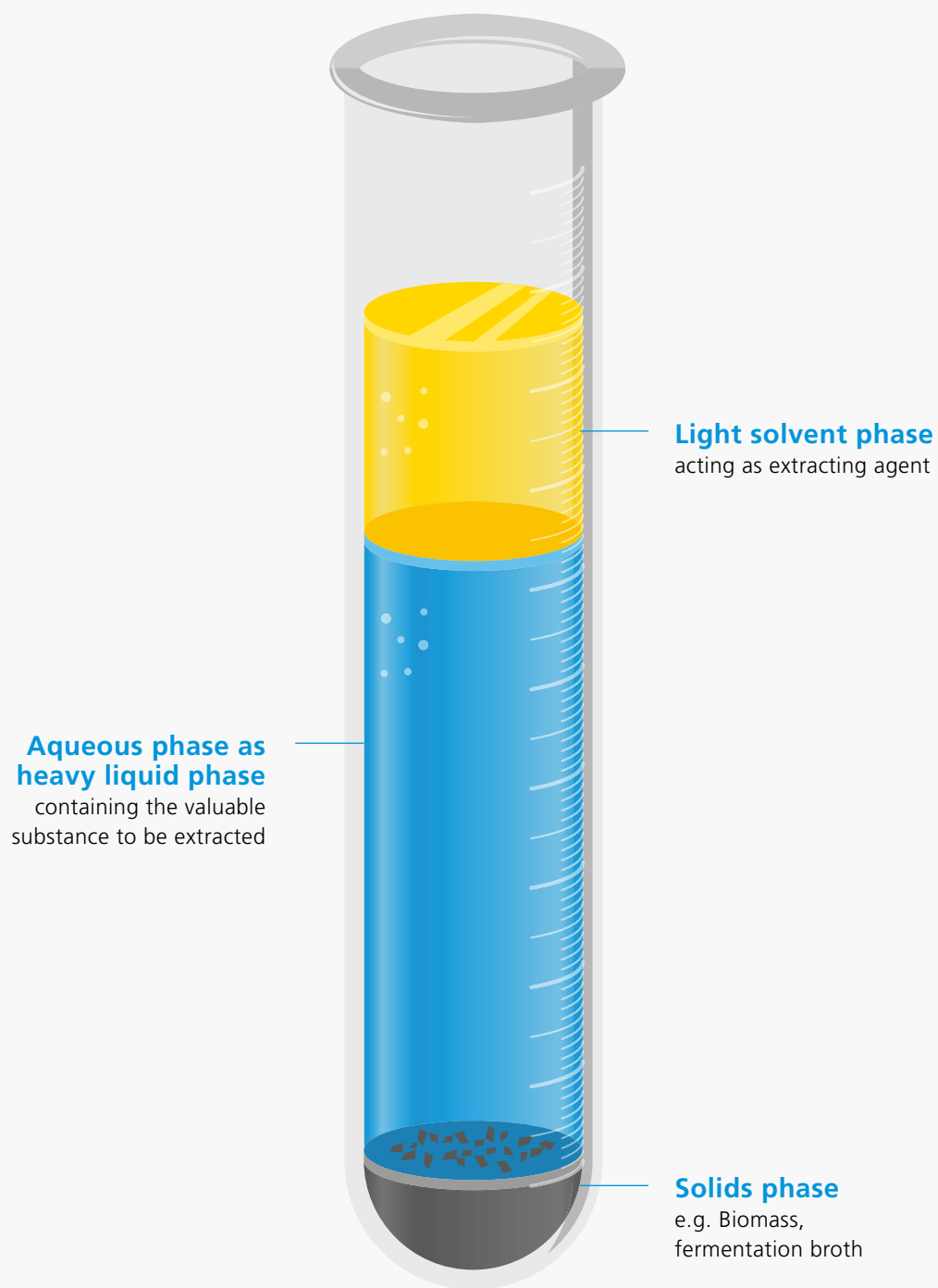




GEA centrifuges in extraction processes



EXTRACTION PROCESSES

are extremely important in a wide range of technical applications, for instance biotechnology, the pharmaceutical and food industries as well as environmental protection. GEA has the optimum solution for you.

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1. Introduction

Extraction is defined as the process of removing a substance or several substances from another one.

The process is extremely important in a wide range of technical applications, for instance biotechnology, the pharmaceutical and food industries as well as environmental protection.

Overall, particularly gentle processes are characteristic of these “life sciences” methods. In biotechnology production installations, the process of separating the valuable substances from the biosuspension and the subsequent purification of such substances with the aid of extraction are key aspects. Sensitive substances are frequently processed in bioprocesses. Their structure and biological activity require very narrow tolerances in the medium conditions particularly with regard to the processing stage of extraction. This has to be adjusted to be brought into line with the ambient conditions. The vital process parameters in this respect are the pH value, the salt concentration and the temperature as well as the structure of the valuable substance.

In numerous areas of application, extraction is the more efficient, more selective and less expensive alternative compared with competing separating methods such as distillation, evaporation and membrane technology. Extraction has become

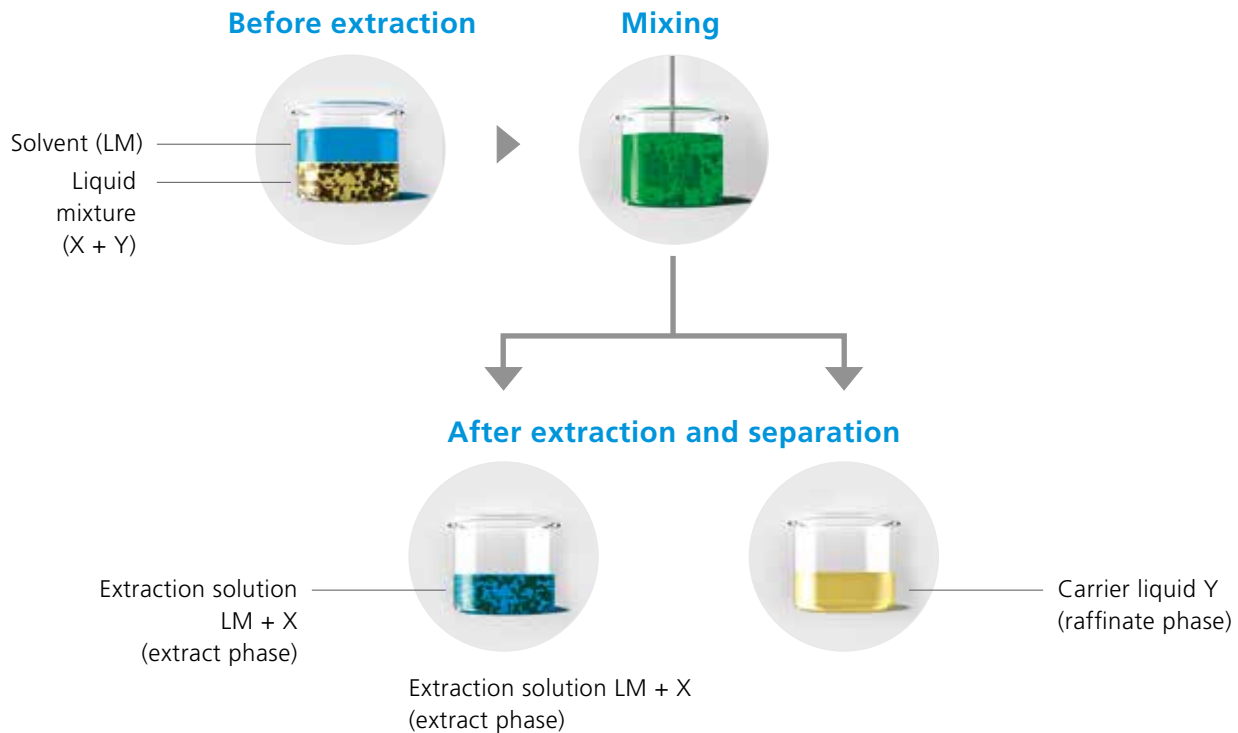
established particularly in conjunction with the following process conditions:

- Minor boiling point differences of the components to be separated or azeotropic separation e.g. separation of isomers, aromatic substances or aliphates
- Heat-sensitive or unstable substances e.g. antibiotics
- Non-volatile substances, recovery and purification of catalysts or heavy metals
- Mixtures with inorganic components which would result in encrustation of evaporator surfaces in conjunction with the thermal separating process
- Separation of low mass contents of a component which is not readily volatile

1.1 Fundamental aspects of extraction

The extraction agent or solvent is extremely important for carrying out an extraction process, as the valuable substance (the extract E), is released with the aid of extraction agent. The nature of the phases which are involved characterize the extraction process as solid-liquid extraction or liquid-liquid extraction.

Liquid-liquid extraction is used for separating vitamin mixtures; a new method is also used for purifying phosphoric acid. The principle of liquid-liquid extraction is illustrated in the following diagram.

FIG. 1 EXAMPLE OF LIQUID-LIQUID EXTRACTION

A fundamental criterion for liquid-liquid extraction is that the extraction agent and the liquid in which the extract is dissolved (the carrier medium (T)) are not miscible. In excess of a certain concentration, two phases form with a clearly defined boundary. A familiar example in this respect is the mixing behaviour of water and butyl acetate.

phase consists only of the carrier medium. Apart from being less than perfectly miscible with the carrier medium, the extraction agent has to meet further requirements.

