VEOLIA

Lithium Processing Capabilities

HPD® Evaporation and Crystallization

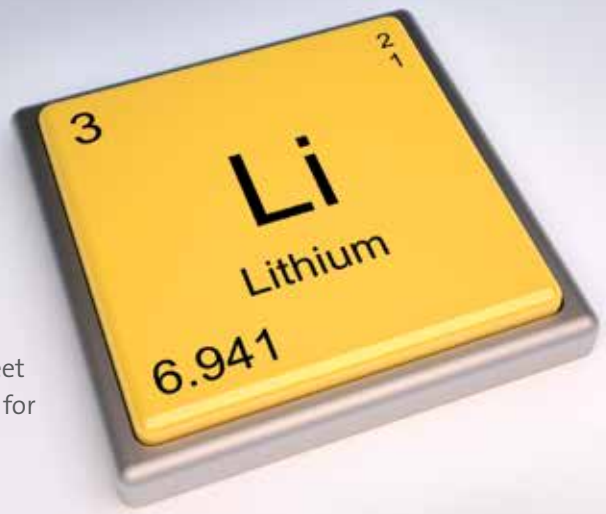
WATER TECHNOLOGIES

Veolia Capabilities for Lithium Producers

Process Development Expertise

Veolia Water Technologies has a long history of supplying systems for purification, recovery, and drying of inorganic chemicals utilizing its HPD® Evaporation and Crystallization Technologies. State-of-the-art research and development capabilities allow understanding of the behavior of multi-component systems, aqueous systems, and system optimization for efficiency, operability, and final product quality.

These process development capabilities are critical in order to meet increasing purity standards in the production of lithium compounds for applications such as advanced electric battery technologies.



Lithium Processing Experience

Veolia has supplied several process systems to leading lithium suppliers worldwide as well as having performed analytical, bench and pilot-scale testing.

- Lithium brine concentration
- Lithium salts crystallization
- Lithium salts purification by re-crystallization
- By-products recovery from lithium processing
- Impurity removal (precipitation, ion exchange, . . .)
- Solid/liquid separation systems and solids handling

Case Study: Testing to Commercial Success

Veolia designed and supplied a lithium producer in Argentina with a complete, modular, skidded HPD® Crystallization system comprised of an evaporator to concentrate the brine solution, a forced circulation cooling crystallizer to precipitate and remove sodium chloride impurities, and forced circulation crystallizer to produce high-purity lithium chloride. Solids handling equipment, including a centrifuge and dryer, were integrated into the overall process design.

Process development played a critical role in the overall project. Veolia's Research Center designed a program to determine crystallization growth kinetics and equipment requirements to achieve habit, size, and purity specified by the client.

Laboratory testing resulted in an extremely accurate prediction of achievable crystal quality. More importantly, the use of bench-scale testing allowed Veolia to directly apply the testing performed to a successful, commercially proven lithium salt crystallization system.

Research & Development

Veolia's 5,000 m^2 Research and Development Center is crucial for development of challenging process designs for HPD® Evaporation and Crystallization technologies.

The facility is home to a wide variety of tools used for investigation of new process designs, testing to support customer projects, and development of new technologies. It is the foundation for design evaluation, feasibility, and process validation as well as improvement and economizing overall system designs.

The analytical, bench-scale, and pilot-scale testing capabilities, with an extensive catalog of data, allows advancement of first-of-a-kind innovations.

This is especially important to design processes for achieving the purity requirements in evolving lithium applications and purity requirements.

Rigorous testing provides the confidence that the commercial system will perform as designed.

A Preferred Partner for Project Development

- In-house Research & Development Center
- Expertise in FEED or phased engineering contracts for challenging process designs and highly complex projects
- In-house, cross-discipline teams including process, mechanical, electrical/instrumentation, structural and civil engineering

Process System and Project Capabilities

- Process integration with complementary Veolia technologies (Reverse Osmosis, Ion Exchange, Filtration systems, . . .)
- Modular supply expertise
- Design, Build, Operate, Maintain (DBOM) project execution
- Process Guarantees
- Aftermarket, field service, and technical support services

Lithium Processing Capabilities

Lithium salts crystallization:

• Lithium Chloride (LiCl) • Lithium Carbonate (Li_2CO_3)
• Lithium Hydroxide anhydrous and monohydrate (LiOH)
• Lithium Sulfate anhydrous and monohydrate (Li_2SO_4)
• Lithium Bromide (LiBr) • Lithium Phosphate (Li_3PO_4), . . .

