Liquids to Value

Separators from GEA Westfalia Separator for the Dairy Industry

GEA Mechanical Equipment / **GEA Westfalia Separator**

Contents

1. Dairy Technology Today

Today, there are applications for separators in all areas of milk processing such as:

- Warm milk separation
- Cold milk separation
- Whey separation
- Buttermilk separation
- Milk and whey clarification
- Milk standardization
- And the removal of bacteria from milk and dairy products

The processing of certain products such as:

- Quark (soft cheese)
- Double cream cheese
- Butteroil
- Low-fat whey powders, such as WPC's
- Optimization in production of lactose
- Recovery of single fractions such as fats and proteins is no longer possible without the aid of specially designed separators

All the separators represent the state-of-the-art in centrifuge construction. They can be operated continuously and offer the highest level of product safety and efficiency.

Continued rationalization and automation in dairies has made it necessary for engineers to modernize old processes and develop new ones. Centrifugal separators are playing an important part in this 'rethinking' process.

The advanced technological sophistication of separators enables the updating of processes to meet modern economic demands. Today's separator installations, incorporating cleaning-in-place (CIP) systems, can be operated 24 hours a day.

Westfalia Separator® hy**vol**® separators with integrated Westfalia Separator **pro**plus system

When it comes to making decisions about new investments, GEA Westfalia Separator offers a new standard in milk processing.

Westfalia Separator hy**vol** separators brand the new separator generation that combines the excellent features of the Westfalia Separator hy**vol** separators with the Westfalia Separator **pro**plus system.

A new generation milk separator with 'SoftStream' inlet system, type MSE 500-01-777

Fast payback times and additional profit from the raw milk used throughout the entire lifecycle are the results you can expect right from the outset.

Westfalia Separator hy**vol** separators with **pro**plus system give you the following benefits:

- **pro**plus system
  Increased protein yield, reduced water consumption, reduction of the solids volume
- Absolute availability
  High throughputs, high efficiency, high economy, a universal solution
- Absolute integration
  Flexible processing, high product quality
- Absolute product protection
  Gentle feed system, gentle product treatment
- Absolute intelligence
  Easy operation, uniform solids discharge, optimum yield
- Absolute economy
  Low maintenance costs, low operating costs, low water consumption, low energy requirement
- Absolute robustness
  Problem-free operation, service-friendly, long service life

Westfalia Separator®
proplus

Westfalia Separator®
hy**vol**

2. Factors Affecting Creaming of Whole Milk

Next to protein, milk fat is the most valuable component of the milk. Based on the dry matter content, the milk fat constitutes about 30 percent of the milk.

The following interdependent criteria and variables are of great importance:

- Nutritive value
  Variables: breed of cow, lactation time, climate and feeding
- Physical properties
  Variables: mechanical and heat treatment
- Chemical properties
  Variables: enzyme reactions, bacterial influence
- Economic importance
  Variables: efficiency of mechanical separation processes