The two phases are known as the extract (E) phase and the raffinate phase (R). The extract phase is the phase into which the extract is transferred from the carrier medium. Ideally, it consists exclusively of the extraction agent and the extract, whereas the raffinate

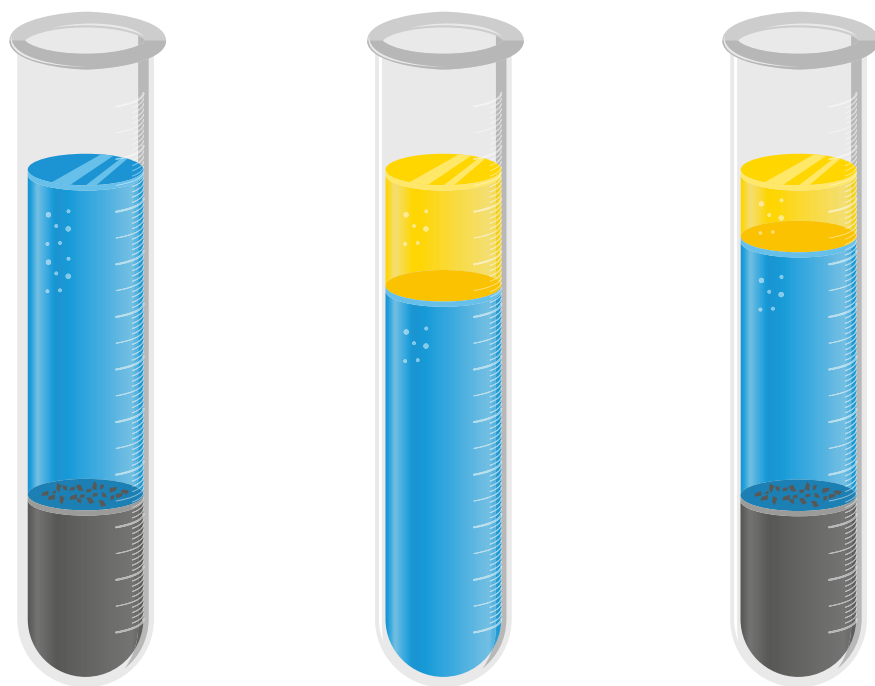


Fig. 2 Various extraction agent/carrier substance mixtures

These criteria include the following:

- Capacity to absorb a large amount of extract (high capacity)
- High degree of selectivity
- Minimum cost for processing the extract
- High availability and low price
- Low level of corrosion
- Low or, if possible, no toxicity

Of the above-mentioned requirements, capacity and selectivity are of primary interest. However, the points corrosion properties as well as toxicity are also becoming more and more significant, particularly when extraction methods are used in the food and drug field (life science) with respect to GMP guidelines. Capacity is a measure of quantity, i.e. it specifies the amount of extract which can be absorbed by the extraction agent.

On the other hand, selectivity is a measure of quality. It expresses the efficiency with which the solvent

distributes the valuable substances over the various phases within a separating stage.

The higher the capacity, the greater is the efficiency with which the volume streams can be adjusted. Assuming that volume streams remain unchanged, a solvent with high capacity is able to absorb more extract than a solvent with lower capacity.

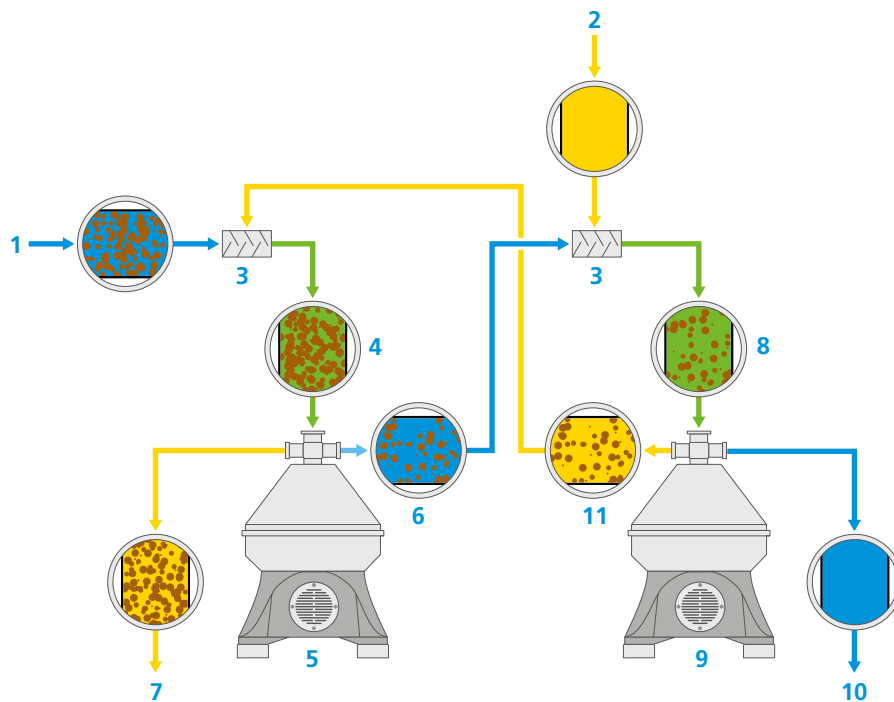
The higher the selectivity, the lower the number of separating stages, this means that the installation or the separating device becomes smaller. When the choice of solvent is being considered, it has to be borne in mind that there is frequently an inverse relationship between capacity and selectivity. In other words, high capacity is frequently accompanied by low selectivity, and vice versa. Accordingly, the choice of solvent is frequently an optimization process in which a compromise has to be found between selectivity and capacity.

2. Typical extraction processes with centrifuges

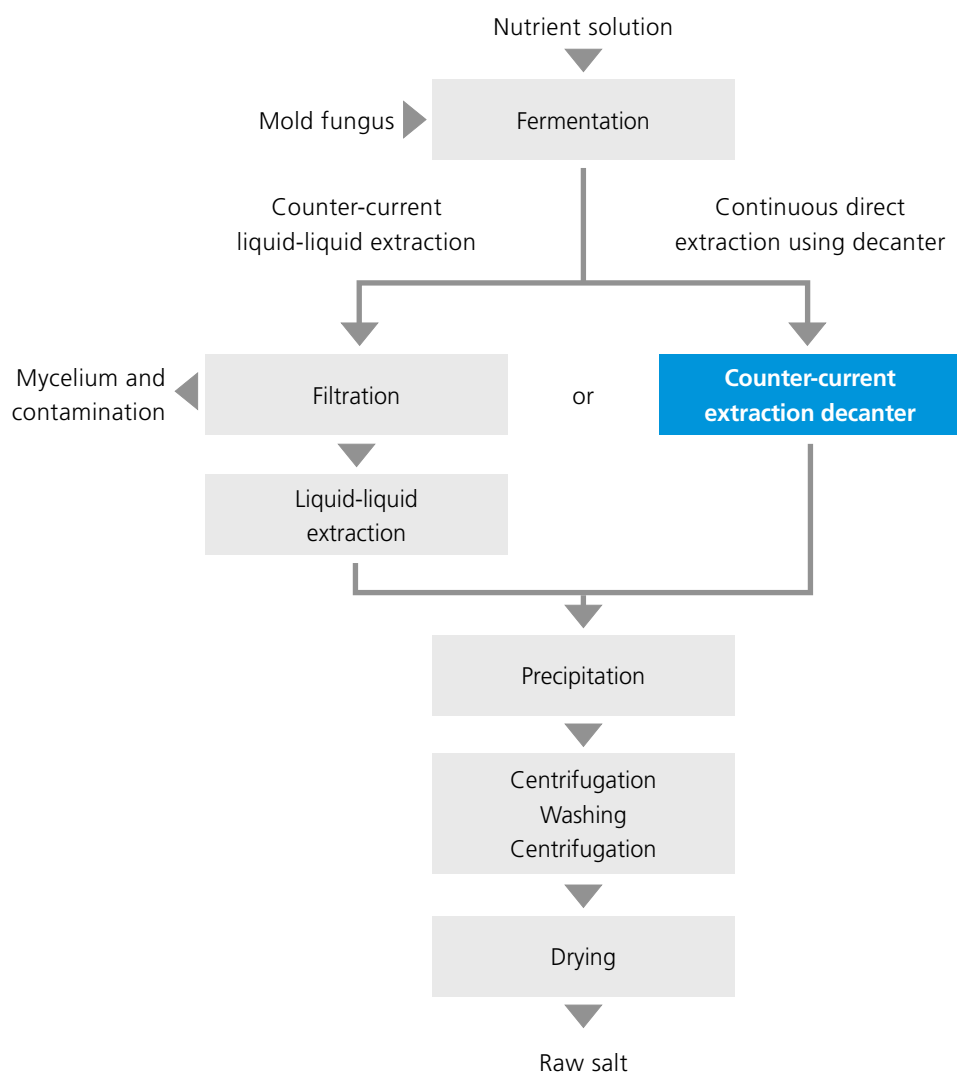
The counter-current arrangement is the most effective extraction method. A much larger proportion of extract is transferred from the carrier medium to the solvent. The concentration gradient as the driving force for the mass transfer

is utilized most effectively in the counter-current process. It requires low quantities of fresh solvent resulting in lower costs for providing the solvent and for separating extract and solvent.

