TECHNOLOGY AND APPLICATION

EVATHERM

A company for crystallization technology

EVATHERM

is a company with worldwide activities in the field of process engineering focused on evaporation and crystallization.

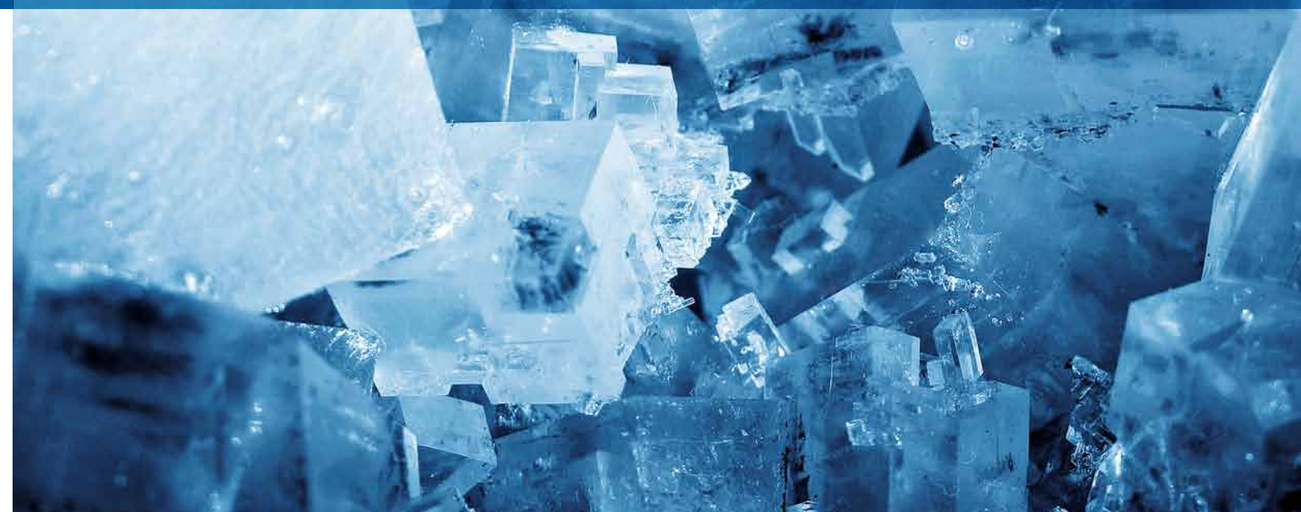
EVATHERM is an independent company, majority owned by its employees. The head office is located in Switzerland with branches in Germany and Hungary.

EVATHERM was founded in the early eighties by specialists highly experienced in thermodynamics and process engineering. The company founders worked before for more then 20 years in the evaporation department of the former ESCHER WYSS. In the very beginning of its history, EVATHERM has been for 10 years a member of the former HPD group (USA). This close cooperation resulted in an exciting merge of the different crystallization experiences.

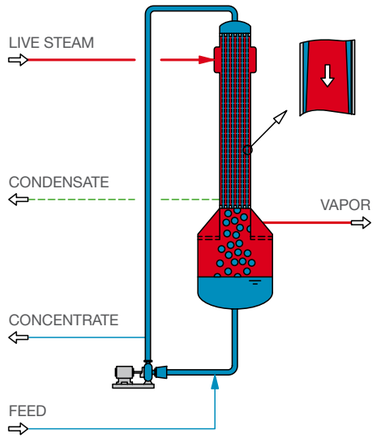
Within a short time, the company has developed into a medium size contractor. As a result of its comprehensive technological know-how, it is now established in the international market with a top ranking among the leading suppliers of evaporation and crystallization plants.

EVATHERM's engineers are continuously improving the company's expertise by innovative research and development of new technologies. Their effort is documented in the extensive reference list of satisfied customers.

EVAPORATION CRYSTALLIZATION



EVAPORATORS AND CRYSTALLIZERS



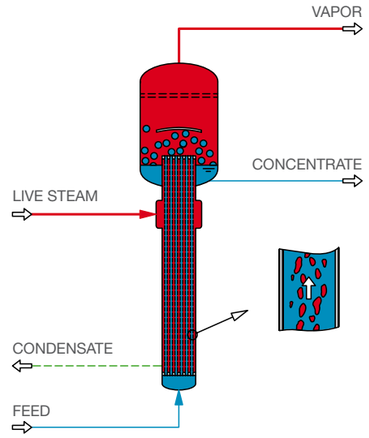
Falling film evaporator

The falling film evaporator is particularly used in application, when the driving force between heat transfer medium and liquid is small.

In a falling film evaporator with separate vapour body and heat exchanger the liquor is fed into the top liquor chamber of the heat exchanger where it is distributed to each tube. The liquor accelerates in velocity as it descends inside the tubes because of the gravity and drag of the vapour generated by boiling. Liquid is separated from the vapour in the bottom liquor chamber of the heat exchanger. The concentrated liquor is discharged from the bottom cone of the vapour body.

