



An Introduction to

INDUSTRIAL WATER DEMINERALIZATION SYSTEMS

A PUBLICATION OF SAMCO TECHNOLOGIES



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Chapter One

WHAT IS WATER DEMINERALIZATION AND HOW DOES IT WORK?



WATER DEMINERALIZATION SYSTEMS

What they are and how they work

In industrial water treatment, demineralization refers to the removal of dissolved solids from feed water and process streams. If you're investigating options for water treatment and purification, you might be asking **"What is water demineralization and how does it work?"**

The following chapter offers a simple explanation of how demineralization works, what you can expect from an average demineralization system, and what contaminants are typically removed by demineralization technologies.

What is water demineralization?

Demineralization is a type of water purification. While it can refer to **any treatment process that removes minerals from water**, the term demineralization is typically reserved specifically for ion exchange (IX) processes used for near total removal of ionic mineral contaminants. Often, the terms demineralization and deionization are used interchangeably.

IX demineralization utilizes both cation and anion exchange resins, sometimes even in the same column or bed. After demineralization, the treated water will be of a high level of purity comparable to distilled water, but typically at a much lower cost.



What's included in a basic demineralization system?

The specific design and components of an IX demineralization system can vary from one application to the next based on process conditions and composition of the stream to be treated. Still, most demineralization systems will include the following components:

- One or more IX columns
- Regenerant dosing system
- Chemical feed storage tanks
- PLC, control valves and piping
- IX resins

There is some flexibility in the configuration of a demineralization system in order to optimally meet various process conditions and purity goals. In designing a demineralization system, consideration should be given to variability of the feed water, level of purity needed, system footprint, tolerance for ion leakage (in particular sodium and silica), and chemical feed requirements, among other factors.

How does demineralization work?

As mentioned prior, demineralization typically refers to the removal of dissolved mineral solids through an IX process. But before we get deeper into how demineralization works, we'll go over the basic principles of an IX reaction.



In the presence of water, minerals and salts dissociate into their constituent ions. These dissolved solids consist of negatively-charged ions known as anions, and positively charged ions known as cations, each of which are attracted to counterions (or ions of an opposing charge). Present within an IX column is a resin which consists of plastic beads to which an ionic functional group has been bound. These functional groups loosely hold ions of an opposing charge through mutual electrostatic attraction. During an active IX cycle, water with dissolved ions is introduced to the resin. The ions in solution will exchange places with the ions on the resin beads, clinging to the resin's functional groups even as the resulting solution is drained away. IX happens when one ion has greater affinity for the functional group than the ion that is already present. The specific ionic contaminants present will dictate whether anionic and/or cationic resin types are needed.

In a typical IX reaction, the exchange of ions simply results in the replacement of contaminant ions with other, less objectionable, ions. In an IX sodium softening system, for example, the objective is to remove hardness ions (e.g. Ca^{2+} or Mg^{2+}) from solution by replacing them with sodium ions (Na^{+}). As a result, the treated solution will have little to no hardness, but it will contain a greater concentration of sodium ions.

While this is acceptable for many applications, some processes demand near-total removal of dissolved solids. That's where demineralization comes in. In demineralization, cations in the feed water are exchanged for hydrogen (H^{+}) ions and cations are



exchanged for hydroxyl (OH^-) ions. The result is water: $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$. In general, demineralization IX systems are available in either two-bed or mixed-bed configurations, as detailed below.

Two-bed IX

Two-bed or dual-bed exchangers use two or more IX resin beds or columns are used to treat a stream, each containing a specific type of IX resin. In two-bed demineralization, a stream is first treated with a strong acid cation (SAC) resin that captures the dissolved cations, and releases hydrogen (H^+) ions in exchange. The resulting mineral acid solution is then routed to the strong base anion (SBA) resin bed. This second step sequesters the anionic contaminants while releasing hydroxide (OH^-) ions, which combine with the existing hydrogen ions (H^+) to form water. The resulting stream is low in TDS and has a nearly neutral pH. While two-bed exchangers are effective for demineralization, sodium leakage can affect the quality of their output, especially for streams with high TDS and/or low pH.

Mixed-bed IX

Mixed-bed exchangers offer a higher water quality compared to twin-bed systems. Mixed-bed ion exchangers hold a mixture of different IX resins housed within a single IX column. When a stream is introduced to the unit, the cation and anion exchange reactions take place simultaneously within the unit, which has the effect of addressing the sodium leakage issues that can compromise the quality of water produced by a twin-bed IX system. While mixed-bed exchangers produce higher quality water, they also require a more involved resin regeneration process. Additionally, mixed-bed units are more



susceptible to resin fouling and/or inferior system function due to fluctuations in stream contents and are therefore typically used downstream of other treatment measures.

