



Solutions for fermentation-derived ingredients



engineering for
a better world

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Applications

Although the original purpose of fermentation was to prevent food spoilage, controlled fermentation processes can be used to create a wide range of probiotics, cultures, algae and yeast products, and is widely used in the dairy industry. It can also be employed to bioengineer flavors, manufacture leavening agents and formulate enzymes or acidulants.

Enzymes, for instance, defined as macromolecular biological catalysts, are responsible for thousands of metabolic processes and are located in every living cell. Highly selective, they accelerate both the rate and specificity of reactions, from the digestion of food (breaking down starch, protein, fat or sugar) to the synthesis of DNA without being expended themselves.

Microbial food cultures (MFCs), including yeasts, molds and live bacteria such as probiotics are used in the manufacture of a wide range of human and animal foods — from fermented vegetable products such as sauerkraut and soy sauce to cheese and yogurts. Similarly, starter cultures, which are grown from undefined, empirically produced species to attain a predictable and reproducible quality and quantity of a known micro-organism, are used in a variety of food industries to produce wine, beer, animal feeds and bakery products, for example.



Our expertise

GEA has a well-established history of designing and delivering equipment for fermentation lines. A comprehensive range of process technologies is therefore available from a single, experienced source.

The expertise of our engineers guarantees the highest process reliability. Perfectly adapted sanitary designs ensure the elimination of dead spots and facilitate both draining and cleaning. As such, we provide our customers with an optimized mix of high output and cost-effective solutions, as well as productivity and flexibility.

To recover and process products such as baker's yeast, yeast extracts, probiotics, algae, enzymes and starter cultures, GEA technology ensures maximum quality, gentle handling and a high degree of end product purity.

We can supply complete lines for almost any type of fermentation-based food ingredient. Focusing on key customer challenges, GEA can help to address issues such as:

- **Product safety:** Avoiding cross-contamination between batches is crucial. Hygienic design and efficient CIP systems ensure product safety and full traceability is provided at every stage of the process.
- **Predictable quality and quantity:** Consistent manufacturing requires a carefully controlled process. GEA automation systems guarantee the reliability and reproducibility of each batch.
- **Gentle product handling:** GEA plant treats micro-organisms with care to ensure the cellular vitality and sterility of your product, and a longer shelf-life.
- **Optimum yield and efficient processing:** Designed to provide consistent and reliable operation, GEA plant also ensures rapid changeovers, minimum product loss and fast, effective cleaning to meet your processing requirements.



Manufacturing solutions

GEA has developed a comprehensive range of technologies, equipment and know-how to configure and install fully integrated manufacturing lines for fermentation-derived ingredients. We work with our customers to tailor optimized solutions that take into account the key requirements of ingredient type, capacity and level of automation.

GEA process design and plant integration

Our expertise spans the complete line, from media preparation and fermentation to downstream processing, including automation and cleaning-in-place (CIP). We can supply preconfigured, standalone equipment and technologies or tailor, deliver and install completely integrated lines that match your plant infrastructure.

Hygienic design and product safety

Backed by more than 50 years of hygienic and aseptic process design experience, GEA builds and configures state-of-the-art cleaning solutions to ensure optimum hygiene and microbiological safety for every line. GEA customers benefit from the highest levels of product safety, reduced downtime and the optimized use of water, power and cleaning agents.

Project management

GEA makes sure that no detail is overlooked, and that every deliverable is achieved on time and within budget. GEA's engineering, installation and process expertise, combined with our manufacturing know-how, means that you can expect optimum plant performance from day one.

From initial concept to final product, we will work alongside you to develop and integrate the production equipment you need. We can calculate mass and energy balances, run simulation programs to evaluate peak load conditions and assess the feasibility of the line. We can also provide floorplans and 3D diagrams to help you visualize your plant.

