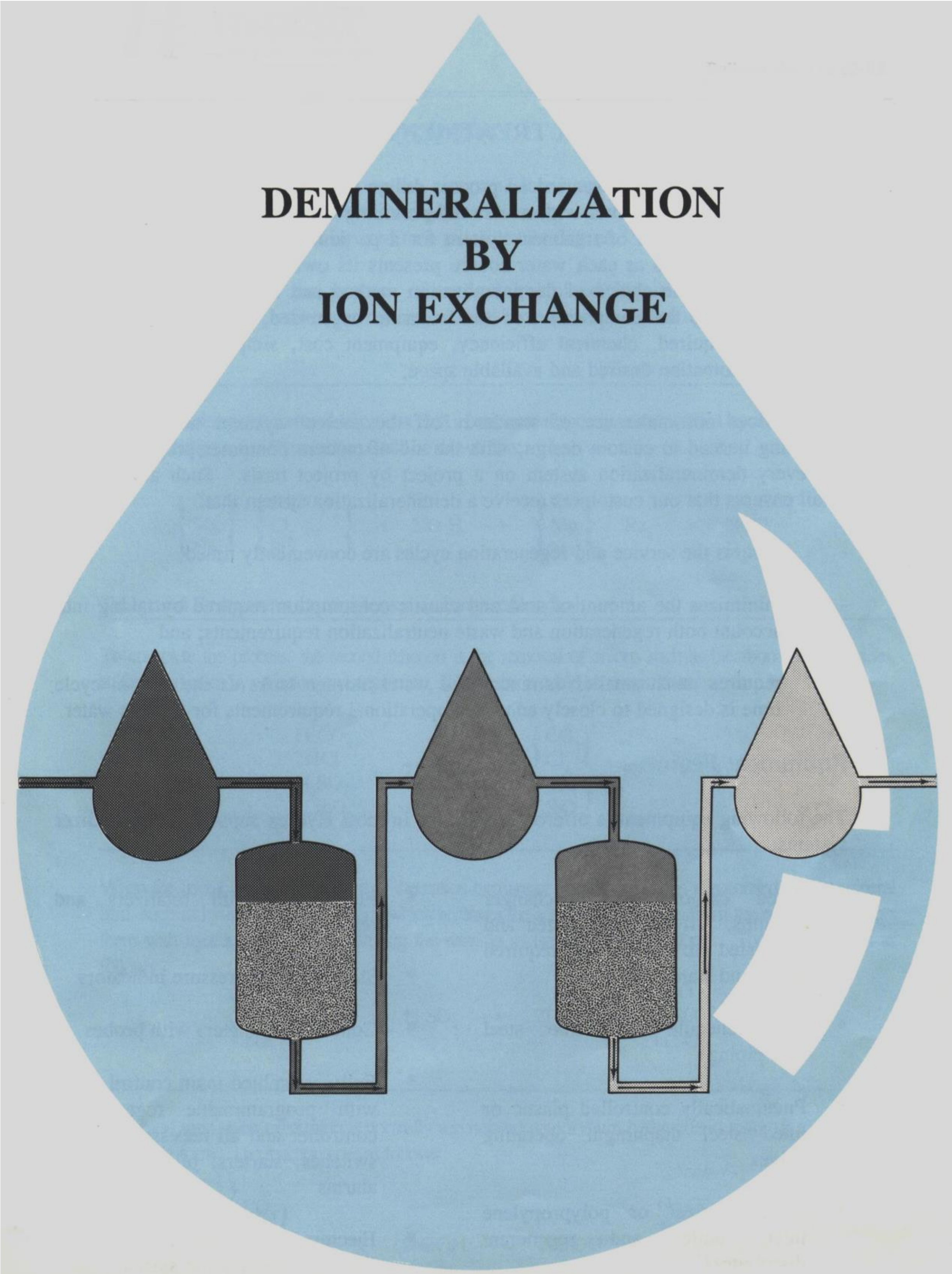
DEMINERALIZATION BY ION EXCHANGE



HYDREX
WATER & WASTE TREATMENT

HYDREX –THE WATER TREATMENT SPECIALISTS

There are no ready made solutions as each water source presents its own individual characteristics and problems. The highly qualified and experienced process design engineers at Hydrex exhaustively evaluate process alternative with a view of providing the most dependable, efficient and cost effective type of treatment system for a particular project. The Choice of demineralization method and resins depends on many factors including the composition of the water to be treated, flow rate, degree of purification required, chemical efficiency, equipment cost, simplicity of operation, degree of automation desired and available space. Sometimes, Reverse Osmosis system may be recommended ahead of an ion-exchange system when Total dissolved Solids (TDS) is higher than 400~500 mg/l in order to reduce chemical consumption.

Hydrex does not make use of standard "off the shelve" systems and equipment, preferring instead to custom design, with the aid of updated computer programs, each and every demineralization system on a project by project basis. Such attention to detail ensures that our customers receive a demineralization system that:

- **ensures the services and regeneration cycles are conveniently timed;**
- **minimizes the amount of acid and caustic consumption required by taking into account both regeneration and waste neutralization requirements; and**
- **requires much smaller demineralizer water storage tanks as the system cycle time is designed to closely adhere to operation requirement for process water.**

Equipment Features

The following equipment is offered as standard in most Hydrex supplied demineralizer system:

- Lined carbon steel or fiberglass exchanger tanks, fully pressure tested to meet the required codes and standard.
- PVC Schedule 80 or lined steel face piping
- Pneumatically controlled plastic or lined steel diaphragm operating valves
- Stainless steel or polypropylene inlet, outlet and regenerant distributors
- Conductivity meters with probes
