *U.S. irrigation takes one of the largest shares of water: **137 billion gallons a day**.*

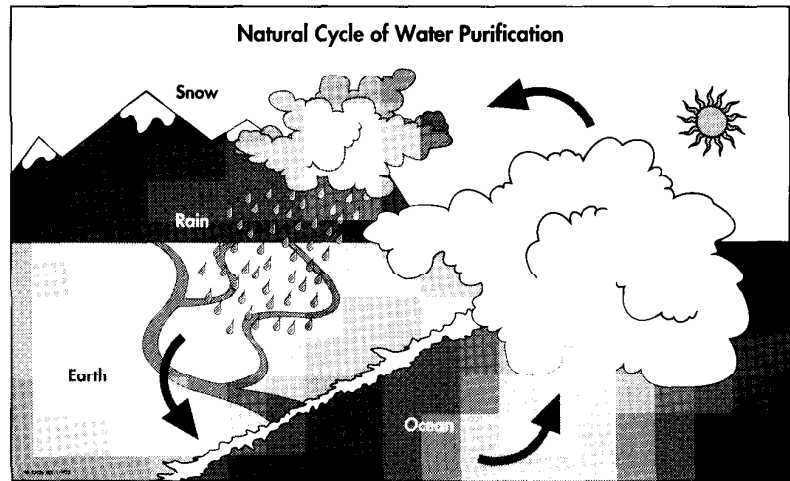
- It can take **one thousand gallons of fresh water** to produce one eight-ounce steak.
- *Power plants that use coal, oil, natural gas, or uranium also need water for steam and cooling, and take **131 billion gallons a day** - more than five times as much fresh water as people use in their homes.*
- The Mississippi River, which drains 2/5 of the lower 48 states, empties into the Gulf of Mexico at a rate of **5.5 million gallons per second**.

These facts were taken from the National Geographic Special Edition: Water, Nov. 1993. This is only the second time in National Geographic's 107 year history that a special edition was published. This should emphasize the fact that SIGNET is part of a vital and growing industry offering new and exciting applications every day.

Part One: Distillation

The Oldest Form of Water Treatment

Distillation is the oldest form of water treatment still in use today. Perhaps, because distillation as a process, closely resembles the natural cycle of water purification. Distillation is the evaporation of water, involving the application of heat to cause a change of phase, producing a vapor free of dissolved and suspended solids in the feed water. Condensation of the vapor produces a considerably purified product.



1.1 Distillation for Water Purification

Distillation processes were used widely by the utilities until the middle of this century. Traditional systems were not very efficient requiring large amounts of energy to cause the water to evaporate. The use of low pressures (vacuum) in addition to heat allow water to vaporize at a lower temperature. In addition to saving energy, the lower temperatures involved reduce the scaling of heat transfer surfaces.

Vacuum distillation equipment is divided into two types of systems, *flash* and *multi-effect*. Typically used in areas where fuel costs are relatively inexpensive, vacuum distillation equipment still remains a cost effective method for producing purified water.

1.2 Flash Distillation

Flash distillation accounts for 80% of all seawater treatment capacity. Flash distillation equipment consists of multiple stages, each operating at a lower pressure. Efficiency of the system increases with the number of stages used. Some systems have as many as

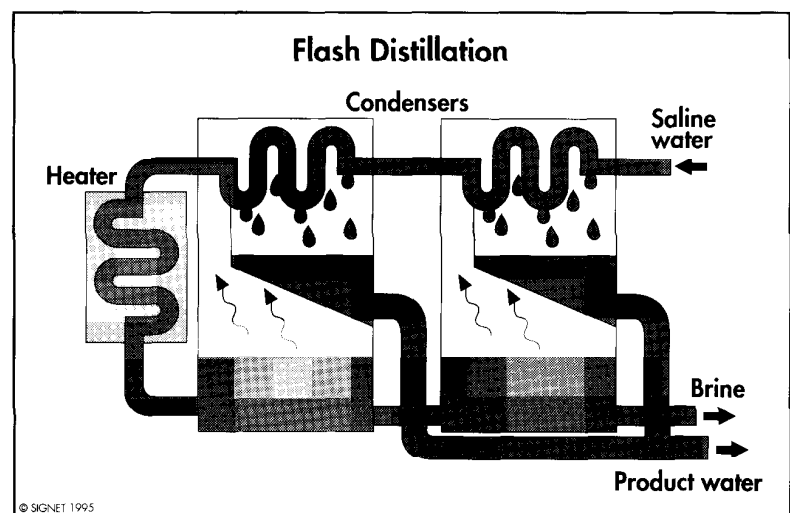
40 stages in all. Heated water enters each stage under partial vacuum. A fraction of this water will flash into vapor upon entering. The vapor then condenses on water cooled tubes and is collected as purified water.

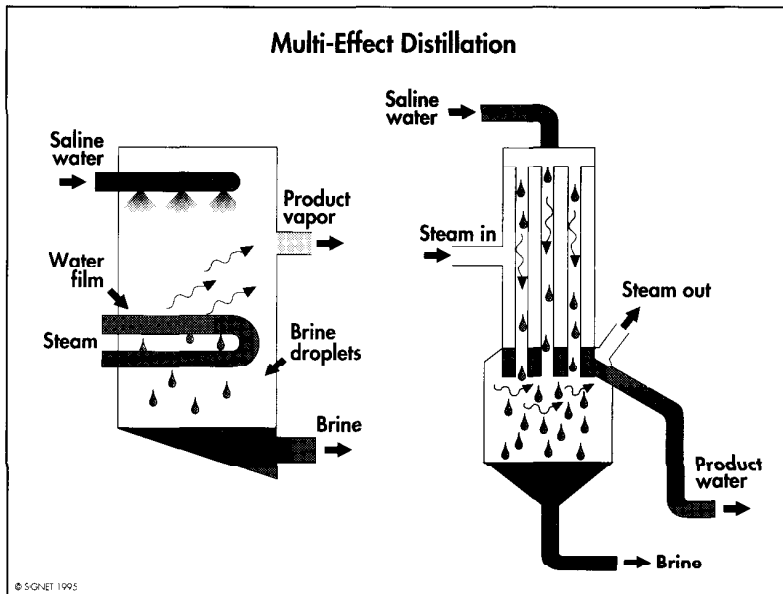
Further filtration of water may occur naturally through the percolation of water through various soil and bedrock types.

