

# Nutritional formula

Outstanding solutions for nutritional  
formula production



# Solutions to support your business



**Complete nutritional formula factory**

Nutritional formulas represent important sources of key dietary components, including proteins, carbohydrates, fats, vitamins and minerals. Each formula will have a precisely defined composition, and can offer complete nutrition for infants and important dietary supplementation for seniors and individuals who have special nutritional requirements.

Powdered products for infants and child nutrition represent the largest segment of the nutritional formula market. This brochure describes how our technology for processing powdered infant and child nutrition can help make your business more competitive, profitable and efficient.

Infant milk formula is fed to children from birth until the age of six months and can represent the baby's only source of nutrition if the mother cannot breastfeed.

Infant milk formula recipes are developed to mimic as closely as possible the composition of human breast milk. All infant

milk formulas must meet precise specifications for chemical composition and microbiological safety. These products are often served by volume, so physical characteristics are also critical.

From the age of six months children progress to follow-on/follow-up formula and growing up milk. These have a different composition than infant milk formulas as they no longer represent the child's only source of nutrition. However, the same strict demands for product safety and quality still apply.

The process for manufacturing a nutritional formula involves the reception, treatment and mixing of a large number of different ingredients. Accurate dosing of each ingredient is critical to ensure correct composition of the final product, and the different ingredients will also require specific handling and processing conditions.

---

**Infant milk formula**

---

---

**Follow-on/follow-up formula**

---

---

**Growing up milk**

---

GEA has decades of experience as a technology partner supplying complete turnkey plants to the nutritional formula industry. We design and install end-to-end processing lines for all kinds of nutritional formula products. Your expertise is in developing top-quality recipes and formulations. Our role is to configure the best systems for handling and processing all the ingredients in your final products.

Our state-of-the-art technologies are designed to maximize plant flexibility and to improve traceability and overall operational efficiency. Our complete process offering means that you can be assured of the safety of the finished product for greater consumer confidence.

Our customer relationship model continues long after delivery of the new plant. We have completed hundreds of dairy projects and also offer plant upgrades, optimization solutions and further training to ensure that your plant continues to meet your business objectives over time.



# Contents

Nutritional formula process	5
Reception, handling, storage and treatment	8
Minor ingredients handling and dosing	11
Mixing and powder dosing	12
Evaporation and spray drying	14
Powder storage, mixing and pre-gassing	17
Powder handling, post-gassing and filling	18
Hygienic plant design for product safety	20
Engineering and project management	22
Automation	23
Sustainable energy solutions	26



# Nutritional formula process



Every manufacturer of nutritional products has individual recipes and product requirements. We add value to your business by delivering application, process and plant design expertise and technology solutions that will meet every expectation.

Process design and selection of appropriate technologies may vary with recipe or with the availability and format of raw ingredients. You will want to work with an experienced partner who can design a plant that is flexible and can manage these variables to meet your final product specification.

We design reliable, efficient solutions with an emphasis on optimizing your product quality, resource usage and waste management so you can concentrate on your business and market goals.





Processing will commonly involve mixing all or most of the dry ingredients into one or more liquid raw material (milk or whey). The plant will need reception facilities for liquid and dry products and access to good-quality milk (or whey). The water content of the mix will depend on the water content of the different ingredients, so an evaporator is used to remove the bulk of the excess water, and then the final powder is processed in a spray dryer. This liquid process has some advantages. The low solids content of the mix can withstand gentle, but efficient heat treatment. It is also possible to store the final mix cold.

The process can be simplified further if the liquid ingredients are substituted by powder ingredients. It is then possible to

combine all the dry raw materials into a powder mix that has the desired composition. The advantages of this approach include reduced CAPEX and OPEX because there is no need to incorporate any wet processing, evaporation or spray-drying steps.