- Flowmeters with totalizers, flowrate indicators and reset registers
- Stainless steel, liquid filled pressure indicators
- Fully assembled control panel with electronic programmable regeneration controller, monitoring instrument and annunciation system
- Ejector or pumps and corrosion resistant delivery lines for regeneration system

DEMINERALIZATION PROCESS

Natural water obtained from wells, rivers or lakes contains dissolved salts, silica and carbon dioxide. The salts are ionized as cations or anions, while the silica and carbon dioxide are dissolved but ionized to a much lesser degree.

Demineralization is the process of removing ionized impurities from water by the utilization of ion exchange resins. There are two basic ion exchange reactions in demineralization.

The first reaction is the removal of cations such as calcium, magnesium and sodium by an acid regenerated cation exchange resin. The reaction could be shown thus:

$$\left\{\begin{array}{l} Ca \\ Mg \\ Na_2 \end{array}\right\} \left\{\begin{array}{l} (HCO_3)_2 \\ CI_2 \\ SO_4 \end{array}\right\} + 2RzH \rightarrow \left\{\begin{array}{l} Ca \\ Mg \\ Na_2 \end{array}\right\} Rz_2 + \begin{array}{l} 2H_2CO_3 \\ 2HCI \\ H_2SO_4 \end{array}$$

The symbol Rz represents the complex ion exchange resin radical.

To complete the process, the second reaction is the removal of anions such as bicarbonates, chorides, sulfates and silica by an anion exchange resin. The reaction could be shown thus:

$$\begin{array}{l} H_2CO_3 \\ 2HCI \\ H_2SO_4 \\ H_2SIO_3 \end{array} + 2Rz\ OH \rightarrow \left\{\begin{array}{l} CO_3 \\ CI_2 \\ SO_4 \\ SiO_3 \end{array}\right\} Rz_2 + 2H_2O$$

When the useful exchange capacity of the cation exchanger is exhausted, it is regenerated with a mineral acid, such as hydrochloric or sulfuric, which removes the accumulated cations from the resin and replaces them with hydrogen ions, thus restoring to its original hydrogen form. The reaction goes as follows:

$$\left\{\begin{array}{l} Ca \\ Mg \\ Na_2 \end{array}\right\} Rz_2 + H_2SO_4 \rightarrow 2RzH + \begin{array}{l} CaSO_4 \\ MgSO_4 \\ Na_2SO_4 \end{array}$$