FIG. 3 2-STAGE EXTRACTION, COUNTER-CURRENT METHOD



- | | |
|--------------------------------------|--|
| 1 Fermentation
broth (feed) | 7 Extract
1 st stage
(valueproduct) |
| 2 Extracting
agent(solvent) | 8 Feed 2 nd
separator |
| 3 Mixing device | 9 2 nd stage
separator |
| 4 Feed | 10 Raffinate
2 nd stage |
| 5 1 st stage
separator | 11 Extract
2 nd stage |
| 6 Raffinate
1 st stage | |

FIG. 4 SOLVENT EXTRACTION OF ANTIBIOTICS, STATINS AND STEROIDS

2.1 Antibiotics

Whole broth extraction – total yield up to 98 %

Antibiotics form the most important group of drugs in the fight against infectious diseases. Representing around 13 % of total pharmaceutical consumption, they have the highest market share of any pharmaceutical product. The pharmaceutical industry extracts antibiotics from fermentation broths.

GEA supports this process with special decanters which result in efficient extraction which is simultaneously kind to the environment. Extraction always consists of mixing and separating, processes which can be viewed as a complex. This is why GEA developed decanters for extracting active ingredients.

This decanter allows suspensions with a high solids content to be processed, and this property makes it suitable for whole broth extraction of antibiotics from the culture solution, which has a high mycelium content. Filtration, which used to be essential, is thereby rendered obsolete, and the continuous process avoids losses of valuable material, a problem associated with filtration.

This increases total yield to up to 98 %. Compared to conventional counter-current extraction, whole broth extraction works significantly more cheaply, if only because filter aids are no longer required. The fermentation broth is not diluted by filter wash water, likewise reducing the requirement for solvent and the risk of infection. As a final consequence, this method also reduces waste water pollution and the volume of waste water produced.

2.2 Statins

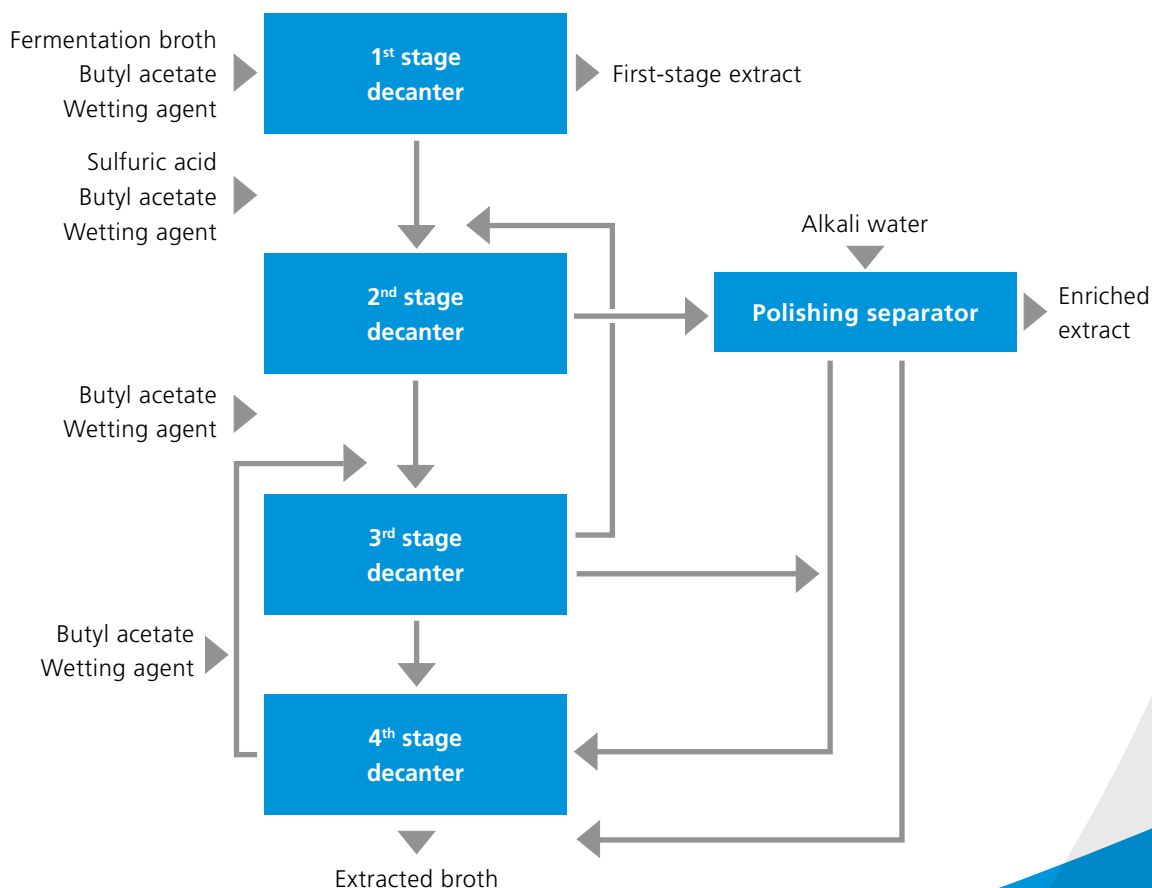
Extraction for hi-tech drugs

Whole broth extraction with GEA decanters plays an important role in spheres other than obtaining antibiotics. Drugs as the so-called statins are also obtained by this method. In pharmacology, a statin is a drug belonging to the class of substances known as HMG-CoA reductase inhibitors. As HMG-CoA is an intermediate of human cholesterol synthesis, statins such as Lovastatins are used primarily as cholesterol-lowering agents (CSE inhibitors). In addition to fat metabolism disorders, statins are also successfully used to treat diseases of our modern society such as diabetes (Pravastatin) or fungal infections (Nystatin). GEA has developed decanters and polishing separators

which can be used to obtain these statins particularly economically by extraction. Under the effect of statins such as Lovastatin, the human body produces less cholesterol. The relative lack of cholesterol means that higher numbers of LDL receptors are formed in the cells; these absorb LDL (low-density lipoprotein) from the blood, rendering it harmless. LDL is considered the most important factor in damage due to an excessively high cholesterol level.

Lovastatin was licensed as a cholesterol-lowering agent as long ago as 1987 and since then has been one of the most important drugs of this kind. The flow chart shows the complex process involved in the extraction of Lovastatin from the fermentation broth.

FIG. 5 SEVERAL STAGE EXTRACTION PROCESS



Decanters operated on the counter-current principle are used in four consecutive stages. A polishing separator obtains the enriched extract. The machines are designed to be gas-tight in accordance with current explosion protection guidelines, with the result that they satisfy all safety specifications. This versatile process can be used in a similar way to obtain Pravastatin and Nystatin.

2.3 Steroids/hormones

Obtaining estrogen and similar substances

Steroids are endogenous hormones such as the sex hormones estrogen and testosterone or the hormones of the adrenal cortex, cortisol and aldosterone. Their significance for the metabolism means that steroid hormones are also very important in medicine, where they are used for hormone therapy as well as in antirheumatic, antiarthritic and muscle-building preparations. Support in obtaining them efficiently is provided by extraction with GEA decanters.

Virtually all steroids are based on cholesterol. In the human body, steroid hormones are synthesized in the endocrine glands and transported to target tissue by the blood.

In the target cells, they dock with highly-specific receptors and perform a key function in the formation of proteins. In order to produce steroid hormones for pharmaceutical applications outside the body, we use extraction from special nutrient solutions. In continuous extraction from GEA, the fermented nutrient solution is treated by liquid-liquid extraction or in a counter-current process. Following precipitation, concentration, crystallization and drying of the extract, the steroid hormones are available in the form of a raw salt and can be correspondingly processed by the pharmaceutical industry.

2.4 Plant extracts

Gentle extraction for sensitive active ingredients

There are some 500,000 species of higher plants around the world, of which around 70,000 serve as a basis for plant-based drugs. Much as applications for vegetable active ingredients vary, they all share one common feature: they are extremely sensitive substances which have to be treated correspondingly gently by the biotechnical process used to obtain them. Decanters and polishing separators from GEA are perfectly designed for this purpose.

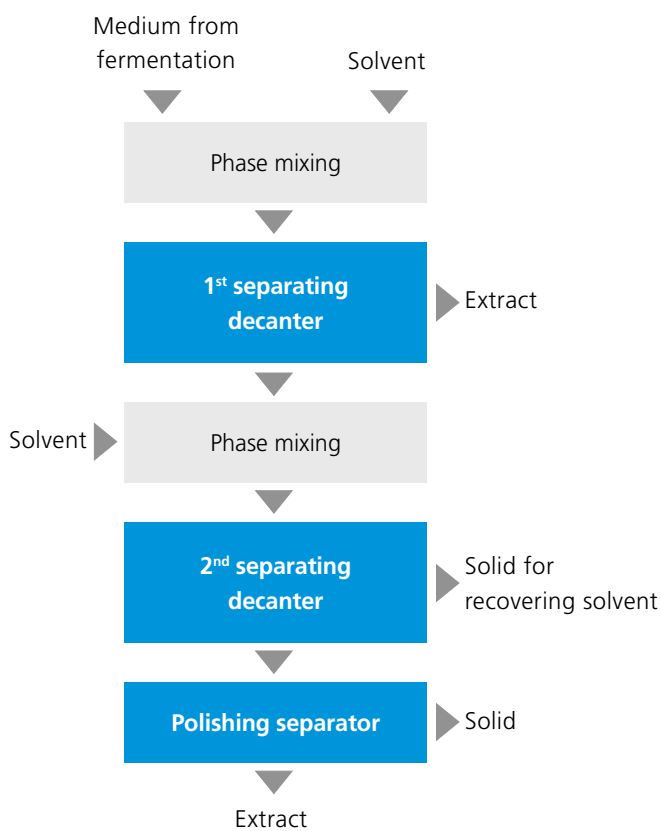
The structure and biological activity of the substances mean that very specific medium conditions have to be used. The extraction process is particularly suitable for this, but has to be precisely adapted to suit process parameters such as pH, temperature, concentration and the delicate structure of the valuable substances.

