What Industrial Facilities Need to Know About

ZERO LIQUID DISCHARGE

A PUBLICATION OF SAMCO TECHNOLOGIES

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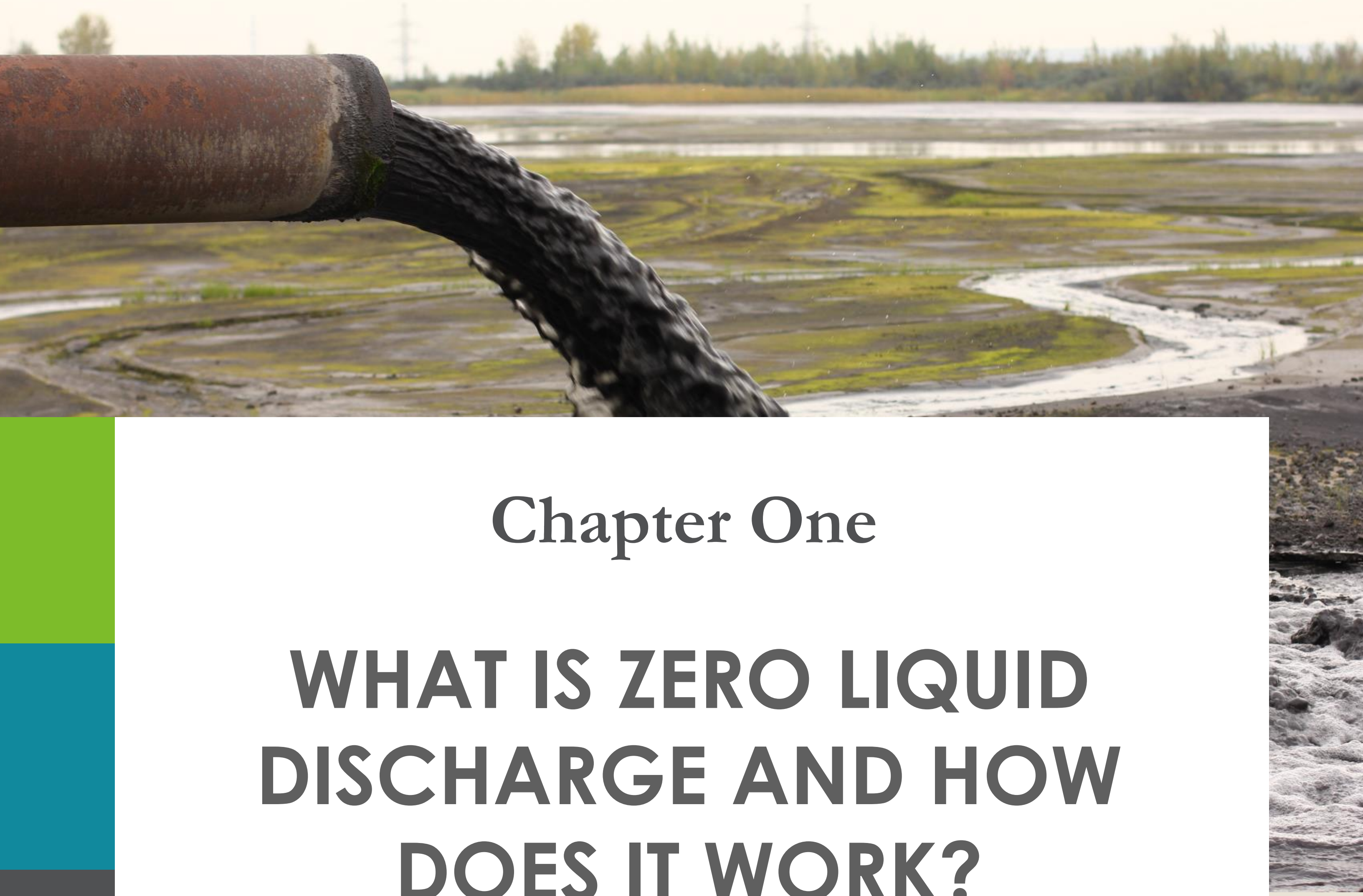


Chapter One

WHAT IS ZERO LIQUID DISCHARGE AND HOW DOES IT WORK?

ZERO LIQUID DISCHARGE

What it is and how it works

Not every industrial facility that produces wastewater will require zero liquid discharge (ZLD). It is usually looked to as a last resort because it can be a complex process that requires a high initial investment.

