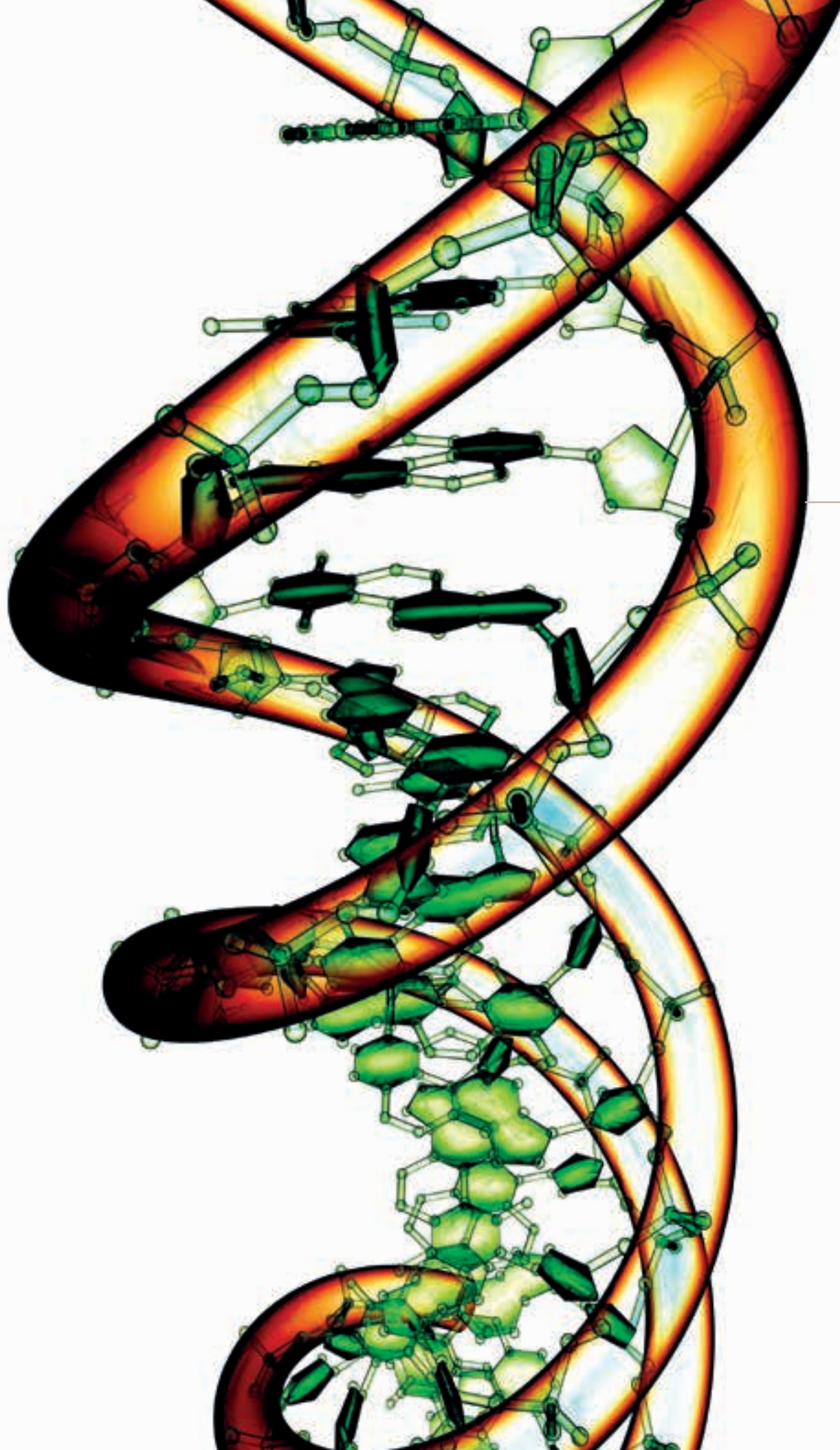




Engineering a greener world

Solutions for next generation industrial fermentation





Achieve your goals with the right support



SYNTHETIC BIOLOGY

A growing number of enterprises, from startups to global companies, are discovering the lucrative opportunities in next generation industrial fermentation by utilizing synthetic biology* to produce mostly “green” products. But exploiting these opportunities is not always simple. It takes a proven, world-class partner who can provide expert support and robust equipment for every step in the industrial fermentation process.