Evaporation occurs inside the tubes of the falling-film evaporator. The unit can be used to concentrate the same non-salting liquids concentrated in rising-film evaporators, and it is suitable for concentrating more viscous liquors.

The retention time for liquor in these evaporators is less than that for a rising-film evaporator. The combination of short liquid retention time and the ability to operate at a low dT makes the falling-film evaporator ideal for concentrating the most heat-sensitive materials.

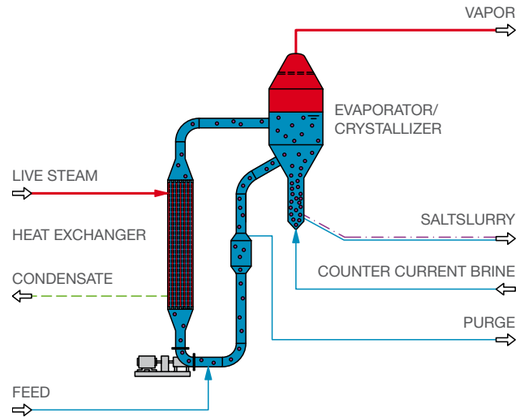


Rising film evaporator

A rising film evaporator is primarily used to concentrate non-salting and non scaling liquors.

If a high increase of concentration in one evaporator stage is required, the rising film evaporator can be the optimal choice. The rising film unit is a very simple and economical device with high heat transfer rates and high availabilities. Operation of the rising film evaporator is straightforward. Liquor is fed into bottom of the heater. There it is heated with steam or any other suitable heat medium. If the vapour pressure of the feed equals or exceeds the system pressure, vaporization will occur immediately.

The liquor climbs up inside of the tubes and therefore additional vapour is generated and the velocity of the liquor-vapour mixture increases to a maximum at the end of the tubes. The liquor-vapour separation takes place in the evaporation body by gravity and by an entrainment separator.



Forced circulation crystallizer

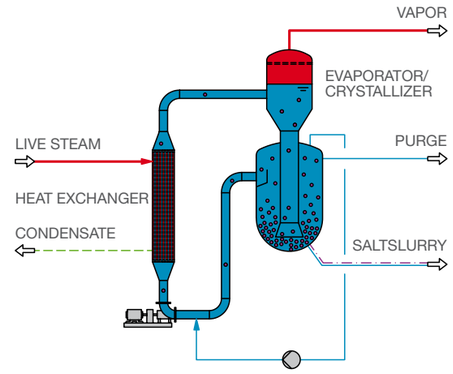
The MSMPR (Mixed Suspension Mixed Product Removal) and the MSCPR (Mixed Suspension Classified Product Removal) crystallizers are the classical devices to crystallize salts.

As the name implies, the liquor in a forced-circulation evaporator is pumped through the tubes to minimize tube scaling or salting when precipitates are formed during evaporation.

Slurry is pumped from the bottom cone of the vapour body through the tubes of the heat exchanger, where heat is added, and back into the vapour body where evaporation occurs. Sufficient liquor height is maintained above the heat exchanger to suppress boiling in the inlet and prevent surface boiling on the tube surface. A high circulation rate is provided for adequate tube velocity to achieve good heat transfer. A sufficient quantity of salt crystals is suspended in the circulating system to provide seed crystals in the boiling zone for salt growth. Adherence to these basic principles of crystallization results in coarse crystals and minimal wall and tube scaling.

EVATHERM Radial Inlet Adapter provides excellent mixing of slurry in the vapour body and generates a very low «thermal short circuit».

A **MSCPR crystallizer** is additionally equipped with a so called elutriation leg (salt leg). The counter current brine replaces the mother liquor and thereby high purity salt is removed from the crystallizer.



Growth type crystallizer

Where crystal growth is critical, our CSMPR (Classified Suspension Mixed Product Removal) growth type crystallizer can be applied.

The growth type crystallizer consists of a concentric two-body arrangement connected by a central downcomer. The lower body (retention or growth chamber) supplies the necessary volume and fluidization characteristics for developed supersaturation release and crystal growth. The supersaturation is released upon a fluidized bed of crystals classified by particle size resulting in controlled crystal growth. By removing the crystalline products from a specific location in the classified bed, a distinct crystal particle size can be targeted.

The upper body (vapour body) is used for evaporation applications where sufficient surface area and disengagement height is required for vapour release. An external pump provides recirculation from the retention chamber through the heat exchanger.

Our growth type crystallizer can produce a narrow distribution of larger crystals. Typical applications for these systems can include ammonium sulphate, ammonium nitrate and potassium chloride.

Depending on the specific product requirements, the growths type crystallizer can also be equipped with an elutriation leg.