Engineering

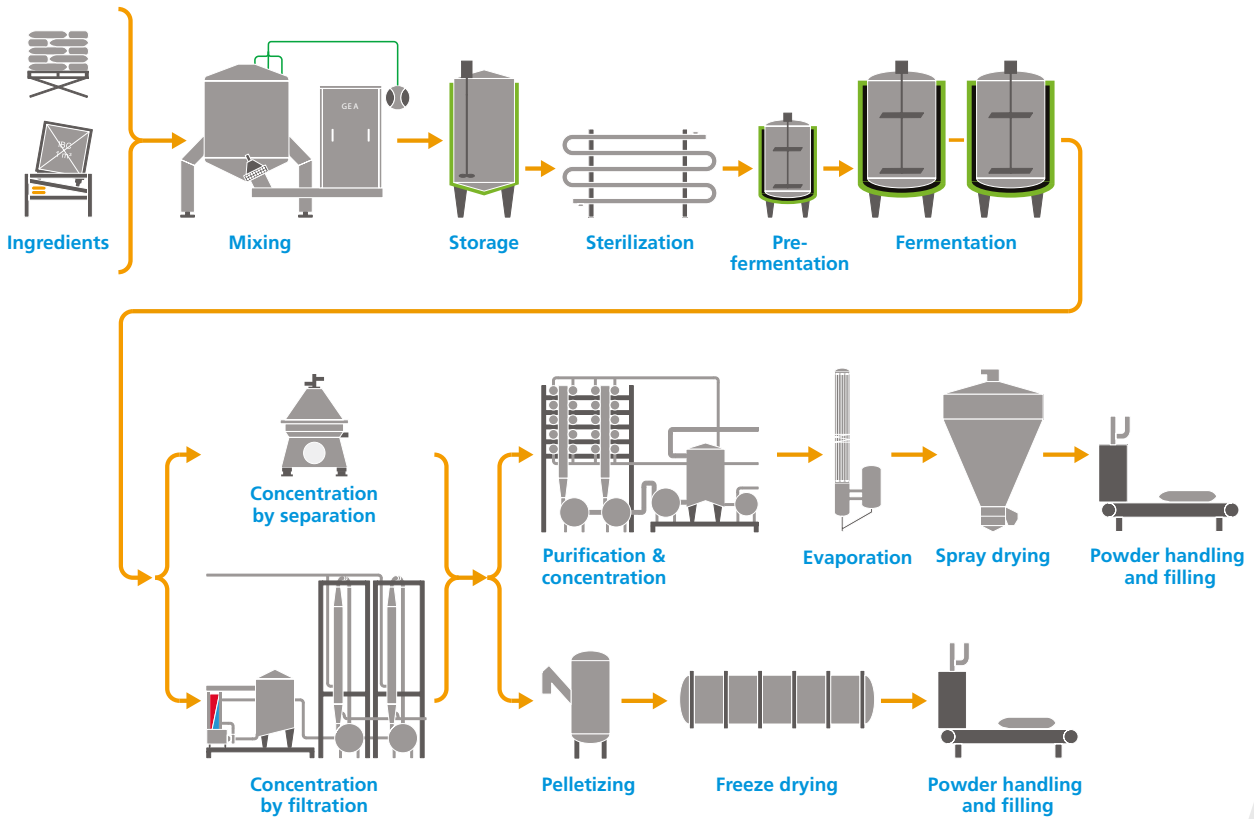
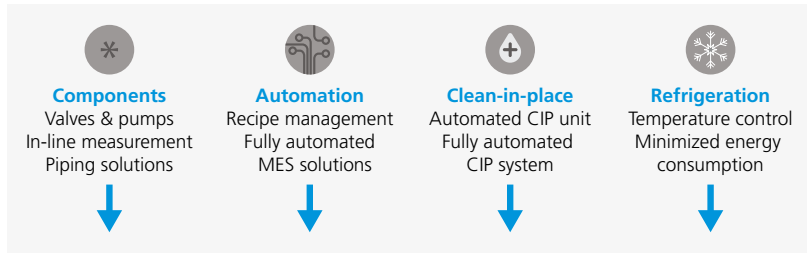
To ensure the shortest lead-times, our engineering teams are able to leverage our global supply chain for key components. At the same time, we can also utilize manufacturing plant around the world to prefabricate large items of equipment to ensure program time lines are met.

State-of-the-art computer modeling enables us to simulate operating conditions and to adjust the design of the plant to suit local conditions. Plant simulation enables us to prove the operation of all equipment prior to production startup, thereby ensuring peace of mind.

Training and support

Our in-house plant automation and service teams work together with you to ensure operational performance of the plant can be achieved by your own staff.

Ongoing training and on-site support is provided by our local and global service teams to ensure consistent reliable operation for the life of the plant.



