

Evaporation and Crystallization Technologies

For Greener Growth

A Greener World Needs Superior Technologies

KBR provides evaporation and crystallization technologies to industrial clients in fertilizer, chemicals, chlor-alkali and other markets. We specialize in regeneration of acids, evaporation, crystallization and complete plant design.

KBR's process knowledge is based on more than 40 years of experience with more than 200 evaporation and crystallization plants, e.g. caustic soda concentration in the chlor-alkali industry and various salts crystallization in the chemical industry. We also have extensive experience in the recovery of acids containing different kinds of impurities, especially of sulfuric acid from the production of titanium dioxide or bleed acid from copper refineries. We have a wealth of experience in the selection of suitable corrosion-resistant materials such as special plastics, glass-lined steel, tantalum, titanium, nickel and impregnated graphite.

Our skilled personnel and reliable sub-suppliers serve customers worldwide, delivering new plants for purification and re-use of industrial effluents or plant upgrades that comply with today's demanding environmental regulations.

KBR acquired technology and engineering company Ecoplaning Oy with its deep expertise in evaporation and crystallization technologies, in 2016. Since then we have continued to grow our offering, scope and capabilities to even better serve our clients.



RECYCLING – FOR THE ENVIRONMENT

Traditionally, the acid used in processes – from titanium dioxide to metallurgical production – was neutralized and discharged into waterways, injected into deep wells or used in fertilizer production, a potential health concern.

Our proven recovery technologies help protect health and the environment by recycling spent acid and other impurities back into the process.

EFFICIENT ENERGY USE

Being energy efficient means both designing for efficiency and choosing the right technologies. As we design our processes and services to be energy efficient, our customers benefit from an improved efficiency and an increased business performance.

TAILOR-MADE SOLUTIONS

We are specialized in providing customer-specific solutions. Our tailor-made solutions are designed to customer's project objectives and are developed in close cooperation with our customers according to their needs.



Smart **Growth** the Green Way

Our mission is to develop, design, construct and deliver environmentally-friendly process plants on a world-wide basis, based on our proprietary technologies, complemented by state-of-the-art third-party technologies.

Ecoplanning guarantees optimum solutions for your particular application based on decades of experience and know-how in environmental technologies and chemical plant engineering.





INNOVATION

We provide innovative solutions that are energy-efficient and environmentally compatible.



SUPERIOR KNOWLEDGE

We value knowledge gained from both theory and experience.



RELIABILITY

We always keep our promises. Our commitment to consistently deliver quality products and services gives customers the level of confidence they require.



CREATING SUCCESS

We work for and with our customers to identify and deliver solutions that exceed expectations. Our customers' success is our goal.



Applications

INDUSTRY SEGMENTS

FERTILIZER INDUSTRY

KBR's wide range of evaporation and crystallization solutions provides extensive capabilities for fertilizer production, including AMS, NOP and MAP crystallization and phosphoric acid concentration and purification.

CHEMICAL INDUSTRY

We provide evaporators and crystallizers for various inorganic and agricultural products. Applications vary from recovery of different effluent streams to high added value chemical products.

CHLOR-ALKALI INDUSTRY

KBR technologies can be used to concentrate caustic soda, a by-product from chlorine production, from 30-32 wt% up to the specification concentration required prior to shipping.

METALLURGICAL INDUSTRY

Our technologies can be used to recover copper sulfate and nickel sulfate in the electrolyte purification process of copper refineries.

PIGMENT & DYE INDUSTRY

In the sulfate process of manufacturing titanium dioxide pigment, a vast amount of sulfuric acid is purified, concentrated and recycled through KBR's processes.