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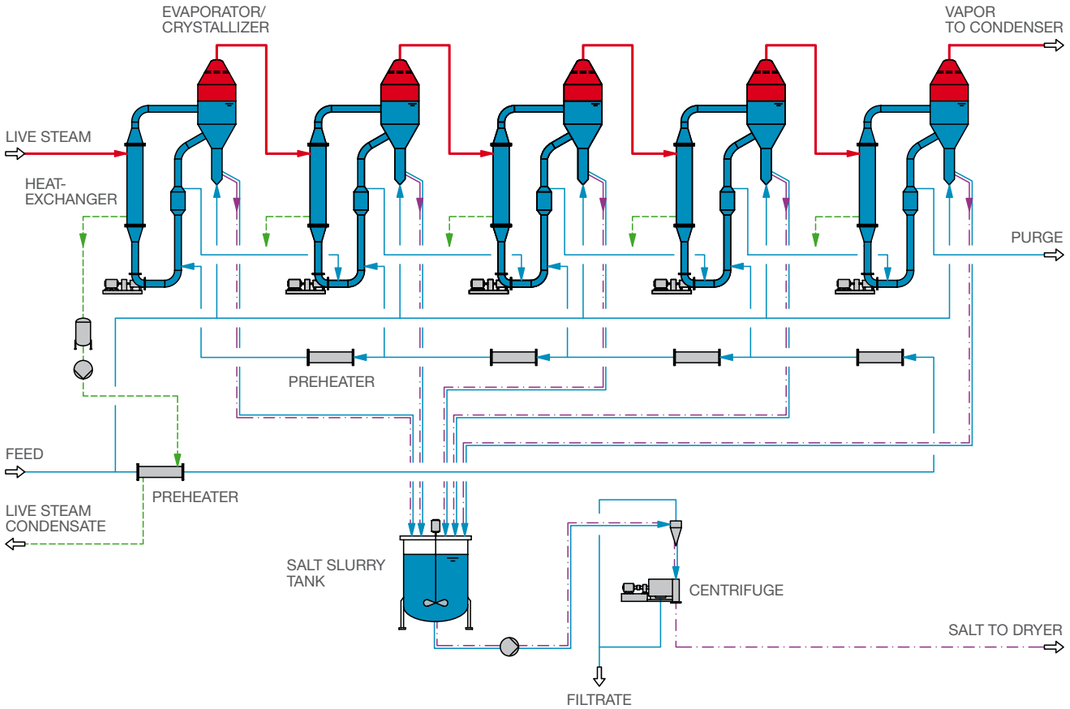


Multiple Effect Evaporation

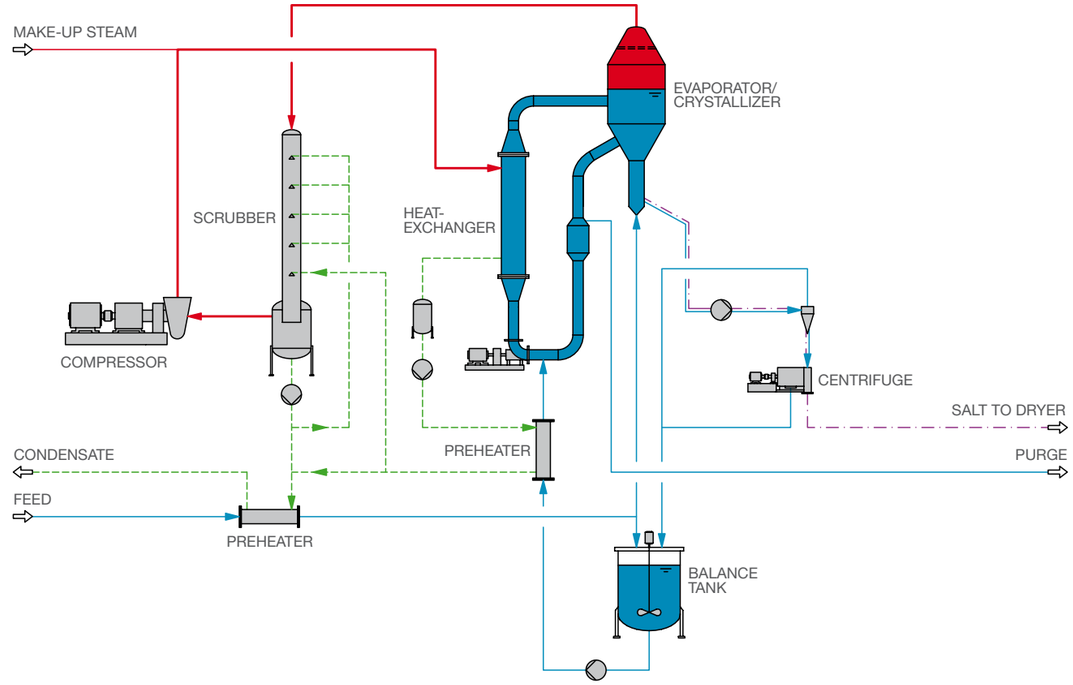
If low pressure steam for heating is available, the Multi-Stage Vacuum system is preferred. Purity levels can be set by the application of the adequate elutriation and purge systems.