1.3 Multi-Effect Distillation

Multi-effect distillation also uses a vacuum to allow water to vaporize at a lower temperature. These systems often take advantage of heat recovery (evaporation) and heat rejection (condensing). As in flash distillation, multiple stages or effects are used. Each stage consists of tubes carrying

Flash distillation vaporizes preheated water which enters a chamber under partial vacuum forming pure water without boiling.





Multi-effect distillation boils steam to evaporate water from film sprayed onto horizontal or vertical tubes.

steam. Feedwater is sprayed onto the tubes where it then vaporizes. The product vapor then moves to the next effect. Distilled water from each effect contributes to the total water produced in the system.

1.4 Distillation Applications

SIGNET flow and analytical sensors, indicators, transmitters, and totalizers are in industrial water treatment applications all over the world. These applications include:

- Flow rate monitoring and totalization
- Chemical pretreatment
- Anti-scalant addition
- Recirculating system monitoring
- Alkali addition
- Heat exchange systems
- Water quality monitor

1.5 Trends in Water Treatment

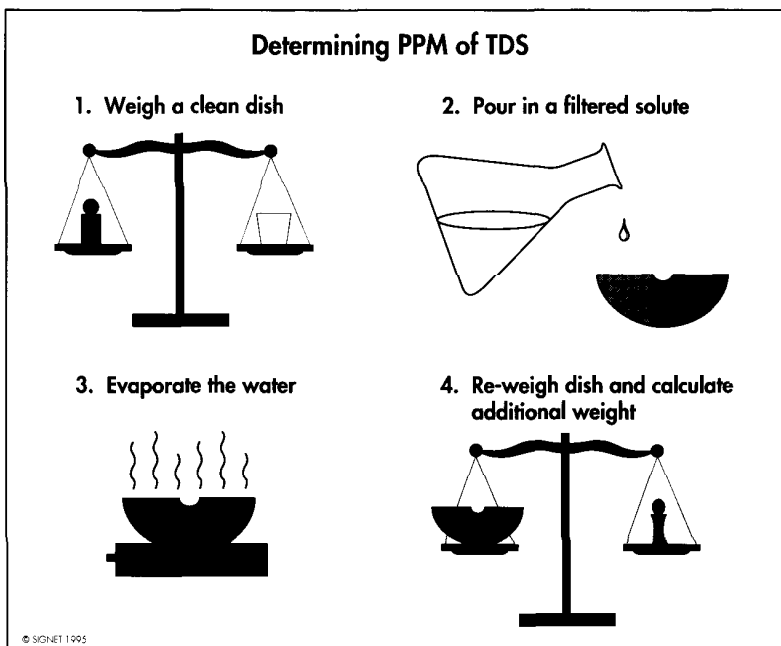
Several years ago many users of distillation equipment switched to ion exchange techniques which allowed for the production of purified water without the need for large amounts of energy.

1.6 Methods for Determining PPM of TDS

TDS, (total dissolved solids) is a measurement of the total weight of dissolved solids within an aqueous solution. This measurement is normally referred to in PPM (parts per million) and is roughly one half the conductivity value (μS).

Differences in the conversion factor (PPMF) can occur based on geographical location and seasonal changes to a water supply. Since most dissolved solids add to a solution's conductance, this extensive lab analysis can be performed on-line with SIGNET conductivity instrumentation.

Parts per million of Total Dissolved Solids (PPM of TDS) is a useful measurement which can be done with SIGNET Conductivity Instrumentation.



Part Two: Demineralization

Demineralizers Used Since the Early 1900's

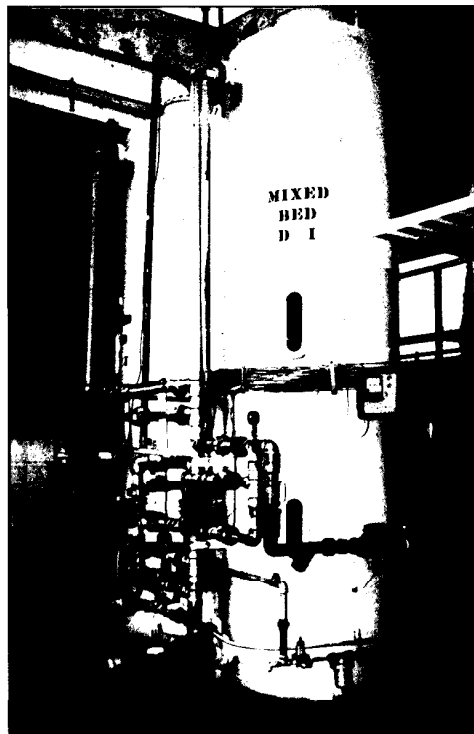
Demineralization is a process involving the removal of dissolved minerals from water. Demineralizers, or ion exchangers, have been in use since the early 1900's. In a demineralization process, impurity ions are exchanged for less objectionable ions on special resin bead systems. As water flows through the beads, the impurities are strongly attracted to charged sites exchanging impurity ions with desirable ions such as sodium, hydrogen, or hydroxyl. The type of resin beads used today have been in use for over 50 years. Manufacturers have designed a wide variety of resins to match particular applications.

2.1 Water Softening

Water softening is the simplest and most common technique for ion exchange. Hard minerals such as calcium and magnesium are exchanged for sodium ions. This is desirable since it reduces the effects of scaling on system components. Since this is an ion exchange of two conductive ions, there is no net detectable change in solution conductivity. Regeneration of the exchange resin is quite safe and simple using only sodium chloride (table salt) solutions. The safety and simplicity of these systems has allowed for the widespread use of softeners in residences and institutions throughout the world.

