Understanding the Basics of

ION EXCHANGE SYSTEMS

A PUBLICATION OF SAMCO TECHNOLOGIES

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Chapter One

WHAT IS AN ION EXCHANGE SYSTEM AND HOW DOES IT WORK?

ION EXCHANGE SYSTEMS

What they are and how they work

Ion exchange (IX) systems are used across a variety of industries for water softening, purification, and separation purposes. While the chemistry of individual ion exchange reactions varies from one application to the next, IX is a treatment process where dissolved ions are replaced by other, more desirable ions of a similar electrical charge.

If you're wondering whether IX is right for your facility, you might be asking **"What is an ion exchange system and how does it work?"**

The following text offers a simple explanation of how IX technology works, what you can expect from an IX system, and how IX is used in common industrial applications:

What is an ion exchange system?

IX systems separate ionic contaminants from solution through a physical-chemical process where undesirable ions are replaced by other ions of the same electrical charge. This reaction occurs in an IX column or vessel when a process or waste stream is passed through a specialized resin that facilitates the exchange of ions. A common example is a water softening IX system, where the goal is to remove scale-forming calcium or magnesium ions from solution.

When the solution is passed through an IX resin composed of concentrated sodium ions, the calcium and magnesium ions are effectively captured from solution and held by the resin while the sodium ions are released from the resin into the effluent stream.

What's included in a basic ion exchange system?

A well-designed IX system conforms to the conditions of a specific application in both physical design specifications and in the chosen IX resin material. Common components of a basic IX vessel include:

- IX resin
- Inlet distribution system
- Regenerant distribution system
- Retention elements
- PLC, control valves, and piping

IX resins are the most critical factor in IX system design. The substances present in the feed stream, as well as other process conditions, will determine the geometric shape, size, and material used in the IX resin.

How does ion exchange work?

By definition, ions are charged atoms or molecules. When an ionic substance is dissolved in water, its molecules dissociate into cations (positively charged particles) and anions (negatively charged particles). Taking advantage of this characteristic, **IX selectively replaces ionic substances based on their electrical charges**. This is accomplished by passing an ionic solution through an IX resin that serves as a matrix where the ion exchange reaction can take place.

Most commonly, IX resins take the form of tiny, porous microbeads, though they are sometimes available as a sheet-like membrane. IX resins are fashioned from organic polymers, such as polystyrene, which form a network of hydrocarbons that electrostatically bind a large number of ionizable groups. As the process or waste stream flows through the IX resin, the loosely held ions on the surface of the resin are replaced by ions with a higher affinity for the resin material.

Over time, the resin becomes saturated with the contaminant ions, and it must be regenerated or recharged. This is accomplished by flushing the resin with a regenerant solution. Typically consisting of a concentrated salt, acid, or caustic solution, the regenerant reverses the IX reaction by replenishing the cations or anions on the resin surface, and releasing the contaminant ions into the wastewater.

What contaminants do ion exchange systems remove?

The most common application of IX is sodium zeolite softening, though other popular applications include high-purity water production, dealkalization, and metals removal. IX can be an extremely effective strategy for removal of dissolved contaminants, though **IX resins must be carefully chosen based on the substances present in the feed stream**, as listed below.

Cationic resins

Cation exchangers can be classified as either strong acid cation (SAC) resins or weak acid cation (WAC) resins, both of which are extensively used for demineralization.

SAC resins are also commonly used for softening, while WAC resins are used for dealkalization applications. Contaminants removed by cation resins typically include:

- Calcium (Ca^{2+})
- Chromium (Cr^{3+} and Cr^{6+})
- Iron (Fe^{3+})
- Magnesium (Mg^{2+})
- Manganese (Mn^{2+})
- Radium (Ra^{2+})
- Sodium (Na^{+})
- Strontium (Sr^{2+})

Anionic resins

Anion exchangers can be classified as either strong base anion (SBA) resins or weak base anion (WBA) resins. SBA resins are frequently used for demineralization, while WBA resins are often used for acid absorption. Contaminants removed by anion resins typically include:

- Arsenic
- Carbonates (CO_3)
- Chlorides (Cl^-)
- Cyanide (CN^-)
- Fluoride
- Nitrates (NO_3)
- Perchlorate (ClO_{4-})
- Perfluorooctane sulfonate anion (PFOS)
- Perfluorooctanoic acid (PFOA)

- Silica (SiO_2)
- Sulfates (SO_4)
- Uranium

Specialty Resins

While specialty IX resins are highly effective for specific industrial applications, their greater specificity generally means greater expense and narrower adoption than conventional IX resins. Chelating resins, for example, are used extensively for concentration and removal of metals in dilute solutions, such as Cobalt (Co^{2+}) and Mercury (Hg and Hg^{2+}). Similarly, magnetic ion exchange (MIEX) resins are often deployed for removal of natural organic matter from feed water.

Chapter Two

DOES YOUR FACILITY NEED AN ION EXCHANGE SYSTEM?

DO YOU NEED AN ION EXCHANGE SYSTEM?

How to know if it's necessary

IX is commonly used across a variety of industries, especially chemical and petrochemical, power, mining and metals, food and beverage, pharmaceutical, municipal, semiconductor, and others. IX can be an efficient solution for a variety of applications, including water softening, purification, separation, and pretreatment to protect downstream equipment and improve operational performance.

If you're looking for cost-effective pretreatment or specialty separation strategies, you might be wondering **"Does my industrial facility need an ion exchange system?"**

IX may be right for your plant if:

You need to reduce hardness

Hardness refers to water with a high dissolved mineral content, typically consisting of calcium and magnesium ions. While mineral content is acceptable—and even preferable—for drinking water, **hardness causes damaging scale deposits on industrial equipment** such as boilers, cooling towers, and pipes. IX softening is effective for reducing hardness, making it a particularly good fit if your facility uses low pressure boilers.

IX softening uses SAC resins to exchange hardness ions for sodium. This means that IX softening is regenerated with relatively safe and low-cost salt brine solutions. However, to avoid excessive regeneration cycles and unnecessary downtime, IX softening is best suited for applications with low total dissolved solids (TDS), while other technologies, such as lime softening, are generally more appropriate for treating water with high concentrations of hardness.

Your processes demand high purity water

IX demineralization and deionization produce high purity water that may be the right choice to treat feed water for high-pressure boilers, or for other applications within chemical, power, electronics, nuclear, or other industries. Compared to IX softening, IX demineralization involves a more complex multistep process. In the first step, the stream is run through a cation exchange resin to remove hardness, sodium, and other metals, and in the second step, the stream is treated with an anion exchange resin that removes anions such as carbonate, chloride, silica, and sulfate. In some cases, a third step is added to treat the stream for alkalinity, as well. Despite the added costs that come with a multiunit system, IX demineralization is often the standard in meeting ultrapure water needs.

You need to remove alkalinity

Alkalinity, or the presence of dissolved carbon dioxide (CO_2), bicarbonate (HCO_3), carbonate (CO_3), or hydroxyl (OH) in water, negatively impacts high heat processes, such as excess foaming and carryover in boilers. **Alkaline contaminants can cause costly scaling and corrosion in boilers, piping, and other equipment** when they react to form carbonic acid and hydroxide.