If a facility is located on a site that has severe water scarcity issues and/or astronomical discharge fees, it might be worthwhile to pursue, but in the instances it's not mandated (some local and/or federal regulations might require ZLD), careful consideration must be made as to whether or not it will benefit your facility.

If your facility does require or is considering it, you might be wondering, **"what is zero liquid discharge and how does it work?"**

The complex answer to this question is simplified and broken down for you in the following text.

What is a zero liquid discharge treatment system?

A ZLD treatment system **utilizes advanced technological water treatment processes to limit liquid waste at the end of your industrial process to, as the name suggests, zero**.

An efficient and well-designed ZLD treatment system should be able to:

- handle variations in waste contamination and flow
- allow for required chemical volumes adjustments
- recover around 95% of your liquid waste for reuse
- treat and retrieve valuable byproducts from your waste (i.e. salts and brines)
- produce a dry, solid cake for disposal

A ZLD treatment system will also help your facility meet stringent effluent requirements, such as the U.S. Environmental Protection Agency's Steam Electric Power Generating Effluent Guidelines. Just keep in mind your facility's requirements will vary based on whether you are discharging into a publicly owned treatment works (POTW) or to the environment under a National Pollutant Discharge Elimination System (NPDES permit).

What's included in a basic ZLD treatment system?

Though the exact components of a ZLD treatment system will vary, a basic ZLD treatment system typically includes some type of:

- **clarifier and/or reactor** to precipitate out metals, hardness, and silica
- **chemical feed** to help facilitate the precipitation, flocculation, or coagulation of any metals and suspended solids
- **filter press** to concentrate secondary solid waste after pretreatment or alongside an evaporator
- **ultrafiltration (UF)** to remove all the leftover trace amounts of suspended solids and prevent fouling, scaling, and/or corrosion down the line of treatment
- **reverse osmosis (RO)** to remove the bulk of dissolved solids from the water stream in the primary phases of concentration
- **brine concentrator** to further concentrate the reject RO stream or reject from electrodialysis to further reduce waste volume
- **evaporator** for vaporizing access water in the final phases of waste concentration before crystallizer.
- **crystallizer** to boil off any remaining liquid, leaving you with a dry, solid cake for disposal

Depending on the needs of your plant and process, these standard components are usually adequate, however, if your plant requires a system that provides a bit more customization, **there might be some features or technologies you will need to add on**. Because of the broad range of industries that use ZLD and the various waste streams produced, ZLD is a highly custom process and these add-ons will depend on your facility's individual needs.

How does a ZLD treatment system work?

Specific treatment processes vary, but a typical ZLD treatment facility process will usually include the following steps:

Pretreatment and conditioning

Pretreatment is used to remove simple things from the wastewater stream that can be filtered or precipitated out, conditioning the water and reducing the suspended solids and materials that would otherwise scale and/or foul following treatment steps.

Typically this treatment block consists of some type of clarifier and/or a reactor to precipitate out metals, hardness, and silica. Sometimes this step requires the addition of caustic soda or lime to help with **coagulation**, a process where various chemicals are added to a reaction tank to remove the bulk suspended solids and other various contaminants. This process starts off with an assortment of mixing reactors, typically one or two reactors that add specific chemicals to take out all the finer particles in the water by combining them into heavier particles that settle out.

The most widely used coagulates are aluminum-based such as alum and polyaluminum chloride.

Sometimes a slight pH adjustment will help coagulate the particles, as well.

When coagulation is complete, the water enters a **flocculation** chamber where the coagulated particles are slowly stirred together with long-chain polymers (charged molecules that grab all the colloidal and coagulated particles and pull them together), creating visible, settleable particles that resemble snowflakes.

The gravity settler (or **sedimentation** part of the ZLD treatment process) is typically a large circular device where flocculated material and water flow into the chamber and circulate from the center out. In a very slow settling process, the water rises to the top and overflows at the perimeter of the clarifier, allowing the solids to settle down to the bottom of the clarifier into a sludge blanket. The solids are then raked to the center of the clarifier into a cylindrical tube where a slow mixing takes place and the sludge is pumped out of the bottom into a sludge-handling or dewatering operation. The settlers can also be designed using a plate pack for smaller footprint.