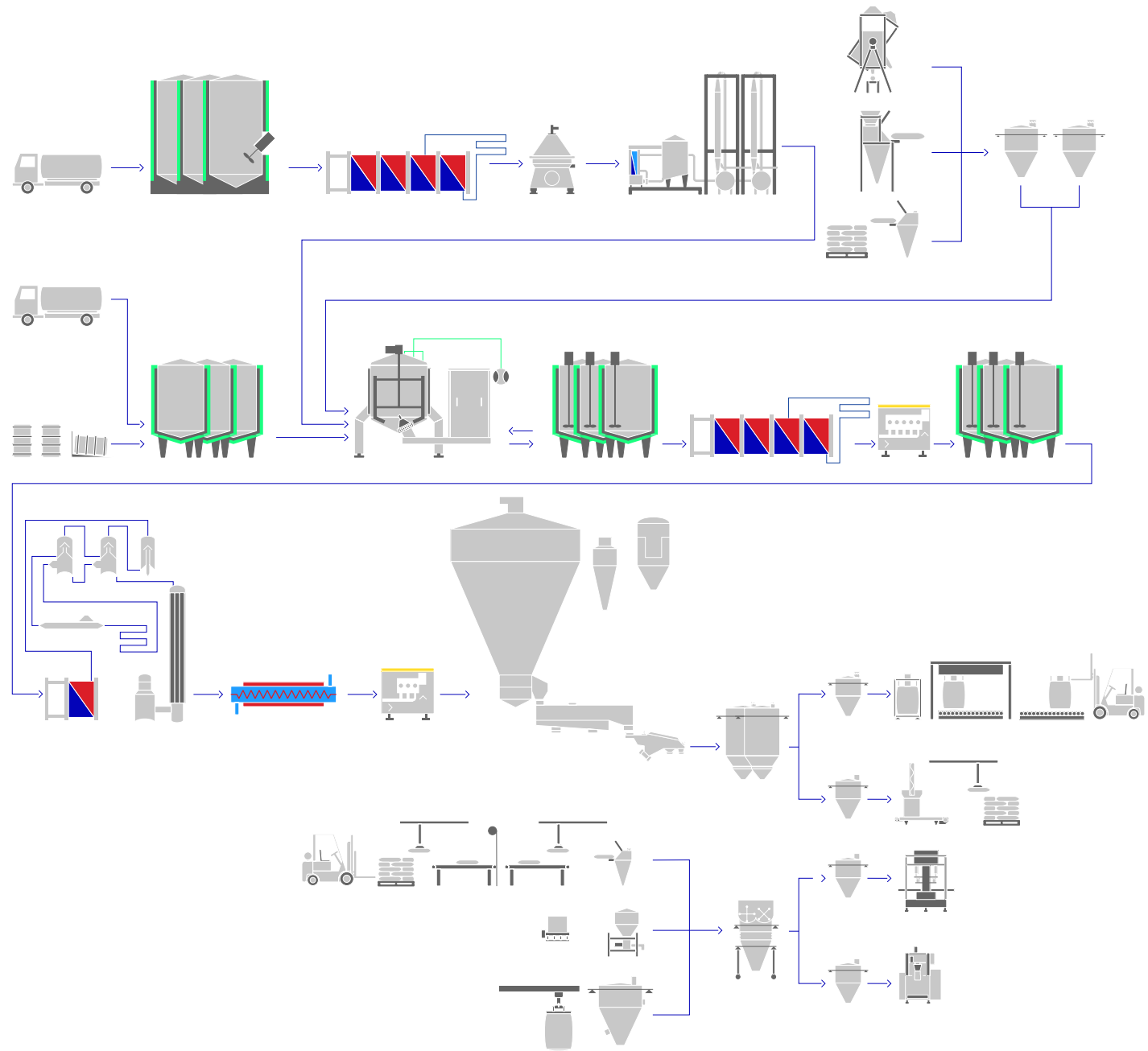
However, dry processing makes microbiological control more challenging. And products manufactured using a dry process carry a risk of deblending in the can or sachet, which may render the product unsuitable for purpose.