* **Syn-thet-ic** (adj) **bi-ol-olgy** (n). **1** the design and construction of new biological parts, devices, systems and **2** the re-design of existing, natural biological systems for useful purposes.



Next generation industrial fermentation

Pioneering innovations in industrial fermentation

With the emergence of synthetic biology – the combination of genetic modification with the principles of engineering – a whole new range of production technologies is being commercialized. Utilizing renewable resources, this new method is taking traditional fermentation to a new level.

For example, products based on biomolecules are capturing a fast-growing consumer market for “green” products. These products can be biodegradable and have a low carbon footprint. As an attractive alternative to petroleum based products, these “green” products include plastics, solvents, polymers, healthcare products, fibers, biofuels and many more.

For enterprises producing these products, whether at a pilot stage or in full commercial production, the sky is the limit. This market is expected to grow significantly in the foreseeable future. Not only are these products sourced from renewable resources, they avoid the use of toxic reagents and intermediate reagents.

Why choose Alfa Laval

Enterprises involved in using genetically modified organisms to produce products such as green chemicals, plastics, novel enzymes and biofuels, partnering with experienced suppliers is critical to success. For example, many enterprises are launching pilot facilities in Europe or the US, and some want to transfer the technology to emerging markets and scale them up.

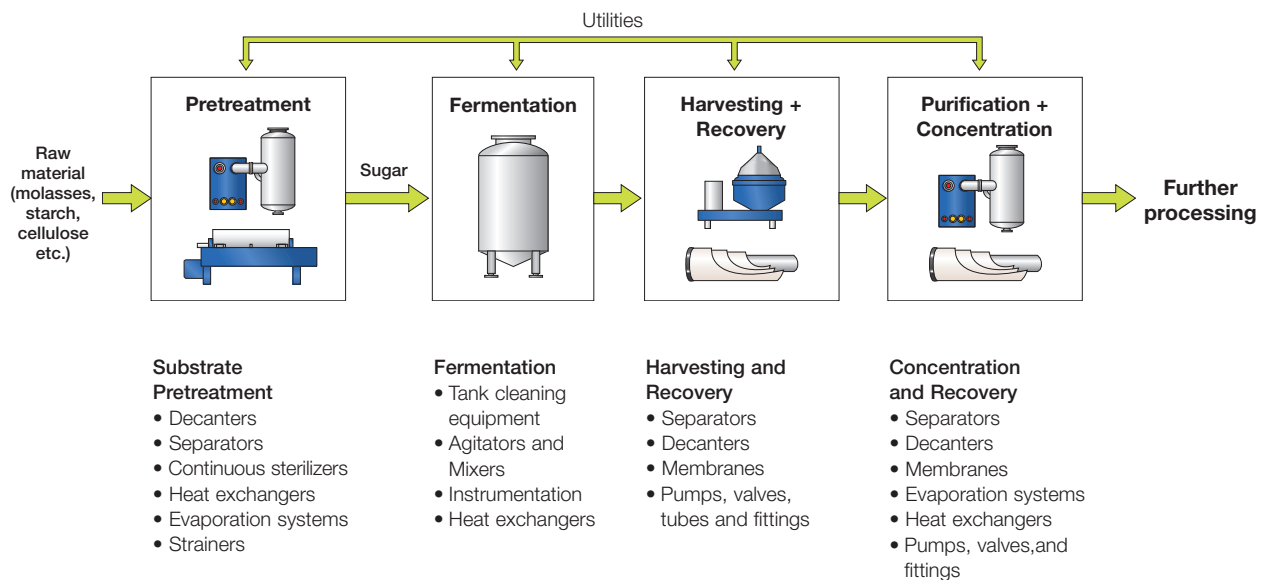
As a leader in separation technology, heat transfer and fluid handling, Alfa Laval has been providing customers with process solutions for 125 years. Our products are used in a wide variety of applications, from food and water supply to energy and pharmaceuticals, to name a few.