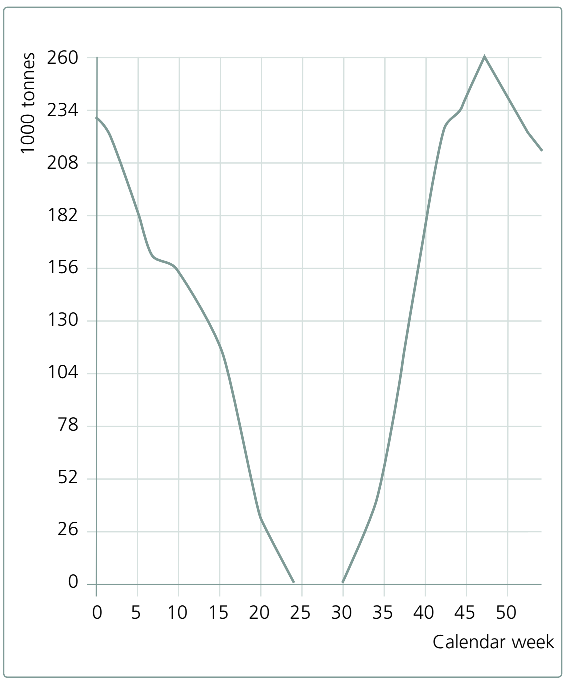


Fig. 3
Proportion of delivered milk in an annual cycle

Whole milk average values:
Fat: 3.7 – 5.3 %
Protein: 3.3 – 4.3 %

In addition to explaining the design possibilities of centrifugal separation technology as applied to the separation of whole milk, this document deals in particular with a number of important technical and engineering parameters that have a decisive influence on the residual fat content in the skim milk.

2.1 Factors affecting milk production

2.1.1 Breed of cow, climate, feeding conditions

Apart from a number of individual tests which do not represent an acceptable cross section, insufficient tests have been carried out to provide indisputable evidence of the effect of the relationship between the mentioned factors on the separability of the whole milk. It can be said, with certainty, that seasonal differences in the separability of the whole milk do occur. These seasonally-dependent deviations can vary in intensity depending on the differences in the amounts of milk delivered. Deviations occurring in the nutritive value of the feed type composition and little or no control of the lactation periods can lead to variations in the amount of milk delivered. However, the effect on separability also depends on differences in the sizes of the fat globules dispersed in the whole milk.

Figures 3 and 4 are extreme examples of differences in the amounts delivered which are typical for the dairy industry in New Zealand.

2.1.2 Mechanical strain in milk production

The various sequential processes that are part of milk production greatly influence the separability of the whole milk.

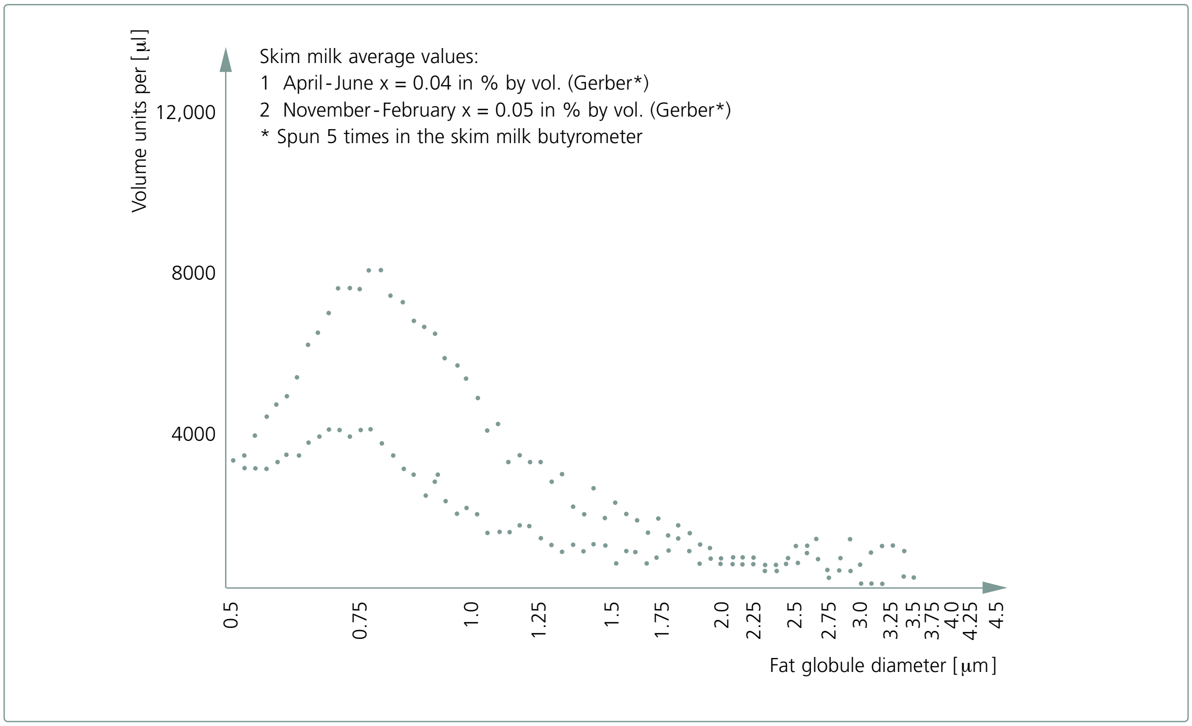


Fig. 4
Size distribution of the fat globules in an annual cycle

These include:

- Preserving extraction of the milk
- Transport of the milk through the milking plant. Care must be taken to separate the air necessary for transport of the milk as much as possible from the milk itself

Necessary to achieve this are:

- Low vacuum level
- Minimal inclines in the pipeline system
- Avoidance of leaks in the pipeline network
- Adequate pipeline cross-sections for the capacity of the plant

As can be seen from figures 1 and 2, the air used to transport the milk is worked into the milk if pipeline cross-sections are small.

In the case of large capacity cross-sections 3 and 4, the air has adequate space above the milk.

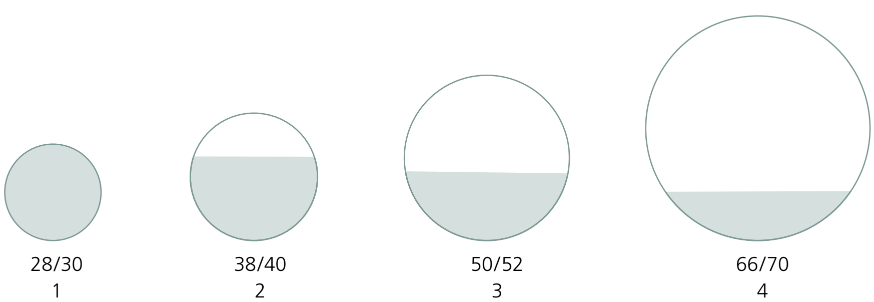


Fig. 5
Diagram of different milk line diameters for the same milk flow

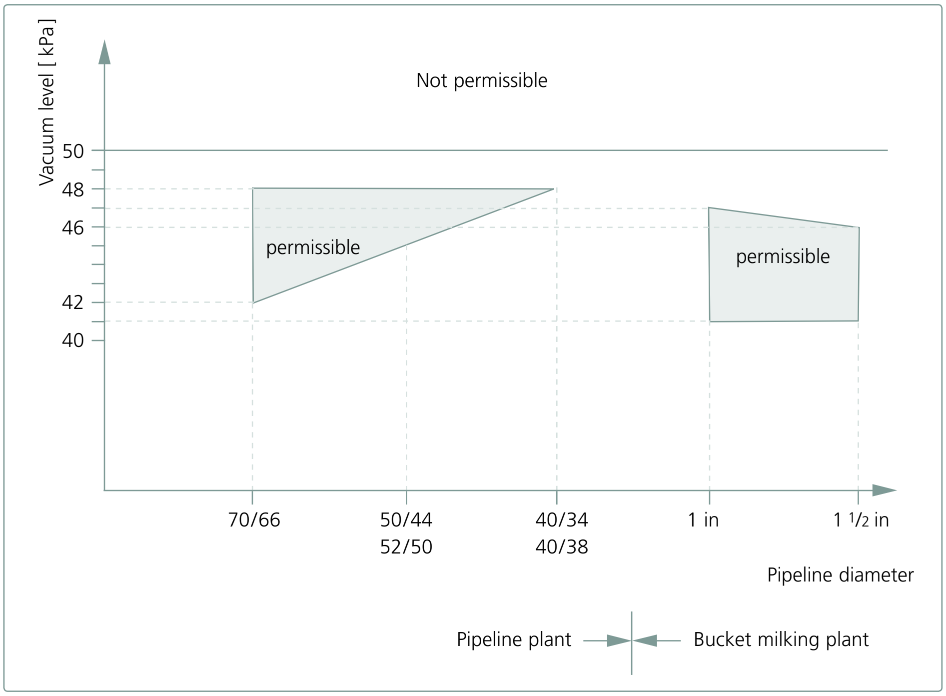


Fig. 6
Diagram of the permissible vacuum levels in milking plants

If optimum transport of the milk is to be achieved, the absolute vacuum level must be adjusted so that it is commensurate with the energy consumed. Fig. 6 gives the different permissible vacuum ranges for pipeline and bucket milking plants, as well as the relevant pipeline diameters.