2.2 Two-Bed Demineralizer

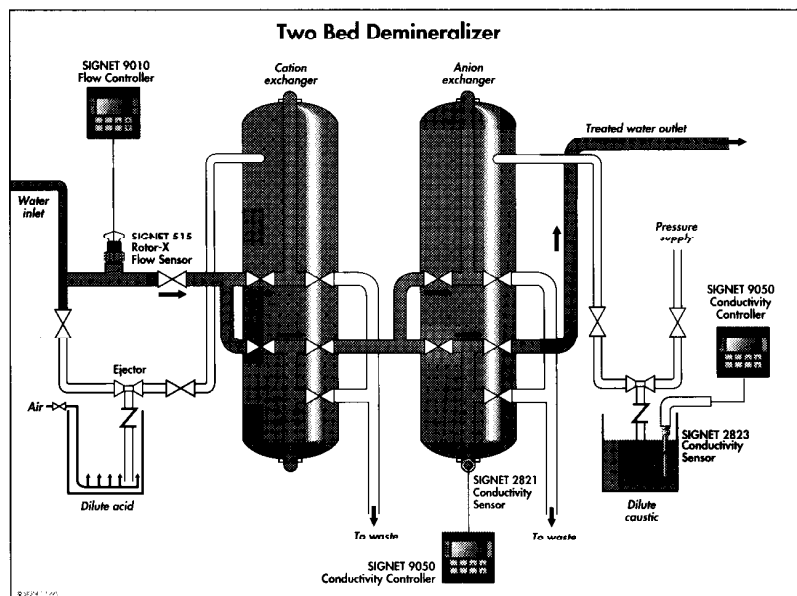
The two-bed demineralizer is a more aggressive system due to the use of strong acids and caustics. Its use is limited to industrial processing plants. These systems employ a Cation

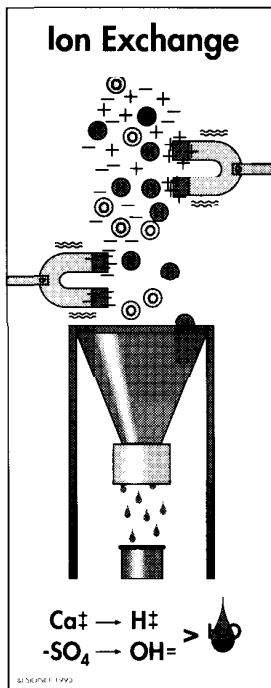


Demineralizers contain sophisticated valve, pipe, and sensor systems for controlling regeneration cycles. The SIGNET conductivity system in the application at left is ideal for monitoring water purity.

exchanger to exchange positive ions for H+ ions. An Anion exchanger then exchanges negative ions for OH- ions. When a paired system is run, the H+ generated in the Cation unit will combine with the OH- generated in the Anion unit, resulting in neutral water (H₂O).

As illustrated below, SIGNET sensors and controllers are ideal for flowrate control, conductivity monitoring, and concentration control.





Ion Exchange is the chemical exchange of ions typically accomplished by a synthetic resin in bead form.

2.3 Mixed-Bed Demineralizer

Often used for water polishing, a mixed-bed unit consists of both the Anion and Cation exchange resins. It does an excellent job removing all remaining ions that are not exchanged in the original Cation or Anion beds. It can be viewed as an infinite number of two-bed demineralizers in series. Effluent from a mixed-bed system can achieve 18 MΩ resistivity (Ultra-Pure). It is not cost effective to use for complete treatment. The mixed-bed regeneration process is more difficult since the Anion and Cation resins need to be separated prior to regeneration.

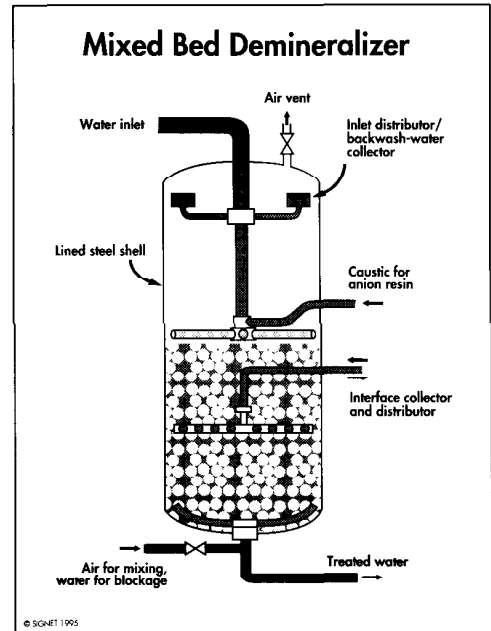
2.4 Regeneration

The first step in any regeneration is backwashing which is accomplished by passing water backwards through the resin bed for a period of time and at a flowrate sufficient enough to expand the bed by 50 to 100 percent. This relieves any compaction of the beads that may have developed, and allows for trapped gasses to escape.

Chemical regeneration is then done by injecting chemical slowly enough to allow the chemical to diffuse into the resin and allow the largest impurity ions to migrate out of the resin. This is followed by a rinse sequence which removes excess chemical concentrations.

2.5 SIGNET Demineralizer Applications

Demineralizer applications are most commonly found in factories and local service bases. Equipment for these applications is often rented and maintained by local service industries. The local service base will often require multiple flow, pH, and conductivity



Often used for "water polishing," a mixed-bed unit consists of both the Anion and Cation exchange resins.

measurement systems to aid in the regeneration of the ion exchange vessels.

Demineralization applications include:

- Flow rate control and totalization of water and regeneration solutions
- Water quality monitoring and control
- Chemical concentration monitoring
- pH neutralization
- System efficiency monitoring

Part Three: Filtration and Reverse Osmosis

Membrane Technology - A Reliable Alternative . . .

Recent changes in environmental regulation are providing impetus for users of ion exchange devices to switch now to membrane technologies such as reverse osmosis. These technologies have increased in reliability, and eliminate the need to neutralize the highly acidic and caustic products associated with ion exchange systems.

Filtration is one of the fastest growing water treatment techniques used today. The efficiency of this system depends on the filter size and pore size of the media being used. Filtration normally follows a clarification process where large suspended particulates are removed. Filters are designed in many different forms to match application requirements.