Media preparation

Media preparation includes formulating, mixing, sterilizing and storing the fermentation medium (nutrients and, if necessary, water and oxygen). The medium should maximize microbial growth and the formation rate of the end product and, at same time, minimize unwanted by-products.

Ingredients handling

Fermentation media are prepared according to the specific requirements of the application and organism to be cultured. The precise, recipe-driven dosage of ingredients (solid, liquid, bulk, etc.) ensures optimal growth conditions and facilitates the mixing of different nutrients in the same equipment.

Mixing

In the BATCH FORMULA[®] mixer, powder is introduced via vacuum below the liquid surface to instantly wet the ingredients. The vacuum system

prevents air ingress and foam formation during powder introduction. Furthermore, integrated process control technology monitors key parameters and guarantees that media specifications and integrity are maintained. The technology can be configured for batch or continuous operation as required.

Benefits

- Vacuum prevents air-incorporation and foaming
- Gentle product handling
- Hygienic design and total batch-to-batch drainage
- Safe and efficient processing



Sterilization

All media must be aseptic and free from living organisms before being transferred to the fermenter. This stage defines the upstream sterile boundary and is a crucial aspect of a successful fermentation process.

A UHT plant, whether heat exchange, direct steam injection or steam infusion, is one of several available sterilization methods, all of which can be customized for specific processes. Easy to control, flexible and convenient, this compact and proven technology ensures that media transfer occurs at the correct temperature.

We offer a comprehensive range of VARITUBE® heat exchangers, which means we can tailor indirect sterilization units to match your capacity and recipes. Compared with conventional sterilizers, GEA tubular heat exchangers are modular, easy to install, extend or modify to match changing capacities and/or processing requirements.

We also offer sterilization systems that use direct steam injection and infusion. Using the former, steam is injected into the product using a direct steam injector, heating the product to the required temperature almost instantaneously. Short processing times at high temperatures offer a number of

throughput advantages compared with indirect heating. With steam infusion, by contrast, steam condenses on the surface of the product. Unlike steam injection and traditional vessel-based heating, the steam infusion process surrounds the product with steam as opposed to passing it through the liquid.

Benefits

- Full control of the sterilization process
- Regenerative energy transfer minimizes operating costs
- Design can be customized for specific process requirements
- Various holding times and temperatures can be selected



Fermentation

The fermentation process, whether aerobic or anaerobic, involves the propagation of the micro-organism and the production of the desired product. GEA offers a comprehensive range of standard and customized fermenters to meet your microbial – bacterial or yeast – culture requirements.

Batch, fed-batch or continuous

Depending on the culture feed strategy and the medium, the fermentation process can be divided into three basic principles: batch, fed-batch or continuous.

In a batch operation, the medium and the culture are fed into the vessel. After that, no components are added apart from oxygen (in an aerobic process) and acid or alkali for pH adjustment. The fermentation is run for a predetermined period and the product is harvested at the end.

In a fed-batch system, additional nutrients are added during the fermentation, which extends the time of operation and the productivity/product concentration of the process. As per batch fermentation, the required products are harvested at the end of the production cycle.

In a continuous process, fresh medium is continuously added and the product — along with the culture — is removed at the same rate, ensuring that constant concentrations of nutrients and cells are maintained throughout the process. Harvesting can be done by filtration to increase the overall cell density and productivity (perfusion culture).



The GEA advantage

Defining the upstream boundary of the production process, aseptic batch fermenters play a critical role in fermentation. Given that all media must be aseptic and free from living organisms before being transferred to the fermenter, the ongoing process can be monitored using multiple sensors – such as pH electrodes and biomass sensors – and parameters can be adjusted in situ by adding supplementary chemicals to the system.

With stirrers that are adapted to provide optimum oxygen transfer rates and cell densities, GEA fermenters ensure long-term sterility during medium or nutrient change, aseptic sampling, aeration, venting or transfer, and highly accurate temperature control.

By maintaining a sterile processing environment, we can ensure that the harvested organisms remain uncontaminated and are delivered “as expected.” Commissioning test runs are done prior to start up.

Plus, by using a continuous process, constant feed and harvest rates can be achieved, which reduces the need for cleaning and, as such, makes the procedure more cost-effective.