Depending on the material in the feed, additional reactors or chemistry may be required for the reduction of metals or silica. Careful consideration must be given to the pretreatment step for a successful ZLD system.

Ultrafiltration (UF) can also be used after the clarifiers instead of the gravity sand filter, or it can replace entire clarification process altogether. Membranes have become the newest technology for treatment, pumping water directly from the wastewater source through the UF (post-chlorination) and eliminating the entire clarifier/filtration train.

Out of this process comes a liquid that is then filter-pressed into a solid, resulting in a solution much lower in suspended solids and without the ability to scale up concentration treatment.

Phase-one concentration

Concentrating in the earlier stages of ZLD is usually done with membranes like reverse osmosis (RO), brine concentrators, or electrodialysis.

The **RO train** will capture the majority of dissolved solids that flow through the process, but it's important to flow only pretreated water through the RO system, as allowing untreated water to go through the semipermeable membranes will foul them quickly.

Brine concentrators, on the other hand, are also used to remove dissolved solid waste, but they are usually able to handle brine with a much higher salt content than RO. They are pretty efficient for turning out a reduced-volume waste.

Electrodialysis can also be used at this part of the ZLD treatment system. It's a membrane process that uses positively or negatively charged ions to allow charged particles to flow through a semipermeable membrane and can be used in stages to concentrate the brine. It is **often used in conjunction with RO** to yield extremely high recovery rates.

Combined, these technologies take this stream and concentrate it down to a high salinity while pulling out up to 60–80% of the water.

Evaporation/crystallization

After the concentration step is complete, the next step is generating a solid, which is done through **thermal processes or evaporation**, where you evaporate all the water off, collect it, and reuse it. Adding acid at this point will help to neutralize the solution so, when heating it, you can avoid scaling and harming the heat exchangers. **Deaeration** is often used at this phase to release dissolved oxygen, carbon dioxide, and other noncondensible gases.

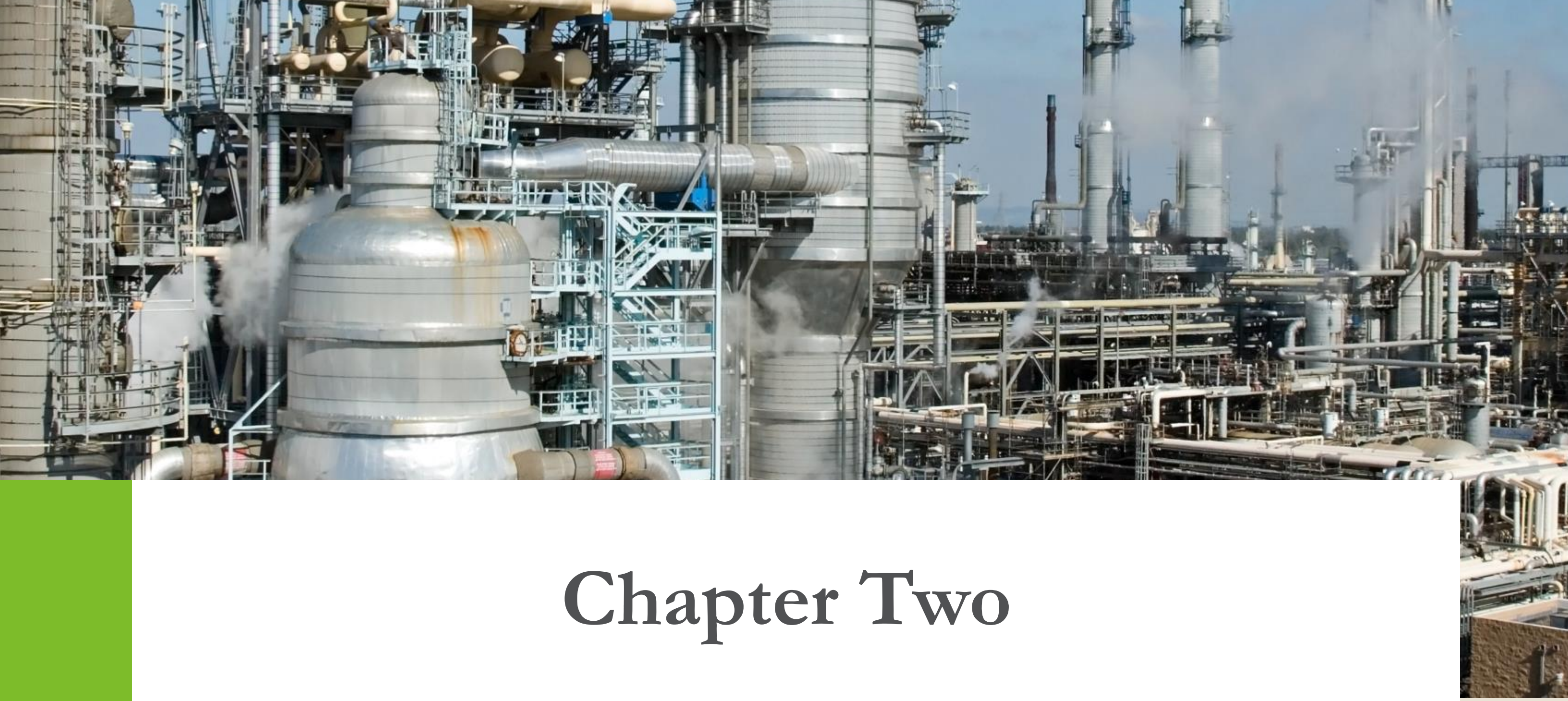
The leftover waste then goes from an evaporator to a **crystallizer**, which continues to boil off all the water until all the impurities in the water crystallize and are filtered out as a solid.