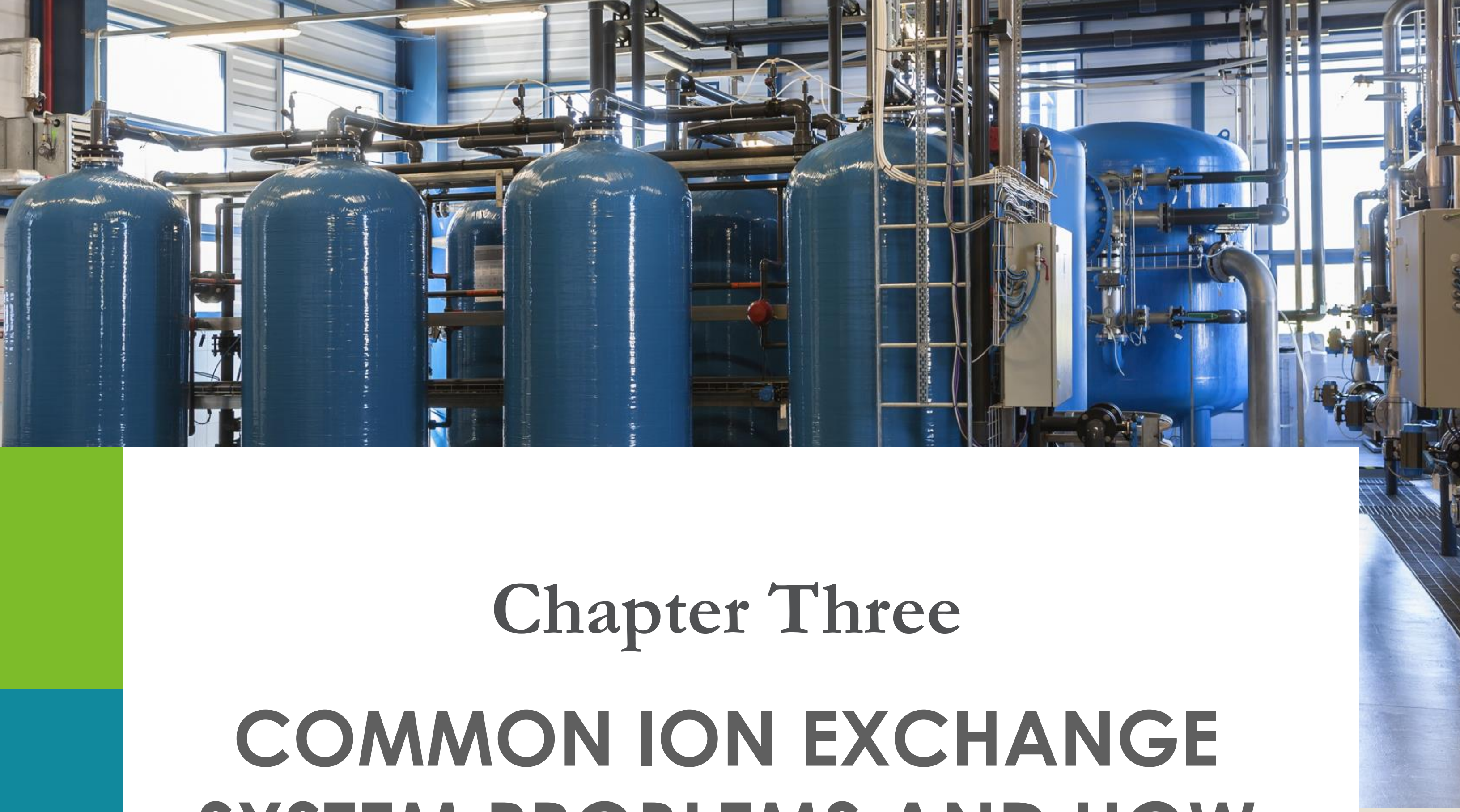
Removal of alkalinity can prolong equipment service life and save on downstream operational costs, however, choosing the right IX dealkalization strategy can depend on the target alkalinity, TDS content, and operational capacity, among other factors.

You need to concentrate or remove metals

IX systems are often used to concentrate and separate out metals in dilute solution, a fact that has contributed to the increasing adoption among electronics, semiconductor, and mining and metals industries. Depending upon the complexity of your process or waste stream, IX can be leveraged for efficient separation of various metals, including cadmium, chromium, copper, cyanide, lead, gold, mercury, silver, and zinc. If your facility is looking for ways to recover valuable metals from waste streams, or to meet metals discharge requirements, then IX may be an ideal solution.

You want to increase product yield

Membrane filtration can often remove the same contaminants as IX, however, membranes lack the selectivity of IX. Because IX can target specific ions for removal while leaving desirable substances in solution, it can be a preferable separation strategy if your facility is looking to optimize product yields. Within the food and beverage industries, for example, IX can be deployed for removal of undesirable colors, tastes, and odors, without unnecessary product waste.



Chapter Three

COMMON ION EXCHANGE SYSTEM PROBLEMS AND HOW TO FIX THEM

COMMON ION EXCHANGE SYSTEM PROBLEMS

What are they? How do you fix them?

