Selecting the Right Type of Industrial Wastewater Evaporator or Crystallizer

There are four fundamental types of industrial evaporators and crystallizers used for wastewater treatment, brine management, or improving water reuse. Lower your risks and improve costs by understanding the trade-offs between the different evaporator types.

Takeaways:

- Before investing in an evaporator, reduce cost by maximizing recovery with upstream membrane systems.
- Understand the application and fit for the four different industrial evaporator types before deciding on the suitable technology for your project.
- Protect your investment by engaging experts to help you prevent scale and corrosion, which diminish evaporator performance.
- Avoid extensive chemical pre-treatment, which drives up operating costs.
- Traditionally, evaporators were used to concentrate saltwater and crystallizers were used to produce solids, however, modern evaporator-crystallizer hybrids can do both.

Get the Most Out of Membrane Treatment Systems before Considering Evaporators

Reverse osmosis systems are usually the most cost-effective water treatment solution. If the concentration of total dissolved solids (TDS) is less than 70,000 mg/L, even if you have reached scaling limits, you still have options to further utilize reverse osmosis and concentrate brines up to 130,000 mg/L. This will reduce your total cost by lowering the size of the downstream evaporator and the energy it consumes. To optimize your project economics, ensure you maximize the performance of your RO system before considering evaporators or other thermal treatment systems. Contact us for a project analysis.

Membrane Treatment Systems

The Four Major Types of Industrial Evaporators

Evaporators treat wastewater by heating it to evaporate volatile solvents like water from the solution, and then cool and condense it to produce freshwater. The purpose is to concentrate non-volatile solutes like inorganic salts and organic compounds and leave behind a more concentrated wastewater stream. There are four common industrial wastewater evaporators:

1. Mechanical Vapour-Recompresssion (MVR) Evaporators

MVR Evaporators use a blower, compressor or jet ejector to compress, and thus, increase the pressure of the vapour produced. The increase in pressure results in an increase in the condensation temperature of the vapour. This vapour is then condensed in a heat exchanger, returning heat to the evaporating water in the next stage. This forms a cyclical process that recycles thermal energy, but requires electrical energy to run the large vapour compressor.

Tips for choosing an MVR evaporator:

- Ensure the vapour compressor you select can handle high rotation speeds and stands up to severe vibrations.
- Consider redundancy, since compressor failures are common, which will result in 0% capacity for your system.
- MVR evaporators can work well on large flows at low TDS, however, they struggle in crystallizer mode as temperature and pressure differences must be larger.

2. Multiple Effect Evaporators

Multiple Effect Evaporator - Photo © Evelyn Simak (cc-by-sa/2.0)

A multiple effect evaporator combines two or more vessels, each maintained at a lower pressure than the last. Heat energy is supplied to the first vessel where evaporation occurs at a relatively higher temperature. Vapours from the first

vessel move to the second vessel due to the pressure difference, where the vapour is condensed. This releases heat that is used to evaporate wastewater in a subsequent vessel. Temperature is lowered in each effect as the heat energy is recycled, and eventually rejected close to atmospheric temperature.

Tips for choosing a multiple effect evaporator:

- Specify non-scaling and non-corroding materials of construction to improve long-term performance.
- Ask about tube scaling on your specific water, and how it can be prevented.
- Plan for maintenance access to any vessels, including access to the tubes for cleaning, as well as confined space entry points and safety equipment.

3. Atmospheric Evaporators

Atmospheric evaporators release their evaporated freshwater directly to atmosphere. Energy consumption is much higher, since the water vapour formed during the evaporation process is not condensed, eliminating the opportunity to reuse the energy.

Tips for choosing an atmospheric evaporator:

- Ensure that you have an abundant source of waste heat, to make the atmospheric evaporator more economic.
- Verify the concentrations of ammonia and volatile organic compounds, such as benzene, toluene, methanol and others. They will create air pollution and odors if evaporated.
- Plan for corrosion-proof specifications and confined space entry during maintenance.