Recycled water distribution/solid waste treatment

If the **treated water** is being reused in an industrial process, it's typically pumped into a holding tank where it can be used based on the demands of the facility.

The ZLD treatment system should have purified the water enough to be safely reused safely in your process.

The **solid waste**, at this point, will enter a dewatering process that takes all the water out of the sludge with filter or belt presses, yielding a solid cake. The sludge is put onto the press and run between two belts that squeeze the water out, and the sludge is then put into a big hopper that goes to either a landfill or a place that reuses the sludge. The water leftover from this process is typically reused.



Chapter Two

DOES YOUR FACILITY NEED ZERO LIQUID DISCHARGE TECHNOLOGY?

NOT EVERY PLANT NEEDS ZERO LIQUID DISCHARGE

Is it necessary for your facility?

If your industrial facility discharges its waste into deep wells, streams, sewers to publicly owned treatment works (POTWs), and/or other waterways, it is likely there are some types of regulations on discharging the waste. With an increasing push toward environmental protection, many industrial facilities and effluent regulators are strengthening strategies to reduce industrial process waste. Some are even going so far as to implement ZLD for this.

You might be asking, **"Does my facility need ZLD technology?"** This chapter breaks down how you can answer this question below:

Local discharge regulations might require ZLD

As always, it is important to be on top of local regulations for your area of business. Pollution of the surrounding aquatic environment is increasingly at the forefront of public concern, and it is likely to continue to be. It only makes sense that regulators will tighten wastewater and discharge limitations to protect the environment and human health.

For example, the recent regulations passed by the U.S. Environmental Protection Agency for steam electric power plants include new rules for limiting harmful pollutants that can be discharged. Some of the recommended methods of treatment for fly ash transport water, bottom ash transport water, and flue gas mercury control system wastewater is ZLD:

TYPE	CURRENT RULE	NEW RULE BAT/PSES (existing sources)	NEW RULE NSPS/PSNS (new sources)
FGD Wastewater	Impoundment	Chemical precipitation + biological treatment	Evaporation
	Included as low-volume waste	Hg, As, Se, NO_2 + NO_3 limits	Hg, As, Se, TDS limits
Fly Ash Transport Water	Impoundment	Dry handling	Dry handling
	Total suspended solids (TSS), oil and grease (O&G) limits	Zero discharge	Zero discharge
Bottom Ash Transport Water	Impoundment	Dry handling/closed loop	Dry handling/closed loop
	TSS, O&G limits	Zero discharge	Zero discharge
CCR Leachate	Impoundment	Impoundment	Chemical precipitation
	Included as low-volume waste	TSS, O&G limits (no change from current)	Additional Hg, As limits
FGMC Wastewater	Impoundment	Dry handling	Dry handling
	Included as low-volume waste	Zero discharge	Zero discharge
IGCC Wastewater	Impoundment	Evaporation	Evaporation
	Included as low-volume waste	Hg, As, Se, TDS limits	Hg, As, Se, TDS limits
Non-Chemical Metal Cleaning Waste	Reserved for future consideration	Reserved for future consideration	Reserved for future consideration

*Summary of technology basis and limitations for new effluent limitation guidelines (ELGs). Source: HDR Inc.
**NOTE: BAT (best available technology); PSES (pretreatment standards for existing sources); CCR (coal combustion residuals; FGD (flue gas desulfurization); FGMC (flue gas mercury control system); IGCC (integrated gasification combined cycle); NSPS (new source performance standards); PSNS (pretreatment standards for new sources).