Benefits

- Fully automatic cleaning and sterilization (CIP/SIP)
- Tailored solutions for efficient temperature control
- Carefully designed agitators for optimal KLA values
- Precise instrumentation monitors all key parameters (pH, pO₂, temperature, agitator speed and weight) throughout the process
- Sterile design (free from dead-leg areas)
- GMP documentation package (if required)
- Sterilization-compatible pressure vessel
- High-grade stainless steel construction (other materials on request)

In addition, a prefermenter can be used to prepare a seed culture (inoculum), which involves growing the pure stock culture in several consecutive vessels to avoid the lag phase that occurs when micro-organisms are introduced into a growth medium.

Centrifugal separation

Designed for the downstream processing of fermentation-derived products, our centrifuges separate the fermentation broth from the biomass and recover, concentrate and wash the harvested cells.

The specific requirements of the centrifuge or separation stage may vary, depending on the type of culture and its use, but the need for gentle treatment is a universal constant. For this reason, all our separators are equipped with a special hydrohermetic inlet that feeds the cells into the prefilled bowl below the level of the liquid.

In addition, double-walled hoods allow indirect cooling of the product and counteract any frictional heat. By avoiding the high temperatures that denature proteins, the cells remain active and the production process stays stable.

Plus, to ensure constant discharge parameters, our viscon nozzle for baker's yeast and our new flexicon nozzle to process starter cultures standardize the discharge concentration regardless of the feed content and facilitate both stable and flexible downstream processing.

The feed concentration often influences the choice of separator. Whether nozzle or self-cleaning (with piston), selection depends on the properties and concentration of the cells. In each case, the designated separator may limit the flexibility of the production process, as not all algal strains or cell cultures can be processed with the same centrifuge.

For example, our 2-in-1 discharge system with piston and nozzle can be operated both as a nozzle and self-cleaning separator. As such, a wide variety of cell cultures can be run on the same machine, such as *Chlorella* algae (1% inflow concentration) and pre-concentrated *Haematococcus* algae (10%). For even more flexibility, we also offer systems with up to three easy-to-replace bowls.

Designed with hygiene in mind, our equipment includes FDA-approved seals and CIP-compatible spray nozzles.

Furthermore, all our centrifuges feature "total ejection" pistons that create enough turbulence in the bowl to flush out even the most stubborn particles from the disc stack. And, to meet pharmaceutical process requirements, we offer steam-sterilizable units with laser welded discs that comply with ASME BPE and GMP prequalification standards.

Benefits

- Gentle product treatment and low temperature processing
- Highly flexible for stable cell properties
- Hygienic design with easy and effective CIP
- ASME BPE compliant and SIP if required
- Low power consumption
- Less space requirements for fast and easy installation



Filtration

During fermentation, effective downstream processing is necessary to ensure high product recoveries and consistently achieve required product quality levels.

Membrane filtration in fermentation processes

Membrane filtration is used to purify and concentrate the fermentation products before the final concentration step (by evaporation) or before drying.

Clarification by filtration

Membrane filtration methods such as microfiltration or ultrafiltration provide superior and consistent permeate/filtrate product quality compared with traditional clarification methods, including rotary vacuum filtration and centrifugation. As well as being flexible enough to run in batch or fed-batch modes, these membrane systems can also be designed to operate in continuous mode.

Fractionation by filtration

Membranes come in numerous molecular weights and can facilitate the fractionation or separation of specific products from the clarified filtrate.

Concentration by filtration

Depending on the product, a membrane filtration process such as ultrafiltration, nanofiltration or reverse osmosis can be used to concentrate the clarified product before evaporation/drying, ensuring consistent product composition.

Polishing process effluent water by filtration

Reverse osmosis can also be used to polish process effluent water. The polished water can subsequently be reused as diafiltration water to improve product recovery rates, CIP systems or discharged with minimal post-treatment.

Benefits of membrane filtration

- Consistent and clean permeate/filtrate using microfiltration/ultrafiltration
- Enables the fractionation of specific products
- Consistent product composition and quality
- High product recovery
- Flexible process: can be run in continuous or batch/ fed-batch modes
- Automated design with less downtime and maintenance
- Modular design for easy expansion
- Inbuilt CIP facility
- Recovery of process effluent water by reverse osmosis



Evaporation

The right choice of evaporation technology is critical to achieving optimum quality and a more efficient process.

After the filtration steps, the fermentation solutions are concentrated in falling film evaporators up to a total solids content of 50% or more (if possible). If further concentration is required, forced circulation evaporators are used. A combined system ensures maximum energy efficiency as well as ease of operation.