In practice a combination of processes is commonly used, so that a base powder is produced using a solubilization and drying process, and then minor ingredients are mixed into

this base powder. This approach allows longer production runs for both the wet processing and drying. One potential drawback is that because some of the ingredients are added dry to the base powder they will not be subjected to heat treatment, and so can potentially introduce a microbiological risk.

In this brochure we will briefly describe key aspects of the different sub-processes, from raw materials reception to packed final product, and suggest how our solutions can support your production process and help to address possible challenges. An overview of the basic processes involved is shown on the right.

# Typical nutritional formula process



# Reception, handling, storage and treatment



MSI skimming separator

## Liquid milk-based ingredients

Liquid milk-based ingredients can include raw milk, skim milk, skim milk concentrates or whey products such as liquid whey or whey protein concentrate (WPC).

How each of the liquid ingredients is stored and treated will depend on its type. Raw milk must undergo pasteurization and separation of cream before it can be used for further formulation. The cream separation step can be carried out using a GEA skimming separator type MSE/MSI. Our separators are designed to minimize product losses, optimize energy consumption, and maximize product quality.

Every nutritional formula producer needs to guarantee optimum hygiene and microbiological safety. You also want to handle ingredients and products gently to ensure that all of the nutritional properties are retained. To optimize the control of bacteria and spores, we offer either bacteria

removal separators or ceramic microfiltration systems, which are ideally suited to removing micro-organisms in milk, including heat-resistant bacteria and spores that can survive pasteurization.

Rather than just inactivate the micro-organisms, our technologies physically remove bacteria and spores from the product. This can eliminate the need for high heat treatment and so help to ensure a better nutritional value to the end product.

In general, buffer storage should be kept to a minimum to reduce CAPEX and OPEX. However, we realize that flexibility is needed for practical production, so we also offer cost-effective tank designs and valve clusters that will ensure your product quality and safety are at the highest level.





Microfiltration plant

### Dry ingredients

Many solid ingredients for nutritional products are delivered to the plant as powders, packed in different pack formats. To ensure product safety, removal of the packaging material and introduction of powder into the process must follow best hygiene practice. Each of those processes is performed in the most appropriate hygiene zones, designated standard, medium or high care. To help you maintain flexibility we offer equipment that can handle powders received in different formats, such as 25 kg bags, FIBC and Rigid IBC.

The powders are emptied from their transport containers and conveyed to hoppers, or silos that are typically equipped with weight control. The process for transferring ingredients from their transportation packaging to the processing line is always designed with hygiene and product safety as key considerations. We can configure solutions that discard the outer (contaminated) bags and hygienically handle the inner bags.

This same equipment can also be used later in the dry mixing process where powdered ingredients are again handled. Dense phase vacuum conveying to the powder storage units reduces dust generation during the transfer to the powder mixing and liquid blending plants.



**GEA Ariete Homogenizer 5400**

## Oil

Typically, nutritional recipes replace milk fat with vegetable oil blends that mimic human milk fat. Oils are received in tanker, drum or IBC format, and are usually flushed with inert gas to limit oxidation – and thus off flavor – during storage. Oil storage tanks are also typically equipped with a hot water jacket so that the oils can be kept above their nominal melting point, without the need for intensive heating.

To avoid cross mixing different oils, we can supply individual reception/ dosing lines for different oil types, configure free-draining pipes, or install a pigging system.

Oils can be dosed into the milk-based ingredients at different stages in the process. The oil/milk mix should always undergo homogenization after oil has been added to the milk-based mix.

# Minor ingredients handling and dosing

Minor ingredients, including vitamins and minerals, also need to be prepared for inclusion in the manufacturing process.