As environmental regulations become more stringent, which it can be fair to expect them to be, recovering/reusing your process water and eliminating the wastewater disposal will help your facility avoid paying large fines in the long run. It is a high initial investment, but again, with fees soaring and only getting pricier, adapting your facility to a ZLD plant will likely pay off in the long run.

Your facility is located in a place with severe water scarcity challenges

Is your facility located in a drought-stricken area, such as California, or a place that has strict limitations on water usage? If the answer is yes, chances are there are rules as to what and how many contaminants you are allowed to release into local waterways, if at all.

Fresh water is becoming scarcer by the day, which can potentially be a detriment to the health of the local economy, water security, and surrounding ecosystem.

By investing in a ZLD wastewater treatment system, you can help your facility conserve water that is important to your process while protecting the resources that are valuable to your local community.

High-cost discharge rates might not be feasible

If you are permitted to discharge your wastewater to local waterways or municipalities, fees to do so can be extremely high—especially in places experiencing drought and for industries that produce complex and harmful wastewater streams.

These fees can include a large, one-time connection fee based on volume and peak demand. Surcharges may also apply in addition to monthly discharge volumes.

By upgrading your facility to ZLD, you are able to eliminate the high cost of waste disposal with the added benefit of reusing recycled wastewater in your process.

Chapter Three

FIVE COMMON PROBLEMS WITH ZERO LIQUID DISCHARGE AND HOW TO SOLVE THEM

FIVE COMMON PROBLEMS WITH ZERO LIQUID DISCHARGE

And a few potential solutions

As more and more facilities are turning to zero liquid discharge (ZLD) for wastewater treatment and effluent reduction—whether it's to comply with local discharge regulations or recycle and reuse as much water as possible in your process—more information is becoming available about the possible issues your facility might face while using ZLD technology. Because of the scope of ZLD systems being used and the difference in treatment depending on your industry and individual process, it's difficult to pin down what you might be seeing specifically, but in a general sense, these are the **five most common problems with zero liquid discharge and possible solutions**:

RO membrane fouling

Reverse osmosis (RO) is an integral part of the ZLD process, but when pretreatment isn't removing harmful solids properly prior to entering the RO phase, it is extremely likely you will see some level of fouling in your RO membranes.

Fouling is an accumulation of deposits in your filtration membranes as a result of contaminants such as:

- Calcium
- Magnesium
- Silica
- Metal oxides
- Bacteria
- And other colloidal and suspended solids

If left untreated, these contaminants can cause deposition severe enough to plug piping and reduce the efficiency of your ZLD process by increasing energy usage and causing damage to your membranes. These issues can even occur in a matter of hours, and **cleaning these membranes proves difficult once they're fouled**, so it's best to avoid this fouling by ensuring proper pretreatment methods in the first place.

Depending on which contaminants are present, your pretreatment options that avoid RO fouling might include:

Ultrafiltration (UF). When you choose the right UF technology for your ZLD system, it is effective in reducing RO membrane fouling by allowing more control when it comes to membrane pore size, turbulence and polarization control, and backwash capabilities.

Keep in mind that it is often difficult to pin down exactly where smaller particles are coming from, and it's common to see them make it through UF (which can filter out particles well below one micron), especially for plants that draw their process water from surface or recycled water sources. Despite pretreatment efforts, it's also common to have to clean RO membranes every couple of days. A thorough evaluation and treatability study of your wastewater stream is helpful in designating the correct technology for your system and can't be stressed enough. It is also advisable to have a complete set of membrane replacements on hand in case they're needed.

Physical/chemical pretreatment. Chemical pretreatment used in collaboration with ZLD systems can be tricky. Again, it's extremely important to implement a treatability study to ensure your water treatment engineers understand exactly what contaminants are entering your wastewater stream and where. Many facilities have a difficult time coagulating smaller particles prior to RO due to certain chemicals used in the process that can hinder the effects of certain coagulants when being processed for ZLD. Some effective chemical treatment (depending on your process and contaminants) can include softening, precipitation, coagulation, and adsorption, among others. *Where* you place your chemical feed is imperative to avoiding RO fouling as well.