What contaminants does demineralization remove?

Demineralization generally results in almost complete removal of minerals, and is thus typically reserved for applications requiring higher level of water purity, such as feed or makeup water for high-pressure boilers, rinse water for food and beverage industries, or process streams used in electronics manufacture, for example. For fresh water applications, demineralization can be a good alternative to distillation, as it is capable of producing water similar in quality to distilled water, but through a cost-effective ion exchange process.

Below we have outlined the most common contaminants treated by demineralizers:

Cations

The cation resins within a demineralization system will exchange cations, or contaminants having a positive charge. Common cationic contaminants include:

- Calcium (Ca^{2+})
- Iron (Fe^{3+})
- Magnesium (Mg^{2+})
- Manganese (Mn^{2+})
- Potassium (K^{+})
- Sodium (Na^{+})



Anions

The anion resins within a demineralization system will exchange anions, or contaminants having a negative charge. Common anionic contaminants include:

- Alkalinity (CO_3^{2-} , HCO_3^-)
- Chloride (Cl^-)
- Nitrate (NO_3^-)
- Sulfates (SO_4^{2-})
- Silica (SiO_2)

A close-up, blue-tinted photograph of a metallic valve handle with a cross-shaped design, set against a blurred industrial background. The handle is the central focus of the top section of the page.

Chapter Two

WHAT ARE THE PROPERTIES OF DEMINERALIZED WATER AND HOW CAN IT BENEFIT YOUR PLANT?



PROPERTIES OF DEMINERALIZED WATER

What are they? How can they benefit your plant?

Demineralization, **the process of removing nearly all dissolved salt and mineral ions from water**, can prove ideal for facilities requiring ultrapure water for a variety of applications. If you have an overall understanding of demineralization but still have questions regarding the possible advantages of using it at your facility, you might be wondering “**what are the properties of demineralized water and how can it benefit your plant?**” Below is a breakdown of those properties and a list of common uses so you can determine whether or not this solution might help your facility meet its industrial water quality needs.

What are the properties of demineralized water?

Demineralized water is usually **made by using ion exchange, electrodeionization, or membrane filtration technologies**, which can be more efficient for creating ultrapure water than processes such as distillation (where water is boiled in a still and condensed, leaving dissolved contaminants behind).



Demineralization by ion exchange, electrodeionization, or membrane filtration can produce water that is **nearly 100% free of minerals and salts including (but not limited to):**

- Alkalinity (CO_3^{2-} , HCO_3^-)
- Calcium (Ca^{2+})
- Chloride (Cl^-)
- Iron (Fe^{3+})
- Magnesium (Mg^{2+})
- Manganese (Mn^{2+})
- Nitrate (NO_3^-)
- Potassium (K^+)
- Silica (SiO_2)
- Sodium (Na^+)
- Sulfates (SO_4^{2-})

Depending on the technology used, **the number of dissolved solids in water that has been demineralized can reach below 10 mg/l and the electrical conductivity can be less than 2 mS/m.**

Using ion exchange or other processes using resins won't remove uncharged molecules, so while demineralization can be counted on to remove almost all minerals and salts, the resulting water might contain some organic contaminants such as certain viruses or bacteria. Using reverse osmosis or nanofiltration to demineralize the water will remove these contaminants.



How is demineralized water beneficial for your plant?

Demineralization is typically reserved for applications requiring higher levels of water purity, such as **feed or makeup water for high-pressure boilers, rinse water for food and beverage industries, or process streams used in electronics manufacture**, for example.

The following list does not include every use for demineralized water, as it can be used for countless applications. It is, however, a representation of the most common applications, broken out by industry:

Power

In the power industry, **demineralized water is often used for boiler feed water and steam generation**. Boilers that generate steam to power turbines require high-pressure boilers and therefore more complex feed water treatment system to remove as many impurities as possible.

When steam is produced inside the boiler, the water particles collect and condense, then are recycled and used as part of the boiler feed water. Technically, the condensate that the steam-making process produces is distilled, but dissolved gases such as oxygen and carbon dioxide are sometimes present. The chemical reactions due to the presence of these dissolved gases can cause severe corrosion on boiler pipes and parts. These gases are typically removed with demineralization, advanced deaeration devices, or chemical



scavengers, so if you have these present, chances are your boiler feed water system will need to incorporate some form of these technologies.