Ion exchange (IX) systems can be an efficient solution for various demineralization, purification, and wastewater treatment needs. In fact, IX systems deliver several advantages over chemical treatment, as they generally require less space, less labor, no sludge disposal, and lower operational costs.

While such benefits are attractive, you might be left wondering **"What are common problems with ion exchange and how do I fix them?"** This chapter will offer insight into the key conditions and issues that compromise the overall efficiency and cost-effectiveness of IX systems, as well as some useful strategies for correcting IX problems.

Common IX problems include:

Resin fouling

The problem

IX resins work by holding electrically charged ions in place so that they may be swapped with contaminant ions in the feed solution.

Some contaminants, however, can bind to the resin, preventing further ion exchange reactions from taking place. Unless this is remediated, **the fouled resin will compromise effluent quality, and ionic functional groups cannot be easily restored through a normal regeneration cycle.**

Contaminants that frequently contribute to resin fouling include:

- Aluminum
- Hardness precipitates
- Iron
- Manganese
- Microbiological
- Oil
- Organics
- Silica
- Sulfate

Possible solutions

While resin fouling decreases IX system performance, it is often reversible through appropriate measures. These must be specific to the foulants present, but in general, caustics are used to remove foulants from anion resins while acids or strong reducing agents are used to remove foulants from cation resins. Similarly, surfactants are typically used to clean oil from fouled resins, though it is necessary to use care in selecting a surfactant that will not itself foul the resin.

Organic fouling is both extremely common and comparatively more difficult to correct. Preventative strategies for organic fouling include prechlorination and clarification, activated carbon filtration, applying a multistep IX with weak and strong base resins, and use of specialty IX resins.

Resin oxidation

The problem

IX resins are comprised of crosslinked polymers that are able to stand up to a variety of substances. Still, they are vulnerable to oxidizing agents, such as nitrates, peroxides, halogen compounds, chlorine, and hypochlorite compounds, among others. When present in a feed stream, **oxidants degrade IX resin polymers, causing them to deform and compact over time.** This compaction obstructs the flow of liquids through the resin bed, which can compromise the overall effectiveness of the IX unit, and lead to inconsistent effluent quality due to channeling in the resin bed.

Possible solutions

While oxidation damage to IX resins cannot be reversed, it can be prevented through various pretreatment measures. Common preventative measures for oxidation degradation include application of activated carbon filtration, ultraviolet irradiation, or chemical pretreatment through the application of a reducing agent.

Thermal resin degradation

The problem

Extremely high or low temperatures can permanently compromise the effectiveness of IX resins. Over time, thermal degradation alters the resin's molecular structure such that it is no longer able to bind with the functional groups of ions that are key to the IX reaction, resulting in compromised operational performance and shorter product life.

Possible solutions

IX resin capacity has an inverse relationship with temperature, so **it is important to consider the recommended operational temperatures and other process conditions to minimize thermal degradation** over time. Generally speaking, cation resins are more resistant to thermal degradation than are anion resins, though both can generally withstand brief applications of high heat for occasional sterilization or other purposes. While prolonged exposure to extreme temperatures usually means a shorter useable life for IX resins, in some cases the costs of more frequent resin replacement may still not outweigh the costs of energy and equipment needed for temperature control.

Other mechanical & operational problems

There are a variety of mechanical, design, and operational problems that can negatively impact IX system performance by contributing to premature resin degradation, and otherwise compromising performance. These commonly include:

Inadequate regeneration

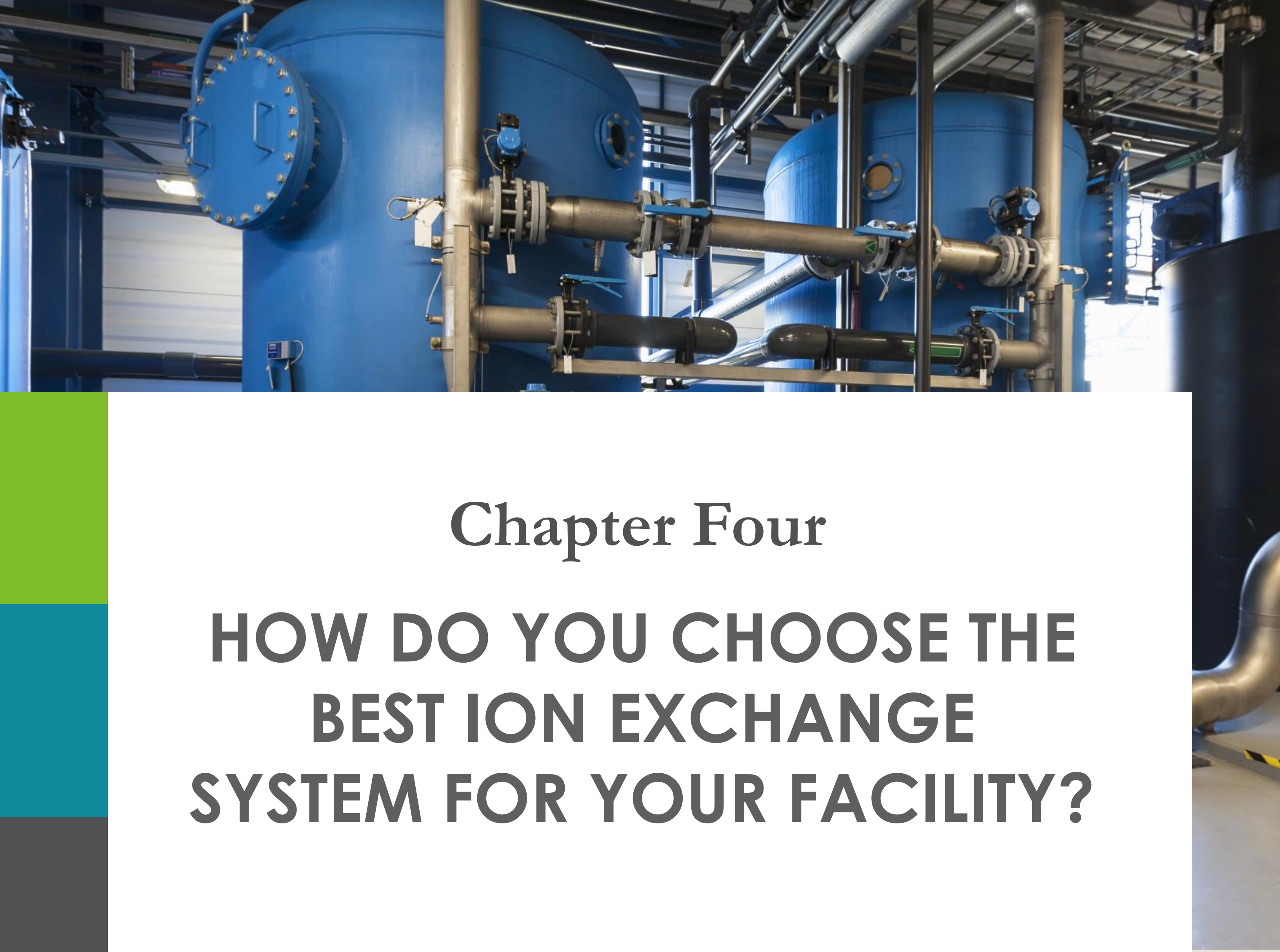
Suboptimal IX system function can result when regenerant solutions are administered incorrectly. Simply **following the resin manufacturer's guidelines for regenerant concentration, application time, and flow control can prevent issues** and ensure consistent IX system function and proper run performance.

Channeling

Channeling occurs when liquids pass through the resin unevenly, carving pathways that result in the uneven exhaustion of the resin, and breakthrough of untreated solution into the effluent stream. Channeling can be caused by incorrect flow rates, failure of the distributor mechanism, inadequate backwashing, and blockages by dissolved solids or damaged resin beads.

Resin loss or migration

Resin loss occurs when resin beads flow out of an IX column, or flow from one vessel to another. There are multiple causes for resin loss, including excessive backwashing and mechanical failures in underdrain screening or other resin retention equipment. Resin loss may also result from fragmentation of resin beads due to exposure to high temperatures, chlorine, and/or osmotic shock, allowing the resin particles to pass through even intact retention screens. **Resin loss and migration reduces overall system capacity and efficiency.** In demineralization systems, for example, the migration of cation resin into the anion unit can result in sodium leakage and excess rinse time.