With a long established commitment to environmental sustainability and a reputation for its robust and cost-efficient products, Alfa Laval is the ideal partner to help extract the most from any fermentation processes. We can help with processes ranging from pretreatment and fermentation to harvesting, concentration and recovery, as well as the utilities that interconnect these processes.



Industrial fermentation process

OUR PRODUCT PORTFOLIO





Centrifugal separation

Paving the way in centrifugal separation

Starting with baker's yeast 125 years ago, Alfa Laval launched the first process equipment for the fermentation industries. Ever since, Alfa Laval has continued to lead the development of centrifugal separation equipment as the industry has evolved. From the traditional applications such as yeast and alcohol, we have developed machines to exploit breakthroughs in antibiotic and vaccine discoveries and, more recently, the biotech revolution. Today, we are pioneering the use of centrifuges in synthetic biology.

Alfa Laval's separators meet the highest standards of hygiene and reliability demanded in the life science industry. Our R&D group comprising of hundreds of experienced engineers use the latest state-of-the-art techniques to build on a century of experience, ensuring our equipment stays at the forefront in terms of quality and performance. For example, advanced and complex processes require multiple separation steps with a number of machines coupled together in an integrated system. This is where Alfa Laval's in-depth knowledge and extensive experience can help our customers find an optimal solution that is not only efficient but also economical.

A comprehensive range of centrifuges

In Alfa Laval's separation systems for the fermentation industries two basic centrifuge types are used: disc stack and decanter centrifuges.

Alfa Laval has a complete range of disc stack centrifuges and decanters, from small pilot plant laboratory machines to large units for full-scale commercial operations. We can handle all types of duties from high-density fermentation to liquid/liquid separation.

Disc stack centrifuges

Due to high g-forces and an enormously increased settling area in the form of a disc stack, these machines can efficiently separate organisms and particles as small as about 1 μm . When the feed solid concentrations are high, nozzle bowl centrifuges, with a continuous discharge of solids are used. When the feed solid concentrations are low to moderate, intermittent solids-ejecting centrifuges are the most effective machines for clarification of process flows.



Alfa Laval supplies machines with throughput capacities ranging from less than 50 liters per hour up to hundreds of thousand liters per hour. These machines can also be configured to separate immiscible liquids, such as oil and water, from each other. Not only this, but also all Alfa Laval machines are designed with the ability to be Cleaned-in-Place (CIP), which is an essential requirement of modern biological processing

Decanter centrifuges

Decanter centrifuges are designed for dewatering and clarification of raw material and relatively thick biological slurries. The separated solids are continuously unloaded by an internal screw conveyor rotating at a different speed from that of the rotor. Decanter centrifuges deliver the solids in a much drier state than disk stack centrifuges, and are less labor intensive than plate and frame filter presses and do not suffer from blocking issues.



Disc stack centrifuges

KEY BENEFITS

- Achieve highest hygiene and reliability standards
- Reach capacity ranges from 50 to thousands of liters per hour
- Flexible scalability from lab to full-scale commercial
- Separate organisms as small as 1 μm (disc stack)
- Reduce waste and contamination risks with Clean-in-Place
- Minimize overall costs and improve environmental footprint



Decanter centrifuges



Membrane filtration

Cross-flow
membrane
filtration
heightens
performance

Since the 1960s, Alfa Laval has been involved in the development and supply of membrane plants. These include cross-flow membrane filtration systems, for processing product streams, from lab/pilot scale to large-scale industrial fermentation-based production.

Solutions to enhance the overall process

Downstream from the fermentation step, Alfa Laval membrane technology can be used for product harvesting and recovery directly from the fermentation broth. In both cases, product yield is maximized with the help of our automated feed and yield control system.

By selecting the optimum membrane type it is possible to combine purification with the recovery step. The removal of impurities can provide improved performance in further downstream processing, resulting in savings in running costs for ion exchange/absorption stages, for example.

Membrane concentration and purification prior to evaporation is often used to minimize energy consumption and improve product purity.