By-product recovery from lithium processing:

• Potassium Chloride (KCl) • Sodium Sulfate (Na_2SO_4)
• Sodium Chloride (NaCl) • Potassium Sulfate (K_2SO_4)
• Boric Acid (H_3BO_3), . . .

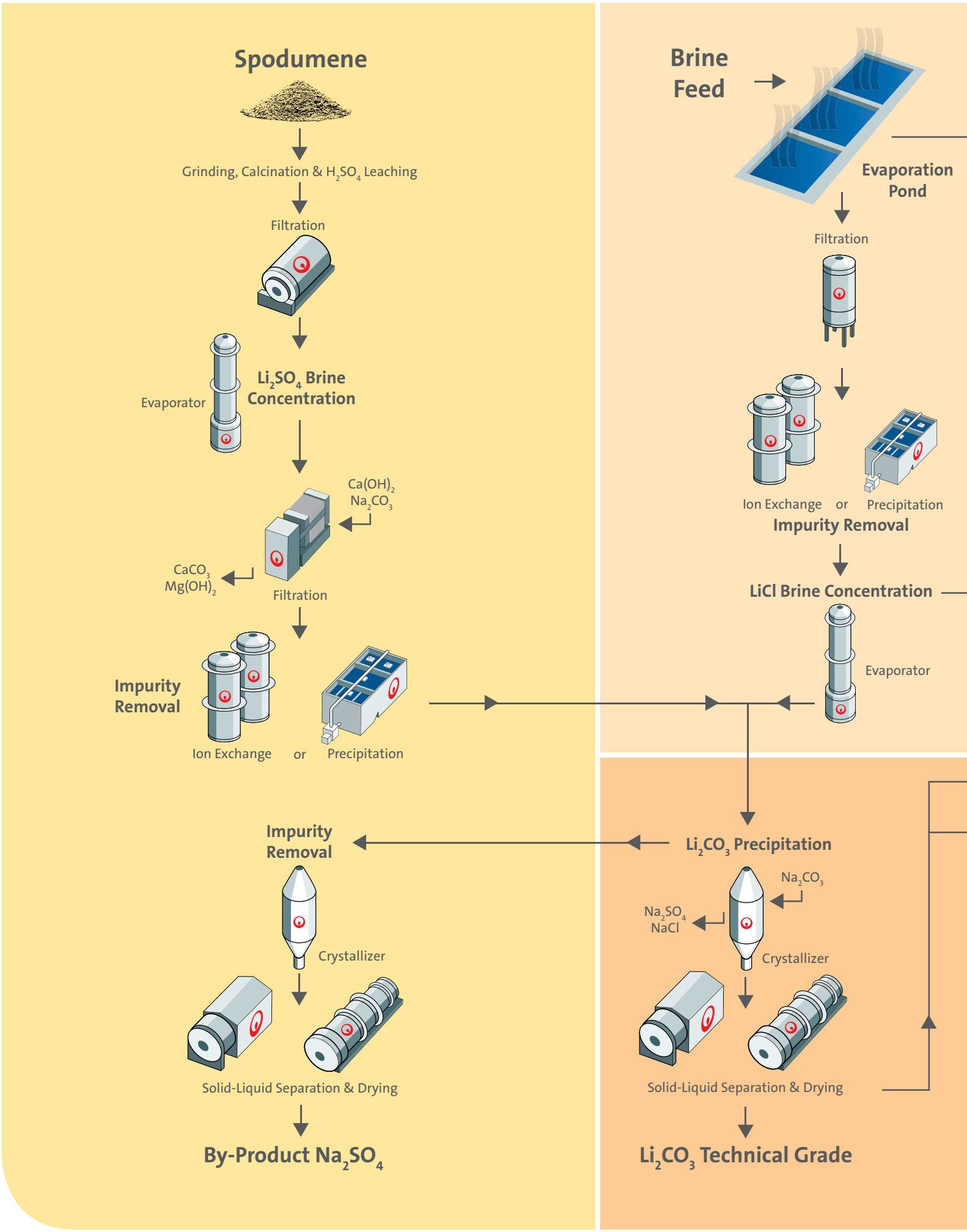
Process Equipment

Evaporator Technologies:

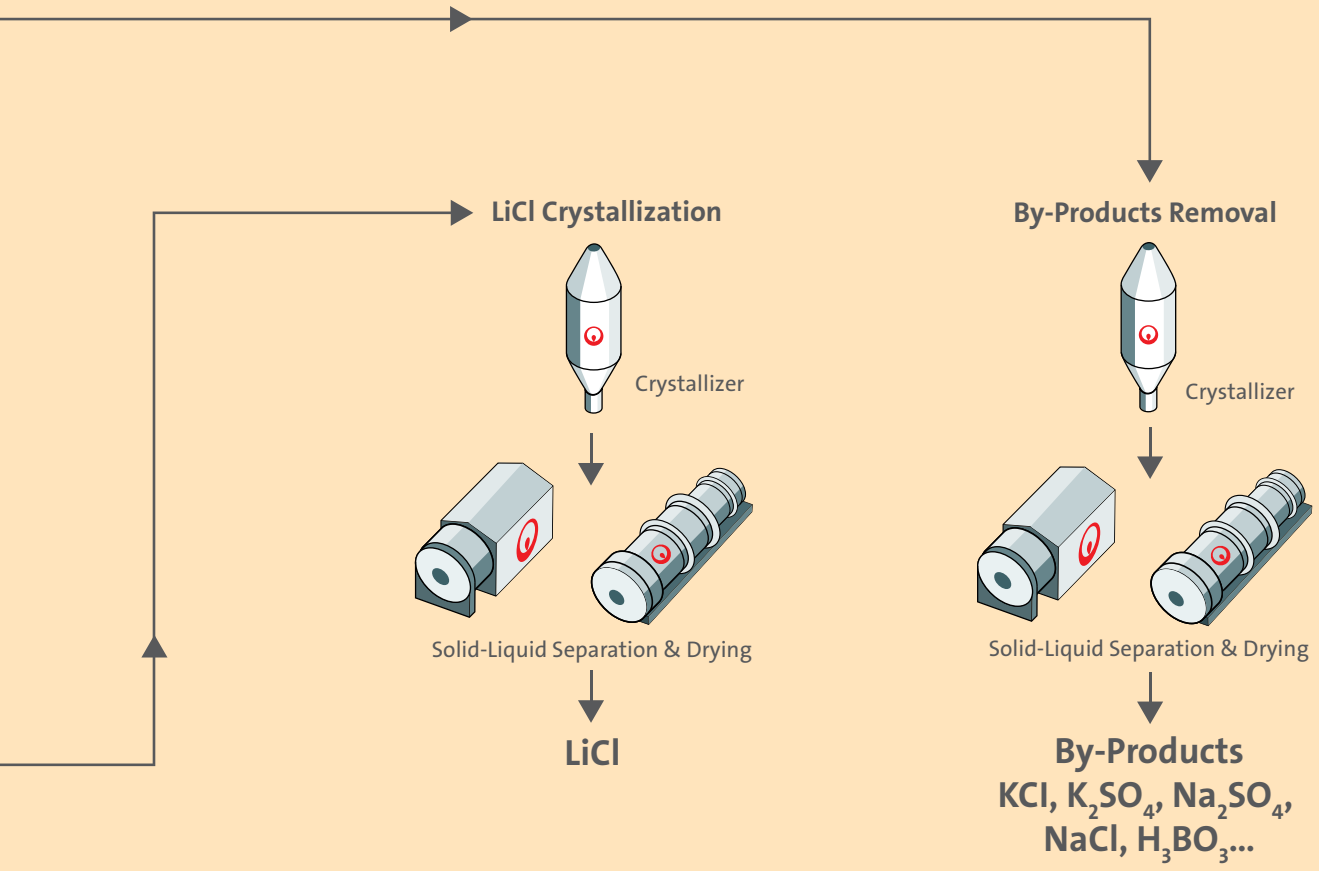
• Thermal Vapor Recompression evaporator
• Mechanical Vapor Recompression evaporator
• Multiple Effect evaporator • Multiple Effect Distillation evaporator • Long-tube Vertical (Rising-Film and Falling-Film) evaporator • Forced Circulation evaporator • Calendria evaporator • Multi-stage Flash evaporator • Horizontal Spray Film evaporator