Concentration is achieved by increasing the total solids content of the product by removing water — using evaporation — prior to storage or the spray drying process. Ineffective evaporation can result in increased viscosity and/or product instability, which makes drying more difficult or could even damage the finished product. Typically, it also results in increased CIP cycles, which makes the process less cost-efficient.

Maintaining careful control of the applied heat is critical during evaporation to ensure the functional properties of the finished product are consistent and within specification. Using the shortest possible residence times and reducing the heat load on the heat exchanger surface are important criteria.

GEA's evaporation systems are designed to achieve maximum plant efficiency with minimum downtime and the optimum balance between steam and electricity use. Above all, our attention to hygienic design is paramount and a key consideration for every customer and application.

Our solutions enable extended operating cycles by reducing product build-up or fouling on the contact surfaces. This translates into higher operational efficiencies and increased profitability.



Benefits

- Highly reliable plant with no moving parts
- Gentle treatment to ensure high quality product (low boiling temperatures under vacuum)
- Energy efficient
- Hygienic design and CIP compatible
- Easy to operate and maintain

Spray drying

The FSD® from GEA is a multi-stage unit that combines spray drying and fluid bed technology in one plant. This solution is ideal for customers who need a high level of flexibility to make powders with different levels of agglomeration.

The FSD® generates uniform, coarse, free-flowing and dustless particles and powders with excellent dispersibility. At the same time, it is also possible to lecithinate the powder for optimal instantizing properties.

The prepared liquid formulation is introduced into the spray dryer through a pressure nozzle, which generates small droplets. Evaporation takes place while the droplets are moving through a heated air flow, which transforms the liquid droplets into dried particles. Powder agglomeration is controlled in the integrated fluid bed.

Benefits

- Controlled spray drying conditions for optimal product quality
- Dust-free and free-flowing powder
- Drying, agglomeration and lecithination in one single operation for cost-efficient and hygienic processing
- Minimal product loss
- Optimized CIP/SIP for fast, effective cleaning and reduced downtime



Pelletizing and Freeze drying

For rapid and optimal freezing, and to prevent oxidation, the product is immersed in liquid nitrogen. The subsequently produced pellets can then be stored frozen and distributed as frozen product or transferred to a freeze dryer to maintain the viability of the microbial cells at ambient temperature.

A key advantage of GEA's Liquid Nitrogen Freezer is the extremely fast freezing process, which not only optimizes production, it also ensures the most appropriate conditions for the downstream lyophilization of fermentation-derived ingredients. Furthermore, as liquid nitrogen freezing forms droplets, the frozen product is dust free and free flowing, resulting in almost no product loss.

Benefits

- Fast freezing
- Minimal product loss
- Uniform spherical droplets
- Compact design
- No moving parts and minimal maintenance

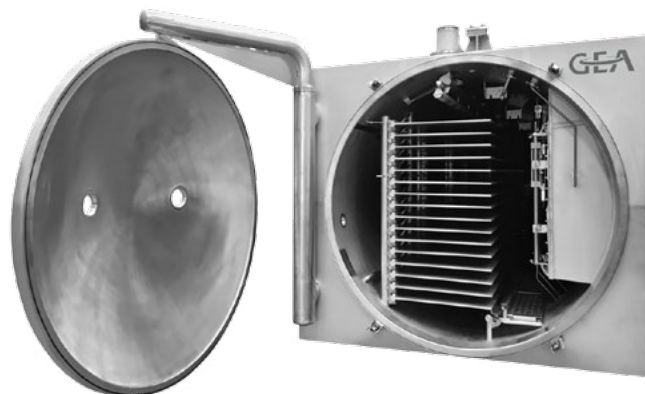


GEA's RAY™ freeze drying technology is designed to meet the strict hygiene requirements of the food ingredients industry, including sensitive applications such as lactic acid bacteria, enzymes, bioactive proteins and yeast. The products are dried under vacuum, ensuring that the inherent water in the product is removed as vapor, which preserves the key constituents.

At the heart of the process is the RAY™ freeze drying chamber, which features radiation heating plates for all sizes and continuous de-icing (CDI) for larger driers to deliver both efficient and uniform lyophilization, and high-quality product. Post-lyophilization (vacuum and cold conditions), products benefit from a long shelf-life, which facilitates storage and transportation.