Spiral technology

Our range of spiral membranes offers cost effectiveness in a compact design where suspended solids load and viscosity are not limiting factors. This applies to stages such as product recovery, purification, concentration and recovery of diafiltration water.

Plate-and-frame technology

The latest developments of our plate-and-frame technology provide a high yield/low running cost solution in cases where the feedstock have relatively high viscosity and suspended solids. A typical example is during product recovery directly from fermentation broth. In certain cases, this platform can also be used in combination with the above spiral technology to optimize process costs.

In some harvesting and recovery applications our ceramic systems are used when steam sterilization is necessary.



'Synergy' technology – the combined solution

The opportunity to combine membrane technology with our other separation equipment can provide a 'synergy' solution that maximizes separation performance while minimizing costs.

From laboratory tests to large-scale production

With the variability of fermentation-based production, initial work on our laboratory/pilot plant to identify the most appropriate membrane configuration is important in the development of a successful production process. This includes rental plant options incorporating bench scale to several hundred square meters scale equipment, ideal for products such as fermentation broths.

Our test equipment, together with our extensive process knowledge and experience, gives us a strong foundation for identifying energy and water efficient optimum solutions. This results in an environmentally friendly, reliable, and cost-effective process for our customers.



PilotUnit Multi

KEY BENEFITS

- Easily scalable solutions from laboratory to large scale commercial production
- Maximize product yield and quality
- Reduce energy and utility costs
- Increase water recovery and reuse opportunities
- Reduce environmental impact



Combined membrane and centrifuge system



Heat transfer

Minimizing size, maximizing performance

Alfa Laval has long been a leader in heat transfer technology. Our highly reliable and efficient heat exchangers are providing our customers around the world with heat transfer solutions that minimize energy consumption and downtime while maximizing performance.

Heat exchangers are used for a number of applications in industrial fermentation, including feedstock preparation, sterilization, fermenter temperature control, product cooling, as well as for evaporation.

Alfa Laval offers gasketed plate heat exchangers noted for their very high heat transfer efficiency as well as their compact size and reliability. With our plate heat exchangers it is possible to extract heat efficiently even when differences between the temperatures of the hot and cold media are extremely small. The result is savings on energy costs.

Continuous sterilization

In the SteriTherm module the fermentation broth is preheated, heated up to sterilization temperature and kept at

this temperature for a defined time. It is finally cooled to process temperature just before it is fed into the fermenter.