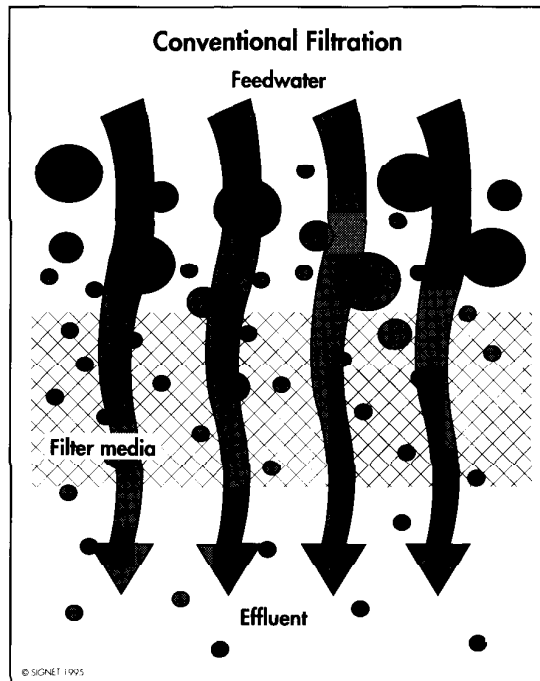
3.1 Conventional Filtration

In *conventional* or *macrofiltration*, the fluid approaches the filter in a head-on (perpendicular) direction. The entire stream passes through the media leaving larger particles behind.

Filtration through sand enables the removal of small amounts of suspended solids. Filtration through granular activated carbon removes organics by adsorption and is often used in the dechlorination of water.

Conventional filters will eventually become clogged with use, and require either a backwash or replacement of the filter media to prevent restricted flow and maintain specified flow rates.

Pretreatment of feedwater is necessary to remove suspended solids. If high levels of suspended solids or biological matter is present, then clarification or



In conventional filtration, the stream moves perpendicular to working medium (head-on).

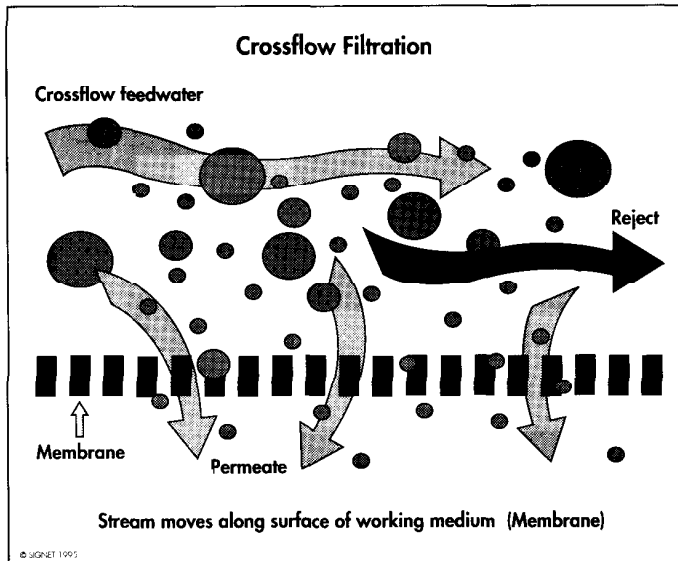
lime softening may be necessary prior to filtration. Disinfection and chlorination may also be needed to reduce microbial activity.

3.2 Conventional Filtration Applications

Flow monitoring and control can be useful for determining filter backwash or replacement cycles. Knowledge of the flow rates during nominal filter operation are necessary in determining if "channeling" of the water is occurring within the filter media

Applications exist in institutional pools and spas which are required to guarantee that the entire volume of water is recycled through the filtration system within a specified period of time. Other conventional filtration applications include:

- Flow rate control and monitoring
- pH/ORP control for simple water treatment such as pool/spa
- Conductivity water quality monitoring

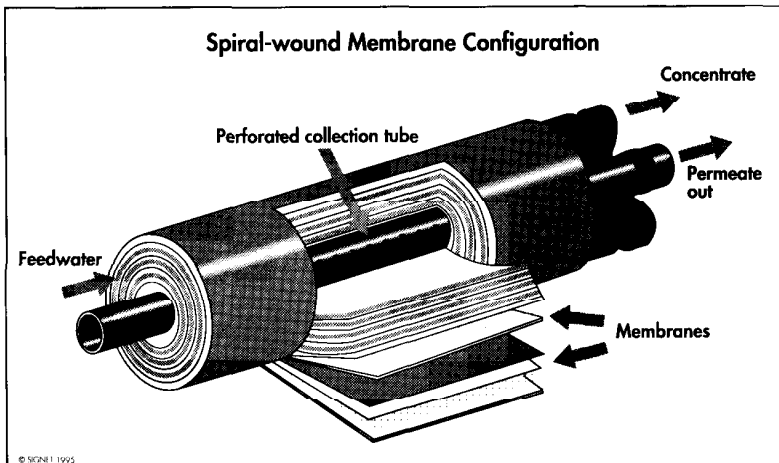


In crossflow filtration, the stream moves along the surface of the working medium (membrane).

3.3 Crossflow Filtration

Crossflow filtration has the advantage of allowing the water to pass along the surface of the working media (membrane). Pressure is applied to the filter forcing water to pass through the membrane where it is collected in a perforated collection tube. An important advantage of this method is that solids and solutes are swept along and exit the filter with the concentrate stream. The most widely used type of crossflow filtration process is referred to as reverse osmosis.

Permeate is collected in perforated axial tube, spacers separate turns and provide turbulence to keep the membrane clean.



3.4 Reverse Osmosis

In 1748, a French scientist experimenting with a pig bladder discovered the natural tendency of water to pass through a semipermeable membrane from a low concentration to a higher concentration eventually reaching equilibrium. The natural pressure that develops is known as osmotic pressure. In reverse osmosis, pressure is applied to the concentrated side of a membrane reversing the natural osmotic tendency and forcing water to pass through the membrane from high concentration to low.

3.5 Reverse Osmosis Membrane Construction

In the cutaway below, water flows through the membrane as the concentrate is passed through the opposite side. The water molecules pass through the membrane and are collected as permeate.