Benefits

- Uniform freeze drying
- Stable products with a long shelf-life, facilitating storage and transportation
- Minimal product loss
- Simple and reliable operation
- Low energy consumption
- High sublimation capacity



Filling

Finished products that may be oxygen sensitive or which have fragile mechanical properties must be handled safely and consistently throughout the finished packaging process to ensure quality is retained.

GEA powder fillers are designed to provide safe and gentle filling of the finished product into bags, boxes or drums. With a wide range of capacities, we provide complete solutions to meet all production requirements.

A unique bottom-up filling process ensures the product is gently handled during filling to prevent breakdown. With a range of interchangeable heads, our fillers can be quickly adapted to switch between packaging formats making them ideal for flexible production plants.

In addition, automated product sampling systems allow for regular product testing throughout production to allow you to monitor product quality during final packaging.

Optional CIP cleaning systems, enable fast reliable cleaning for those applications that require complete control of cross-contamination in between batches.

Complete solutions for closing, coding, labeling and palletizing of the finished container will ensure that your product is delivered to the warehouse in optimum condition.

Our range of optional automation solutions will allow the complete integration of the product filling system with your plant supervisory control and data acquisition (SCADA) systems providing seamless control and product traceability.

Benefits

- Accurate filling: on-head weighing minimizes product loss and maximizes profit
- In-built dust control reduces losses and potential hazards
- Optional CIP between batches minimizes downtime



Flow components

To ensure safe operation, reliable product quality and repeatable security of outcome, every component of a GEA processing line is designed to meet the strictest hygiene standards.

Valves

As product and process safety has the highest priority within aseptic applications, GEA aseptic valves are equipped with a hermetic sealing element to avoid any ingress of micro-organisms into a sterile process. The Aseptomag® valve line is based on stainless steel bellows technology, whereas the D-tec® valve line uses stem diaphragm technology to hermetically seal the sterile process pipe. The VESTA® valve line benefits from PTFE bellows technology and has its origin in the pharmaceutical industry. Additionally, GEA offers VARIVENT® hygienic valves for matrix-piped process plants.

Pumps

GEA is a full-line supplier of premium pump solutions. We offer a great variety of hygienic pumps in two modern pump lines (GEA SMARTPUMP and VARIPUMP) developed for different applications and requirements. The GEA hygienic pump portfolio includes centrifugal pumps (end-suction, self-priming and multi-stage pumps) as well as rotary lobe pumps. Our hygienic pump design ensures high product quality and excellent cleanability, which saves time, water and cleaning agents. Sensibly rated high-efficiency motors help you to keep energy consumption as low as possible.



Cleaners

GEA Cleaning Technology has been developed for sustainable practice, with special emphasis on saving valuable resources in the cleaning process. Whether using orbital, rotating or static devices, our cleaners achieve the best cleaning results in multiple industry sectors. Incorporating our systems into your production can help you to reduce production downtime, waste disposal costs, water and detergent consumption. The units can be installed in various applications, such as fermenters, spray dryers or mixing and storage vessels.

Product recovery systems

GEA product recovery systems help you to recover valuable products and reduce both waste disposal costs as well as water and detergent consumption.

For application-specific solutions, our high quality, reliable and efficient flow components are easy to use and maintain, providing benefits in terms of sustainability and low lifecycle costs.



Industrial refrigeration and sustainable energy solutions



Integrated cooling expertise

Precise temperature control in the processing chain is critical to ensure hygiene and yield end products of the highest quality. GEA's industrial refrigeration solutions provide the right temperatures for your processes. Offering detailed engineering for the integration of utilities functions into the production processes, GEA's tailor-made solutions provide a holistic way to improve your operations, minimize energy consumption and reduce your total cost of ownership.

Benefits

- Smooth, safe, efficient and reliable production processes.
- Highest end product quality.
- Value-added, turnkey, single-supplier integration with broader GEA solutions.
- Reduced energy costs and carbon footprints via energy saving and energy management solutions.

Reducing costs – improving our planet

The majority of the energy needed for processing systems goes to meeting precise cooling and heating requirements. These systems therefore represent the largest opportunity to reduce costs. GEA's expertise extends to identifying these energy saving and energy management opportunities. We provide measurable, innovative solutions with short payback times aimed at reducing your total cost of ownership.