The efficiency of a phytopharmaceutical product also depends on adequate and consistent dosage of the plant extract, so industrial standardization is of huge significance. Plant extracts are defined as concentrated preparations of liquid, solid or viscous consistency. As a rule they are obtained by maceration (extraction to equilibrium with water or alcohol) or percolation (extraction to exhaustion with water or alcohol). A key factor in production is selection of the extraction agent. Water-soluble (hydrophilic) constituents can be extracted with water, whilst fat-soluble (lipophilic) constituents are extracted from a particular part of the plant with alcohol or other solvents.

Compared to competing separation processes such as distillation, concentration and membrane technology, extraction has proved more efficient in terms of process technology, more selective and cheaper in numerous applications. It is not only extremely gentle, but is also characterized by a low energy requirement. The decanters and polishing separators from GEA used in the pharmaceutical industry cover

all processes and modes of operation: liquid-liquid extraction can be realized, as can liquid-liquid-solid and liquid-solid extractions, whether in one or more stages on the cocurrent, counter-current and cross-current principles. The flow chart shows a typical plant extraction process.

FIG. 6 PLANT EXTRACTION



2.5 Pectin

From citrus fruits to setting agent

Pectin (from the Greek “pektos” = gel) occurs in all higher terrestrial plants. Citrus fruits occupy a special position, as they have an unusually high concentration of pectin substances (about 25 % moist mass of the whole citrus fruit). The pectin obtained from the citrus peel is used mainly as a setting agent in the food industry, but also for pharmaceutical and cosmetic products. The pectin process with GEA centrifuges provides today's producers with an extraction process which is as gentle on the product as it is efficient.

Following a special initial treatment of the fresh peel and storage in mechanized silos, the dried peel is milled and fed into the extraction process.

The pectins are extracted by a variety of acids with a pH-value of 1 to 3, at a temperature between 65 °C and 85 °C and for an extraction period of 0.5 to 6 hours. Extraction delivers a raw extract with 0.3 to 1 % pectin. Separating this viscous solution from the heavily swollen and in some cases disintegrated pomace cake is the key technical problem in the pectin industry. In the pectin process shown in the flow chart, this task is managed by combining a number of decanters and a filter press. The extract then runs through the separator and precoat filtration before the pectin is precipitated using isopropanol. The excess precipitant is then separated by a gas-tight decanter until only dry pure citrus pectin with good storage properties remains.

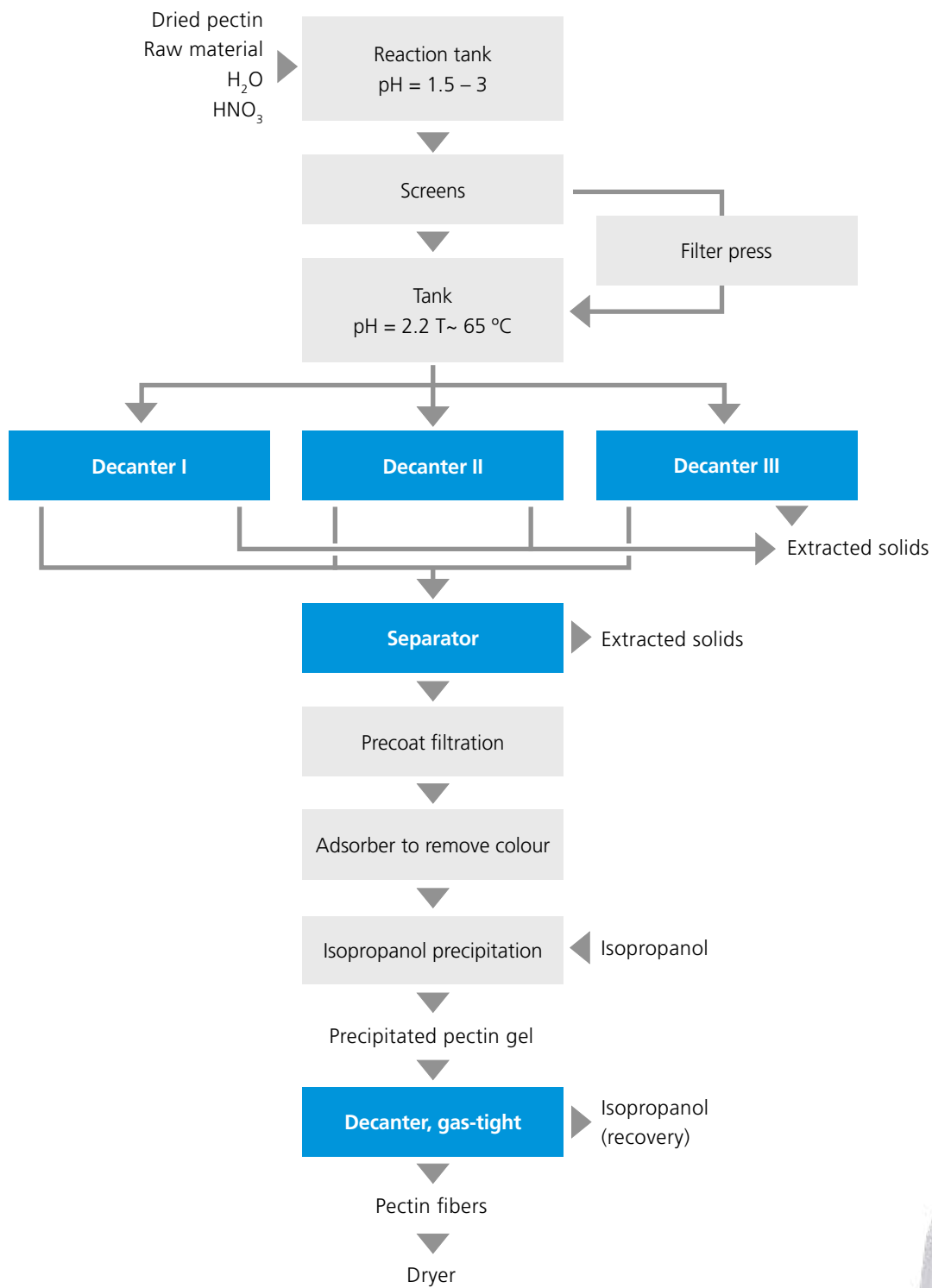
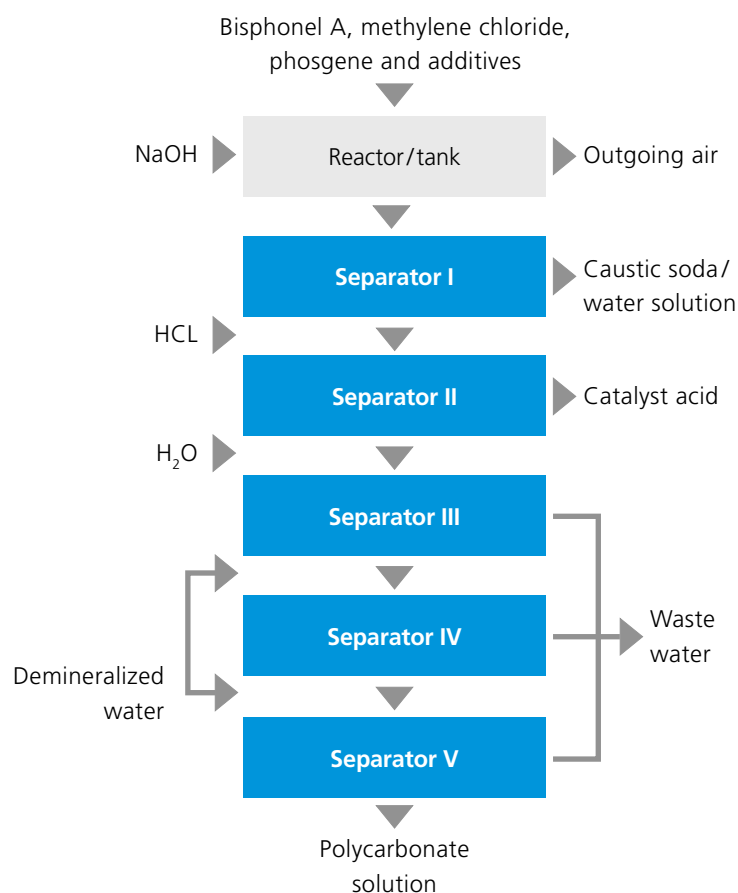
FIG. 7 OBTAINING PECTIN

FIG. 8 PRODUCTION OF POLYCARBONATE

2.6 Polycarbonate

Polymer washing processes

Polycarbonates are some of the most popular plastics as a result of their excellent transparency and impact resistant properties.