System scaling

Similar to fouling, scaling occurs in the RO membranes and heat-related treatment (such as evaporation) when small particles that get through pretreatment and filtration form deposits, but scaling forms much harder deposits than what you see with fouling. The result is reduced water permeability, greater energy usage, and damaged membranes and equipment.

In order to lower the possibility of scaling, scale-forming minerals need to be removed in pretreatment and other parts of the ZLD process where they might be present. Many facilities have good results when using cold-lime softening followed by ion exchange technology in pretreatment.

Alkalinity (pH) can also play a major role on scaling. As pH increases, many scale-forming compounds decrease in solubility, precipitating out in higher rates when the water is heated.

Another factor that can affect how much scale formation takes place is the **amount of the scale-causing contaminants** present in the water. If the volume of these scale-causing contaminates becomes greater than their natural saturation point due to evaporation, scale is likely to occur regardless off the alkalinity or temperature, so you can see there are several factors that will determine how much scale your system will accumulate.

Treatments to prevent these issues might include pH control, chemical scale inhibitors, and degassifiers.

Problematic balance of TSS/TDS

With ZLD, it is important to remove minerals to the right concentration, especially when using evaporation or other thermal-related methods of treatment. Adding heat to solutions with an incorrect ratio of total suspended solids (TSS) to total dissolved solids (TDS) can quickly and easily result in corrosion of piping and fouling and/or scaling.

As water evaporates, the solids remaining concentrate. If they are not properly removed in blowdown or prevented in the first place by properly pretreating the wastewater, these solids and hardness begin to **build up on heat transfers and other internal piping**. This can clog the system and lead to downtime or failure. In general, it's best to ensure water and makeup water chemistry is being treated properly to avoid this issues in the first place, as once the scale is formed, it's difficult to remove.

These ratios are of TSS to TDS vary depending on your system, as will the treatment options, but in general, ensuring your level of TSS and TSD to the proper concentrations will ensure a smoother and more efficient process.

Corrosion

During certain parts of the ZLD process, such as crystallization and dewatering, it's important to be aware of the cause and effects of corrosion.

When there are **higher salt concentrates in the remaining liquor or brine, it can cause a breakdown in the piping or other mechanical parts of the system**. Sometimes spray driers can help, as they can offset the solubility of certain salts, but in general, it's important to use corrosion-resistant construction materials such as nickel- and titanium-based alloys.

Scale buildup can also cause corrosion and the loss of heat transfer, so again, much of the contamination that can cause corrosion in the thermal parts of the ZLD process need to be addressed based on the individual system. The chemical balance, concentrations, level of heat, and pressure can all contribute to this complex calculation.

Chemical feed

It is generally advisable to minimize chemical use with ZLD technology, as much as possible. **Chemical feed on a ZLD system can add another level of complexity to an already complicated process**. For example, many chemical treatments for cooling water include certain dispersants to prevent fouling and scaling, but the benefits these chemicals offer the cooling tower water treatment process make it more difficult to effectively use coagulants when they need to be removed via clarification or filtration.

Since wastewater is so complex because of the variety and level of contamination, the use of chemicals in your ZLD process need to be monitored *very closely*.

Even the point of the process at which you introduce these chemicals can have an adverse effect on your process, and there are many facilitates that experience ZLD treatment issues because of this. Certain chemicals can also affect filtration membranes and other construction materials, so make sure to raise this issue when consulting your water treatment specialist.

Chapter Four

HOW MUCH WILL A ZERO LIQUID DISCHARGE SYSTEM COST YOUR FACILITY?

HOW MUCH ZERO LIQUID DISCHARGE COSTS

Pricing, factors, etc.

It can be challenging to find a system for your facility that is both environmentally friendly and cost effective, especially when more and more effluent regulations are tightening and dwindling your discharge options.

If your facility's goal is to eliminate discharging these pollutants that normally flow into deep wells, streams, sewers to publicly owned treatment works (POTWs), and other waterways, ZLD might be a good fit. Just keep in mind that, **realistically, ZLD often only makes economic and environmental sense when there are certain criteria being met**.