The Multiple Effect Evaporation plant is maybe the most classical process for evaporation plants. The principle is quite simple. The first effect is heated by live-steam; the following stages are heated by the vapours of the upstream unit. With the number of effects the live steam consumption can be reduced accordingly.

The number of effects can not be increased arbitrarily as the maximal available temperature range is given. On the low-temperature end (the last effect) the ambient conditions such as cooling water or air temperature are limiting factors. On the high-temperature end the available steam pressure, mechanical design and the corrosion resistance of the selected material determines the upper limit.

Achieving an optimal design means to find the optimum between energy- and investment costs. Beside of the correct number of effects the preheating concept plays the most decisive role. Sophisticated preheating systems make the difference between standard and «high-end» installations.

In order to ensure optimal plant efficiency in terms of primary energy consumption, the steam should be generated at higher pressure in order to utilize the exergy for power generation by a counter pressure steam turbine or better a gas or steam turbine cogeneration unit. The back pressure steam can be used to heat the evaporation plant. At a low evaporation capacity, where the utilization of a cogeneration system is not feasible, the overall efficiency can be improved by thermal vapour recompression system called TVR (ejector system).



Mechanical Vapour Recompression (MVR)

If electrical power on a favourable price is available, a vapour recompression process can be the logical choice. EVATHERM has improved the Mechanical Vapour Recompression (MVR) technology and became industry standard.

An evaporation plant with Mechanical Vapour Recompression (MVR) works like an «open heat-pump» (Carnot process), where the vapours are recompressed up to the pressure level of the heating steam. The driving energy for the evaporation process results from the isentropic enthalpy increase of the vapour steam. The vapour condensate and the purge stream as well are used to preheat the feed nearly to the operation temperature of the unit. Due to this intensive heat recovery the make-up steam consumption is in the most cases nearly zero.

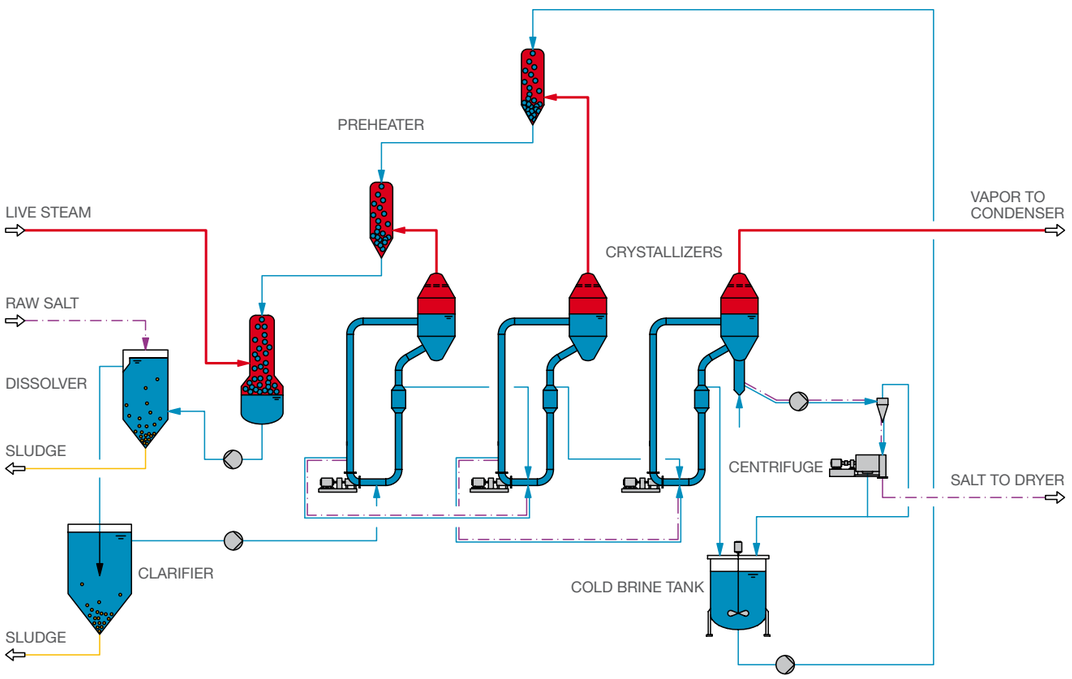
The compressors are volumetric rotating machines, which mean they work with a constant volumetric flow rate on a given speed. Subsequently the steam mass flow varies depending on the suction pressure of the compressor.