Cooling of the milk on the farm is also of great importance.

Here, attention must be paid, among other things, to the following:

- Avoidance of foaming, particularly when the milk from the first milking is fed into large refrigerated tanks
- Large temperature fluctuations by thermostatic control which have switching intervals of e.g. 3 – 4°C (37°F - 39°F)
  In comparison, switching intervals of approx. 1 °C (34°F) can be achieved with electronic thermostats. This helps to reduce the danger of icing of the milk, particularly with the milk from the first milking, e.g. by setting the cooling temperature to 3°C (37°F)
- Entering the area of critical temperature

According to Prof. Kessler, Weihenstephan, particularly high levels of free fat (FF) can be produced by mechanical strain, e.g. by the stirring process, in the temperature range of 20 – 30°C (68°F - 86°F). As can be seen from the diagram, a 'small' optimum area occurs in the production of free fatty acids (FFA) in the temperature range of 15 °C (59°F).

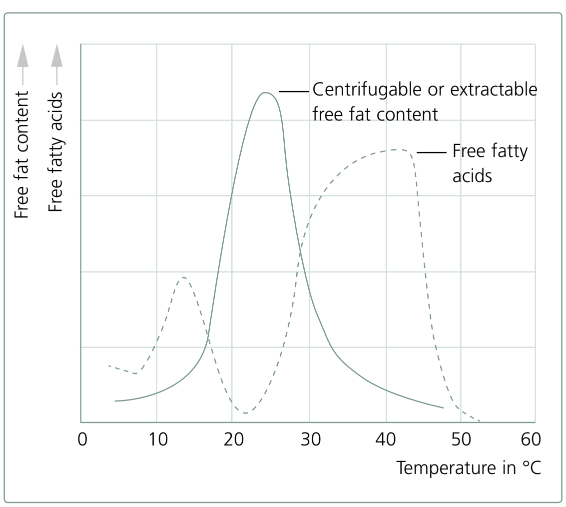


Fig. 7
Quality curve of the free fatty acid content and free fatty acids after mechanical strain of the milk or cream

