LENNTECH
WATER TREATMENT SOLUTIONS

Brine FAQ

1) What is brine?

Brine is a water solution that contains high concentrations of one or many kind of salts. It may occur naturally (e.g. salt lakes, underground, seawater, etc.) or from industrial processes (e.g. desalination, oil and gas, mining, etc.). Industrial brine tends to be more complex and sometimes contain organic materials. Salts included in the brine can be for example chlorides and sulfates of sodium, calcium and magnesium.

2) What industries produce brine?

Industries that produce high salinity wastewater streams as main or by-products are heavy industries, oil and gas, textile, coal-to-chemical, desalination, food and dairy or battery industries.

3) What are examples of brine wastewater streams?

Examples of hypersaline wastewater streams are Membrane System Rejects (NF, MF, UF, RO), Mine Drainage, Flue Gas Desulfurization (FGD) Blowdown / Purge Refinery, Gas to Liquid (GTL), and Coal to Chemical (CTX) Wastewaters, Produced Water (Conventional, Fracking, SAGD), Scrubber Blowdown, NOx Injection Water, Demineralization Waste, Integrated Gasification Combined Cycle (IGCC) Gray Water and Landfill Leachate.

4) What is desalination brine?

In the desalination process we have a product and a by-product stream. The product, called permeate, is the pure water with some of the dissolved solids that pass through the process and together they compose the produced fresh water. Desalination brine is a by-product liquid stream with higher concentrations of most of the feed's dissolved solids, some of the pretreatment additives (residual amounts of coagulants, flocculants, and antiscalants), organics, microbial contaminants and any particulates rejected by the RO membranes.

5) What is brine made up from?/ What are brine constituents?

Typical Chemical Constituents of Concern can be Total Suspended Solids (TSS), Total Dissolved Solids (TDS) like Sodium (Na^+), Magnesium (Mg^{2+}), Chloride (Cl^-), Phosphate (PO_4^{3-}), Strontium (S^{2+}), Sulfate (SO_4^{2-}), Potassium (K^+), Fluoride (F^-), Calcium (Ca^{2+}), Boron ($^{B+}$), Barium (Ba^{2+}) and Nitrate (NO_3^-), COD/BOD, Ammonia (NH_3), Oil & Grease, Silica and high/low pH.

6) What is brine disposal?

In most cases, the easiest way to get rid of the important brine flow is to discharge it. The usual end destinations of the brine are surface water bodies (sea, lakes, etc.), sewers, deep-wells, agricultural lands, and evaporation ponds.

7) What are common brine disposal methods?

Surface water discharge is the most common alternative because it can be applied to all desalination plant sizes. Sewer disposal is the mostly applied method for the discharges of small desalination plants. Deep well injection application is most suitable for medium and large-size inland BW plants. Land application and evaporation ponds are usually applied for small and medium-size plants where the climate and soil conditions provide for high evaporation rates and year-round growth and harvesting of halophytic vegetation.

8) What are brine disposal costs?

Brine disposal costs in practice can vary between 10 to 1,000 $/m^3. All depends on the composition of the brine and the disposal method.

For example, the construction costs for a 40,000 m^3/day SWRO desalination plant at 45% recovery - 48,900 m^3/d brine entail, Surface water discharge 6.5-30 $mil., Sewer discharge 1.5-6 $mil., Deep well injection 15-25 $mil., Evaporation pond 140-180 $mil., Spray Irrigation 30-40 $mil.

9) Why treat brine prior to disposal?/ Why treat brine?

The main reasons for treating brine are, 1) Meeting tight brine disposal government regulations, 2) Recovery of valuable materials in the waste streams, 3) Decreased waste volumes and management costs, 4) Recycling water on-site, 5) Reducing truck costs for off-site disposal.

10) What is brine treatment?

Brine treatment is a process accustomed for high salinity wastewaters where its purpose is to reduce/eliminate the liquid volume of the effluent or remove/recover specific/ all contaminants.

11) What are common brine treatment methods?

Brine treatment methods include conventional technologies such as evaporators or crystallizers. In the last years innovative methods such as (high pressure) reverse osmosis, nanofiltration, electrodialysis, forward osmosis and membrane distillation are appearing more and more in the water market.

12) What are brine treatment costs?

Each technology has a certain purchasing cost, but an important parameter for calculating the costs and eventually the payback period are the operating costs. The OPEX can change drastically based on what process is selected especially for electrical power and steam-generating facilities. MVC Evaporator 18-20 KWh/m^3 capacity, Crystallizer >50 KWh/m^3 capacity, EDR 6.73 KWh/m^3 capacity, Forward Osmosis 29.91 KWh/m^3 capacity, Membrane Distillation 47.41 KWh/m^3 capacity (*check the description of Table 4 in Lenntech ZLD page for more information).

13) What are brine treatment examples?