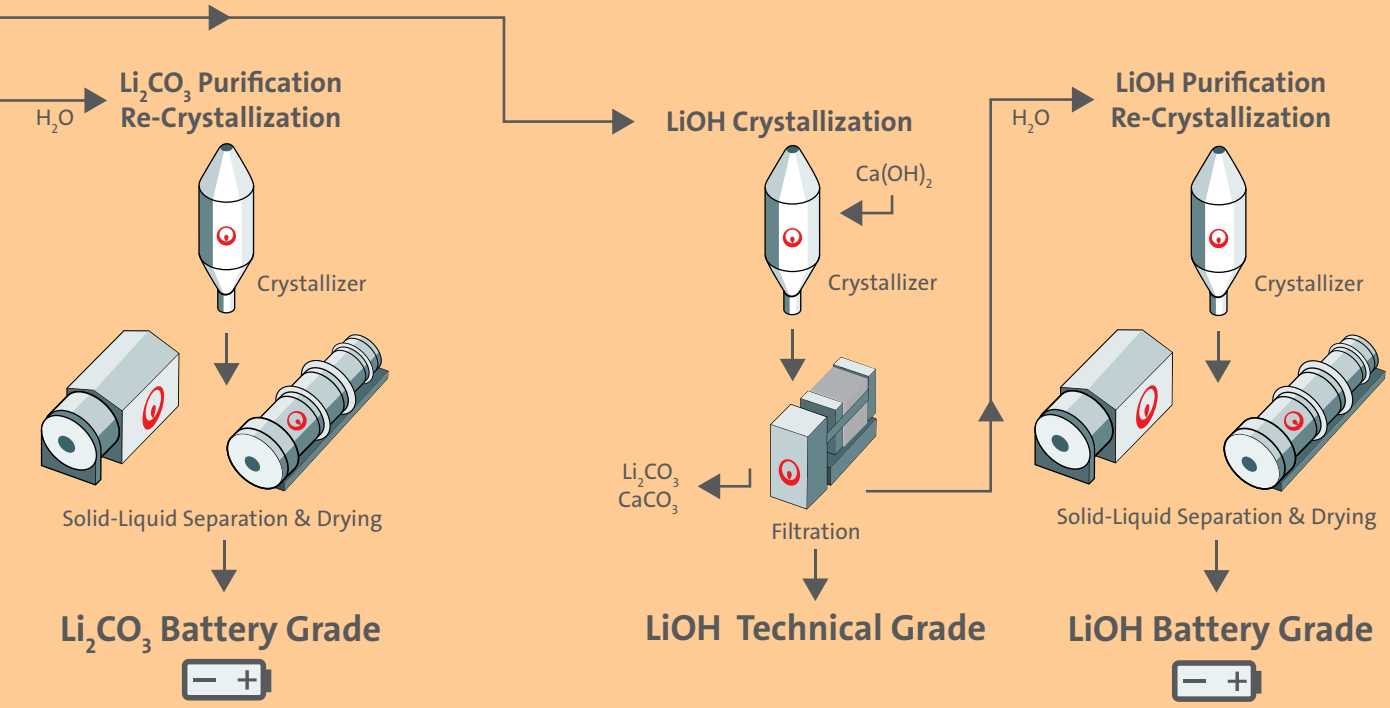
Crystallizer Technologies:

• Draft Tube Baffle (PIC™) crystallizer • Vacuum crystallizer
• Cooling crystallizer • Forced Circulation crystallizer
• Growth™ (Oslo type) crystallizer • Reactive crystallizer
• Adiabatic Flash crystallizer • Calendria crystallizer


Spodumene
Grinding, Calcination & H_2SO_4 Leaching
Filtration
Evaporator
Li_2SO_4 Brine Concentration
$Ca(OH)_2$
Na_2CO_3
$CaCO_3$
$Mg(OH)_2$
Filtration
Impurity Removal
Ion Exchange
or
Precipitation
Brine Feed
Evaporation Pond
Filtration
Ion Exchange
or
Precipitation
Impurity Removal
LiCl Brine Concentration
Evaporator
Impurity Removal
Crystallizer
Solid-Liquid Separation & Drying
By-Product Na_2SO_4
Li_2CO_3 Precipitation
Na_2CO_3
Na_2SO_4
NaCl
Crystallizer
Solid-Liquid Separation & Drying
Li_2CO_3 Technical Grade

Conventional Lithium Processes





Resourcing the world

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