The minor ingredients can be introduced at different stages in the process. When deciding on the dosing point it is important to consider that:

- Dosing must be accurate to ensure correct composition of the final product
- The dosing point must allow for the added ingredients to undergo pasteurization if required
- The dosing point should ensure that the added ingredient is not negatively affected, for example by reduction, oxidation, sedimentation, or denaturation
- The dosing point should be selected to ensure that minor ingredients are correctly mixed into the product at the correct time

If minor ingredients are dosed into the liquid mix they are normally dissolved in water prior to dosing. How dry minor ingredients are handled will depend on the quantities required in the recipe.

For small amounts weighing and dosing could be carried out as manual operations, whereas for larger quantities minor ingredients may be handled using a semi automatic or automatic system. We can configure a solution that will meet your processing needs.



GEA HYGiTip Bag Emptying System

# Mixing and powder dosing



GEA BATCH FORMULA® PRO High Shear Mixer

Every infant milk formula is blended as a precise mix of multiple ingredients. These may include dry powders and different oil types as well as the liquid milk or whey products. Each ingredient will require a particular solution for safe and reliable handling.

Mixing plays a key role in ensuring reliable, consistent processing of complex formulations. We provide key know-how about mixing processes and concentrate handling, and will work with you to design systems that match your capacity and throughput and ensure accurate batch control as well as reliable, consistent product mix composition.

Our MIXING FORMULA® system represents a state-of-the-art rethink on traditional mixing technology, so you can achieve high-quality homogeneous, lump-free concentrate quickly and efficiently. The MIXING FORMULA® technology incorporates a high-shear mixer that optimizes the mixing process. The technology can be configured as a batch solution (BATCH FORMULA® Mixer) or designed to optimize continuous processing (INLINE FORMULA® Mixer).



Using the MIXING FORMULA® system dry ingredients are dosed into the liquid ingredients by means of a vacuum. Powders are introduced below the liquid surface to ensure fast wetting and solubilization, and to reduce foaming and incorporation of air. From the vacuum mixer, the product may be circulated over a mix tank until the batch is complete. To help preserve the powder-liquid interface we have designed the VARIVENT® POW shut-off valve which features a full bore opening to prevent powder lumps blocking the inlet. The VARIVENT® POW valve also minimizes wear on the gasket, especially when working with abrasive powders such as lactose.

Minor ingredients such as vitamins, minerals, or ingredients for pH adjustment may either be added to the vacuum mixer or incorporated at a later stage, for example during concentrate storage or at the spray dryer feed line. Alternatively, vitamins and minerals can be added to the powder from the spray dryer.

Homogenization is carried out to micronize the particles and oil droplets, which ensures optimum oil distribution. High pressure homogenizers are used routinely in dairy applications as they apply dynamic high-pressure energy to break particles in the fluid down to the smallest, potentially nanometer-scale size.

The high pressure homogenization process creates an emulsion that is stable when the mix is concentrated, dried, packed and resolubilized by the end customer.

When liquid processing has been completed for each batch, preparation of the next batch is started so that the downstream process is continuously fed.



# Evaporation and spray drying

Once the product mix has passed quality assurance (QA) checks, it is heat treated to ensure microbiological safety, and then concentrated by evaporation and spray drying to remove water. The goal is usually to concentrate the product as far as possible using an evaporation system, which is the most cost-effective method for removing water.

We offer solutions for direct and indirect product heating, which can be applied for processing product mixes with different characteristics, at specified temperatures, and with defined results for bacterial control. The optimum solution will often involve a combination of indirect and direct heating.

GEA offers different systems for microbiological control. These include our low thermophile system, a UHT plant, direct steam injection, or steam infusion technologies. We configure systems that are easy to control, flexible and convenient,

and take into account your processes, running times and demands for final product quality.

Choosing an evaporation system will also depend on multiple product-, plant- and process-related considerations, including energy source and energy price, functionality and flexibility.

We offer a wide range of evaporation solutions, which we adapt to your specific requirements. All of our solutions are designed with optimum hygiene and product safety features, minimizing energy consumption through the use of energy-efficient technologies and energy recovery functionality. All of our falling film evaporators are equipped with a liquid distributor, which utilizes the best hygienic design.