For example, if the facility is in an area with no sewers and can't, by regulation, discharge its waste to the environment, ZLD might be beneficial, treating the water to eliminate liquid waste. Sometimes facilities want to recycle or recover valuable materials in their wastewater. ZLD or near-ZLD technology can benefit facilities like this, too.

If you are thinking your facility might require ZLD technology, you might also be wondering **how much does a ZLD treatment system cost and what are the factors that affect that cost?** This chapter breaks the answer to this question down for you below:

What's included in a basic ZLD system?

The specific technologies that will make up a facility's treatment system will vary greatly depending on (1.) the volume of dissolved material present in the waste, (2.) the system's required flow rate, and (3.) what specific contaminants are present. The required technologies will also affect the system's cost.

Despite the possible variations that depend on your facilities wastewater characterization, **a ZLD system is, again, generally a three-step process consisting of the following "blocks" of treatment and equipment**:

1. Pretreatment and conditioning. Pretreatment is used to remove simple things from the wastewater stream that can be filtered or precipitated out, conditioning the water and reducing the suspended solids and materials that would otherwise scale and/or foul following treatment steps.

Typically this treatment block consists of some type of clarifier and/or a reactor to precipitate out metals, hardness, and silica. Out of this process comes a liquid that is then filter-pressed into a solid, resulting in a solution much lower in suspended solids and without the ability to scale up concentration treatment.

2. Phase-one concentration. Concentrating is usually done with membranes like reverse osmosis (RO), brine concentrators, or electrodialysis. These technologies take this stream and concentrate it down to a high salinity and pull out up to 60–80% of the water.

3. Evaporation/crystallization. After the concentration step is complete, the next step is generating a solid, which is done through thermal processes or evaporation, where you evaporate all the water off, collect it, and reuse it. The leftover waste then goes from an evaporator to a crystallizer, which continues to boil off all the water until all the impurities in the water crystallize and are filtered out as a solid.

The degree to which these steps are implemented in your specific ZLD system will vary depending on your facility's individual needs. It is important to have a thorough wastewater treatability study done to be sure the contaminants present in your wastewater stream are dealt with accordingly.

In short, the specific contaminants, volume of those contaminants, and required system flow rate will all affect what technologies make up your ZLD system, and ultimately this will also affect the cost of it. For example, if your plant runs consistently at a lower flow rate, you're usually looking at a lower capital cost for your ZLD treatment 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 should always be factored into the ZLD treatment 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. Sometimes inlet buffering tanks can be installed to minimize the peaks in flow and concentration of contaminants.

Other important factors to consider when pricing a ZLD treatment system

Upfront planning. Developing the concepts, designs, and regulatory requirements for your project is the first step to planning your ZLD treatment system.

The cost of engineering for this type of project can typically run about 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 ZLD treatment system, the size of your system and your plant location will affect your cost. 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 ZLD treatment 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 this 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 ZLD treatment system prepackaged, this will typically save you 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 ZLD treatment 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.

When you are looking to purchase your system, check with your manufacturer to see if there is a facility where the system can be constructed closer to you, if not on-site.

***Operation costs*.** 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 wastewater treatment plant's life cycle.

This might help you consider whether or not you want to spend more on your system initially or over time. With ZLD systems, operational cost review is critical, especially for electrical power and steam-generating facilities.

Other possible costs and fees. When purchasing a ZLD wastewater treatment 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?

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. You can learn more about SAMCO's ZLD wastewater treatment systems on our website here.

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

When it comes to treating your wastewater for ZLD, even though the treatment option and costs can be complex, all in all, you are looking at a system that can run upwards of **$25 to $50 million at a flow rate of one to three thousand gallons per minute** when you factor in all the needed equipment, engineering, design, installation, and startup. Smaller systems that run about **one to 20 gallons per minute can cost between $250,000 to over $2 million**.

The pretreatment is fairly inexpensive and is fairly similar to primary wastewater treatment. The membrane processes are a little more expensive, but they're similar to the membrane processes used in water treatment and purification treatment. They are more expensive because they are concentrating waste to yield higher recovery rates.

The biggest expense will be on the evaporative and crystallization section. (On overall equipment cost, about 60–70% of the cost will go to evaporation/crystallization block. 30–40% on front-end pretreatment and RO. The bigger the system gets, the more these numbers will fluctuate.)