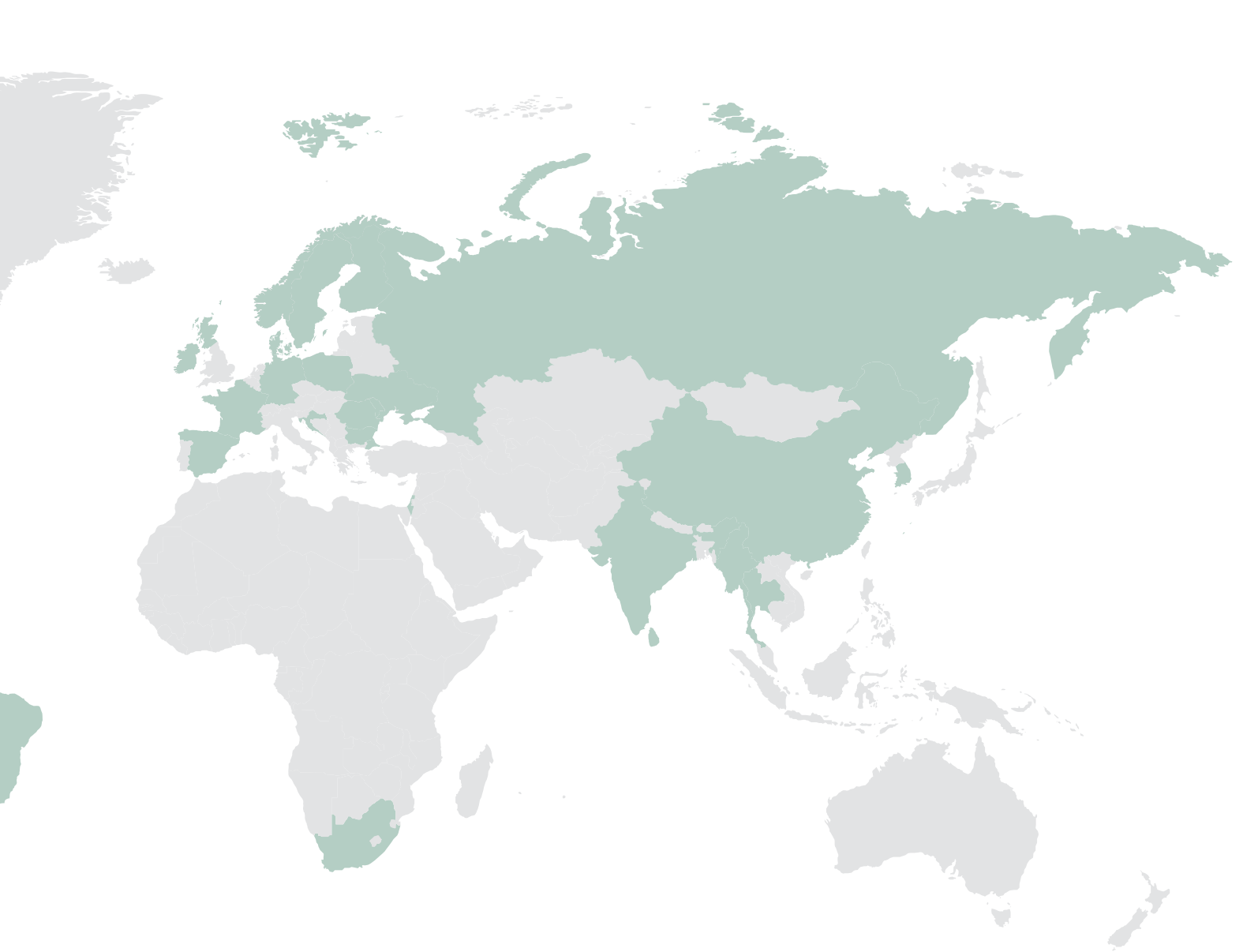
FOOD INDUSTRY

Our processes are used in the food industry to concentrate sugar juice, vinasses and molasses. Ecoplaning also has experience in the purification and concentration of phosphoric acid.

PULP INDUSTRY

KBR technologies can be used for fly ash recrystallization, sodium chlorate crystallization and removal of non-process elements.





Indonesia



China



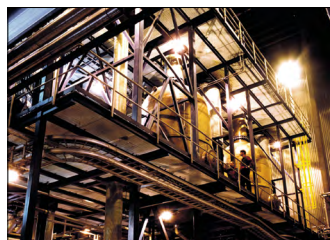
Czech Republic



Sweden



Jordan



Finland



Germany

Evaporation

FALLING FILM EVAPORATORS

Liquid flows downwards by gravity along the inner surface of vertical evaporator tubes. A short residence time of liquid on the heating surface and the ability to use a low temperature difference make Falling Film Evaporators suitable for heat sensitive liquids. These evaporators can be operated between 0 and 100% of the design capacity while still maintaining good plant stability.