The membranes are classed as either cellulosic (made of cellulose acetate or triacetate) or non-cellulosic. Cellulosic membranes are low in cost, but the feedwater must be chlorinated to prevent biodegradation and held in a narrow pH range (4 to 6) to avoid hydrolysis.

Non-cellulosic membranes have a relatively wide pH range (4 to 9 for fully aromatic polyamide - PA; 2 to 11 for TFC types). Membranes can operate up to approximately 100°F and may be damaged by over temperature conditions. Unnecessarily low temperatures will reduce permeate flow rates below design values.

Operating pressures for an RO system can range from 35 psi for domestic (in-home) systems, and up to 1000 psi for

seawater desalination. New advances in membrane construction are increasing the pH range allowable for operation

3.6 Reverse Osmosis Systems

Reverse osmosis systems are highly effective at removing many substances including dissolved salts, with efficiencies (rejection ratio) advertised at 95 to 98%. In fact, 41% of the membrane market is in water and wastewater treatment. The single largest application is desalination of sea, river or brackish water to produce drinking water. In order to meet capacity demands, multiple "trains" of filters are used. The concentrate must be disposed of and may be routed to a waste disposal area, or evaporated to solid waste or purified salt (resource) in a desalination process. The permeate

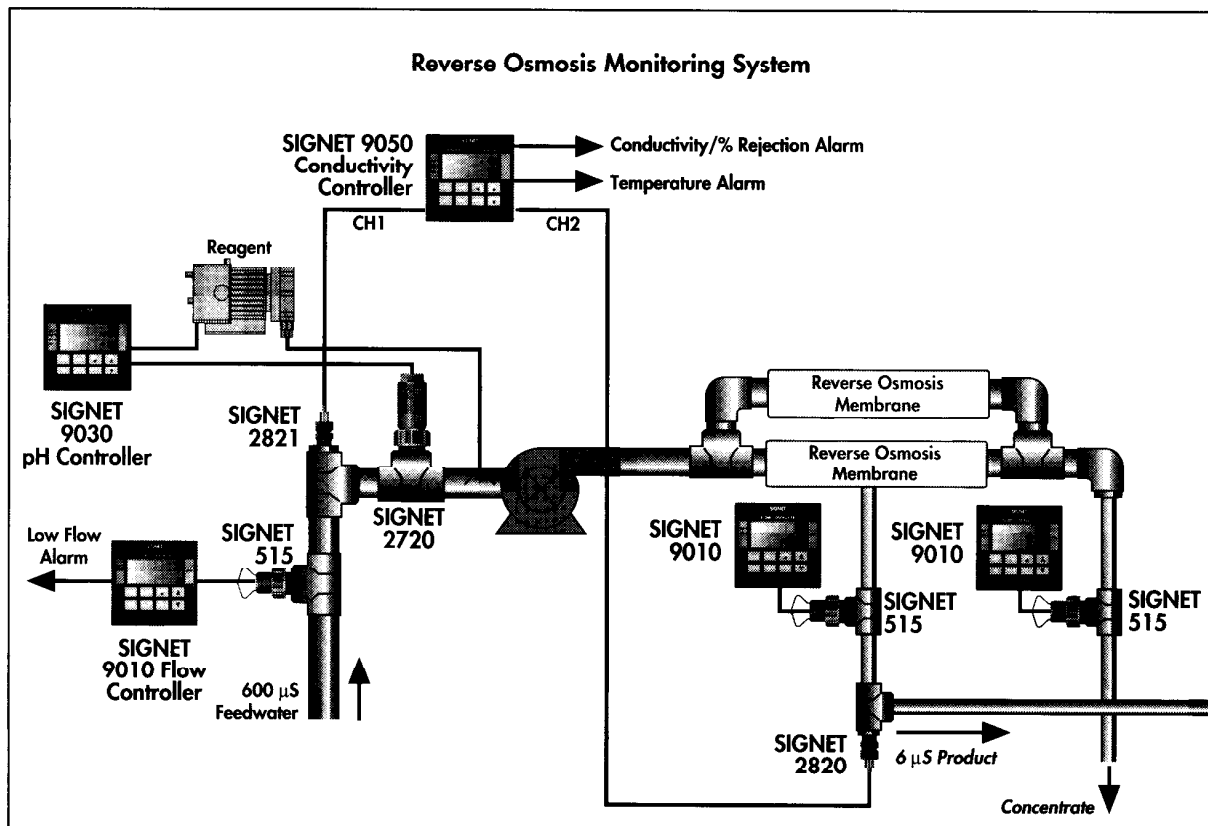
(clean water) can be stored, or further treated for additional use.

Reverse osmosis is more energy efficient than multiple distillation when treating salt water. Other advantages RO systems have over distillation and demineralization (ion exchange) are that the systems do not use hazardous regeneration chemicals, do not require large amounts of energy, and the systems are easy to maintain and service.

3.7 Typical RO Applications

- Flow rate control and totalization of feed, product, and concentrate
- Conductivity system efficiency monitoring
- Water quality monitoring μS or TDS
- pH neutralization of concentrate and membrane protection

In the RO system below, SIGNET flow sensors monitor, control and totalize system feed, product, and wastewater. SIGNET pH sensors pretreat water to protect RO membranes, and neutralize wastewater. SIGNET conductivity sensors monitor membrane performance, determine rejection ratio provide thermal protection for RO membranes. Pressure sensors verify pump performance and indicate membrane fouling or failure.