Refinery

Refineries use demineralized water, like in the power industry, to feed their high-pressure boilers. Hardness and dissolved solids can wreak havoc on a facility's equipment, and softening is often not enough treatment for most high-pressure boilers and process streams. Since many higher-pressure boilers require a higher quality of water with less contaminants than some lower-pressure boilers, demineralization by ion exchange or membrane filtration (reverse osmosis or nanofiltration, mostly) is typically part of the water treatment train.

Petrochemical and Chemical

For the petrochemical and chemical industries, high-purity boiler feed water is also required. Demineralization is used for this.

Demineralization can also be used to treat cooling tower blowdown (which can also apply to other industries mentioned). If the water from your blowdown needs to be discharged, any discharge your system creates will need to meet all regulatory requirements. In certain areas where water is scarce, there could be large sewer connection fees, and demineralization systems can be a cost-effective solution here because they can help minimize the cost to connect to water and sewer lines. The discharge of your cooling tower bleed must also meet local municipal discharge regulations if your effluent



is being returned to the environment or a publicly owned treatment works (POTW).

Food and Beverage

Demineralized water is often used to sanitize containers and equipment. It is also used in certain food processing applications, although membrane filtration is usually the technology used so organic material, bacteria, viruses, etc., can be eliminated. Food and beverage production require ultrapure water at all parts of the manufacturing process due to quality regulations, so demineralization is often part of the overall water treatment process.

Pharmaceuticals and Cosmetics

Deionized and distilled water are used in the manufacturing of pharmaceutical products and cosmetics in order to control product quality and safety. Different methods of producing demineralized water for different uses, rinsing, and cleaning will be reverse osmosis or deionization while formulations typically use distilled water.

Other industries

Demineralized water are both used for cleaning and rinsing applications across a wide variety of industries including chemical production, mining, as well as solvents in applications as diverse as electrocoating, where they function as a carrier for paint solids or in research labs where they may be used to make a variety of solutions.



Chapter Three

WHAT IS THE DIFFERENCE BETWEEN DEMINERALIZED, DEIONIZED, AND DISTILLED WATER?



DEMINERALIZED, DEIONIZED, AND DISTILLED WATER

What are the differences?

Purified feed water and process streams can be a critical aspect of ensuring consistency in production and equipment performance. While it's easy to imagine why purified water is essential to so many industries—including cosmetics, food and beverage, power, pharmaceutical, and microelectronics, among others—you may still be wondering **“What is the difference between demineralized, deionized, and distilled water?”**

This chapter compares and contrasts these common types of purified water, and gives an overview of the basic terminology and processes involved in demineralization, deionization, and distillation.

How are demineralized, deionized, and distilled water similar?

Demineralized, deionized, and distilled water share in that they are all types of purified water, meaning that they have undergone some treatment process to remove impurities and make the treated water suitable for a given use. While they are of similarly high quality, the distinction between the three lies in which treatment process is used to produce them.



The terms “demineralization” and “deionization” are often used interchangeably, with both referring to ion exchange (IX) processes used to remove nearly all dissolved solids from a stream. Less commonly, “demineralization” is used to refer broadly to any or all treatment processes used to remove dissolved solids from a liquid, encompassing not just IX, but filtration processes such as reverse osmosis (RO) and Nanofiltration (NF) as well. For our purposes here, we’ll stick to the more common definition and look at how demineralization and deionization collectively compare to distilled water, which is that **they have similar applications**.

Demineralized/DI water and distilled water alike can be used for applications requiring high purity thresholds.

Distilled water offers slightly greater purity than DI (bacteria, organics, and particulate), though owing to its greater cost, it is generally reserved for only those applications with particularly stringent purity standards such as in pharmaceuticals. It is also used as part of an evaporation process for ZLD.

How are demineralized, deionized, and distilled water different?

Demineralized/deionized and distilled water offer similarly high purity. Still, there are a few characteristics that set them apart from one another, as detailed herewith.



They are produced through different processes

The chief difference between DI and distilled water is the process by which they are produced. Demineralization and deionization consist of an IX process where a stream is passed through one or more IX resin beds. The specialized resins contained in the IX unit(s) remove dissolved solids based on an electrostatic attraction between the ions in solution, and those on the resin.