FORCED CIRCULATION EVAPORATORS

The solution is circulated by a circulation pump through the heat exchanger tubes with high velocity. The vaporization takes place in the vapor head where the vapor and liquor are separated by gravity and/or by centrifugal force. Forced Circulation Evaporators are suitable for liquids containing solid impurities or for crystallization processes.

RISING FILM EVAPORATORS

The liquid moves, by natural circulation from the bottom to the top of the tubes as vaporization takes place. Rising Film Evaporators are of a fairly simple design leading to low investment and operating costs when compared to other evaporator types. They require a higher temperature difference than other types and can be recommended only with relatively pure liquids.

VAPOR RECOMPRESSION TECHNIQUES

Primary energy consumption can be reduced by compressing vapors either mechanically by blowers or thermally by steam. The compressed vapor is reused as a heating media for further evaporation. Vapor recompression can be incorporated with falling film or forced circulation type evaporators. Vapor recompression is suitable for liquids having a low boiling point such as dilute salt or acid solutions, for waste waters and in many food industry applications.

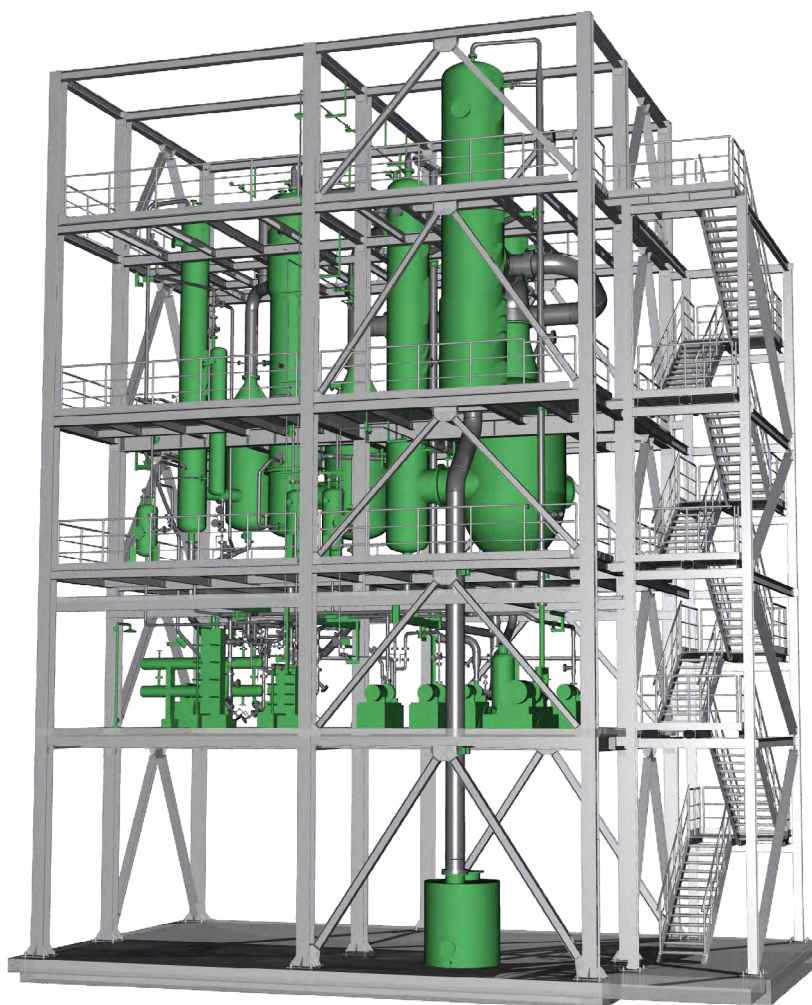
YOUR EVAPORATION SPECIALIST

KBR has supplied more than 100 evaporation processes for various applications and techniques all over the world. Many of our evaporators are built for environmental reasons in order to decrease the volume of harmful effluent or to obtain a sellable product, for example, from dilute waste acid streams.

The most suitable evaporator type is chosen case by case, taking into consideration numerous factors like the physical properties of the product (boiling point, viscosity, sensitivity to temperature, etc.), scaling or foaming tendency, impurity content, etc. The process liquids treated by KBR's evaporators are highly corrosive, therefore the selection of construction materials is essential and influences the whole design process. In order to ensure optimum material selection and utilization, each evaporation process is tailor-made for every application.