Fig. 8
Cooling the milk
on the farm

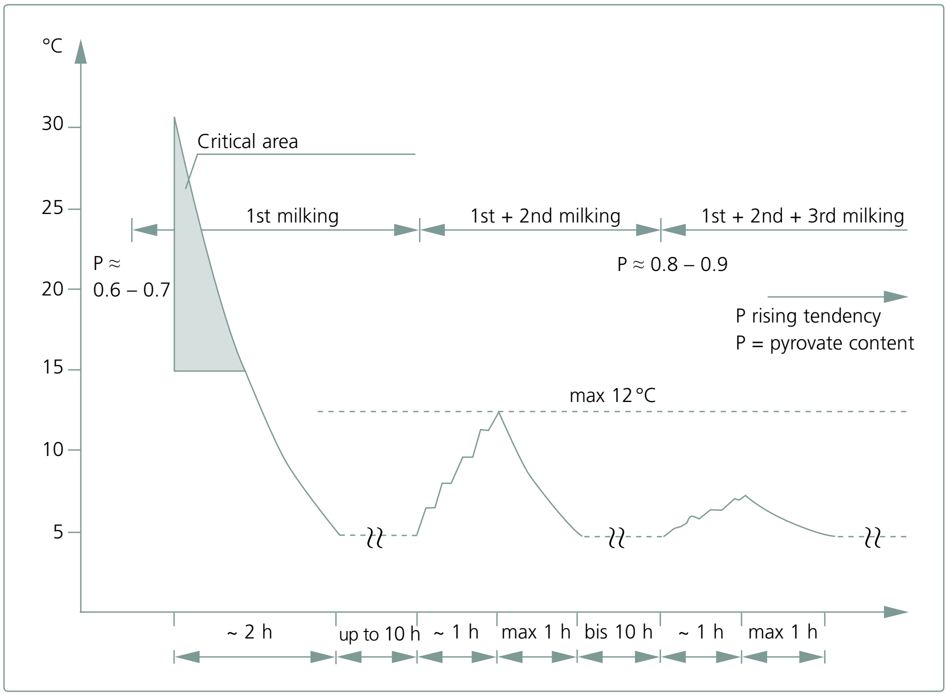


Fig. 8 shows that in fact only in the case of the first milking is there danger of damage to the fat, as the second and all other milkings do not enter the critical temperature range owing to the instantaneously occurring mixing temperature.

2.2 Factors affecting milk processing

2.2.1 Transporting the whole milk to the dairy

Care must be taken when transporting the whole milk that the cooling chain is not broken. Consequently the milk transporting vehicles must be equipped to suit the transporting times and climatic conditions.

The motion of tank vehicles only partially filled causes turbulence in the liquid, and this can damage the milk. Correct cleaning of the tank (CIP) is essential.

2.2.2 Milk reception, whole milk store

Three particularly important conditions must be met with respect to the intake of the milk at the dairy if the separability of the whole milk is not to be impaired.

First of all, it is important to avoid as much as possible the entrainment of extraneous air during emptying of the milk truck and filling of the tanks. The type and design of the agitator can also affect the milk.

Normally it is not possible to completely avoid the entrainment of air in the milk. Consequently, the whole milk should be given sufficient time to ‘de-gas’ before further processing. For this reason, the whole milk should not be fed directly from the milk truck into the processing line.

It is also important to ensure that each pumping process employed for conveying the milk has optimum hydraulic efficiency. If the feed conditions are subject to fluctuation, the pumps should be equipped with a variable-speed drive. They can then be set to their optimum speed of operation via comparison of the reference and actual values, e.g. by inductive measurement of flow.

This gentle pumping process has no measurable effect on the separability of the whole milk. However, there is a negative effect with pumps that are throttled, for example to 60 – 70 percent of their maximum speed. As a consequence, an additional residual fat content of as much as 10 percent or more is obtained in the skim milk.

As shown in Fig. 9, it should not be possible to influence the operation of the pumps.