Another form of deionization, called electrodeionization (EDI) is similar in principle to IX DI in that it removes dissolved solids based on their electrostatic charges. It differs in that it leverages electricity and semipermeable IX membranes rather than resins. EDI is used across a variety of industries for polishing post RO.

Distillation is a fundamentally different process from deionization. In distillation, a liquid is heated in a still to boiling, then the resulting water vapor is cooled in a condenser, and the purified liquid water is then captured in a sterile container. Thus, **where DI removes contaminants from the water, distillation effectively removes the water from the contaminants**, which are left behind in the still after the water has evaporated away. In a high-purity system, DI or RO product water will be fed to the still as makeup.

They have different operational costs

For most industrial applications, DI is far more cost-effective than distillation. This is because distillation requires significant energy expenses for heating, circulation, and cooling, especially for the large volumes of water needed to support production on an industrial scale.



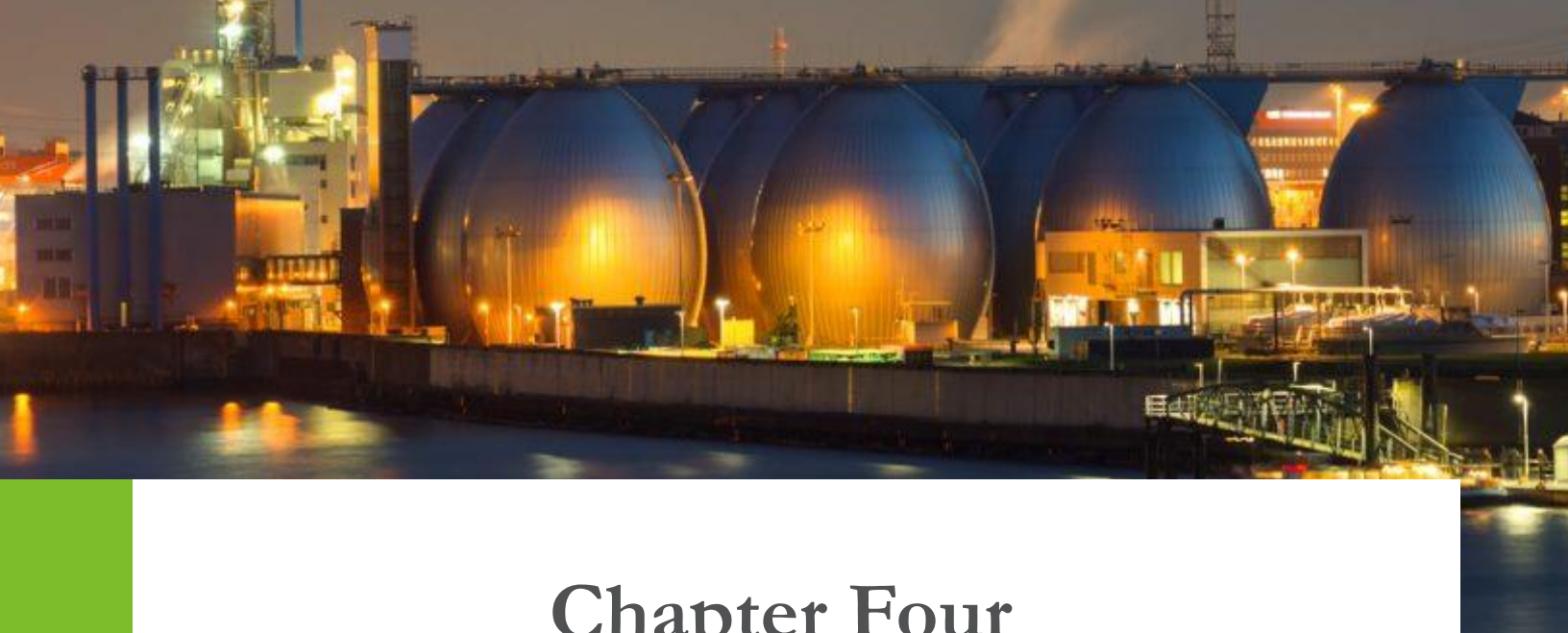
Over the last few decades, innovations such as vapor compression and multiple effect distillation setups have led to greater energy efficiency, but they are still costly to run comparative to other purification technologies.

The ongoing operational costs of a DI system are comparatively quite low. DI typically requires minimal energy costs, generally only to power pumps to circulate water, as well as chemical costs for resin regeneration.