EVAPORATION PLANTS FOR

- Sulfuric acid
- Caustic soda
- Phosphoric acid
- Potassium chloride
- Calcium chloride
- Steep waters
- Sweeteners and sugars
- Molasses and vinasses
- Waste waters
- Fertilizer liquors



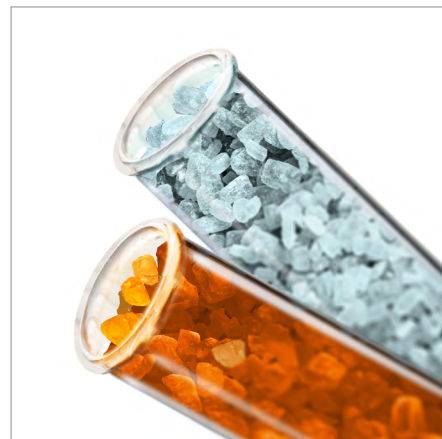
Crystallization

Crystallization from solution retains its importance as an industrial process because many materials are marketed in crystalline form. However, crystallization can also be used to separate dissolved impurities from process liquor, allowing for recirculation of valuable solvent.

Supersaturated conditions in the crystallization vessel are required for crystallization. Depending on solubility properties, supersaturation can be achieved either by concentrating the solution, lowering the solution temperature or a combination of these two. Concentration can be realized either by single stage, or in order to save energy, multi-stage evaporation.

The choice of crystallizer type depends on the crystallization behavior of the solute, such as crystal growth rate, nucleation rate, shape of solubility curve, etc. Product requirements, such as desired crystal size and purity, are also parameters that are taken into consideration when selecting the most suitable process. The processes can be either continuous or batch operated.

Controlling the properties of the crystallized product is challenging, but KBR has completed nearly 100 crystallizing processes, giving us a solid background in designing reliable and easy-to-use processes for customers all over the world.



CRYSTALLIZATION PLANTS FOR

- Ammonium sulfates
- Ferrous sulfates
- Sodium sulfates
- Nickel sulfates
- Copper sulfates
- Potassium sulfates
- Sodium chloride
- Sodium chlorate

FORCED CIRCULATION CRYSTALLIZERS

Crystallization occurs during evaporation and it is followed by slurry handling and solid-liquid separation. This type of crystallizer suits a wide range of salts that are crystallized by evaporation but has limited capability to control crystal size or crystal size distribution.

DRAFT TUBE CRYSTALLIZERS

The draft tube design provides optimum agitation for the process. This type of crystallizer can be used for evaporation, crystallization or for evaporative cooling crystallization, and be operated either as a batch or continuous process.

DRAFT TUBE BAFFLE CRYSTALLIZERS

The crystals are separated from the liquid in the baffle area before the liquid is heated in the heat exchanger. This configuration results in heating circulation relatively free of crystals; only very small crystals and nuclei will follow the mother liquor to the heat exchanger and these are dissolved during heating. By removing fine crystals from the liquid, the Draft Tube Baffle Crystallizer allows control of crystal growth to achieve desired crystal size and crystal size distribution.

EVAPORATIVE COOLING CRYSTALLIZERS

Cooling is achieved by lowering the pressure, which causes flashing. The crystallization vessel can be either a simple agitated tank or a draft tube vessel that can be operated as a batch or continuous process. Evaporative cooling crystallizers can be used for liquids having strong scaling or fouling potential because there are no heat exchange surfaces.

SURFACE COOLING CRYSTALLIZERS

Cooling is achieved either in a separate heat exchanger or with cooling coils in a crystallization vessel. Surface Cooling Crystallizers can be operated as a batch or continuous process but the former is preferred due to scaling and crystal formation on cooling surfaces.