Separators are used in the phase boundary method in the production of polycarbonate in which the polycarbonate, after the reaction, is dissolved in an organic solvent. A second water phase contains dissolved salts and unwanted additives. Pure polycarbonate is obtained by distilling off the solvent after being washed electrolyte-free.

The washing process is carried out in a multistage process with acid and completely desalinated water. Separators with a solid-wall bowl are used for separating the polymer solution and washing liquid in the individual washing stages.

The aim is to achieve not only extreme purity but also minimum residual water content in the organic phase to meet the market's increasingly stringent product quality requirements. These product requirements are met precisely by using separator technology at high speeds. Solid-wall, disc-type separators of type XTC are used at the acid stage; these have all product-contact components made of high corrosion resistant materials.







3. Centrifuges in extraction processes

Centrifugal extraction is the link between thermal and mechanical process engineering. The choice of solvent is based on thermodynamic and chemical/physical principles, whereas the design of the centrifuge and the separating process are based on mechanical principles.

Advantages of centrifugal extraction of GEA

- **Low phase hold-up**
have a low solvent requirement and can accordingly reduce operating costs
- **Short contact time**
to a large extent avoid valuable substance decay and achieve a higher overall yield
- **High stage efficiency**
minimize the number of stages and reduce the investment costs
- **High load range and optimum throughput capacity with minimum space requirement**
minimize investment costs
- **Close contact time distribution**
achieve a significant improvement in substance interchange between the phases by avoiding backmixing and achieve a higher overall yield

- **Separation of systems with low density differences and high viscosities**
can considerably extend the range of solvents which can be used and achieve higher product backmixing and achieve a higher overall yield qualities
- **Efficient phase separation**
achieve a higher overall yield
- **Optimum substance transfer due to fine drop distribution**
achieve a higher overall yield
- **Operations not affected by solid contaminations**
achieve higher process security and availability

3.1 Mixers

An extraction stage always consists of a mixing unit and a centrifuge unit. The mixing unit can be a static mixer or a dynamic one. In the case of the dynamic mixing unit, there are two equipment alternatives; first the centrifugal mixer and second the integrated mixer in the bowl head of separators.

3.1.1 Centrifugal mixer

In the case of the centrifugal mixer, the two phases to be mixed are pumped jointly into a rotating mixing drum (2), where they are accelerated to the circumferential velocity of the bowl. The centripetal pump (3) discharges the liquid mixture from the mixing drum. The two phases are mixed intensively in the channels of the centripetal pump. The mixed liquid is then discharged from the mixer at outlet (4). The pressure in the discharge line is adjusted with the aid of a throttling valve; this affects the suspension in such a way that the channels of the centripetal pump are immersed under the surface of the suspension and prevent any air intake. The hermetic version is the standard version for gas-tight applications. A slide ring packing ensures a hermetic seal between the drum and the hood. The slide ring packing consists of a stainless steel housing slide ring and a counter-ring made of hard carbon.

The output of the 3-phase AC motor is transferred directly from the horizontal motor shaft to the mixer drum. The variable speed mixer with a frequency converter drive is a further development of the original ZA mixer. In this solution, a frequency converter can be used for infinite electric adjustment of phase mixing. The mixing characteristics can accordingly be adjusted individually, and this aspect is of great importance particularly in the case of “multipurpose” applications. The drop size and the required turbulence vary as a function of the speed. The frequency converter enables the performance of the mixer to be adjusted at any time.

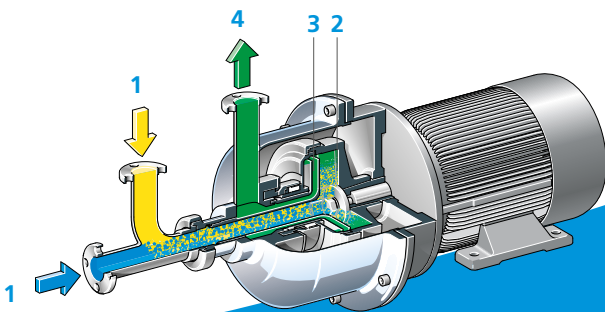


Fig. 9 Drum of a centrifugal mixer in hermetic design, type ZA 40-67-905

3.1.2 Integrated mixer in the bowl head

Besides the mixers installed upstream of the centrifuges, it is also possible for a facility for mixing the extract phase and raffinate phase to be installed inside the actual separators. A mixture to be separated is fed in through feed (1). The extract phase of the next stage or fresh extraction agent (4) is mixed with the heavy phase separated in the separator (the raffinate) in the centripetal pump (5). The mixed phase is discharged from the separator at outlet (3). The clarified extract phase leaves the separator through the light phase discharge (2). Apart from the facility for mixing in the centripetal pump chamber, it is also possible for the extraction agent (4) to be added to the raffinate directly before it enters the separator. The actual process whereby the two phases are mixed takes place in the distributor chamber of the bowl (6) under the action of centrifugal force.

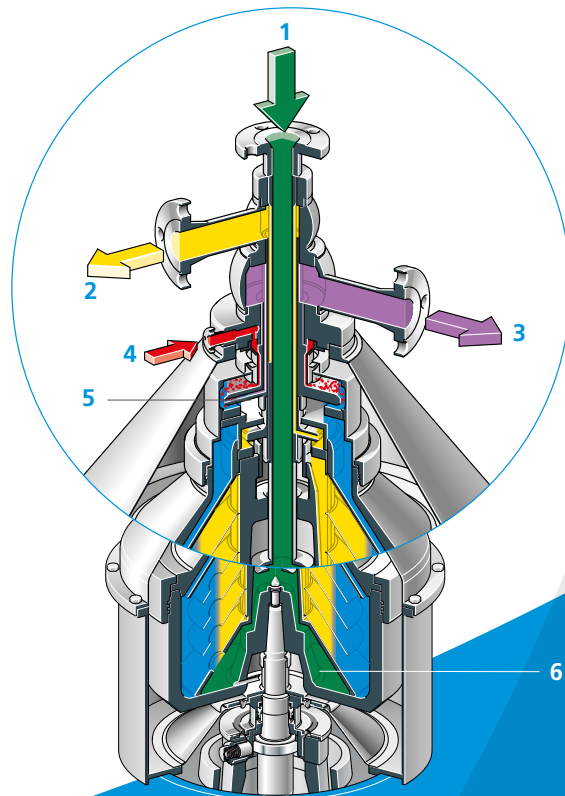


Fig. 10 Section through the bowl of a solid-wall separator with mixing device in the bowl head

3.2 Centrifuges

There are various options available for the extraction process, whereby the appropriate variant and as such the choice of the centrifuge to be used is determined by the nature of the phases.

3.3 Liquid-liquid extraction

Disc-type separators in the versions with solid-wall bowls and self-cleaning disc-type bowls are used for liquid-liquid extraction processes.

FIG. 11 OVERVIEW OF CENTRIFUGAL EXTRACTION PROCESSES AND EQUIPMENT FROM GEA

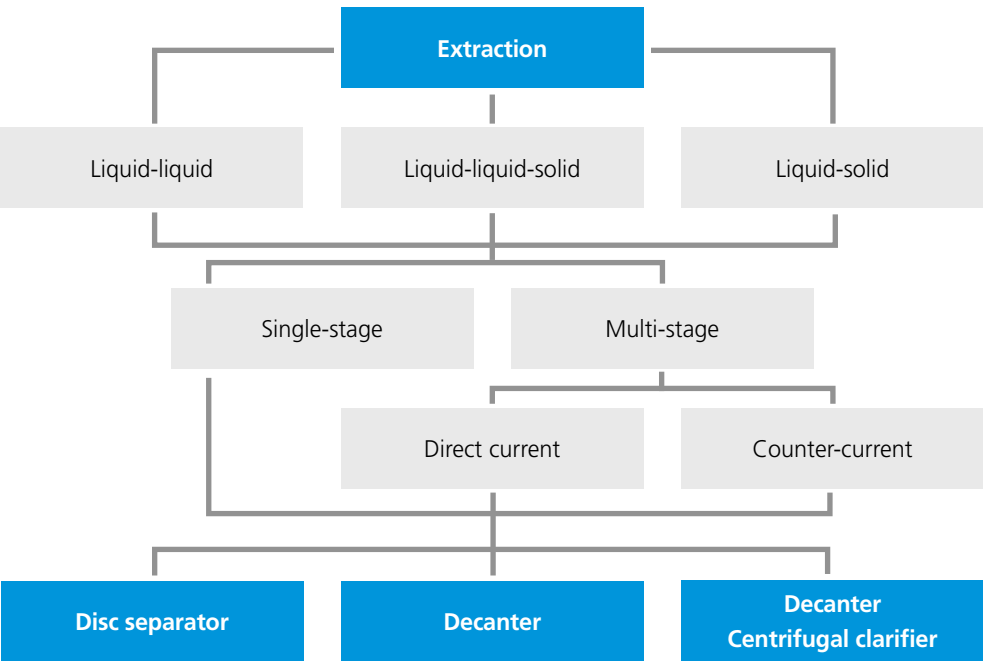


FIG. 12 OVERVIEW: SOLID CONTENT AS A SELECTION CRITERION FOR CENTRIFUGAL EXTRACTORS

Phases solids content in % (by vol.) centrifugal extractors	Extraction process					
	Liquid-liquid	Liquid-liquid-solid			Liquid-solid	
	< 0.1	÷ 7	÷ 15	÷ 60	÷ 7	÷ 60
Separator with solid-wall bowl	<div><div></div><div></div></div>					
Self-cleaning separator	<div><div></div></div>					
Self-cleaning clarifier					<div><div></div></div>	
Nozzle-type separator					<div><div></div></div>	
Clarifying decanter					<div><div></div></div>	
Separating decanter	<div><div></div><div></div></div>	<div><div></div></div>	<div><div></div></div>	<div><div></div></div>		