They remove different contaminants

As mentioned in a prior section, deionization is highly effective for near-total removal of ionizable substances, however, due to the nature of the IX reaction, DI is not effective for removal of non-ionic substances such as organic or biological contaminants. For this reason, it may be necessary to employ some form of filtration to pretreat a stream prior to IX.

Distillation, on the other hand, is capable of removing nearly all contaminants, including ionic organic or inorganic substances as well as biological contaminants. While distilled water offers very high purity, it may be contaminated when volatile materials rise away with the water vapor and end up in the distillate in what is known as carry-over. Distilled water will also carry over inorganic material in small amounts so the purity regarding TDS will be higher than DI. Additionally, distilled water is able to readily dissolve materials it is exposed to, therefore, it must be stored carefully to prevent contaminants from leaching into the treated water from the air or storage containers.



Chapter Four

WHAT IS THE BEST WAY TO DEMINERALIZE INDUSTRIAL PROCESS WATER?



DEMINERALIZING INDUSTRIAL PROCESS WATER

What is the best method?

Demineralization, or the removal of virtually all ionic mineral contaminants from water, is crucial for producing water of sufficient purity for a variety of industrial applications. Demineralized process water is used to ensure the quality and consistency of various products, as well as to ensure consistent and predictable function of sensitive equipment. While it's clear that demineralized water is useful for a range of applications, you might be wondering **“What is the best way to demineralize industrial process water?”**

We'll describe common demineralization system designs and offer some considerations for determining which technologies are best for your plant and processes.

Choosing the best demineralization technologies

By definition, demineralization is the near-total removal of inorganic salts from water. In most industrial process water treatment applications, this is accomplished through ion exchange (IX). Given that IX demineralization systems can be designed to meet various needs, there is no one best way to demineralize process water.



Instead, **choosing the best demineralization strategies comes down to matching IX system design to your unique process conditions, purity specifications, and plant environment.**

The underlying principles of the demineralization process are the same from one system to the next, but there are two main aspects where a system can be customized to fit a specific application. The first of these is system configuration. IX demineralization systems are typically offered in either of two configurations, including:

- **Twin-bed ion exchangers.** Twin-bed demineralization systems consist of two columns or beds, one containing a cation exchange resin, and the other containing an anion exchange resin. Process water is cycled through the beds sequentially, first through the cation resin, where mineral contaminants are replaced by hydrogen ions, and next through an anion resin, where mineral contaminants are replaced by hydroxyl ions, which combine with the hydrogen ions to form pure water.
- **Mixed-bed ion exchangers.** Mixed-bed demineralization systems are a single unit or column that houses a mixture of cation and anion exchange resins. As process water is cycled through the resins, IX reactions take place repeatedly within the unit, resulting in comparatively greater removal of ionic contaminants comparative to twin-bed systems.

The second aspect is the selection of specific resin products to be used within the IX unit. There are hundreds of IX resins on the market today, many of which offer functional benefits for specific applications.



Below, we've outlined some key factors to consider in order to help you to navigate these key aspects of IX system design, and ultimately zero in on the best demineralization solution for your needs.

Process water quantity and consumption

Plants whose processes demand large quantities of demineralized water are often better served by twin-bed IX demineralization systems. The reason for this is twofold. First, dual bed systems consist of multiple columns versus the single column mixed-bed configuration. Secondly, twin-bed IX systems offer a comparatively simpler resin regeneration process, allowing for potentially less downtime, and less consumption of regenerant chemicals and/or rinse water each time the IX resins are exhausted.

You can get a rough estimate of the total volume of process water that your demineralization system can treat before a regeneration cycle is needed by simply dividing the exchange capacity of IX unit by the total dissolved solids (TDS) present in a representative sample of your process water. Understanding your capacity needs will help you to predict the frequency of resin regeneration cycles and resin life, and to decide whether it's worth it to invest in a larger unit.

Process water purity specifications

Finding the best demineralization strategy also depends on the level of purity needed to support a given process or to protect downstream equipment from corrosion or other damage. Mixed-bed demineralization units produce water of a comparatively higher purity than do twin-bed units, and are therefore employed for



processes requiring the most stringent purity standards, such as microelectronics and pharmaceutical manufacturing, or feed water for high-pressure boilers. Mixed-bed demineralization typically employs a mixture of strong acid cation (SAC) resins and strong base anion (SBA) resins, generally with a higher ratio of SAC relative to SBA resin. Typically, mixed-bed units are deployed for polishing to achieve extremely pure water.