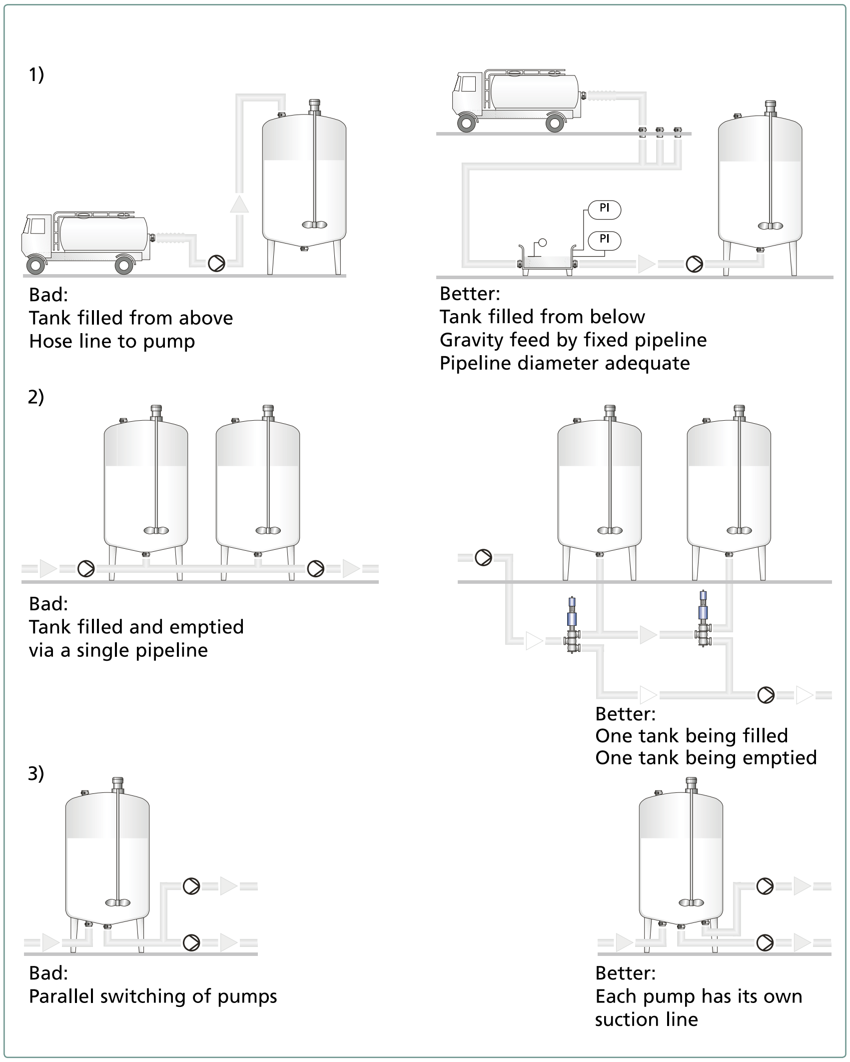


Fig. 9
Different pump operations for transporting the raw milk

Example 1) shows the problem of air entrainment. In examples 2) and 3), in comparison, mutual impairment of pump operation also leads to entrainment of air and mechanical strain of the milk. In example 3) the pump connected in parallel impairs separation efficiency by up to 1/100 percent.

2.2.3 Age of the milk

Because of the two-day collection of the milk from the farms customary today, and the consequent need to keep the milk cold at temperatures of 3 – 5°C (37°F - 41°F), the separability of the whole milk is reduced. The reason is that, as the milk is held for so long at a low temperature, very small 'water droplets' bind with the fat globules. With the whole milk simultaneously subjected to mechanical strain, e.g. due to stirring, the fat globule membrane undergoes a partial structural change. An increase in specific density occurs, on the one hand due to the exchange of the original membrane components with proteins from the serum (carrier liquid), or as pure protein absorption of the membrane. However, the greater portion remains in the skim milk, thereby increasing the residual fat content.

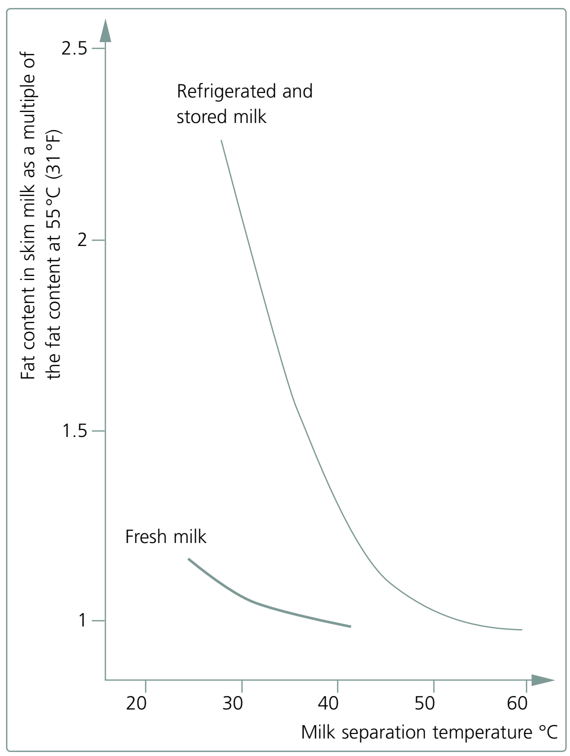


Fig. 10
Residual fat content in the skim milk after processing of cold-stored and fresh whole milk