The anion resin upon exhaustion is normally regenerated with sodium hydroxide to restore it to its original hydroxide form. The reaction goes as follows:

$$\left\{\begin{array}{l} CO_3 \\ CI_2 \\ SO_4 \\ SiO_3 \end{array}\right\} Rz_2 + 2NaOH \rightarrow 2RzOH + \begin{array}{l} Na_2CO_3 \\ 2NaCI \\ Na_2SO_4 \\ Na_2SiO_3 \end{array}$$

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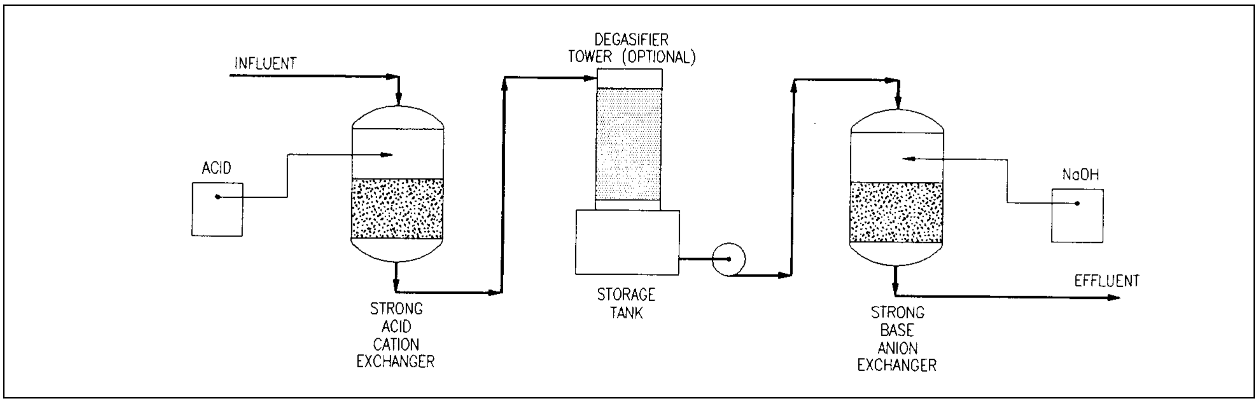
Various Types of systems and resins are employed to accomplish deionization to various degrees. A general description of the more widely used system follows.

TWO-STEP DEMINERALIZED SYSTEM

A demineralization system in which a cation exchanger is followed in series by an anion exchanger is commonly called a "two-step" system. In applications which required silica removal as well as the removal of other materials, a system using strong acid resin in the cation exchanger and strong base resin in the anion exchanger is employed. The majority of ions are removed by this system, producing an effluent containing zero CO_2 and very little dissolved silica. Effluent conductivity normally ranges from 4 to 15 micromhos, depending upon the amount of sodium in the raw water and the level of chemical dosage employed for regeneration.

In instances where waters have medium to high alkalinity levels, placing a degasifier between the cation and anion exchanger bed volume and a considerable saving in caustic consumption. The degasifier removes the CO_2 generated by the cation exchanger rather than requiring the anion exchanger to remove it.