Acid Recovery

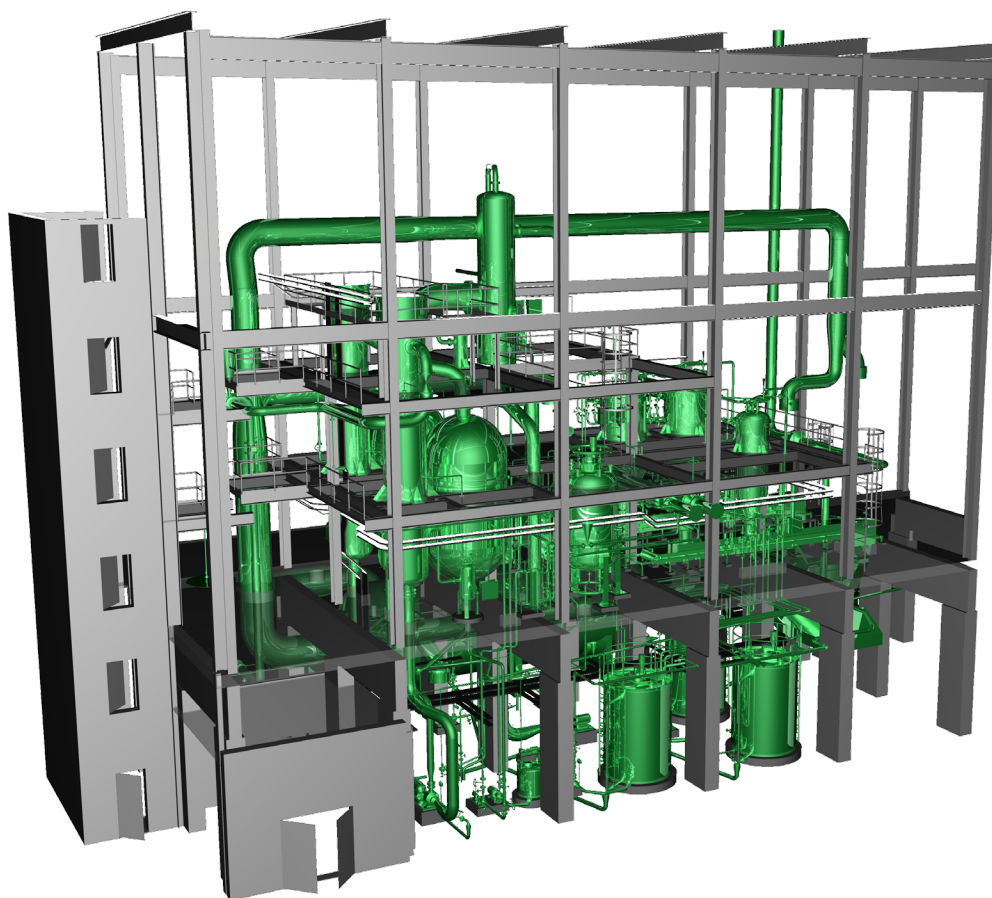
Sulfuric acid recovery is an application that has made Ecoplaning a renowned name in the chemical process industry. This application combines our core areas of expertise, evaporation and crystallization, with strong experience in solid-liquid separation and use of special construction materials such as plastics, graphite, silicon iron and special alloys.

This technology is widely used in processes especially within the titanium dioxide and metallurgical industry, in addition to other branches of the chemical industry. In the titanium dioxide (TiO_2) industry alone, more than 4 million tons of spent acid are processed in Ecoplaning plants annually. This corresponds to 1.9 million tons of evaporated water annually. Spent acid treatment in the TiO_2 industry includes crystallization, removal of copperas

together with other impurities and acid concentration to the appropriate level to be used in the digestion phase of the TiO_2 process.

In the metallurgical industry, acid recovery is used in copper smelters to purify electrolyte from tankhouses and produce copper sulfate and nickel sulfate. After purification, acid is returned to the main process, and valuable sulfate products can be sold to the market.