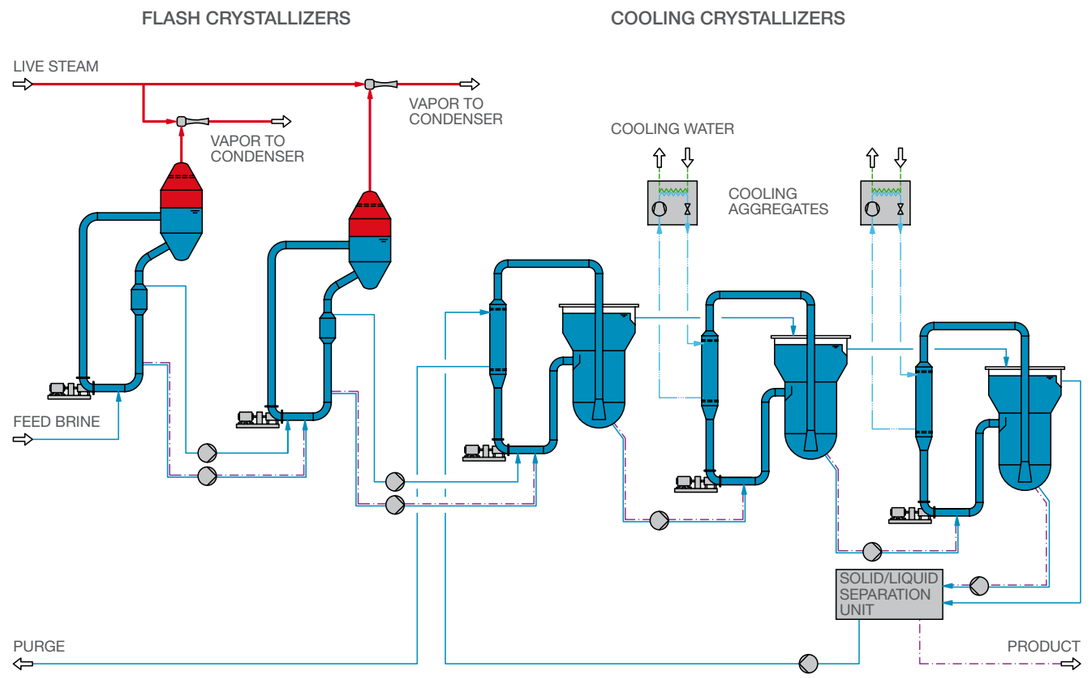
The main characteristics of a MVR system are summarized below:

- almost no steam consumption
- no cooling water requirement
- flexible operation

The thermo-dynamical design of such a unit has to be done very carefully in order to operate the compressor on its highest efficiency. Very important is the design of the crystallizer. As the economy of the MVR process depends on the necessary pressure increase of the vapours. The so called «thermal short circuit» should be minimized or entirely be avoided; good experiences have been made with the **EVATHERM MSCPR Crystallizer** with radial inlet nozzle.

TECHNOLOGIES





Recrystallization

Recrystallization of solid salt is a process which renders very high purity salt using comparably little thermal energy and chemicals.

In opposite to the 2 processes described before the Recrystallization Process requires solid salt as feed input. Principally cold dissolving and hot dissolving of the solid salt as well is possible, hereunder the hot dissolving process is described.

The Recrystallization Process is very similar to the multiflash evaporation plant. The undersaturated recirculation brine is getting saturated with solid salt at atmospheric pressure and it will be led downstream into the several flash crystallizers working on different pressures. Due to the temperature drop in each crystallizer water evaporates and subsequently the oversaturation will start the crystallization. The purge from the last crystallizer will be pumped through preheaters columns (mixing condensers), where the cold saturated brine will be mixed with the hot vapours coming from the evaporators. Finally the output from the columns is an undersaturated brine which goes into the saturators. Process heat losses are compensated by means of booster heaters. Especially advantageous is the application of an additional cogeneration unit in form of a diesel generator, where the waste heat can be used for the heat loss compensation.

The specific advantages of this process are evident:

- very high product purity
- low specific steam consumption
- low chemical consumption
- almost neutral water balance (only a few make-up water needed)

An interesting alternative can demonstrate the combination of the **Recrystallization with a MVR System.**

Cooling crystallization

The cooling crystallization can be applied when the solubility gradient of the solution increases steeply with falling temperature or when a vaporisation of the solvent has to be avoided.

Depending on the specific task a vacuum cooling or a surface cooling process, which is an atmospheric process, can be applied.

At the vacuum cooling crystallisation the supersaturation of the solution is caused trough the evaporation of the solvent and through the cooling of the mother liquor as well. The crystallizers are designed as flash units very similar to the evaporators used in the recrystallization process. The vacuum is generated by means of high performance ejectors with condensing system.

On the other hand, at the surface cooling crystallisation the supersaturation is only a result of the temperature decrease of the liquid. EVATHERM's surface cooling crystallizers are characterized by proper supersaturation control and limited scaling tendency, even at very low temperature. Installations with operating temperatures of -10° C to -20° C have already been realized successfully.

A combination of both technologies shows the figure above. A sophisticated **Cooling Energy Recovery** makes this process as a valuable and feasible alternative to other processes.