**Dryer exhaust system**



**Evaporator with MVR fan**



GEA MSD® spray drying plant

After evaporation, the concentrate moves via small buffer tanks to the spray dryer feed line. GEA spray dryers for nutritional products are typically equipped with two or more feed lines so that the spray dryer can operate 24/7. Each of the feed lines can be cleaned individually without stopping the dryer. This not only maximizes dryer utility, but also reduces the risk of scaling.

Each feed line includes a GEA TCM heater to preheat the concentrate. A high pressure pump generates exactly the correct pressure required for the atomization nozzles to ensure optimized atomization. Often the high pressure pump can be equipped with a homogenizing valve to carry out final homogenization of the mix prior to drying. This is vital if the mix has not yet undergone homogenization or if ingredients, such as sensitive oils, are added to the dryer feed line to avoid exposure to heat and oxidation. Our high pressure pumps and homogenizers are recognized worldwide for their performance and reliability.

Spray drying is a critical stage in producing a consistent and stable powder structure and density, and to ensure that the powder at the bottom of the package is identical to that at the top. Our spray drying technology is designed to give you the assurance of optimum powder quality, consistency and stability, with every batch.

Spray dryers from GEA are equipped with air dispersers that ensure optimal air flow in the chamber and therefore maximize contact between particles and drying air, which helps to prevent the wet particles from reaching the chamber wall.



GEA SANICIP® bag filter

We can size the spray drying chamber to match the required capacity, and tailor the equipment according to the type of atomization and the product to be dried. For nutritional products, the typical choice is the MSD® chamber, which is equipped with a DDD® air disperser, a static, integrated fluid bed in the bottom and an air exhaust in the top of the chamber. This configuration aids agglomeration, which is a key property that determines wettability and solubility, and ensures uniform bulk density.

As the atomization and agglomeration processes are key to final product quality we offer the SPRAYEYE® camera system to improve surveillance, which is also important from a safety perspective.

Spray dryers for nutritional products such as infant milk formula are always equipped with cyclones to separate the powder fines from the chamber/fluid bed exhaust air. SANICIP® bag filters are often used after the cyclones to recover remaining powder fines and satisfy environmental requirements. The powder fines from the cyclones are returned to drying chamber.

After drying, the powder is cooled in the VIBRO-FLUIDIZER® external fluid bed and is then sifted using a vibrating sifter.

All of our evaporators and spray dryers are developed with a focus on performance, easy maintenance and hygiene, and can be cleaned using our efficient CIP (clean-in-place) nozzle systems.

# Powder storage, mixing and pre-gassing



Pre-gassing system for modified atmosphere powder packing lines (MAP)

Powdered ingredients are unloaded and conveyed to intermediate storage units. Base powders and ingredients can be dry-mixed to achieve a homogeneous product, which is then either gravity-fed or conveyed to the packaging plant.

Prior to packing into containers, a hopper and vacuum receiver system is used to remove oxygen (pre-gassing) and to replace the atmosphere with nitrogen, which results in a low residual oxygen level. By removing the oxygen the product becomes more shelf-stable and the flavor is preserved over a longer time period – up to two years in some cases.

## Benefits

- Flexible handling of tipped ingredients in bulk or small package format
- Monitoring of batch size during mixing to ensure accurate final composition
- Minimization of interstitial air in the powder to increase shelf life and stability and preserve flavor profile
- Gentle conveying to prevent breakdown of agglomerated powder prior to packing



# Powder handling, post-gassing and filling



Powder is pneumatically conveyed to and from powder silos or hoppers using dense phase vacuum or positive pressure transport. Both transport modes are gentle on the powder, minimizing powder attrition, and helping to preserve the physical structure and quality of the final product.