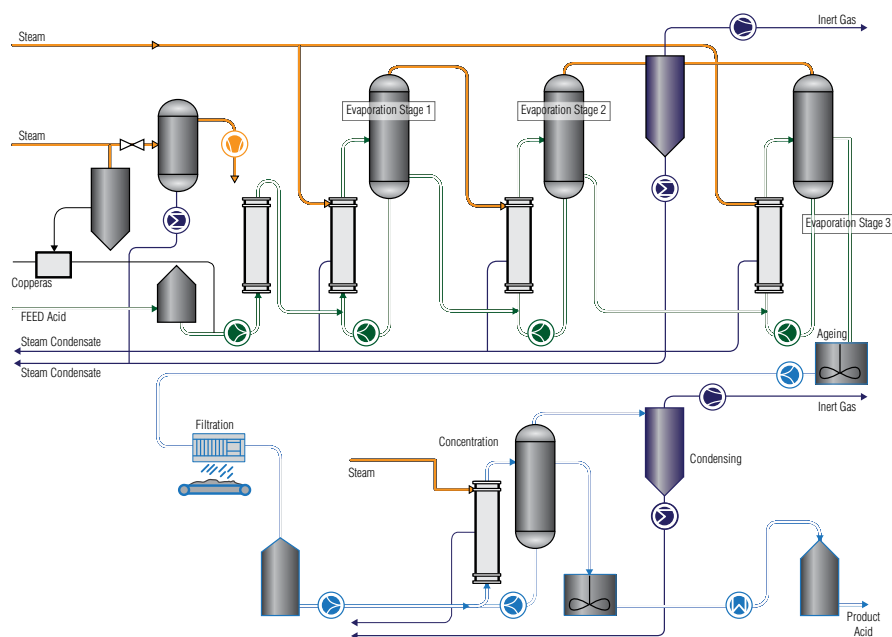
KBR's acid recovery technology is also used to purify and concentrate weak wash acid from the sulfuric acid plant. This application includes acid concentration and simultaneous precipitation of metal salts that are filtered out from the concentrated acid.



TECHNOLOGY

Typically the diluted spent acid concentration varies from 5 to 25% and the desired final concentration is 50 to 70%. For this application, a multistage – normally a two-or three-stage vacuum evaporation unit – is the optimal solution. Depending on the acid properties, either falling film or forced circulation evaporation may be chosen. At the final concentration, the solubility of most dissolved metals is reduced for precipitation, and they may be separated from the mother liquid by filtration. In some cases, the final concentration needs to be even higher to meet the process requirements. To reach the final concentration of 80 or even 90%, more evaporation stages are required – typically additional one- or two-stage evaporation units.

KBR has a long history and excellent knowledge of selecting the right materials for different acids in various concentrations and temperatures. Typical construction materials are different plastics, various stainless steels, graphite, zirconium, silicon iron and titanium. In high-concentration applications, even more exotic alloys are needed, such as niobium, tantalum, etc.