For processes with slightly more forgiving purity standards, dual-bed demineralization systems may be a better choice, as they can be less costly to maintain. Twin-bed demineralization systems employ sequential IX columns, most commonly with a SAC resin followed by an SBA resin. This general-purpose IX system configuration produces demineralized water of a sufficient grade to support most industrial processes, such as rinse water for food and beverage manufacturing and low pressure boilers. Alternatively, twin-bed systems that use a SAC resin followed by a weak base anion (WBA) resin are sufficient for applications requiring a relatively lower grade of demineralized water. These systems are sometimes used for rinse or cleaning water in industrial settings, or where there is relatively little silica present in a feed stream.

Process conditions

There are a variety of other factors to consider in identifying an optimal demineralization strategy. These include:

- **Temperature.** To ensure a longer operating life for your resins, select resin products that accommodate the temperature of your process stream. Consult manufacturer-recommended operating temperatures when selecting an IX resin.



- **Hardness/TDS.** Streams with high hardness can put a strain on demineralization systems, forcing more frequent regeneration cycles and shorter overall resin life. This can be mitigated by employing a two-step IX system with a WAC unit ahead of a SAC unit or by employing some form of pretreatment, such as RO.
- **Variable stream content.** Mixed-bed units are more susceptible to resin fouling and inferior system function in the presence of unanticipated contaminants. Thus, if the contents of your process stream fluctuate over time, a twin-bed demineralizer may be a better choice. Alternatively, various pre-treatment strategies may be employed ahead of a demineralizer to protect it from variability in stream content.
- **Maintenance and downtime.** IX resins will become exhausted through normal use cycles and will require periodic regeneration and replacement. For lower-capacity systems, it is possible to contract with a servicer for offsite resin regeneration and replacement, as is the case for most modular demineralization systems. If your plant would prefer to shoulder its own resin maintenance, however, you'll need to determine how much downtime is acceptable to permit periodic resin maintenance. For production lines with low tolerance for downtime, it may be best to choose a design that permits removal of resin for external regeneration. This allows for the flexibility to rotate in a backup quantity of resin while one batch is being regenerated.

These are just some of the process conditions that will determine which types of demineralization are best suited to a given process.



Choosing the best demineralization system for your plant is often a highly individualized undertaking which can be simplified by a qualified water treatment specialist. An expert can perform analyses to help you understand your demineralization goals and challenges and can help you to identify the best water treatment technologies for your unique process water needs.



Chapter Five

HOW MUCH DOES A WATER DEMINERALIZATION SYSTEM COST?



DEMINERALIZATION SYSTEM COST FOR YOUR PLANT

Pricing, factors, etc.

If you're exploring options for industrial demineralization, you might be asking **"How much does a water demineralization system cost for your plant?"**

This chapter offers a simple explanation of what's included in an average demineralization system, what those systems typically cost, and the factors that drive these costs up and down, focusing on ion exchange in particular.

What's included in a basic water demineralization system?

Demineralization is a type of water purification referring to the removal of dissolved solids from feed water, process, and waste streams. Demineralization systems can refer to any treatment process or technology that removes minerals from these streams. Typically done with ion exchange (IX) or reverse osmosis (RO), depending on the facility's needs, demineralization can provide near-total removal of ionic mineral contaminants.



When discussing demineralization by ion exchange, there are a wide variety of technologies that exchange one ion for another and use a variety of regeneration chemicals to achieve a required level of purity. When figuring out what will go into a facility's system, it's important to also consider what ancillary equipment will be needed to support the ion exchange system. The footprint of ion exchange is relatively small compared to other treatment technologies, but many systems will require additional feed pumps and tanks.

IX demineralization utilizes both cation and anion exchange resins, sometimes even in the same column or bed. Following demineralization, the treated water will be of a high level of purity comparable to distilled water, but typically at a much lower cost.

Determining which technologies should make up the system will be affected by several factors:

Pretreatment

Preceding ion exchange, when used on raw feed or waste water, there is usually some type of pretreatment required, such as **microfiltration or conventional clarification**; what that pretreatment is will depend on the contaminants in the facility's water source. Pretreatment needs to be considered carefully because, in some cases, it can add about 30% to 50% to the total job cost and double or triple the size of the footprint (especially if the project site requires clarification). Also keep in mind that sludge from the pretreatment system may need to be treated with filter presses, which, if needed, will need to be incorporated in the system plan.



Chemicals and resins

If chemicals are needed, a **chemical handling system to store the chemicals and feed them to the ion exchange system** is typically required. For a robust industrial chemical handling system with storage tanks, metering pumps, and forwarding pumps, cost can be around **\$100,000 to \$500,000** or more, depending on the size.