We offer two solutions for pre-gassing, the process by which interstitial air is replaced using an inert gas prior to packing:

- Vacuum pre-gassing is carried out as part of the vacuum transport system, which pulls air out of the powder vessel until a deep vacuum is reached. Nitrogen is then added until the internal pressure inside the vessel reaches atmospheric pressure.
- Gas flushing is a continuous process, whereby powder is gravity-dosed in the vessel, and the N<sub>2</sub> gas is percolated through the lower part of the vessel before being discharged at the same rate as the infeed of fresh powder.

Depending on your project needs, we also offer post-gassing, the process of substituting interstitial air with an inert gas after the container is filled with powder, with probes for 25 kg and bulk packaging.





**RBF-800Li (Limited Intervention) powder filling system**

### **Powder packing**

A range of powder filling solutions is available to complement the pre- and post-gassing technologies, so that we can provide you with an integrated solution for modified atmosphere packing (MAP).

Our semi-automatic and automatic powder packing solutions cover most bulk formats.

For packing in bulk 25 kg (55 lb) bags our range of multi-wall bag/sack fillers is designed to pack powdered products at rates of 4.5 t/h to 12 t/h or more, with an accuracy of 10 g (0.35 oz) or better.

Our range features a bottom-up filling system, which, compared to conventional top filling systems, minimizes air displacement and dramatically

reduces dust emissions. This makes our filling equipment very clean and safe to operate. Reduced product loss through better dust control means greater product yields for you.

By adding downstream equipment, we can provide you with a complete solution for automated bag filling, conditioning and quality checking, which can be combined and matched with any manual or automated palletizing system.

# Hygienic plant design for product safety

Overall plant design and selection of the best equipment and components will help to ensure a reliable, and durable plant that can be cleaned efficiently using CIP (clean-in-place) systems. We recognize that hygienic design extends beyond that of the individual components – it is a holistic approach to overall plant design that puts your products and operator safety first. Our technologies give you peace of mind when selecting key process components.

Every component and plant is designed to meet the strictest global hygienic and aseptic standards. Using our components you can be confident of complete and efficient cleaning and drainage. Our plants are designed to be reliable and easy to maintain, so you have the assurance that they will give you optimum performance for their complete lifespan.

Because we recognize hygiene as a safety issue, our component and plant designs are based on a hygienic design, which is informed by guidance coming from global standards organizations.



GEA CIP nozzle



**GEA CIP station**

Our innovative CIP solutions also meet all critical hygiene standards to guarantee product safety at every point of the process. Tailored solutions configured to meet individual requirements ensure efficient commissioning, while also reducing total cost of ownership, for example, by optimizing the use of water and detergents. Seamless integration of technologies, coupled with sophisticated plant automation, safeguards trouble-free operation and maintenance, to deliver solid financial benefits.

Optimized plant design ensures that we can match all the parameters that characterize your process. For powder handling and packing, easy access for inspection and dry cleaning is key. Liquid processing solutions are always designed to minimize bacterial growth.

To reduce the contact of product directly with hot surfaces, we have developed innovative preheaters and an advanced

pasteurizer with direct steam injection. This swirl heater provides fast and efficient heating for product heat treatment prior to evaporation. The design and operation lengthens the production run between cleaning cycles, and avoids the risk of bacterial growth, including thermophiles and their spores. For efficient evaporator CIP we have introduced a “hydro cyclone”, which collects and discharges impurities that would otherwise block the distribution plates above the calandria during CIP.

Spray dryer technology from GEA is equipped with appropriate drying air filtration and CIP facilities. All surfaces in contact with the product comply with international standards, and materials are FDA approved. Our equipment is always designed to ensure complete drainage during CIP. GEA drying plants are constructed with smooth surfaces, are designed to avoid hollow spaces, and are equipped with CIP nozzles whenever appropriate.