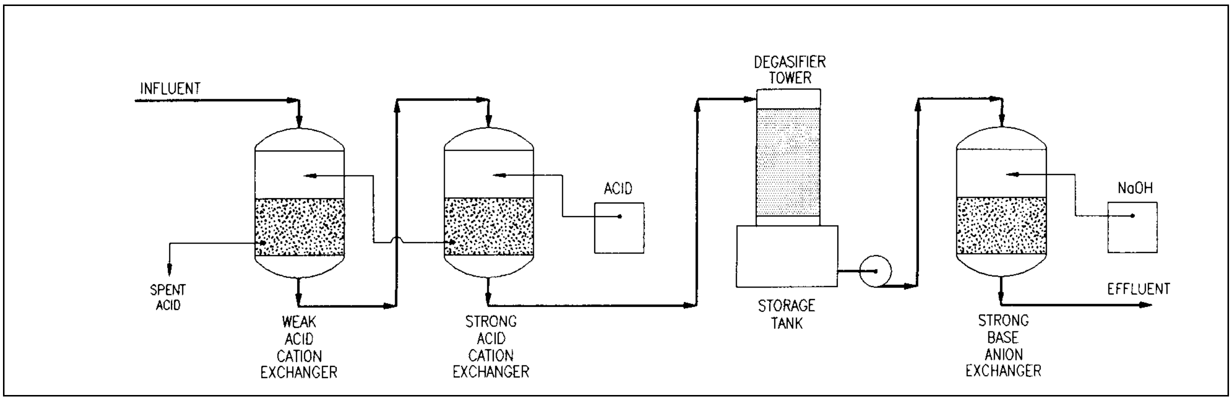
A fully automatic demin. train installed in a beverage factory for product manufacturing and for rinsing process.

A two train demin. system installed in the Philippines steel coating plant for boiler feed water treatment.

THREE STEP SYSTEM WITH DEGASIFIER

When high levels of hardness and alkalinity are present in the water to be demineralized, a three-bed system with deagasifier is often the most economical system to operate.

The bulk of the hardness is removed by the weak acid unit, which is more efficiently regenerated, thus considerably reducing acid consumption.



A Two train 3900m^3/day fully automatic demin.system installed in the San Miguel Brewery at San Fernando, Philippines. A pump type regeneration system was provided. The system was expanded to 4900m^3/day by the installation of the third train.

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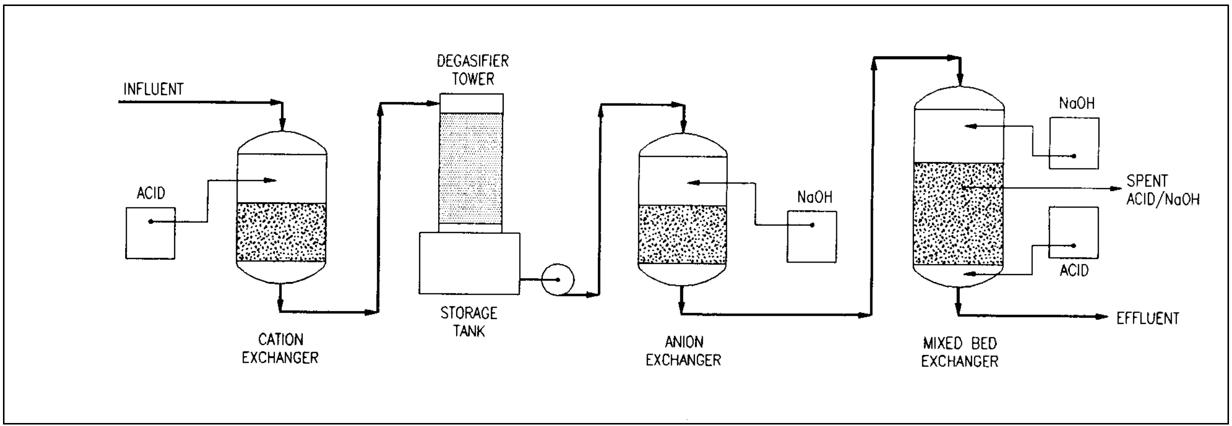
MIXED BED SYSTEM

A mixed bed exchanger contains both cation and anion resins in an intimately mixed single column. In essence, this corresponds to an infinite series of cation-anion exchangers. It produces an extremely high quality water that could not be attained by a multi-bed system alone. An effluent conductivity of up to 18 mega-ohm can be achieved by a system which included a mixed bed.

While mixed beds produce the highest quality treated water possible, they are less economical to operate, more complicated to regenerate and more costly than two-step systems. Their use is therefore limited to polishing applications where a high degree of purity is required. Mixed bed units normally follow a multi-bed system for complete removal of all dissolved solids.