Chapter Four

HOW DO YOU CHOOSE THE BEST ION EXCHANGE SYSTEM FOR YOUR FACILITY?

WHICH ION EXCHANGE SYSTEM IS BEST FOR YOUR PLANT?

Here's how to tell

Thanks to their unique ability to selectively target specific contaminants for removal, ion exchange (IX) systems can be an extremely efficient solution for separation and purification of process and waste streams. While they are most commonly used for softening applications, IX systems are also widely used for dealkalization, purification, metals removal, and other specialized uses. Given their effectiveness for so wide a variety of applications, it can be a challenge to identify an ideal IX solution for your needs.

If you're thinking about adding a new IX system to your treatment train, or upgrading an older system, you might be wondering **"How do I choose the best IX system for my industrial facility?"**

Whether your goals include cutting operational costs, reducing product waste, or otherwise boosting efficiency, this chapter identifies key process factors to consider when building an IX system to meet your production needs.

Know your process conditions

IX is a selective separation strategy, meaning that it can be used to target specific ionic contaminants in solution, while leaving behind other materials**. The best IX systems are designed around the composition of your process stream, the desired level of purity, and the costs associated with operating and maintaining your treatment train**. While seemingly straightforward, these variables are complex and interrelated, and they have a huge impact on what IX technologies are best for your needs.

What types of IX resin should you use?

An IX unit is mechanically very simple, essentially consisting of a column that contains a specialized material known as an IX resin. All the work of an IX system is performed by the resin, which acts as a substrate to facilitate the exchange of similarly charged ions.

While IX resins can carry a significant upfront investment, properly maintained resins can offer a long service life of four to 10 years. The best IX system designs take process conditions and the contents of the feed stream into account so as to minimize operational costs and downtime associated with regeneration cycles and to maximize usable life of the resin.

IX resin material

IX resins are made from polymers in the form of microbeads, and, less commonly, sheet-like membranes used in electrodeionization process. The most common IX resins are fabricated from either gel or a macroporous polymer, each of which is best suited for certain process conditions.

Generally, **gel resins are best for standard water treatment operations**, as they offer a greater capacity and regeneration efficiency. On the other hand, **macroporous resins are best for aggressive conditions**, with their greater chemical and mechanical resistance making them able to stand up to high temperatures, significant osmotic shock, and/or exposure to oxidizing agents.

IX resin types and common applications

IX resins target contaminants for removal based on their electrical charges. With few exceptions, cationic resins swap out positive ions, while anionic resins swap out negative ions. Key IX resin types and common uses are outlined below, though there are many other resin and application options as well.

- **Strong Acid Cation (SAC) resins** are often the best choice for water softening and demineralization applications. SAC resins are a relatively safe and cost-effective method for removal of scale-forming hardness, such as calcium and magnesium, as they may be regenerated with a concentrated salt solution, such as a sodium chloride brine. When used in the hydrogen cycle with sulfuric or hydrochloric acid (HCl) as a regenerant, SAC resins are also highly effective for demineralization.
- **Weak Acid Cation (WAC) resins** are a cost-effective choice for dealkalization applications where the feed water has a high proportion of hardness to alkalinity. The WAC resin accomplishes this by removing divalent cations (e.g. calcium), and replacing them with hydrogen / sodium depending on process conditions. Depending upon process needs, the IX process may be followed with degasification and/or pH adjustment.