Part Four: Clarification

New Regulations for Municipal Water Treatment

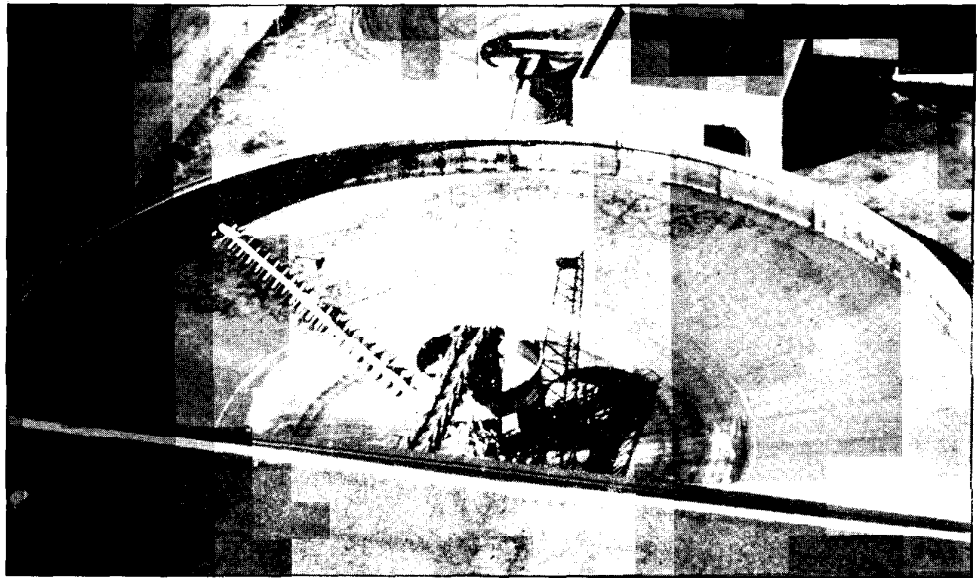
The primary goal of any municipal water treatment facility is to supply clean, good tasting water to its customers. The increase in polluted water sources and groundwater contamination, and new advances in the study of disinfection by-products is forcing municipal plants to adopt new standards for water quality.

unequaled opportunity for sales growth as all municipalities must adopt the new standards.

4.1 Clarification

Clarification is applied early in the water treatment process to provide colorless, clear water. This is done by removing the suspended particles in the water. Economic removal is sometimes

In circular tanks, scrapers (plows) attached to a rotating arm rotate slowly around the bottom of the tank. The clear surface water of the tank flows from the tank by passing over a weir at a low velocity.

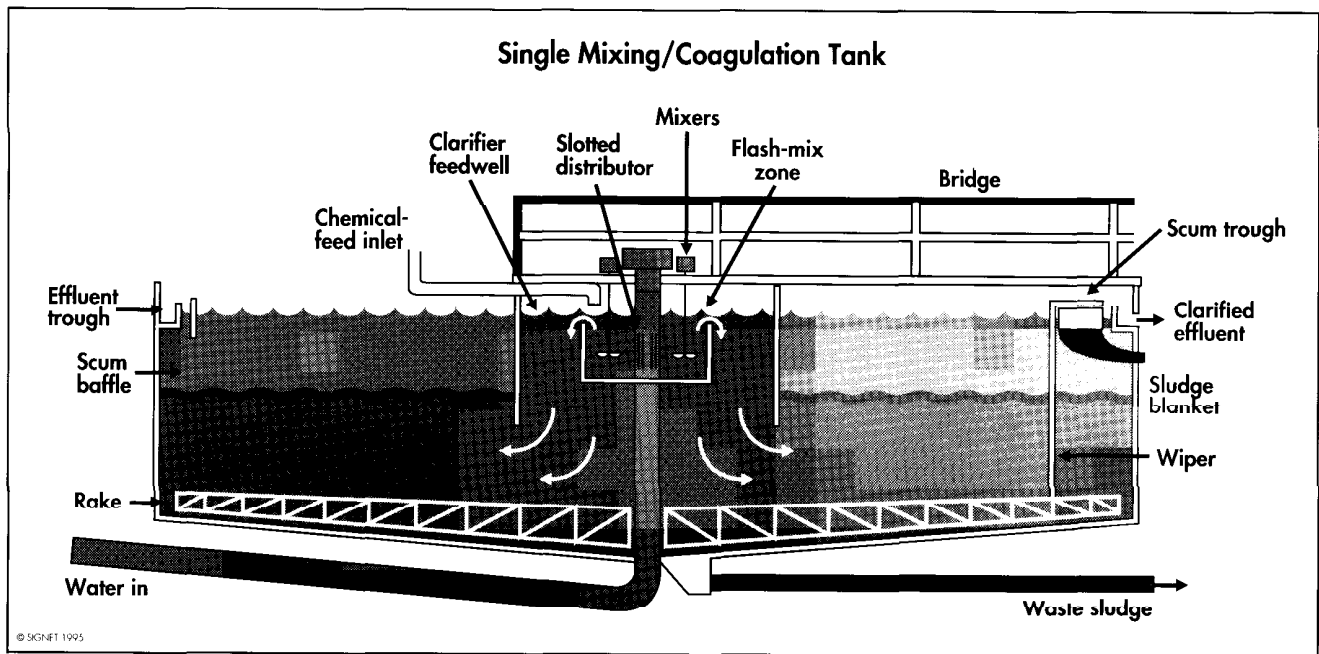


The standards for municipal water treatment plants are dictated by the EPA. In 1974, the EPA was mandated by congress to release regulations concerning maximum contaminant levels, and the best available technology for the removal of those contaminants.

In 1986, regulations were released mandating that municipalities test for 83 known contaminants. Every three years, an additional 25 contaminants must be identified, the maximum contaminant level set, and the technology for its removal identified. This will provide an

accomplished by flowing water through a basin at velocities low enough to allow sand and silt to settle. To speed up this process, clarifiers were developed.

The original clarifier design is the Horizontal Tank Clarifier. Incoming water is mixed rapidly with a coagulant, then slowly with the flocculent in the settling basin to create larger, more quickly settling floc. Sludge is pulled from the bottom of the sludge "blanket" and clarified water is removed from the top.



4.2 Single Mixing Coagulation Tanks

A second clarification technique is the single mixing coagulation tank. Floc is added in the center where a high velocity allows proper mixing. The slower velocity at the outer edge allows settling of the solids to occur. The sludge is pulled from the bottom and the clarified water is removed from the top.

4.3 Lime Softening

Lime Softening is required to prevent solids from settling and producing a hard scale. Lime softening is the most common method used by municipalities. Impurities are removed with precipitation of lime, sodium carbonate and sodium hydroxide. This process requires a 60 to 90 minute retention time, but can be operated at ambient temperatures.