4. Humidification-Dehumidification (HDH) Evaporators

Humidification-Dehumidification Evaporators

Humidification-Dehumidification Evaporators operate similar to multiple effect evaporators, although they recycle heat across the effects at lower temperatures.

These evaporators have the following advantages:

- Operate at atmospheric pressure, avoiding both pressure vessels and vacuums, resulting in simpler permitting and maintenance.

- Non-metallic construction that leverages reinforced fiberglass to avoid corrosion and reduce scaling potential. This provides reduced surface energy, which acts like Teflon in a frying pan to decrease the sticking potential of salt.
- The volumetric chambers used in HDH evaporators cost less than steam-based chambers and are less prone to corrosion, although they are roughly three times larger.

Combining the Advantages of Each Evaporator

SaltMaker Evaporator Crystallizer Installed at BC Site

The SaltMaker Evaporator Crystallizer combines three of the above industrial evaporator designs. First, it leverages the HDH cycle so it can be constructed from lower cost, fibre-reinforced plastics that enable easy maintenance, and reduce the risk of scaling and corrosion. The SaltMaker also comes in two optional configurations:

- The multiple effect configuration enables greater energy efficiency and recycles the 80 to 95°C heat through four or five effects.
- The open-to-atmosphere configuration can use low grade waste heat of 60°C or more and offers a higher treatment capacity per unit of plant size.

The SaltMaker is also designed for dual operation:

1. As an evaporator to concentrate brines.
2. As a crystallizer to produce and extract solids.

Read more about the advantages that the SaltMaker design offers compared to conventional evaporator and crystallizer designs.

Contact Saltworks for help selecting the suitable industrial evaporator for your project.

Evaporators	Fit & Tips	Installation & Operations	Typical Project Economics Profile
Mechanical Vapour Recompression (MVR)	*Widely used on non-scaling flows as a concentrator up to 20% salt mass (80% water).* *Ensure metallurgy and maintenance access.* *Ensure chemical cleans are planned for during design phase.*	*Custom designed and built to each need.* *Must consider chemical pre-treatment for scaling.* *Pressure vessels and high-speed compressor operating on vapour represent a severe and common single point of failure risk.*	*Low grade waste heat is not available and thermal energy is expensive, while electric power is available.* *Brine has low scaling potential or requires extensive chemical pre-treatment.*
Multiple Effect Evaporators	*More common where heat recycling is desired, and non-scaling flows need to be concentrated up to 20% salt mass.*	*Custom designed and built to each need.* *Must consider chemical pre-treatment for scaling.* *Considered more reliable*	*Low pressure steam is available at low cost.* *Brine has low scaling potential or requires extensive chemical pre-*

	Ensure metallurgy and maintenance access. *Ensure chemical cleans are planned for during design phase.*	*than MVR due to reliance on thermal energy and cooling source, rather than compressor.*	*treatment.*
Atmospheric Evaporators	*Check for volatile potential in discharge vapour to prevent pollution that destroys your investment value.* *Typically, only capable of concentrating to 15-18% salt mass.* *Consider if low grade waste heat is abundant.* *Scaling can be more likely due to air injection.*	*Low cost and easy to install, however, a plume will be present that may release damaging volatiles or odors. Some atmospheric evaporators have been shut down after less than a year of use due to stakeholder concerns about air pollution and health hazards.*	*Brine has low scaling potential and contains no volatiles.* *Abundant waste heat available.* *Vapour plume construction options are available.*
Humidification Dehumidification (HDH)	*More suitable on scaling flows, and pre-treatment costs can be avoided in plants with self-cleaning, such as the SaltMaker.* *Concentrate to 30% salt mass with ease, or produce solids.*	*Plan for roughly 2x greater space requirements than conventional, steam-based evaporators.* *No steam ticketed operators required.*	*Desire to concentrate higher than conventional evaporators, or produce solids and achieve zero liquid discharge.* *Consider staged investment and future expansions of production capacity.* *Thermal energy is reasonably priced (closed-to-atmosphere) or waste heat is abundant (open-to-atmosphere).*

Considering an Industrial Evaporator? We can help.

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