Possible applications can be:

- Na_2SO_4 / Glaubersalt crystallization
- Potash- and Magnesium salt recovery

APPLICATIONS

The applications of EVATHERM's technology are as versatile as the chemical industry itself. Reliable technology and well functioning plants are the company's strength.

EVATHERM continues to improve the existing technology in order to achieve higher energy efficiency, better product quality and reduced operating costs. Through its close co-operation with the clients and its extensive experiences in the chemical industry EVATHERM develops new processes tailored to the specific demands of the clients.

EVATHERM's process plants and equipment has been successfully used for many years for different applications. Following some typical applications:

Salt Works

Salt is an important component of our live. The demand of the industry in high purity NaCl is continuously increasing. The production of NaCl belongs to the most energy consuming processes in the base chemical industry.

Therefore it is decisive to choose the most suitable process considering all environmental and energy aspects in order to ensure the economic efficiency for a long term.

EVATHERM belongs to the worldwide leading engineering companies serving the salt industry. Independently from the raw material source – solar salt, rock salt, brine or seawater, EVATHERM will find the optimal process that suits the customer's needs in terms of energy efficiency, product purity and purge handling.

Yearly several million tons of salt is produced in numerous EVATHERM salt plants world wide.

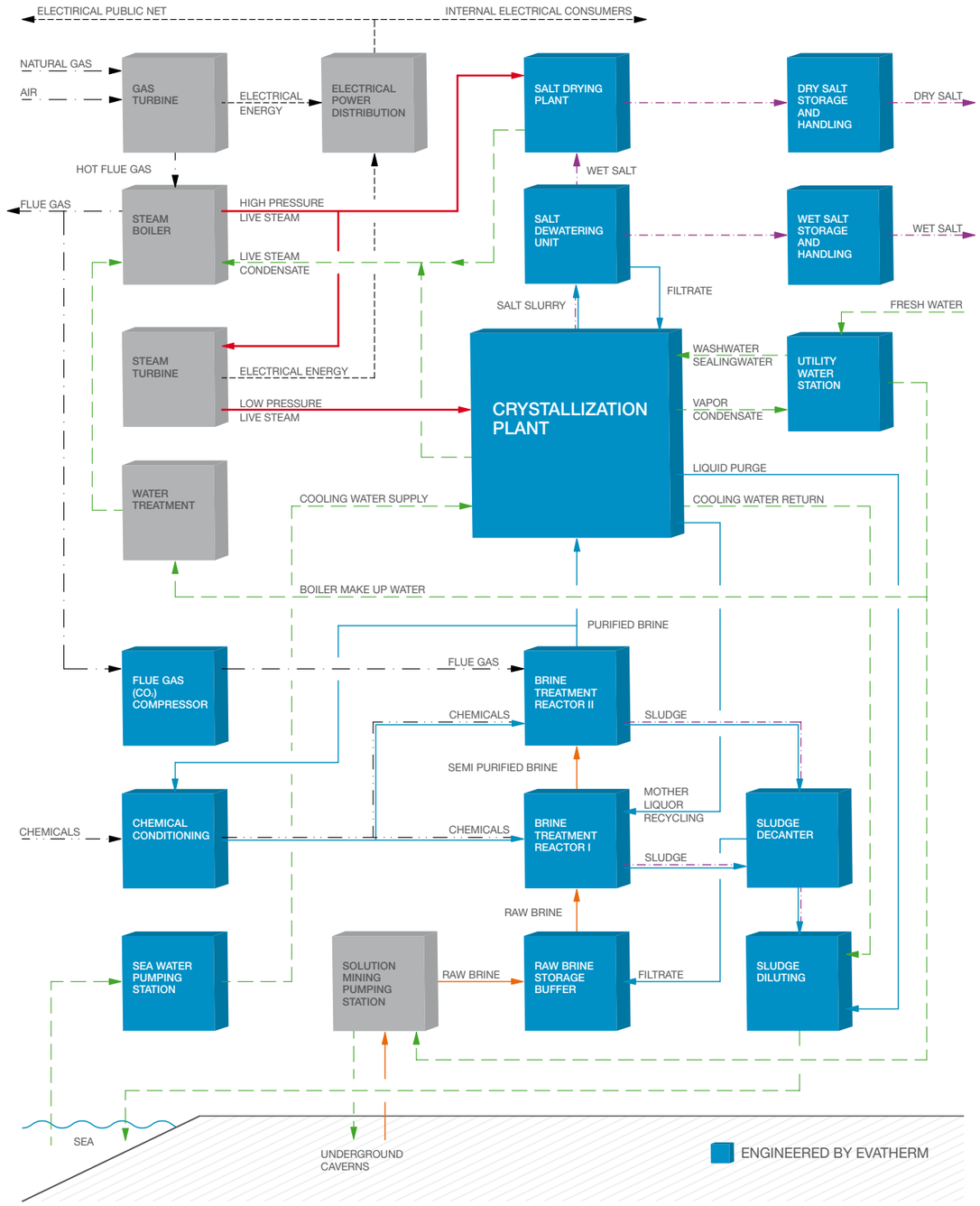
We have the know-how and capability to offer the full technological range for modern salt production:

- Solar salt works (by partners)
- Salt wash- and upgrading plants
- Solution mining (by partners)
- Chemical brine treatment
- Vacuum salt plants by MVR, Multiple-effect, Recrystallization
- Salt handling and packing

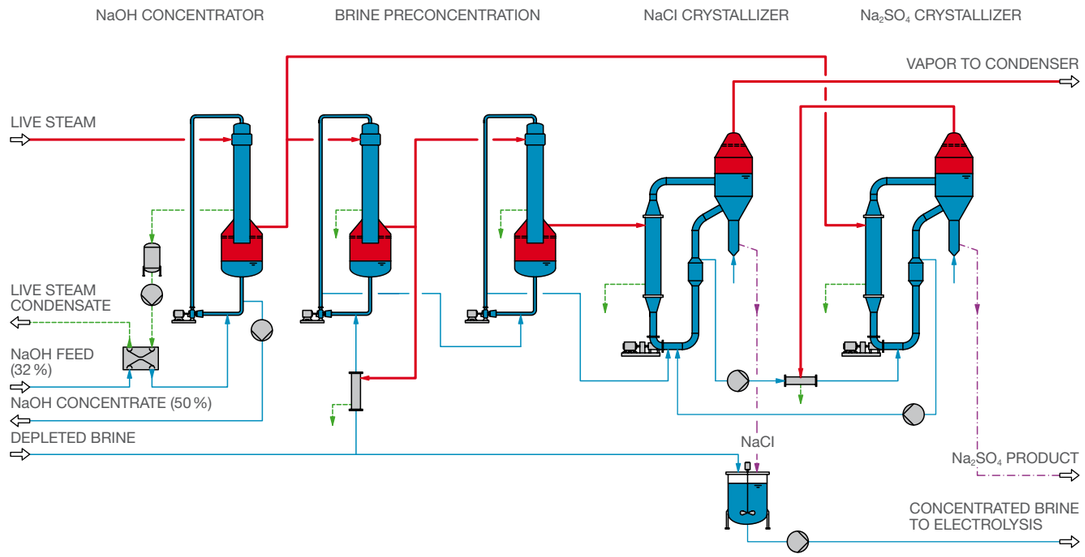
The **Chemical Brine Treatment** is the key to optimal salt purity with low chemical consumption. EVATHERM has extensive experience in batch purification and can supply a system that takes all relevant factors into consideration for best results.

A modern salt plant does not consist only of an evaporation plant, moreover the whole production process has to be considered beginning with the raw material input and ending with the final product handling. Special attention has to be paid to the energy generation, which is the key question for the profitability of a vacuum salt plant. The following block diagram shows an example of such a comprehensive survey integrating the energy generation by means of a cogeneration unit into the overall process.

Block diagram of a modern salt plant



APPLICATIONS



Chloralkali Industry

The chloralkali industry is an integral part of the economy of many countries around the word. EVATHERM provides innovative solutions for the brine circuit, sulphate removal and caustic concentration.

Beside of the know-how for **Caustic Soda Concentration Units** and modern **Salt- and Brine Purification Plants,** EVATHERM owns a dedicated technology for the sulphate removal from the depleted brine circuit. Instead of a precipitation with Ba-salts, a **Thermal Sulphate Removal Process** can be a more environmental friendly and economical solution. By means of a so called **Fractional Crystallization** the sulphates are crystallized as Na_2SO_4, which is a valuable by-product for the industry. Different solubilities for each compound on different temperatures are the driving force for the selective separation of Na_2SO_4 from a NaCl-Na_2SO_4-$NaClO_3$-brine.

The combination of a Caustic Soda Concentration Unit together with a Thermal Sulphate Removal Process shows one of the latest developments in the Chloralkali Industry (see process flowsheet above). A sophisticated process link on the steam side brings significant savings in the consumption of thermal energy and investment costs as well.

Our technology for the **Hypo-Chlorite Recovery** is an important contribution to our commitment to the environment protection.

CHEMICAL INDUSTRY

EVATHERM's evaporation and crystallization systems are utilized in many diverse operations in the processing of numerous inorganic and organic substances for chemical firms. The following listing highlights some main applications in the chemical industry:

Potash- and Fertilizer Industry

- Crystallization of diverse Potassium and Nitrate salts
- Effluent treatment
- Magnesium salt recovery

Detergent Industry

- Production of Na_2SO_4 salts from different sources

Power Industry

- Cooling tower effluent treatment

Pulp and Paper Industry

- Black liquor concentration

Mining- and Metal Industry

- Contaminated water evaporation
- Metal recycling processes
- Treatment of galvanic waste water

Caprolactam Industry

- Crystallization of $(NH_4)_2SO_4$

And many others…

Environment Protection

All industrial facilities are affected with today by increasing environmental awareness. Everybody becomes environmentally responsible by recycling and reducing contaminated effluents. EVATHERM contributions to these efforts are innovative concentration, purification and separation technologies for:

- Evaporation plants for scrubber effluents
- Zero discharge systems for power stations
- Selective product or by-product recovery from waste water
- Caustic- and acid concentration plants

SERVICES

Our business is focused on the engineering, delivery of key equipment and complete turn-key installations as well. Extensive technical services complete our range of assistance such as

Consulting services

- feasibility studies
- operation and plant analysis

Engineering studies

- basic engineering services
- HAZOP studies
- authority engineering

Plant installations

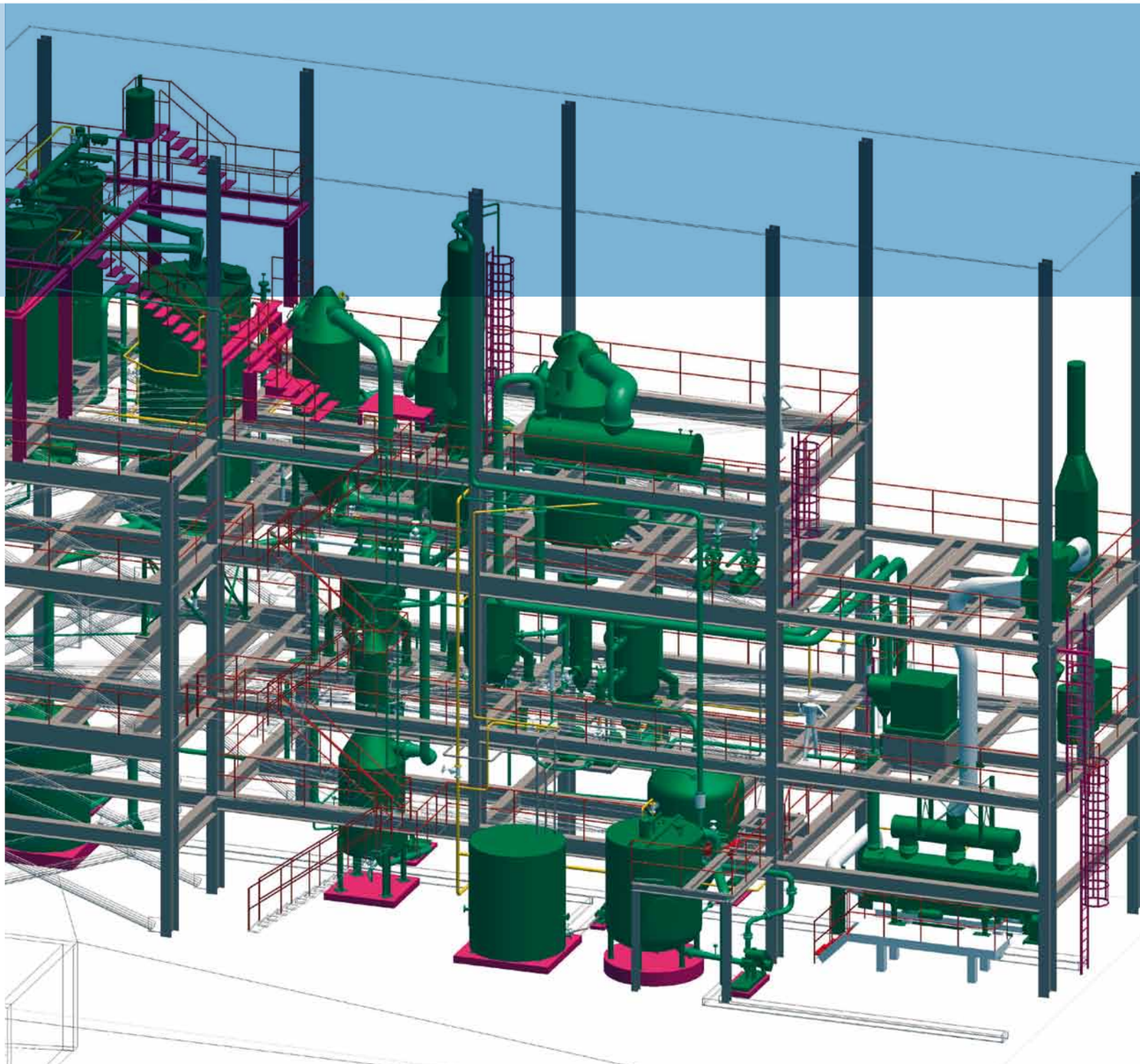
- detail engineering services
- equipment supply
- plant modernizations
- turn-key installations

After sales services

- training of staff
- commissioning
- supply of spare parts
- revision
- trouble shooting
- construction supervision

Pilot Plant Facility

As an expression of our commitment to continuous process development, we have established a modern laboratory and pilot plant. Many of our projects have been initiated here, whether it is a new process concept or it is the investigation of unknown physical properties.



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