When using ion exchange as a polishing technology, a facility can opt for offsite regenerable ion exchange. This is a service provided by an outside contractor, and typically, depending on flow rates and how often you change out the resin, they can add cost anywhere **from \$30 to \$100 per cubic foot** for offsite services. These resin services are usually reserved for polishing applications because if the resin is changed frequently, the cost for the offsite regeneration can be more than installing a polishing technology to regenerate onsite. Also keep in mind a typical rule of thumb is that resins will need to be replaced every three to five years.

Posttreatment

On the posttreatment end, the water coming out of the ion exchange system will usually go directly to process or to a big holding tank (as required for refineries and big power plants, who typically store one to two days' worth of water to avoid downtime), so the cost of that tank and any associated pumps will need to be factored in. This is often determined by the facility's discharge agreements, such as the local maximum and average monthly discharge limits to the environment or POTW.



The main factors of ion exchange system cost

All in all, there are four main factors that drive fluctuation in the cost of an ion exchange demineralization system:

- What are the **system's flow-rate requirements** going to be, or what amount of water do you need to process per day and how fast?
- What is the **quality of the water** coming into the facility and what level of contamination?
- What is the required **ion (and general) chemistry** of the stream after it's treated for use?
- What **construction materials** are required?

If you can answer these questions, it will help you narrow down what your needs might be and provide a better sense of the budget you might be looking at.

Flow rates

In general, if your plant runs consistently at a lower flow rate, you're usually looking at a lower capital cost for your ion exchange demineralization system. If your plant generally runs a greater flow in a shorter amount of time, your capital cost is usually higher for equipment.

Flow rates are always factored into the system cost, so be sure you measure this as efficiently as possible prior to requesting a quote in order to get an accurate cost estimate for your system.



How many solids need to be removed

The number of dissolved solids the facility needs to take out per gallon of water (usually measured in parts per million) is an important factor that goes into planning an ion exchange system, because the higher the amount of contamination, the bigger the ion exchange vessels have to be to handle them.

Water and ion chemistry

Along with the volume of ions that need to be removed, it's important to know the chemistry of the ions:

- What ions are there and in what ratios?
- How many suspended solids and total dissolved solids (TDS) are there?
- What is the makeup of that TDS?
- How much hardness, chloride, sodium, silica?
- What are the other ions in the water?

This will affect the type of equipment you have and how many vessels and what is in those vessels in terms of resin. For example, ion exchange is sometimes used to separate valuable minerals, such as gold, silver, uranium, etc., and how the resins are charged will affect how efficient they will be in removing these minerals.

Construction materials

Some facilities will do just fine using PVC pipe and FRP tanks for lower flows with very simple controls. Others, such as those processing thousands of gallons a minute, will require and stainless-steel



construction and design. Prices for these materials range from inexpensive plastics to high-end rubber-lined or stainless-steel vessels and/or piping.

Other important factors to consider when pricing an ion exchange system

- **Up-front planning.** Developing the concepts, designs, and regulatory requirements for your project is the first step to planning your demineralization system. The cost of engineering for this type of project can typically run 10–15% of the cost of the entire project and is usually phased in over the course of the project, with most of your investment being allocated to the facility's general arrangement, mechanical, electrical, and civil design.
- **Space requirements.** When planning for a demineralization system, the size of your system will affect your cost, and the footprint is usually reasonable depending on what other ancillary equipment needs to be included, so keep in mind that sometimes your plant location can affect the cost of your system.
- **Installation rates.** Another thing to keep in mind is the installation rates in your area. These sometimes also fluctuate by location, so be sure you're aware of the cost to install the system and factor this into your budget. In areas where installation costs are high you may want to consider prepackaged modules versus build-in-place facilities.



- ***Level of system automation needed.*** When it comes to the level of automation you need for your demineralization system, there are two options. The first is a higher level of automation where you won't need an operator present for much of the time. With type of automation, you can eliminate much of the human error associated with running the plant, and although this option is costlier up front (an initial investment in more sophisticated PLC controls and instrumentation), the ongoing labor costs are less. The second option is a lower level of automation with less capital cost, but with added labor, this can end up costing you more in the long run.
- ***Turnkey and prepackaged systems.*** If you are able to order your demineralization system prepackaged, this will typically save you about two – three months in construction time at about the same cost or less. A benefit to having your system prepackaged is that the production facilities and fabrication shops that assemble your system are, more often than not, highly knowledgeable about the type of system they are manufacturing. This results in a quick and efficient fabrication versus build-in-place facilities. Sometimes when you hire a field crew, there is a bit of a learning curve that can add extra time and/or cost to a project. SAMCO specializes in these types of turnkey, prepackaged systems, and for more information about what we offer, you can visit our website [here](#). Installation costs will vary, but typically range between 15–40% of the project cost, depending on the specifics of prepackaging and amount of site civil work needed.