CIP & Automation

Hygienic production

Microbiological control measures and hygienic process design are critical considerations when processing fermentation-derived ingredients. As such, efficient cleaning-in-place (CIP) systems are a fundamental aspect of any high-quality production plant. Solutions from GEA can be tailored in terms of process design and heat treatment to meet the specific requirements of your application and deliver the correct cleaning media to any point-of-use in a timely manner.

Effective CIP systems not only play integral roles in ensuring microbiological safety and eliminate cross-contamination, they also minimize the use of cleaning agents and water to significantly reduce downtime and lower costs.

Our CIP solutions remove any leftover product from the plant, tank surfaces, heat exchangers, pumps, pipes, etc., and our SIP systems are designed and built to achieve high levels of microbiologic control. Guaranteeing product safety is our number one concern.

Process automation

To meet your specific process automation requirements, our systems and services range from basic process control to integrated, enterprise-wide networks with an MES (manufacturing execution system). Built on extensive industry know-how, our MES solutions enable every stage of the production process to be managed and monitored, ensuring both optimum use of resources and consistent product quality.



GEA Service – For your continued success

Working with GEA Service means partnering with a dedicated team of service experts. Our focus is to build, maintain and improve customer performance throughout the entire life cycle of the plant and its equipment.

Beginning of Life Services

Getting you started with seamless support for instant productivity and performance

Lifetime Services

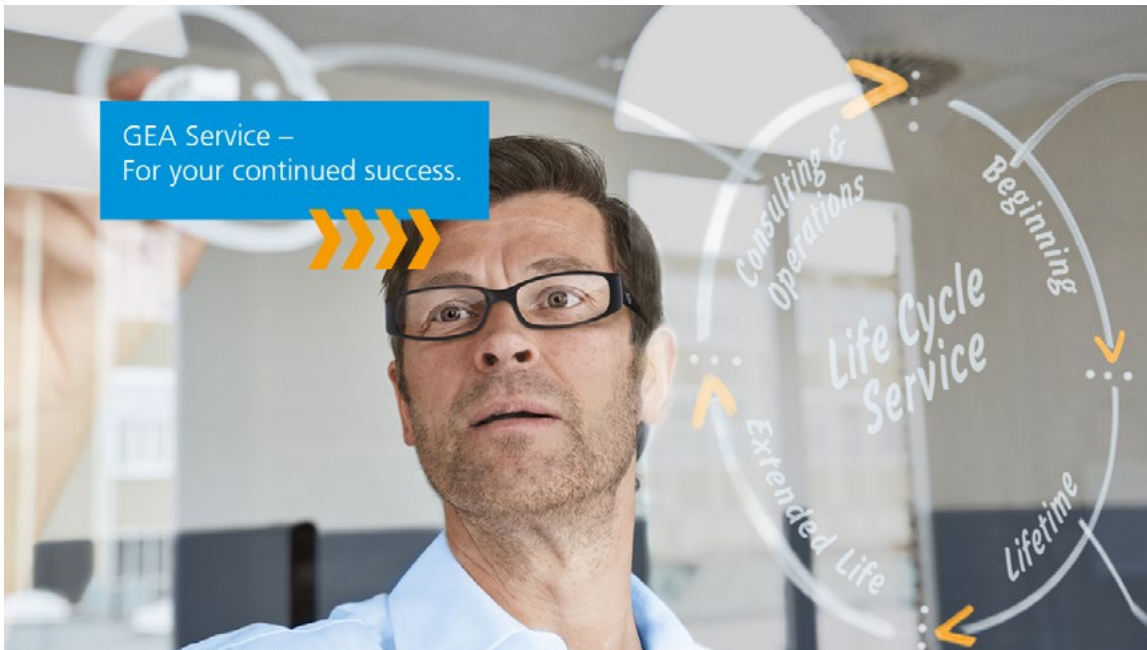
Keeping it running with the cost-efficient way of ensuring safety and reliability

Extended Life Services

Constantly improving by sharing our knowledge to safeguard your investment

Consulting & Enhanced Operations

Together with you by enduring commitment to you and your business





We live our values.

Excellence • Passion • Integrity • Responsibility • GEA-versity

GEA is a global technology company with multi-billion euro sales operations in more than 50 countries. Founded in 1881 the company is one of the largest providers of innovative equipment and process technology. GEA is listed in the STOXX® Europe 600 Index. In addition, the company is included in selected MSCI Global Sustainability Indexes.

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