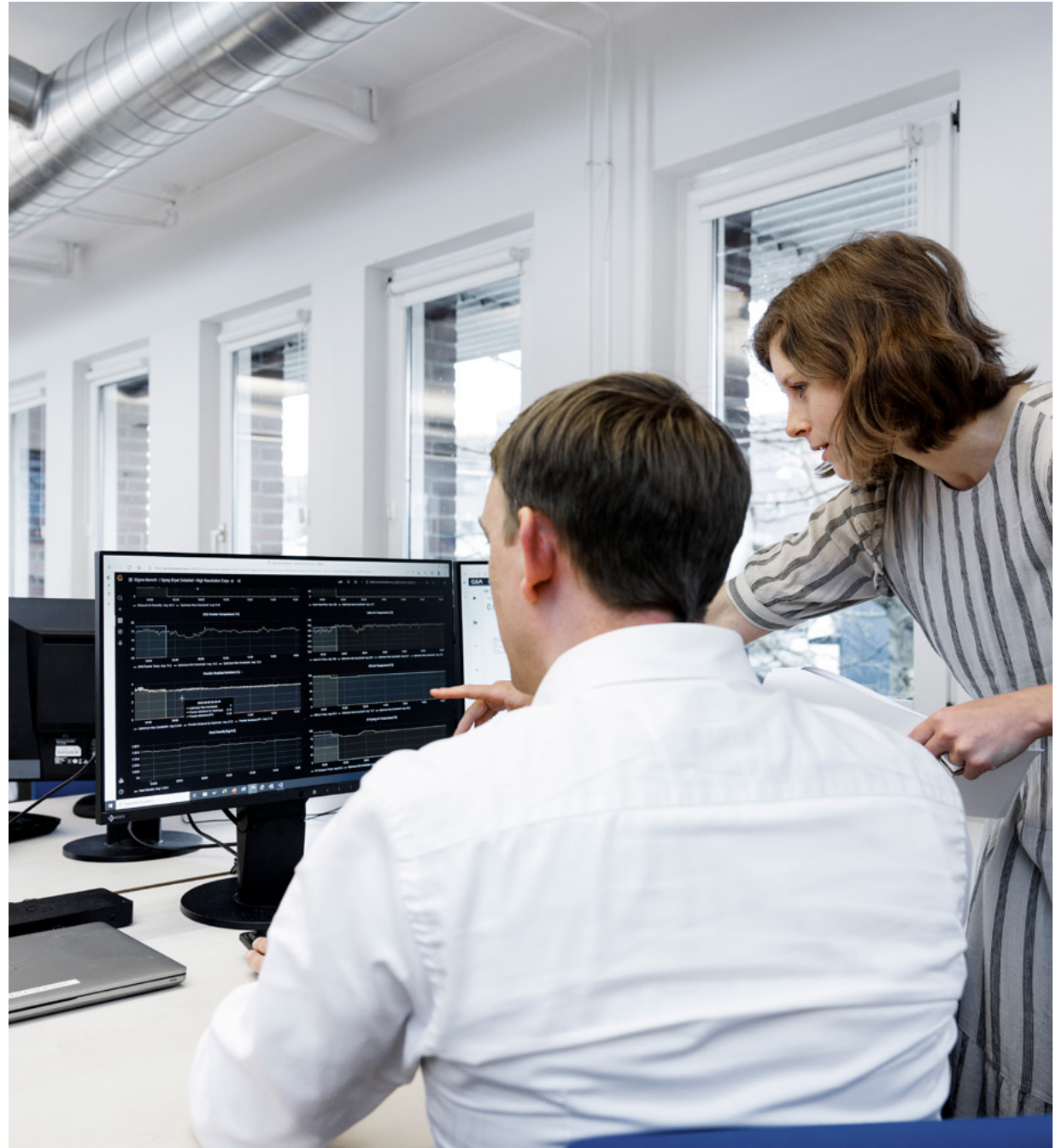


# Engineering and project management

We understand that delivering high-value projects requires careful planning and financial control so that key business objectives can be achieved. We know how important it is to accomplish every deliverable, on time, and to meet all your quality expectations. A contract with us gives you the assurance of a dedicated project manager, who will work with you every step of the way.