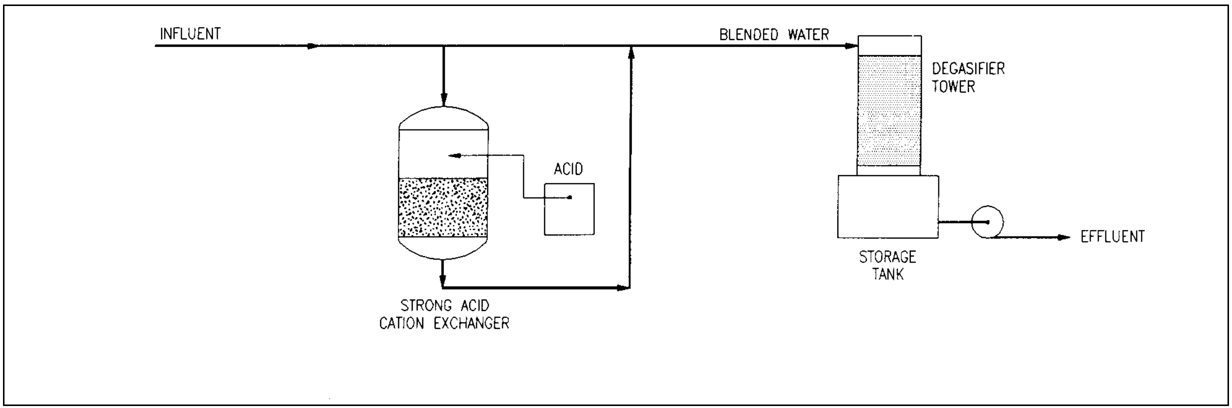


A fully automatic two train 900m^3/day demin. System is equipped with polishing mixed bed to produce ultra pure water for La Tondena Inc., Philippines.

A fully automatic skid mounted, two train demin. System with two bed plus mixed bed, is ready for delivery to Indonesia. The system was built to the most stringent specification outlined by Bechtel.

DEALKALIZER SYSTEM

In instances where reduction of alkalinity to a specific amount and partial rather than complete removal of hardness are required, a dealkalizer system may be employed. In such a system, the effluent from a hydrogen cation exchanger is mixed enough raw water so that its bicarbonate alkalinity neutralizes the acidity and furnishes whatever alkalinity is desired. The blended water is then passed through a degasifier. The blending is done ahead of the degasifier so that the CO_2 liberated by the neutralization, as well as that liberated in the hydrogen cation exchanger will be reduced to the level required.



A two train strong acid cation exchanger with degasifier installed in a bottling plant in Calasiao, Philippines to replace an existing lime soda dealkalization / softening system.

REGENERATION SYSTEMS

Each time an ion exchange unit is regenerated, a predetermined amount of chemical must be introduced into the resin bed at a controlled concentration, at a precise rate and for an exact duration for the regeneration to be effective. Any deviation could cause problems such as poor regeneration, precipitation of solids on the resin, loss of resin capacity and chemical wastage.

Co-current and Counter-current Regeneration

Hydrex offers both co-current and counter-current regeneration systems. Conventional co-current regeneration, in which the service cycle operates in the same direction as the regeneration cycle, has relatively few operational considerations to take into account and system design is straight forward.

Counter-current regeneration, on the other hand, is becoming an alternate technique despite the higher capital cost and operating complexity. Its primary benefit when used in conjunction with cation exchangers is its ability to obtain relatively high quantity treated water as sodium leakage can be kept to a minimum. Thus, effluent conductivity normally ranges from 1 to 4 micromhos, as compared to 4 to 15 micromhos for a co-current regenerated two bed system. In addition, improved regeneration efficiency can be obtained, thus providing savings in chemical cost.

Counter-current regeneration is used in conjunction with anion exchangers when silica reduction to relatively low levels is an important process consideration, as in the case of medium to high pressure boiler feedwater.

FOR FURTHER INFORMATION

A full range of water and wastewater treatment systems and equipment are available from Hydrex. For further information, please contact us or our authorized agent.

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