Suitable for light solvents

Suitable for heavy solvents

3.3.1 Separator with solid-wall disc-type bowl

The separator is equipped with a solid-wall bowl. The product flows through the hydrohermetic feed, which minimizes the shearing forces for sensitive products, and is broken down into a light phase and a heavy phase in the disc stack. The separated components are discharged under pressure by means of the corresponding centripetal pumps through outlets. The use of a disc stack increases the equivalent clarification area Σ of the separator many times over compared with a centrifuge with the same volume which consists of a single chamber. Depending on the particular product characteristics, the bowl can be equipped with discharge bore holes so that the suspension can be drained for maintenance purposes from the bowl when the machine has come to a standstill; the advantage of this arrangement is that maintenance personnel do not have to come into excessive contact with the process media. At the same time, CIP (cleaning-in-place) is also possible without the bowl being opened. The selected pair of centripetal pumps also enables the separating zone to be adjusted in an optimum manner even when there is a major density difference between the products; the separating zone can be adjusted depending on the volume of the products involved. The separating zone is adjusted by adapting the regulating rings. These regulating rings also guarantee extremely efficient separation even when there are major fluctuations in the composition of the phases.

In the gas-tight version, which is always essential when used for handling solvents, this separator is equipped with explosion-protected components, and the machine is of flame-proof enclosure. The frame chamber, sealing chamber and gear chamber are equipped with connections for inert gas blanketing. An external control unit regulates and monitors the

pressure and the flows to the corresponding chambers for each operating status of the separator. The solid-wall disc-type separator is used primarily for separating liquid mixtures with no or with only minimal solid contents (less than $< 0.1\%$ by vol.), as otherwise it would be necessary for operation to be interrupted frequently in order to remove the separated solids from the separator either manually or using flushing programs.

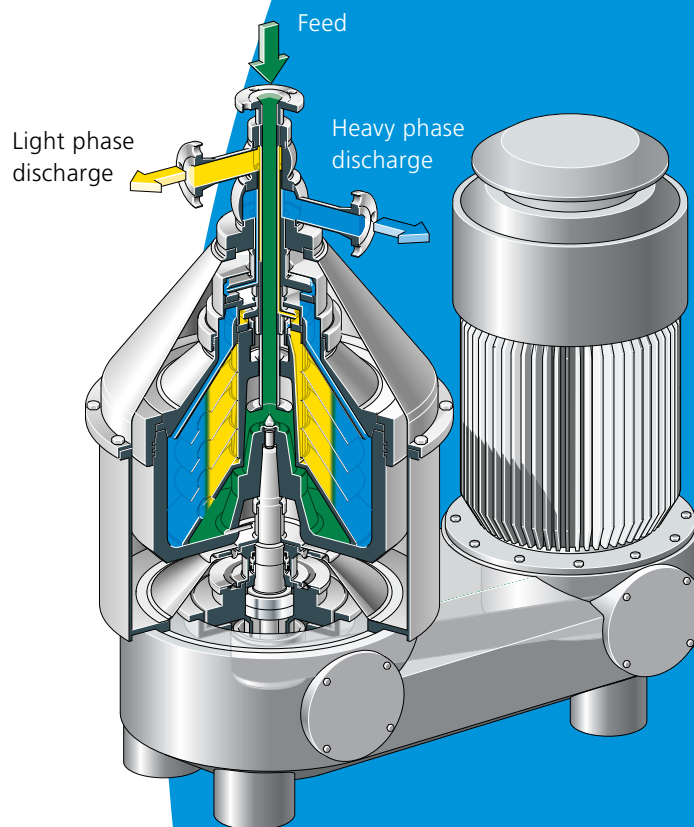


Fig. 13 Section through a bowl of a separator with solid-wall bowl

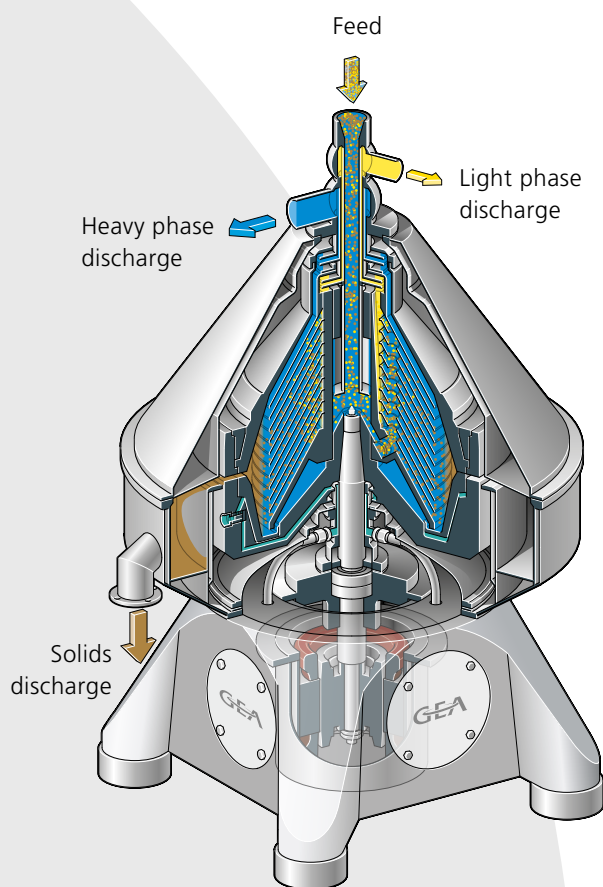


Fig. 15 Section through the bowl of a separator with a self-cleaning disc-type bowl

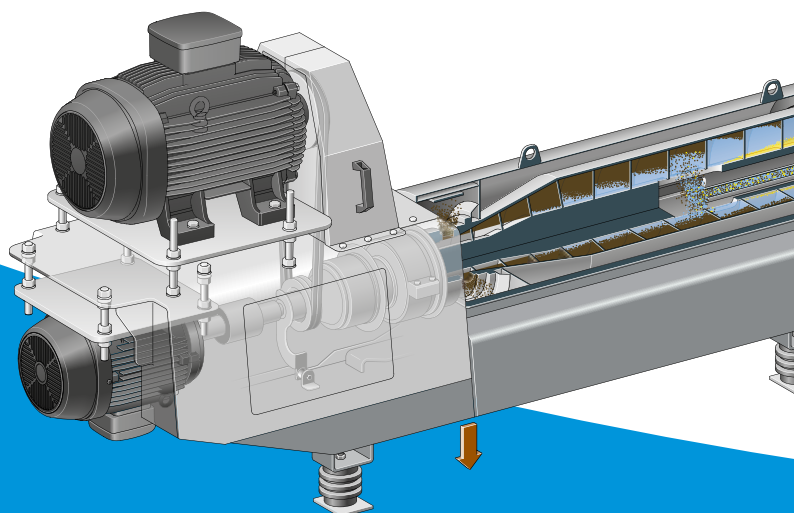
3.3.2 Separator with self-cleaning disc-type bowl

Unlike the situation with the solid-wall disc-type separator, self-cleaning separators are able to discharge the separated solids at full bowl speed, which means that they are also able to operate with products with a solid contents of up to 7 % (by vol.). However, it has to be borne in mind that separators are liquid-oriented machines and are not used primarily for removing solids.



Fig. 14 Installation with type XSC 35 separators

Fig. 16 Section through an separation decanter



3.4 Solid-liquid-liquid extraction

3.4.1 Separating decanters for extraction

Decanters are a very efficient means of carrying out liquid-liquid extraction with a high solids content. This separating decanter is a scroll-type centrifuge with a cylindrical conical solid-wall bowl. A scroll adapted to the bowl wall rotates with a differential speed inside the bowl.

These decanters are able to extract phases from the suspensions. A typical area of application for these machines is the extraction of antibiotics from fermentation solutions. The suspension to be extracted, e.g. fermentation broth with the extracting agent, flows through the external centrally arranged inlet tube and is fed into the machine via distributor slots in the scroll of the bowl. The extracted suspension (raffinate) is discharged under gravity from the discharge of the machine. The sedimented solids are conveyed by the scroll which rotates at a differential speed in relation to the bowl, and are discharged under gravity together with the raffinate. The extraction agent flows to the cylindrical end of the bowl against the flow direction of the suspension to be extracted, and is then discharged under pressure via the centripetal pump. Both phases, namely the extract and the raffinate, flow through the clarifying zones to enable the phases to be separated efficiently. In order to permit safe operation in explosive surroundings, the decanter has been provided with a gas-tight design and can also be blanketed with inert gas.