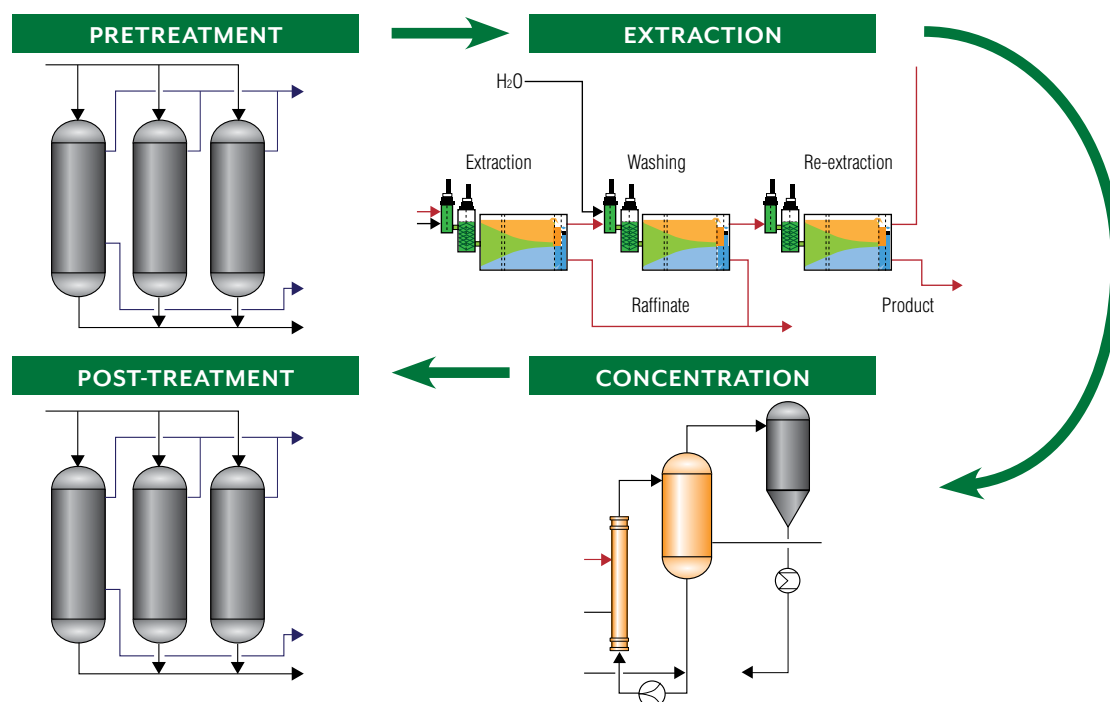
CASE: MANUFACTURE OF TITANIUM DIOXIDE

Production of titanium dioxide from ilmenite or slag results in the formation of spent acid containing 20-25% sulfuric acid and 10-15% metal salts. EcoPlanning's spent sulfuric acid recovery plants use a forced circulation evaporation process in which the spent acid is concentrated from 20% H_2SO_4 up to over 90%. The process consists of pre-concentration, ageing, filtration and final concentration units.

Phosphoric Acid Purification

Phosphoric acid produced by the wet process route, also known as green phosphoric acid, contains a certain level of impurities and can be used for fertilizer production without further purification. Most other applications require higher purity phosphoric acid. Phosphoric acid purified to technical grade can be used for the production of STTP (Sodium Tripolyphosphate), drip irrigation fertilizers, various crop nutrients, detergents, and animal feed products. Acid further purified to food grade can be used for a variety of applications in the food industry.

KBR has the expertise to design and build tailored solutions to meet the even the most demanding requirements. Our team can design the entire complex process chain and build phosphoric acid purification for any capacity-anywhere in the world.



Simplified process diagram of the Phosphoric Acid Purification plant.

TECHNOLOGY

Pre-Treatment

Depending upon the types of impurities in the green phosphoric acid and the desired final product specifications, a range of unit operations can be utilized in the pretreatment section. Typically, pretreatment units remove excess sulfate, toxic metals such as lead, arsenic and cadmium, and fluoride via precipitation and filtration. Organic matter and color are removed by activated carbon filtration.

Extraction

The primary purification section utilizes liquid-liquid extraction. EcoPlanning's extraction process applies well-proven and robust mixer-settler technology that ensures flexible and stable operation. The extraction process consists of three stages:

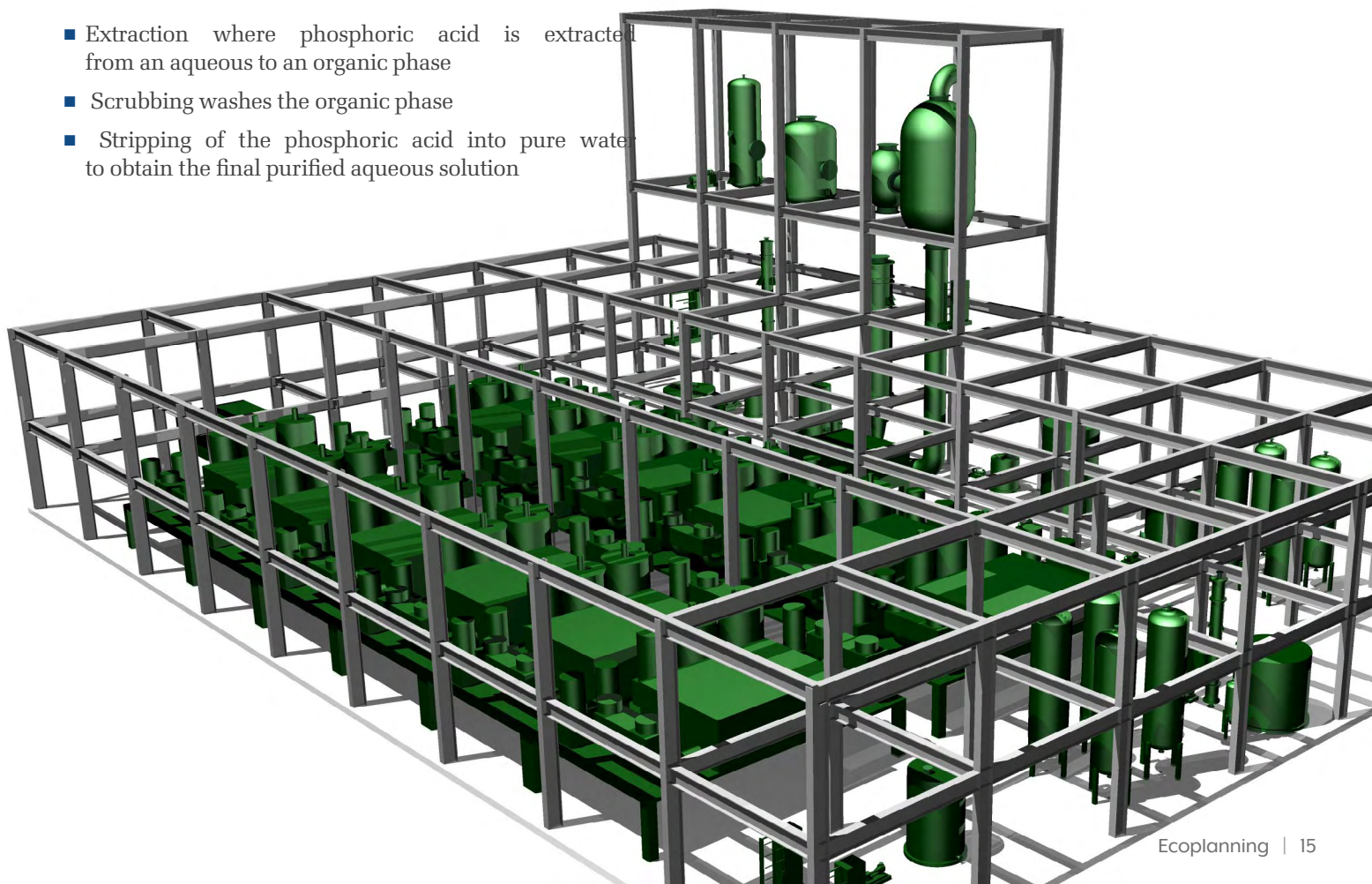
- Extraction where phosphoric acid is extracted from an aqueous to an organic phase
- Scrubbing washes the organic phase
- Stripping of the phosphoric acid into pure water to obtain the final purified aqueous solution

Concentration

Phosphoric acid concentration is usually required for transportation or to meet specific end-user requirements. This task can be accomplished with a single-stage evaporator. Evaporation is carried out at relatively low temperature and high vacuum to prevent polymerization of phosphate. Any chlorides or fluorides remaining in the product are captured in the hot vapor in the evaporator.

Post-Treatment

The concentrated acid is cooled and filtered with a polishing filter to remove any remaining impurities. Remaining organic matter and color are removed with activated carbon filtration. Low-fluorine specifications can be obtained through additional fluorine stripping.



About KBR, Inc.

KBR is a global provider of differentiated professional services and technologies across the asset and program lifecycle within the Government Solutions and Energy sectors. KBR employs approximately 37,500 people worldwide (including our joint ventures), with customers in more than 80 countries, and operations in 40 countries, across three synergistic global businesses:

- Government Solutions, serving government customers globally, including capabilities that cover the full lifecycle of defense, space, aviation and other government programs and missions from research and development, through systems engineering, test and evaluation, program management, to operations, maintenance, and field logistics
- Technology Solutions, including proprietary technology focused on the monetization of hydrocarbons (especially natural gas and natural gas liquids) in ethylene and petrochemicals; ammonia, nitric acid and fertilizers; oil refining and gasification
- Energy Solutions, including onshore oil and gas; LNG (liquefaction and regasification)/GTL; oil refining; petrochemicals; chemicals; fertilizers; differentiated EPC; maintenance services (Brown & Root Industrial Services); offshore oil and gas (shallow-water, deep-water, subsea); floating solutions (FPU, FPSO, FLNG); program management and consulting services

KBR is proud to work with its customers across the globe to provide technology, value-added services, integrated EPC delivery and long term operations and maintenance services to ensure consistent delivery with predictable results. **At KBR, We Deliver.**



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about KBR Ecoplanning

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