- ***Shipping the system to your plant.*** When having your ion exchange system shipped to the plant, you usually want to factor in about 5–10% of the cost of the equipment for freight. This can vary widely depending upon the time of year you are purchasing your system in addition to where your plant is located in relation to the manufacturing facility.
- ***Operation costs.*** For operational cost when it comes to ion exchange, the big cost can mostly be found in the chemicals used and the power to run the system, so careful consideration has to be done to ensure you calculate what the operational cost and chemical consumption will be. Part of that is the waste coming out of the ion exchange has to be neutralized because it's high pH and lower pH...you have to neutralize that for discharge. It may have to go to a chemical waste treatment facility either on site or just plain neutralization discharged to a POTW sewer for treatment by someone else. This needs to be carefully considered...what the costs are and what that post treatment technology is going to be. Also keep in mind that particular technology packages cost a certain amount to purchase up-front, but you need to also factor in system operating costs over time. For decisions like these, you need to weigh the pros and cons of initial versus long-term cost investment in addition to what works for your company and staff. You will likely want to look into having someone develop an operating cost analysis so your company can plan ahead for the operating cost over your ion exchange plant's life cycle. This might help you consider whether or not you want to spend more on your system initially or over time.



- ***Other possible costs and fees.*** When purchasing an ion exchange system for demineralization, you might also want to keep in mind what other hidden costs and fees might be. For example: Will there be any taxes on the system or additional purchasing fees? What are your possible utility costs to the installation area? Will there be any environmental regulatory fees and/or permits? Any ongoing analytical compliance testing you need to pay for?

It is important to understand and look into any extra costs or hidden fees you might incur. For example, does your area have connection fees for discharging treated ion exchange? For more information about the possible connection fees in your area, check with local regulators. Many times, the fee is based on the volume of water your plant requires and varies based on whether you are discharging to the local municipal facility or into the environment. Regulations are typically stringent and are becoming more so every day. There is also consistent monitoring over time required. You will need to acquire some sort of permit to discharge and you're your plant approved before releasing any waste and failing to comply to your local restrictions can result in heavy fines so it's worth making sure you're on top of the current requirements in your area.

Also consider that there will be costs to treating the secondary waste produced by the system. With stringent environmental regulations, you will need to either treat the waste for hauling away or solidify with a filter press/evaporator and transport to third party disposal firm.



Ask your system manufacturer about options that might be cheaper to install. They might be able to shed some light on the more installation-friendly systems with suggestions on how to keep your costs to a minimum.

The bottom line

Since ion exchange can be very complex, as can be the cost, let's take a very simple system to start: a 20 gallon per minute system with two vessels (cation/anion), all FRP and PVC piping, using eductors instead of chemical feed pumps, with a simple control panel and minimal instruments might run **\$50,000 to \$100,000**. For the same system in rubber-lined steel vessels with stainless-steel piping, high-end valves, a PLC control panel with instrumentation, and chemical feed pumps, the project might be **\$200,000 to \$400,000**.

If you need higher quality water, you might be adding on a polishing mixed bed and that might add another **\$100,000 to the higher end system**.

For larger systems at about 2,000 gallons per minute using a proprietary packed bed technology, such as DOW's ADVANCED AMBERPACK™ or UPCORE™ Ion Exchange technology with two trains and a polisher to get low silica and low sodium, it would be a counter-current design with a sandwich pack polisher to get to less than 5 ppb silica and sodium might be **\$5 million to \$10 million**. A system like this would be for big petrochemical plant, refinery, or power plant where high-quality water well over 1 megaohm and sodium and silica down to 5 to 10 ppb range would be required.

HOW CAN SAMCO HELP?

SAMCO has over 40 years' experience in identifying appropriate demineralization technologies to help lower costs and waste volumes while increasing product quality. For more information or to get in touch, contact us to set up a consultation with an engineer or request a quote. We can walk you through the steps for developing the proper solution and realistic cost for your water demineralization system needs.

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