3.5 Solid-liquid extraction

3.5.1 Clarifying decanters

Before entering the decanter, the extraction product, which has previously been comminuted, broken down or ground down, is mixed intensively with the extraction agent in a separate mixer. The inlet through which the suspension flows into the decanter is arranged axially in relation to the rotating bowl. The solid-wall bowl has a cylindrical section for efficient clarification of the liquid and a conical section for dewatering the solids. The scroll, which rotates with a slight differential speed relative to the bowl, conveys the solids (extraction residue) to the solids discharge at the conical end of the bowl. The extract is conveyed to the cylindrical end of the bowl where it is discharged via a centripetal pump.

3.5.2 Clarifying separators

In the case of solid-liquid extraction processes with low solid contents (up to approx. 7 % by vol.), clarifiers with a self-cleaning disc-type bowl can also be used as an alternative solution. Because of their higher speeds and clarifying area, these machines provide a higher clarifying performance than is the case with decanters.

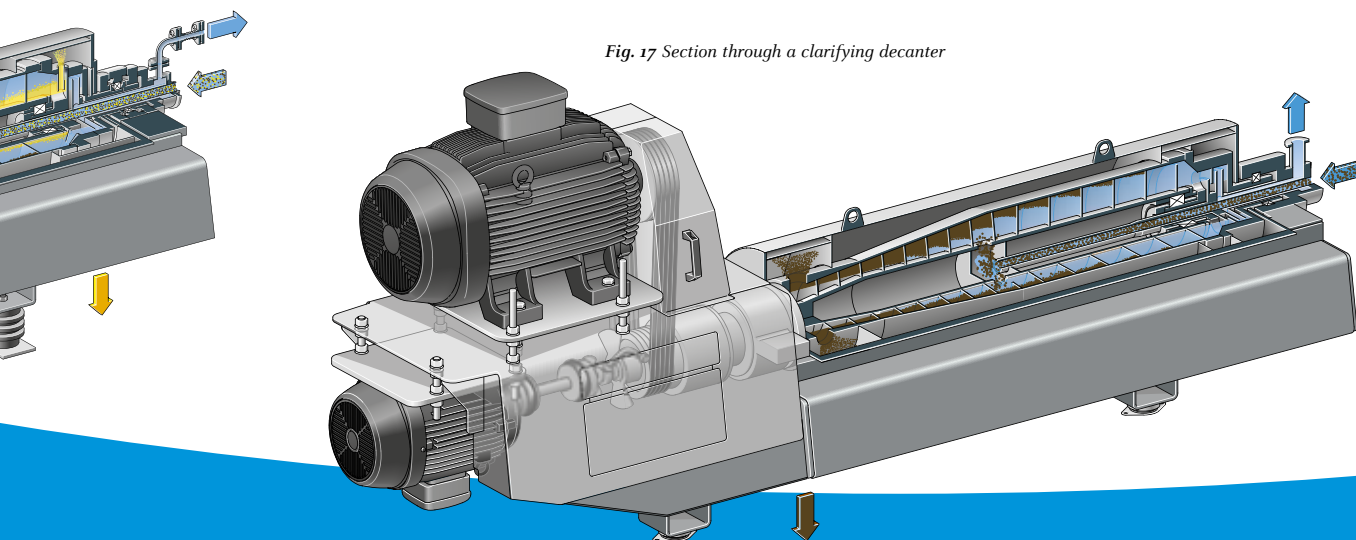


Fig. 17 Section through a clarifying decanter

3.6 Alternative processes:

Filtrate extraction or whole broth extraction

Both processes are suitable for extracting antibiotics (e.g. scraps) from a fermentation solution. The filtrate extraction process makes use of disc-type separators with an upstream filtration system.

The whole broth extraction process makes use of separation decanters (see fig. 16 Continuous counter-current decanter).

3.6.1 Filtrate extraction: Antibiotics

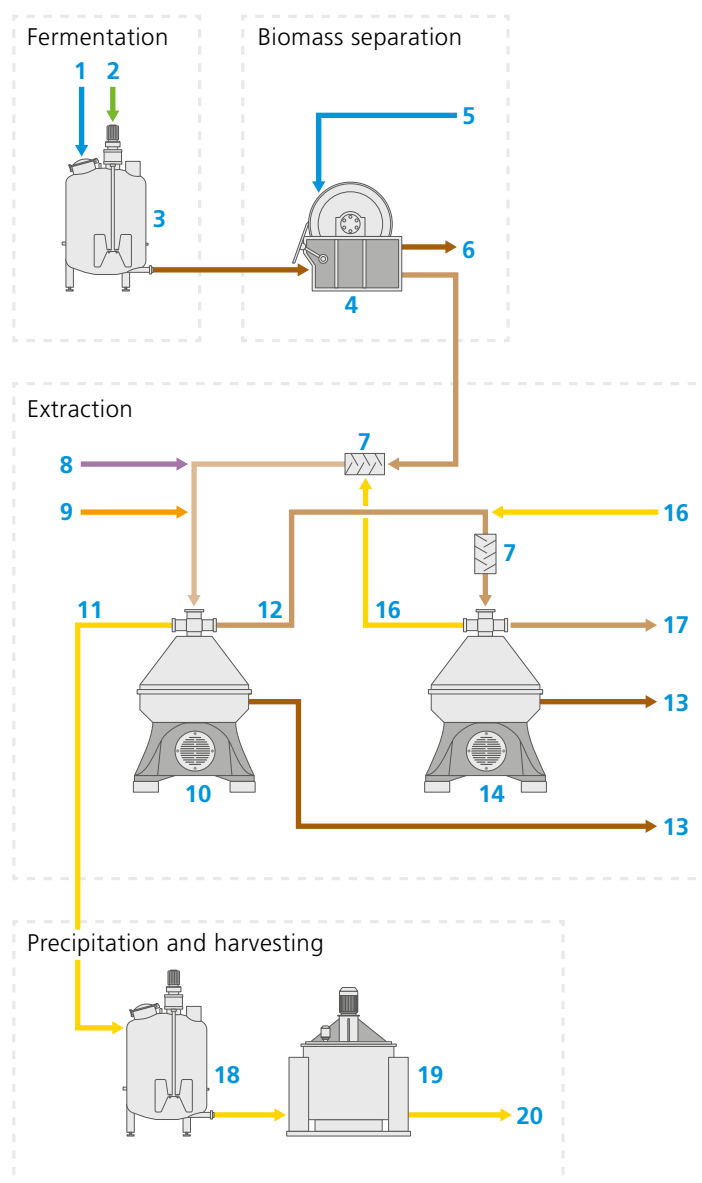
In the first step, the aqueous biomass which contains the fungal mycelium is channelled via a vacuum bowl filter and separated. The filter cake which forms on the bowl is washed with water in order to achieve a maximum yield of penicillin. Subsequently, sulphuric acid is added in order to change the pH value in such a way that the conditions for mass transfer are optimized. The addition of wetting agent ensures higher separating efficiency during the extraction process. The aqueous fermentation solution from which most of the solids have been removed is then conveyed to the first disc-type separator in the

2-stage counter-current extraction stage, where it is mixed with the solvent from the second separator which already contains penicillin. The solvent which is discharged from the first separator is subsequently precipitated and processed in centrifuges until the provisional end product – penicillin raw salt – is obtained in the purity required by the manufacturer. The maximum efficiency of the two separators is maximally equivalent to that of two theoretical stages, and is 94 – 96 % measured against the feed to the first separator. However, the filtration stage upstream of the extraction stage means that this method suffers several disadvantages compared with the whole broth extraction process:

- Increased risk of contamination due to use of wash water
- Increased use of solvent – higher energy costs for recovering valuable substance from the extraction solution (more wash water → more raffinate → more solvent → higher costs)
- Loss of valuable substance (> 5 %)
- Only filterable mycelium structures from fermentation can be processed.



FIG. 18 2-STAGE COUNTER CURRENT EXTRACTION WITH SEPARATORS



Example antibiotic extraction

Fermentation

- 1 Nutrient solution
- 2 Aeration
- 3 Fermenter

Biomass separation

- 4 Drum filter
- 5 Wash water
- 6 Waste biomass

Extraction

- 7 Mixing device
- 8 Acid or caustic
- 9 Demulsifier
- 10 1st stage separator
- 11 Extract 1st stage
- 12 Raffinate 1st stage
- 13 Solids waste
- 14 2nd stage separator
- 15 Fresh solvent
- 16 Extract 2nd stage
- 17 Raffinate 2nd stage

Precipitation and harvesting

- 18 Precipitation tank
19 Basket centrifuge
20 Antibiotic raw substance

3.6.2 Whole broth extraction

The use of decanters offers major advantages. The decanter is able to extract suspensions with a solids content of up to 60% (by vol.), which means that only a single stage is necessary for separating the solids (the fungal mycelium) from the fermentation solution and for extracting the valuable substance (the antibiotic). This means that the prefiltration stage can be dispensed with and that the extraction stage can be installed directly downstream of the fermentation stage. Sulphuric acid and wetting agent are added to the fermentation solution, which is then processed in the 2-stage counter-current process.