Overview of Markets Served by SIGNET Products

- Water purification
- Biotechnology
- Semiconductor
- Waste water treatment
- Chemical processing

Others

- Agriculture
- Food and beverage
- Sanitary
- Aquaculture
- Printing
- Textile

Polymer is added to rapidly moving water at the center of the coagulation tank to produce initial flocculation. A low velocity in the clarifier feedwell promotes floc growth.

Glossary

Acid: A substance with a low pH, typically a liquid. Acids most commonly used in water conditioning to regenerate cation resins are HCl (Hydrochloric Acid) and H₂SO₄ (Sulfuric Acid).

Acre Foot: The amount of water which would cover an acre of land, one foot deep or 325,829 gallons.

Activated Carbon: Carbon which has been subjected to high heat, or burned in the absence of oxygen with steam injection. The resulting carbon is extremely porous.

Adsorption: A process in which a gas, vapor or liquid is electrostatically or chemically attracted to, and held by the surface of a solid.

Alkali: A basic substance. Typically a metal hydroxide with a high pH.

Ammonia: NH₃, NH₄O₄ A caustic chemical sometimes used in the regeneration of weak base anion resins.

Anions: Chlorides (Cl⁻), Sulfates (SO₄²⁻), Nitrates (NO₃⁻), Carbonates (CO₃²⁻), Silicates

Backwash: An upflow of water through an ion exchanger or filter to clean or re-stratify the media.

Base: A chemical substance with a high pH.

Bed: A vessel containing ion exchange resin. The term comes from observations made on ion exchange properties of flower beds, made over 400 years ago, and still in use today.

Brine: Water with a high concentration of NaCl (sodium chloride) (salt).

CTA Membrane: (Cellulose Triacetate) A reverse osmosis membrane that must be fed water with a chlorine residual because it is vulnerable to bacterial attack. It will operate in a pH range of 5-8 pH, and will provide RO water of reasonable quality.

Cations: Sodium, Calcium, Magnesium, Potassium, Iron, Manganese

Caustic Soda: (Sodium Hydroxide - NaOH) Caustic Soda is available in liquid form at 50% concentration or in dry flake form. Caustic soda is used to regenerate Anion resin.

Channeling: Channeling occurs when water forms its own "channel" or path of least resistance through a filter. Typical causes of channeling are too low a flow rate or an insufficient backwash resulting in "firm" strata which ruin the distribution of the water through the bed.

Chemical Oxidation: A process that uses oxidizing chemicals to break down harmful contaminants such as chlorinated hydrocarbons and cyanide.

Chloride: An anion found in water with no sterilization properties, and in normal concentrations, no taste or odor.

Chlorination: The application of chlorine to water or wastewater, generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

Chlorine: (Bleach) (ClO 12.5%) A dissolved gas and oxidizing substance used to kill microorganisms in water that would otherwise pose a threat to human health.

Clarification: A particle removal process using high-rate rapid settling devices, including conventional lamella-type settlers, circular clarifiers, heavy-duty drag-chain clarifiers and tube settlers for high solids/sludge thickening applications.

Coagulation: (or flocculation)
A process by which a chemical coagulant or flocculent is added to water, causing the particles to agglomerate into larger groupings (flocs), which can then be removed by gravitational settling.

Colloid: A particle that is halfway between a solid particle and a molecule.

Dechlorination: The removal of chlorine from the effluent of a treatment plant.

Deionization: Demineralization of water through the use of ion exchange resins.

Demineralization: A process by which dissolved minerals are removed by deionization, distillation, reverse osmosis, and electrodialysis.

Desalination: Processes that remove salt from water, such as reverse osmosis, ion exchange, distillation and evaporation

Disinfection: A process that destroys or deactivates harmful microorganisms via ultraviolet irradiation, ozonation, thermal energy and/or chemical sanitants.

Distillation: The technique of boiling water to produce vapor, and the condensing of that vapor back into water again

Distillation Anions: Chlorides, Sulfates, Nitrates, Carbonates, Silicates

Electrolytic Processes: Processes in which metals are removed and recovered from industrial wastewater with equipment that attracts the metal ions by electrolytic deposition.

Equalization of wastewater: A process that combines different wastewater streams in a collection area (usually a tank or equalization pond) before treatment to minimize spikes in pH, temperature, contaminant levels, etc.

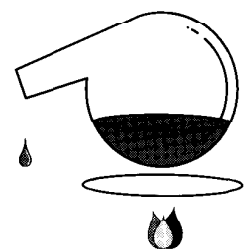
Exhaustion: Ion exchange resin that has a majority of available sites taken up with impurities. For example, cation resin loaded with ions and ready to be treated with acid.

Fast Rinse: The rinse that follows the chemical injection and displacement rinse. It is a true rinse to blow out all remaining chemical in the ion exchange bed.

Feed Water: The raw water introduced into a reverse osmosis system.

Filter Aid: A chemical (usually a polymer) added to water to help remove fine colloidal suspended solids.

Filtration: A process that removes solid matter and impurities from a fluid stream by passing it through a variety of devices, including wire and cloth-covered pressure filter leaves, tubular elements, ceramic and polymeric membranes, micro- and ultrafiltration units, upflow and downflow media filters, filter cartridges, as well as greensand, anthracite, carbon, diatomaceous earth, walnut-shell, multimedia, pressure and gravity filters.



Glossary (continued)

Flocculation: The gathering together of fine particles to form larger particles known as floc.

Freeboard: The empty space in an ion exchanger or filter above the media bed.

Grain: The weight of 1/7000 of a pound. It is typically used to describe the amount of dissolved solids in water.

Granular Activated Carbon: (GAC)
A form of activated carbon used in water purification.

Hardness: Dissolved minerals in water, specifically Magnesium (Mg) and Calcium (Ca). Hardness minerals precipitate out of water easily which can cause problems for certain processes.

Head Loss: An indirect measure of loss of energy or pressure occurring when water passes through a pipe, bar screen, filter, or other obstruction.

Hydrochloric Acid: (HCl) Dissolved Hydrogen Chloride gas. A strong oxidizing acid sometimes called Muriatic Acid.

Ion Exchange: The chemical exchange of ions typically accomplished by a synthetic resin in bead form.