We combine core technologies with extensive process know-how to deliver tailored solutions across all product applications. Your GEA project team will include experienced engineers who can configure the best design for your plant. We will configure and tailor the optimum solutions for the core process, but also focus on making your plant environmentally sustainable, using advanced technologies that can help to reduce resource consumption and recover heat and water. And of course, your project manager will make sure that installation and commissioning are as smooth and seamless as possible.

From plant upgrades to complete large-scale green field process plants, we employ strong project, financial and resource management to ensure you get world-class solutions.



# Automation



GEA Codex®: scalable automation solution

Reliable automation systems are vital to ensure optimum process performance. We appreciate that every customer will have specific requirements, so we tailor individual automation solutions that combine proven hardware from selected suppliers with GEA Codex® software modules.

Partner with us and we can design an automation solution that will be optimized for your needs, all supplied from a single source.

## Benefits for your plant will include:

- Local and centralized plant monitoring and control, as well as mobile access
- High performance human machine interface (HMI) systems based on the ISA101 standard with consistently themed, user-friendly dashboards and screens to simplify user interaction
- Recipe management, including production order handling
- Process optimization and standardization
- Process repeatability with minimal variation
- Improved plant, product and operator safety
- Product traceability
- Connection to your ERP system

By employing big data, machine learning, and advanced algorithms, our solutions can help to unlock the full potential of your production lines.

## Your benefits

- Stability in operation
  - Ease of planning
  - Consistent product quality
- Plant operation at maximum capacity and efficiency, with compensation for:
  - Operator skills
  - Weather
  - Feed quality
- Transparent relationship between plant operating conditions and economic output



GEA OptiPartner is one of our optimization solutions for spray dryers. You know that even the smallest deviation in quality and consistency during the drying process can lead to downstream problems, to rejected product or loss of production time. We have developed OptiPartner to help minimize these deviations, to give you precise control of residual moisture in the final powder and to optimize drying conditions in the spray dryer.

Using GEA OptiPartner you can maximize the spray dryer's capacity and increase yield while precisely regulating moisture content in the final powder. Complementing GEA OptiPartner is our POWDEREYE® instrument, which issues out-of-specification warnings to the operator, so corrective action can be taken and costly out-of-specification production avoided.

Installed after the last drying stage, POWDEREYE® gives you key information so that you can fine-tune your process parameters. The POWDEREYE® technology measures at operator-defined intervals:

- Residual moisture in the powder
- Scorched particles (using high resolution imaging)
- Bulk density
- Tapped density





### **Know-how through research and development**

Dairy product manufacturers worldwide strive to deliver high-quality, value-added products, and they innovate to meet market demands. However, new product development can be a labor-intensive, costly investment. Complex formulation work, detailed process design and plant validation may make the prospect of developing new products daunting.

We understand all these issues, so we have built dedicated test centers where you can access critical process technologies including separation, formulation, mixing, evaporation, and drying.

You can work confidentially with our experts to test and trial new products, formulations and processes at the pilot scale before investing in equipment and solutions for highly scaled production. We will help you to evaluate the final product properties and to refine the process design before you scale up.

# Sustainable energy solutions

Most of the energy consumed by dairy process systems is used to meet precise cooling and heating requirements. These systems can offer a key opportunity for cost reduction. Our expertise extends to identifying every energy-saving and energy-management opportunity. We provide measurable, innovative solutions with short payback times, which are aimed at reducing both total cost of ownership and carbon footprint. For example, our heat pump technology upcycles byproducts of the processing chain, including waste heat, back into the production cycle.

## Your benefits

- Reduced expenses
- Smaller carbon footprint
- Achievement of sustainability goals
- Decrease in use of natural resources and lower
- CO2 emissions, which helps protect the planet



GEA AddCool high temperature heat pump solution

**GEA Process Engineering A/S**

Gladsaxevej 305  
2860 Soeborg, Denmark

Tel +45 39 54 54 54  
[gea.com/contact](http://gea.com/contact)  
[gea.com/dairyprocessing](http://gea.com/dairyprocessing)