Some examples of brine treatment applications include, 1) Cooling tower blowdown in heavy industry and power plants, 2) Ion exchange regenerative streams particularly in food and beverage processing, 3) Flue gas desulfurization, wet wastewater stream, 4) Municipal potable water systems, wastewater streams, 5) Process water reuse from agricultural, industrial and municipal streams, 6) Various industrial wastewater streams from the textile, coal-to-chemical, food and dairy or battery industries.

14) How can you treat high salinity/ hypersaline organic wastewater?

It's really case by case but technologies like advanced biocarriers, advanced oxidation or non thermal crystallization can treat these hard wastewaters.

15) Why is preconcentration important in brine treatment?/ How can you decrease brine treatment costs?

The pre-concentration of the liquid waste stream is a very important step due to the fact that it reduces the volume of the waste and downsizes significantly the very costly evaporation/crystallization step. Usually it is achieved with electrodialysis (ED) or membrane processes which consist of Forward Osmosis (FO) and Membrane Distillation (MD)

16) What is evaporation?/ What are evaporators?

Evaporation is the removal of most water from solution and normally takes place at boiling point of water. Occurs at temperature below boiling point and is typically influenced by humidity. Evaporators include a heat exchanger which task is to boil the solution and they also have a method to separate the vapor from the boiling solution. Evaporator types can be categorized according to their length and the positioning (horizontal or vertical) of the evaporator tubes which can be inside or outside of the main vessel.

17) What is crystallization?/ What are crystallizers?

Crystallization is the production of a solid (crystal or precipitate) formed from a homogeneous, liquid which is concentrated to supersaturation levels (concentration>solubility) at that

temperature. The available crystallization processes are the following three, 1) Supersaturation by cooling the solution with trivial evaporation, 2) Supersaturation by evaporation of the solvent with little cooling, 3) Evaporation by a combination of cooling and evaporation in adiabatic evaporators (vacuum crystallizers). Crystallizers can put up with the continuous crystallization of all sparingly and highly soluble sodium salts such as sodium chloride and sodium sulfate, without excessive scaling and cleaning frequencies

18) What is High Pressure RO?

High- or ultra-high pressure RO elements can operate up to 120 bar resulting in water recovery up to 80%, high solute concentrations (12%) which means the reduction of the downstream brine effluent and thus its treatment processes. They are used for the recovery of salts in process streams and concentration of waste streams in various industries.

19) What is Nanofiltration?

The nanofiltration technique is mainly used for the removal of two valued ions and the larger mono valued ions such as heavy metals. This technique can be seen as a coarse RO (reversed osmosis) membrane. Because nanofiltration uses less fine membranes, the feed pressure of the NF system is generally lower compared to RO systems. Also the fouling rate is lower compared to RO systems

20) What is electrodialysis (ED/EDR)?

Electrodialysis is a membrane process that uses electrodes to create an electric field which pushes negative and positive ions through semipermeable membranes with attached positively or negatively charged species respectively. ED is used in multiple stages to concentrate the brine to saturation levels. It is often used together with RO for very high water recovery. ED differs from RO because it removes the ions and not the water and vice versa for RO. Due to this fact silica and dissolved organics are not removed with ED which is important if the clean stream is to be reused. ED requires solids, as does RO, solids and organics removal from the feed. In EDR the polarity of the electrodes is reversed several times an hour and the fresh water and the concentrated wastewater are exchanged within the membrane stack to remove fouling and scaling.

21) What is forward osmosis (FO)?

FO is an osmotic membrane process with a semipermeable membrane that unlike RO doesn’t use applied pressure in order to achieve separation of water from dissolved solutes like ions, molecules and larger particles. That means a lot less of energy for the process in comparison to

RO. In general FO uses thermal and electrical energy. Thermal energy can be substituted with low grade waste heat which can be found everywhere in most industrial or nearby areas.

22) What is membrane distillation (MD)?

MD is a thermally driven transport process that uses hydrophobic membranes. The driving force in the method is the vapor pressure difference between the two sides of the membrane pores, allowing for mass and heat transfer of the volatile solution components (e.g. water). The simplicity of MD along with the fact that it can use waste heat and/or alternative energy sources, such as solar and geothermal energy, enables MD to be combined with other processes in integrated systems, making it a promising separation technique.

23) What is brine recovery?

In order to deal with brine management, there have been increasing efforts worldwide to reduce brine volumes with zero liquid discharge (ZLD) technologies. One option to decrease the ZLD-relative costs is be recovering the valuable contaminants in the desalination brine streams. This way the recovered materials could be sold and thus raise the profits of a desalination plant. Alternatively the recovered materials could be used within the industrial facility using the desalination process and so reduce the operation cost. The feasibility of the material recovery process from brine depends from the technical limitations of the available technologies and their energy and cost considerations, but also from the market fluctuations for the materials that are recovered.