The yield of two extraction decanters operated in a counter-current arrangement is 95 – 96%. Laboratory trials have demonstrated that, depending on the particular substance system, a theoretical stage coefficient of up to 1.7 per extraction decanter is possible. In order to separate very fine solid particles, the solvent (extract) which is discharged from the first extraction decanter can be polished in a downstream disc-type separator; this enables extremely pure extract to be obtained. The following process stages – precipitation tank and basket-type centrifuge – are identical to the final stages of counter-current extraction with disc-type separators.

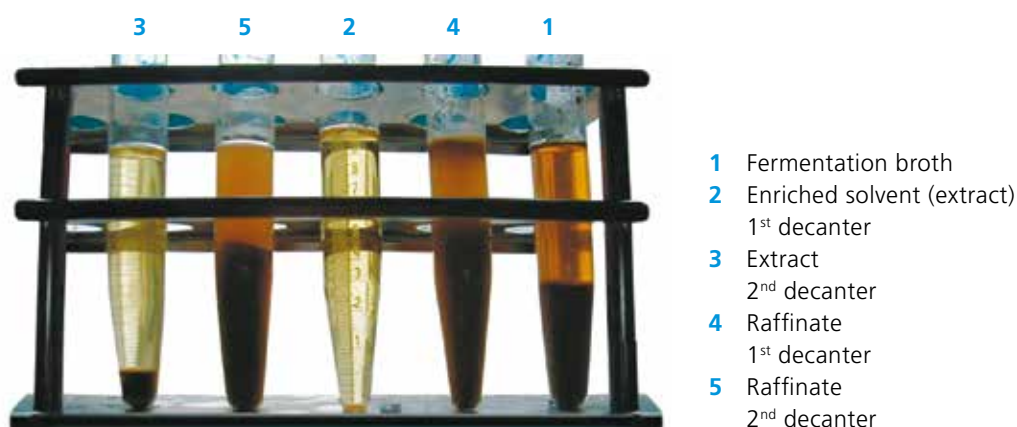
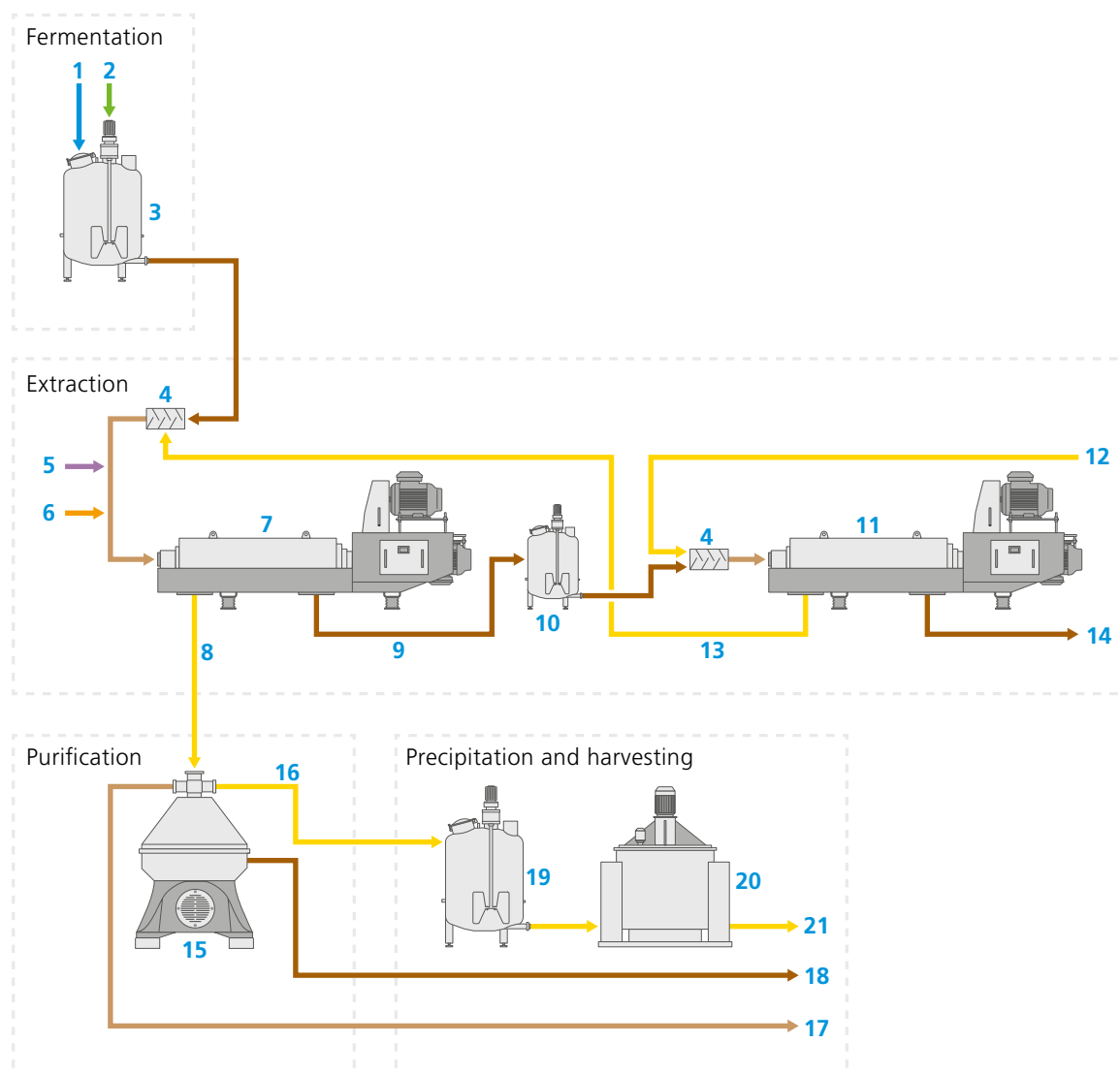


Fig. 19 Spinning samples of a 2-stage direct extraction

FIG. 20 2-STAGE COUNTER CURRENT EXTRACTION WITH DECANTERS

Example antibiotic extraction

Fermentation

- 1 Nutrient solution
- 2 Aeration
- 3 Fermenter

Extraction

- 4 Mixing device
- 5 Acid or caustic
- 6 Demulsifier
- 7 1st stage decanter
- 8 Extract 1st stage
- 9 Raffinate 1st stage

- 10 Buffer tank

- 11 2nd stage decanter

- 12 Fresh solvent

- 13 Extract 2nd stage

- 14 Raffinate 2nd stage

Purification

- 15 Disc separator
- 16 Light liquid (extract)
- 17 Heavy phase discharge
- 18 Solids waste

Precipitation and harvesting

- 19 Precipitation tank
- 20 Basket centrifuge
- 21 Antibiotic raw substance

4. Explosion-proof centrifuges

Specific centrifuges are used in the chemical and pharmaceutical industry for clarifying and separating readily pharmaceutical flammable liquids. Theoretically, such applications can result in critical concentrations of solvent vapours and oxygen inside the centrifuge that can cause explosions or fires. However, the vapours must also be prevented from escaping so as not to pose a risk to the health of the operators. Both these risks can be prevented reliably by using gas-tight centrifuges from GEA.

No sparks, no static charges, no hot bearings – the test criteria of the strict European ATEX standard are of course implemented in all GEA explosion-protected centrifuges. In addition, before the start of operation, the centrifuge is flooded with inert gas and blanketed with a slight excess pressure so that no further oxygen is able to penetrate. This is because fire is not possible without oxygen. When processing sensitive liquids, the necessary inert gas atmosphere in the separator is automatically monitored throughout the entire operation.

ATEX 95 (directive 94/9 EC)

A directive for machines operating in hazardous surroundings has been in force in Europe since 1 July 2003. This affects numerous applications in the chemical and pharmaceutical industries, particularly where gas-tight machines are used. According to the directive, the first step is to carry out a risk assessment of the relevant machines to identify any present or potential risks.

The measures are documented and the documentation is submitted to an Entitled Body. In specific terms, this means that GEA decanters are now equipped with failsafe vibration monitoring equipment, a temperature measurement facility as well as an inert gas facility.

All electrical equipment must have been awarded an ATEX certificate or a manufacturer declaration. This directive is only applicable to new machines. A separate directive ATEX 137 (directive 1999/92 EC) is applicable for operators of installations in hazardous areas. In this way, operators have also been obliged to carry out risk assessments for existing installations.

GEA improves inert gas concept

Requirements with regard to safety and reliability have become more stringent for separators and decanters used in zones with a risk of explosion. The existing inert gas concept is constantly improved to meet these requirements. The latest European standards, as well as GEA's practical operating experience, are incorporated in the concept. As has been the case with most existing concepts, the atmosphere in the separator is displaced with inert gas before every start-up and the excess pressure is maintained during operation to meet the requirement for minimum inert gas consumption.

The fittings and measuring devices used have been subject to an extensive test and have also been optimized as far as investment costs are concerned. The new inert gas supply facility complies not only with the familiar directive 94/9 EC (ATEX) but also with the TA Luft, i.e. product leakages from the equipment are reduced to a minimum using state-of-the-art technology.

GEA places great emphasis on complete and easy-to-understand operator documentation as well as a carefully performed conformity assessment procedure (CE symbol). The company also provides information concerning the correct installation of separators and decanters in zones that are exposed to the risk of explosion.



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