Ion Exchange Resin: A synthetic substance made of specially treated plastic (polystyrene cross linked with divinylbenzene) which has the property of being able to exchange ions. Resin takes the form of small spherical plastic beads, about 1 mm in diameter.

Ions: Electrically charged atoms or groups of atoms. The charge of a single ion may be positive or negative:

ions of metals such as calcium Ca^{++} , magnesium Mg^{++} , sodium Na^{+} , and of Hydrogen H^{+} are positively charged and are called CATIONS. Their charges are balanced by negatively charged ANIONS such as chloride Cl^{-} , sulfate $SO_4^{=}$, etc. These ions are known as electrolytes because they conduct electricity.

Media: The material in a gravity or pressure filter.

Media Filtration: A filtration process in which solids deposit on filter media such as ion exchange resins, carbon, anthracite, sand, quartz, manganese greensand, anthrafilt and garnet.

Membrane Filtration: A process used to separate components in a liquid by applying hydraulic pressure across the surface of a semipermeable membrane.

Microfiltration: A membrane filtration process that removes particles and bacteria within the size range from 0.1 to 10 micrometers.

Micron: One millionth of a meter (0.000001 meters). Typically used to measure particle or microorganism sizes.

Mixed Bed Deionization: A process that purifies water using two ion exchange resins mixed in the same tank. One resin is a cation exchange resin which exchanges positively charged ions. The other resin is an anion exchange resin which exchanges negatively charged ions. When the resins are mixed, and the water passes through the resin bed, it encounters a cation resin bead, then an anion resin bead, then cation, then anion and so forth.

Module: Reverse osmosis membrane(s) installed in a pressure vessel.

Muriatic Acid: A specific strength of Hydrochloric Acid of about 36%. (See Hydrochloric Acid)

Nitric Acid: (HNO_3)
A strong oxidizing acid.

ORP: (Oxidation-Reduction Potential, REDOX) The electrical potential (mV's) required to transfer electrons from one compound or element (the oxidant) to another compound or element (the reductant) and used as a qualitative measure of the state of oxidation in wastewater treatment systems.

Oil/Water Separation: A process that removes oil and solids from wastewater down to the ppm range.

Ozonation: The application of ozone to water, wastewater, or air, generally for the purposes of disinfection or odor control.

Ozone: (O_3)
A gas used primarily to kill any microorganisms present in water. Ozone is created at the point of use by either Ultraviolet radiation, (subjecting air or oxygen to electromagnetic radiation of a wavelength of 1849 Angstroms), or by Corona Discharge (passing air or oxygen through an electric arc). Ozone acts as an oxidizing agent, and can cause chemical changes with nonliving organics and will react with reducing agents.

pH: The measure of acidity or basicity of a liquid. The pH range is from 0 to 14, with 7 being neutral.

PPM: (parts per million) (mg/L) refers to the total weight of dissolved solids in solution and is a good general purpose indicator of water purity.

PPMF (parts per million factor):
The conversion factor used by SIGNET instruments for converting conductivity readings to ppm readings. It is roughly one half the conductivity value.

Packaged Deionization: A deionizer system capable of automated regeneration.

Percent Recovery: The amount of water recovered by the RO membranes as a percentage of the feed water.

Percent Rejection: The quantity of dissolved solids rejected by the RO membrane.

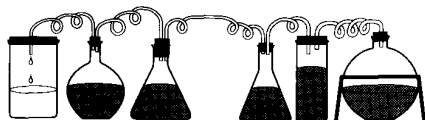
Permeate: Water forced by pressure through an RO membrane. It also refers to pure water produced by a reverse osmosis system.

Polymer: A chemical used with other chemical coagulants to aid in binding small suspended particles to larger chemical flocs for removal from water.

Precipitation: The separation of an insoluble substance from a solution.

Product Water: The pure water produced by a reverse osmosis system.

Resistivity: A measure of the dissolved solids in water obtained by passing an electrical current through the water. The greater the resistance to current, the better the water



Glossary (continued)

Reverse Osmosis: The application of pressure to water, forcing the water molecules to pass through a semipermeable membrane from the concentrated side to the pure side, reversing normal osmotic flow.

Saturated Brine: Water with as much salt in it as it can hold without precipitation.

Service Deionization: A portable exchange deionizer system that is transported from a central regeneration plant to a location where deionization is to take place, and returned to the plant for regeneration.

Service Run: A complete deionization process.

Sludge: The settleable solids separated from liquids during processing, or the deposits of foreign materials on the bottoms of streams or bodies of water.

Sodium Hydroxide (NaOH): Caustic Soda used to regenerate the Anion resin.

Specific Conductance: A numerical expression ($\mu\text{S}/\text{cm}$) of the ability of water or wastewater to conduct or carry an electric current.

Sterilizer: A substance or process that kills microorganisms.

Strong Base Anion Resin: Ion exchange resin which removes all anions from water replacing them with $[\text{OH}^-]$.

Sulfuric Acid (H_2SO_4): A strong acid used alternatively with Hydrochloric acid for the regeneration of Cation resin.

Suspended Solids: Particulate impurities that can be removed using mechanical filters.

Thin Film Composite (TFC) Membrane: A type of reverse osmosis membrane impervious to bacterial attack, can operate in a pH range of 2 to 12, provide excellent RO water, and must be fed with chlorine free water.

Total Dissolved Solids (TDS): A measurement of the total weight of dissolved solids within an aqueous solution. This measurement is normally referred to in PPM (parts per million).

Two Bed Deionization: Deionizers that purify water using two ion exchange resins in two different tanks. One tank contains cation exchange resin which exchanges positively charged ions. The other tank contains anion exchange resin which exchanges negatively charged ions.

Ultraviolet Sterilization: Typically a stainless steel housing containing a mercury-vapor lamp that emits ultraviolet radiation. The radiation kills microbes, bacteria and viruses. It will oxidize organic material.

Vacuum Distillation: The distillation of water under a vacuum increasing the vapor pressure of water and allowing more purified water production with the same heat input.

Weak Acid Cation Resin: A high capacity resin that removes cations associated with alkalinity. It can be used in softening and deionization.

Weak Base Anion Resin: A very high capacity resin that removes only the strongly basic anions, allowing the weakly basic anions to remain in water.

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