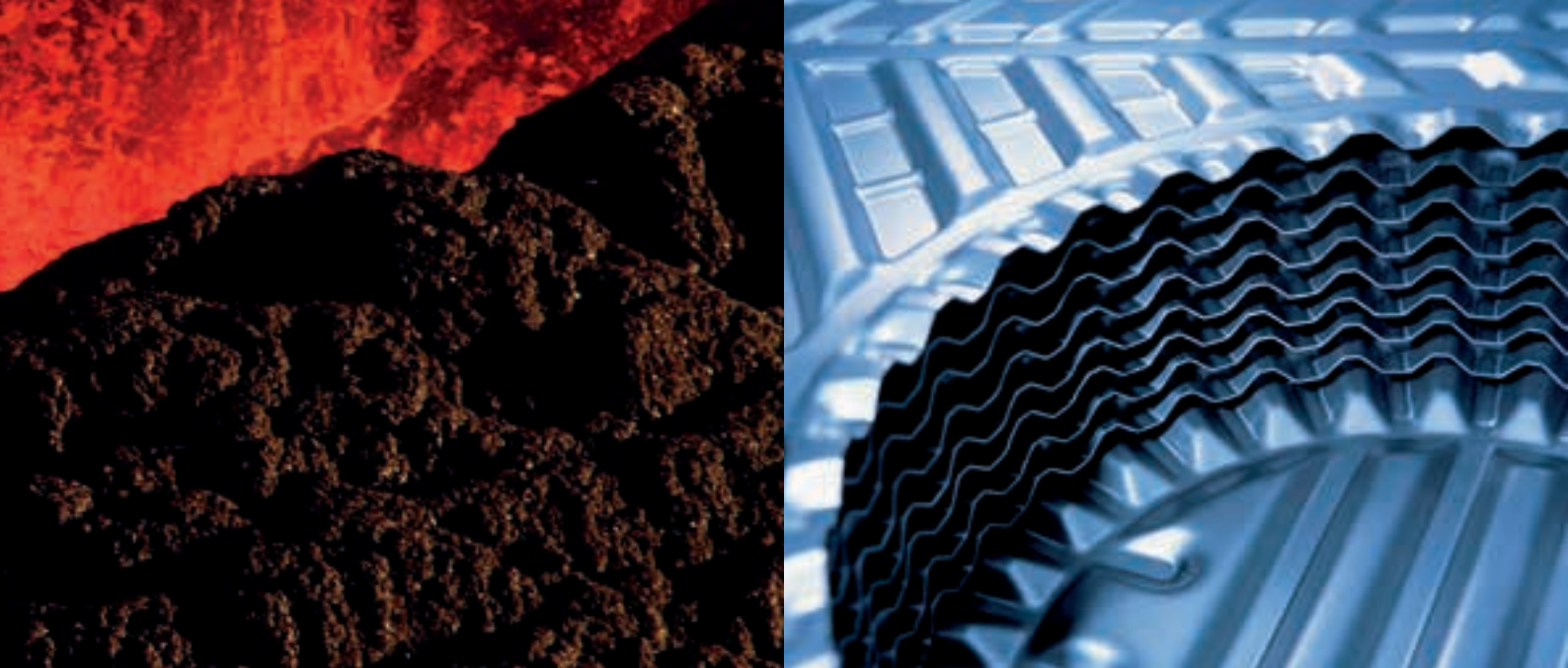
Continuous sterilization in the SteriTherm module provides close control of the sterilization process and gentle treatment of the fermentation medium. It also offers excellent heat recovery – up to 80% lower steam and cooling water consumption compared to batch sterilization. The benefit of continuous sterilization is less degradation of the product due to the very short holding time at a high temperature.

Fermenter temperature control

To control the temperature of the fermentation process, our wide-gap heat exchangers are an ideal choice. In addition to their exceptional resistance to clogging, they feature high thermal efficiency.

Evaporation systems

The AlfaVap plate evaporator is ideal for concentrating a wide range of products, including enzymes, amino acids, organic acids and other fermentation products. It is the preferred



evaporator for heat sensitive products since the boiling temperature can be very low, resulting in less degradation and product loss.

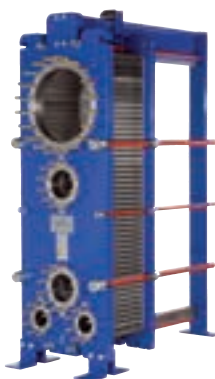
The low hold-up volume of the AlfaVap ensures a very short residence time for the product inside the evaporation unit.

A complete AlfaVap evaporation system can easily be accommodated in most existing buildings since it occupies much less space than other types of evaporators and has relatively low weight.

Condensers for evaporation systems

Alfa Laval offers a range of plate type condensers known as AlfaCond, designed for condensing vapors under low pressure or vacuum conditions. AlfaCond is highly efficient and compact.

A benefit is less fouling on the cooling water side due to the high turbulence created by the special design of the plates. The wide gap vapor channels ensure a very low-pressure drop on the vapor side.



AlfaCond condenser

KEY BENEFITS

- Save space with compact solutions
- Decrease maintenance costs
- Reduce installation costs
- Minimize energy consumption
- Low temperature operation (evaporators)



AlfaVap evaporator



Fluid handling and Management

Optimizing the flow process

In every step of the fermentation process, from pretreatment to concentration and recovery, our fluid handling equipment play a critical role in a number of areas. These include moving, controlling, diverting, managing and measuring the movement of fluids in the process.

Pumps

Alfa Laval pumps are optimized for performance and energy efficiency that results in trouble-free operation and low total lifecycle costs.

In designing Alfa Laval pumps, the gentle treatment of fermentation liquids to minimize stress, combined with the ability of the pump to repeat the process, is critically important. This approach, combined with excellent surface finish and efficient cleanability to avoid contamination, account for our pumps' excellent performance.