- **Strong Base Anion (SBA) resins are available in various types**, the characteristics of which must be weighed to determine the best fit for a given application. SBA resins are good for silica removal, especially for streams with low free mineral acid (FMA) content. Other excellent uses for SBA resins include removal of uranium. SBA resins are also effective for removal of nitrates (NO_3), though efficiency may be compromised by excess regeneration cycles if the feed water contains high concentrations of sulfates. Lastly, SBA resins are able to bind with halogens.
- **Weak Base Anion (WBA) resins** are effective for deionization applications where removal of carbon dioxide (CO_2) and/or silicon dioxide (SiO_2) is not required. WBA resins are also effective for acid absorption, as they work to neutralize strong mineral acids.
- **Chelating resins** are effective for removal and/or recovery of metals from solutions, including solutions with high dissolved solids concentrations. Applications using chelating resin include sodium (Na), potassium (K) and lithium (Li) brine purification for feeding electrochemical cells, hydrometallurgy, metals concentration, and recovery for metals such as cadmium (Cd), cobalt (Co), nickel (Ni), and copper (Cu).

IX column configuration

Depending upon the needs of a specific application and characteristics of a treatment train, IX systems may include one or more resins, and/or multiple IX columns.

Examples of common IX system configurations are given below, though there are many other variations to suit specific applications.

- **Mixed bed units** contain both cation and anion resins in a single IX column, and are used to produce ultra-high purity water with a near-neutral pH and low rinse water requirements.
- **Twin bed systems** include a paired set of IX columns, one of which contains an SAC resin, and the other contains an SBA resin. Twin bed IX systems are used for softening applications that do not require stringent purity standards.
- Split stream dealkalization involves operation of two SAC beds operating in parallel, where feed water is divided between the two beds, with one operating in the sodium cycle as a softener that yields full alkalinity, and the other operating in the hydrogen form as a demineralizer that removes all alkalinity. The streams are then blended to achieve a target alkalinity.

Conduct a treatability study

Wondering where to start? The best way to identify an optimal treatment plan is to conduct a treatability study. Treatability studies often use a combination of lab analysis and pilot testing to help you to better understand the makeup of your process and waste streams, and to evaluate how well certain treatment strategies perform at your plant. **Treatability data is crucial in narrowing the wide field of available IX resins and system design options**, helping to confine your search to those IX technologies that will best meet your needs.

Chapter Five

HOW MUCH DOES AN ION EXCHANGE SYSTEM COST?

WHAT ION EXCHANGE SYSTEMS COST

Pricing, factors, etc.

When industrial companies require ion exchange technology, one of the first questions we typically hear is, **"How much does an ion exchange system cost?"**

This can be difficult—but not impossible—to narrow down because of all the factors that can go into engineering and putting together a system to meet the facility's needs.

In the text below, we outline what goes into a typical ion exchange system**, what the factors are that drive that cost up and down, and what a few specific ion exchange system configurations might cost**:

What's included in a basic ion exchange system?

Ion exchange covers 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.

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

Let's say a facility needs an ion exchange system that removes metals from a brine stream. There might be two chemicals used to clean the resins on a regular basis, so the facility will need to store and manage these chemicals and resins. One of the main things you should plan for here is a **chemical handling system to store the chemicals and feed them to the ion exchange system**. For a robust industrial chemical handling system with storage tanks, metering pumps, and forwarding pumps, cost can be around $100,000 to $300,000 depending on the size.

On the wastewater side, ion exchange can remove specific metals, like nickel, cadmium, lead, or mercury, etc. These require very specific ion exchange resins that can be very expensive (sometimes $1,000 per cubic foot or more).

In cases like this, a facility should be cautious when planning their ion exchange system, as the resin can end up costing more than the actual system.

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 service 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 treatment 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 is desirable?
- What is the **ion (and general) chemistry** of the stream?
- 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 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 volume of contaminants, 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, silicia?
- 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

Upfront planning. Developing the concepts, designs, and regulatory requirements for your project is the first step to planning your ion exchange treatment 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 an ion exchange treatment 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. For example, if your plant is located in a place that is very expensive when it comes to space, you might want to aim for a smaller footprint, if possible.

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 ion exchange 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 more costly upfront (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.

When deciding whether or not to invest in more costly controls, you need to consider what works for your company and staffing availabilities.

***Turnkey and prepackaged systems*.** If you are able to order your ion exchange 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. 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 upfront, 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, 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.

Also be sure to 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.

This type of system 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 $300,000**.

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 $7 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 helping design and engineer some of the most effective ion exchange systems in the industry. For more information about what we offer and how we can help your facility, please visit our website or contact us to schedule a consultation with one of our engineers.

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