Chapter Five

HOW TO CHOOSE THE BEST ZLD SYSTEM FOR YOUR FACILITY

CHOOSING A FACILITY'S ZLD TREATMENT SYSTEM

What to look for when making your decision

As mentioned in previous chapters, an industrial company that produces wastewater as a byproduct of its process will usually require some type of wastewater treatment system to help it avoid harming the environment, human health, and the facility's process if the water is being reused. The water treatment system will also help the facility evade incurring heavy fines and possible legal action if wastewater is being improperly discharged into a publicly owned treatment works (POTW) or to the environment under a National Pollutant Discharge Elimination System (NPDES permit).

In some cases, local and federal regulations will require ZLD, or you might be looking for a solution that will help your facility solve water scarcity and/or astronomical discharge rates. But **ZLD is usually a last resort and something your facility will turn to when there are no other feasible options**.

If your facility *is* pursuing ZLD, **how do you choose the best ZLD treatment system for your plant**?

The answer to this question can sometimes be a bit complex and depends on a variety of factors. We've simplified and broken down what this might mean for your plant below:

How do the wastewater characterizations of your facility determine your ideal ZLD treatment system?

One of the largest factors that will determine the best ZLD treatment system for a facility is the equipment that will go into the actual makeup of the system, and the technologies used will depend on the contaminants (and their respective volumes) your facility generates.

As mentioned previously, the specific technologies that will make up a facility's treatment system will vary greatly depending on (1.) the volume of dissolved material present in the waste, (2.) the system's required flow rate, and (3.) what specific contaminants are present.

Despite the possible variations that depend on your facility's wastewater characterization, **a ZLD system will generally consist of a three-step process with the following "blocks" of treatment. (Please note, these are described more at length in Chapter One.)**:

1. Pretreatment and conditioning; removes simple things from the wastewater stream that can be filtered or precipitated out, conditioning the water and reducing the suspended solids and materials that would otherwise scale and/or foul following treatment steps.

2. Phase-one concentration. Concentrating is usually done with membranes like reverse osmosis (RO), brine concentrators, or electrodialysis. These technologies take this stream and concentrate it down to a high salinity and pull out up to 60–80% of the water.

3. Evaporation/crystallization. After the concentration step is complete, the next step is generating a solid, which is done through thermal processes or evaporation, where you evaporate all the water off, collect it, and reuse it. The leftover waste then goes from an evaporator to a crystallizer, which continues to boil off all the water until all the impurities in the water crystallize and are filtered out as a solid.

The degree to which these steps are implemented in your specific ZLD system will vary depending on your facility's individual needs, as do any add-ons that will account for your specific industry and contaminations.

For example, if your facility produces waste that contains calcium, magnesium, silica, or other colloidal and/or suspended solids, your ZLD system will likely need to include ultrafiltration or chemical treatment to avoid the reverse osmosis membranes—an integral part of the ZLD process—from fouling. Also, because the ZLD process often includes an element of heat, it's important to manage the volume of certain scale-causing contaminants and pH to avoid damage to your ZLD equipment.

Because these systems are largely custom and extremely complex, it is advisable to work with your water treatment specialist to help you develop the best solution.

What is the result of a treatability study and/or pilot test?

A wastewater treatability study is a **study or test that will determine *if* the wastewater can be treated for your process and *how* it needs to be treated**. If the study is done correctly, it will clearly identify the contaminants present in your wastewater stream, helping ensure the proper treatment solutions are considered and implemented in your wastewater treatment system.

This step is **critically important** when choosing the best ZLD treatment system for your plant. After having a roadmap of maybe two or three technology platforms that meet your base and operating cost, running an efficient treatability test will help validate the assumptions you've made about possible contaminations and solutions to remove them. This streamlines to process and takes out any guesswork, ensuring your facility is getting the best possible solution for your unique situation.

Also keep in mind that even though the study might seem thorough on paper, **there's nothing better than running pilot testing in the field to validate the treatment/technology assumptions, optimize design,** because during this phase, other problems can arise and be found prior to choosing the components of your system, which can help save you from any effluent violations down the line.

HOW CAN SAMCO HELP?

SAMCO has over 40 years' experience helping design and engineer some of the most complex wastewater treatment systems in the water industry. For more information about what we offer and how we can help, please visit our website or contact us to schedule a consultation with one of our skilled engineers.

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