With optimized designs, our pumps not only can reduce energy costs and CO₂ emissions, but boost productivity due to their reliability and low maintenance requirements. A simple example of this is in the centrifugal pumps front-loading

modular seal design, which shares the same mechanical seal throughout the range. This modular concept, which applies to our entire pump portfolio, makes replacement and inventory simple, efficient and cost effective.

Our emphasis on continuous product development is helping to introduce improvements to existing pump technologies, such as the LKH centrifugal pump and the SRU positive pump. These improvements enhance their performance, reliability and Clean-in-Place (CIP) capabilities, which require less water and energy than competing solutions.

Valves

In designing our valves, intelligent reliability is our guiding principle. For example, our valves are constructed with a minimal number of moving parts to optimize uptime and avoid unnecessary wear. They are also equipped with leakage detection and defined compression of seals ensuring high performance and hygienic level of the customer's process.



New technologies also provide valve bodies without welds, for example our Unique Mixproof range ensuring high integrity and strength. Our latest product encompassing this principle is the Alfa Laval Unique Control LKB with a built in actuator with integrated intelligent sensing and control.

Automation and monitoring

ThinkTop, which has redefined the way industries view valve automation and monitoring, detects the slightest deviation in the opening or closing of a valve plug, further minimizing the risk of leakages and possible contaminations. The information obtained from the sensor system can be used to track operation from batch to batch – a critical factor in safety, particularly in applications where purity is critical.



Centrifugal pump

KEY BENEFITS

- Ensure trouble-free operation
- Achieve high quality repeatable processing
- Reduce total cost of ownership
- Achieve high energy efficiency
- Reduce environmental impact
- Reliable



Unique Mixproof



Unique Control



Rotary Jet Head



Service and support

Extending performance on a global basis

To ensure that processes are functioning at their peak throughout their lifespan, service backup and support is needed. Few products function at maximal lifetime value without proper care and attention.

Alfa Laval provides a range of services to ensure our customers equipment achieves maximum uptime and optimization of the equipment. The services are supported by our global supply chain of genuine Alfa Laval spare parts. Regardless of whether there is one facility or several geographically dispersed sites, Alfa Laval has service centers and local service teams that provide limitless support on a local, regional or global level.

Agreements tailored to our customers' needs

Alfa Laval's Performance Agreements consist of individually tailored service packages that address clear operational and maintenance needs. Fully flexible, these may contain anything from start-up and regular maintenance to upgrades, online monitoring and complete process optimization.

We will design a unique solution that ensures maximum performance with low operating costs.

While our customers focus on their core business, we will take responsibility for the whole product lifecycle. We also provide different support activities during the product lifecycle such as operator and maintenance training. We also offer consultancy services in which our specialists advise on methods to optimize the Alfa Laval equipment.

In other words, our customers can choose from different services for different pieces of equipment in their plant. At the end of each year, the customers can review the agreement with an Alfa Laval representative and make the changes necessary. Our Performance Agreement offers maximum flexibility at a fixed, budgeted cost.

A Performance Agreement ensures maximum uptime, reduced service costs, faster payback time and better, more profitable performance.



Alfa Laval global service centers



With Alfa Laval's global parts and service organization, equipment is fully backed up by a team of service engineers who help prolong equipment service life and keep processes up and running.

KEY BENEFITS

- Customize performance agreements that meet customers' needs
- Extend equipment life cycle
- Minimize maintenance costs
- Increase uptime and availability
- Secure on-site services as needed on premises
- Global parts and service organization

Alfa Laval in brief

Alfa Laval is a leading global provider of specialized products and engineered solutions.

Our equipment, systems and services are dedicated to helping customers to optimize the performance of their processes. Time and time again.

We help our customers to heat, cool, separate and transport products such as oil, water, chemicals, beverages, foodstuffs, starch and pharmaceuticals.

Our worldwide organization works closely with customers in almost 100 countries to help them stay ahead.

How to contact Alfa Laval

Up-to-date Alfa Laval contact details for all countries are always available on our website at www.alfalaval.com