This process is to some extent reversible. By increasing the separation temperature the fat globule membranes can be returned almost to their original state. For this reason, higher separation temperatures are used today than were customary in the past. Fig. 10 illustrates the behavior of separation efficiency as a function of the holding time at low temperature.

2.2.4 Quality of the whole milk

The separability of raw milk depends, in addition to total bacterial count, among other things on the:

- pH level
- Free fat values (FF)
- Free fatty acids (FFA)
- Size distribution of the fat globules

The influence of foreign particles is normally not important. However, if there is a high level of impurity in the milk, centrifugal clarification, e.g. directly after delivery, will improve its separability. If these influencing factors have been largely taken care of, a statement can be made as to the extent to which the whole milk has already been subjected to mechanical strain, and thereby to possible damage of the milk fat.

Statements and their limitations through detection of FFA (free fatty acids by the BDI-Method)

The values for FFA at delivery of the whole milk to the dairies obtained from the literature and our own measurements at the end of the 1960s was 0.4 – 0.5 milliequiv. / kg. If the data obtained since the middle of the 1980s is used as a base, then, in the milk producing countries with a relatively high level of industrialization of milk production, the FFA values are between 0.8 – 1.0 milliequiv. / kg as a rule today. Fig. 11 shows, among other things, the curve of the FFA taken over the course of a year in Switzerland during the second half of the 1980s. Knowledge of the FFA value has a certain importance today in judging cold, unpasteurized whole milk, butter and cheese-making processes.

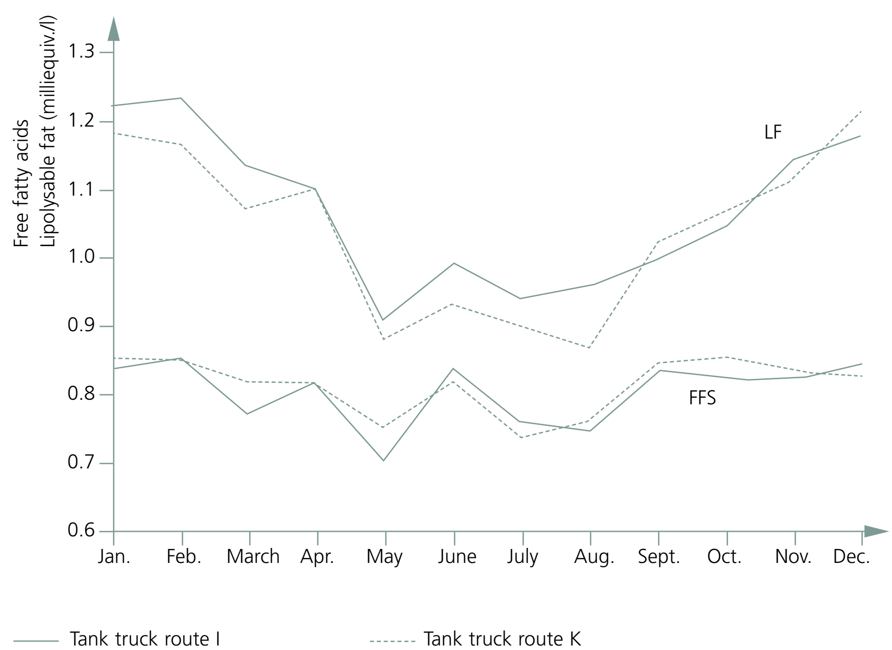


Fig. 11
Content of free fatty acids and lipolysable fat in whole milk on delivery to the dairy during the year (Zurich)

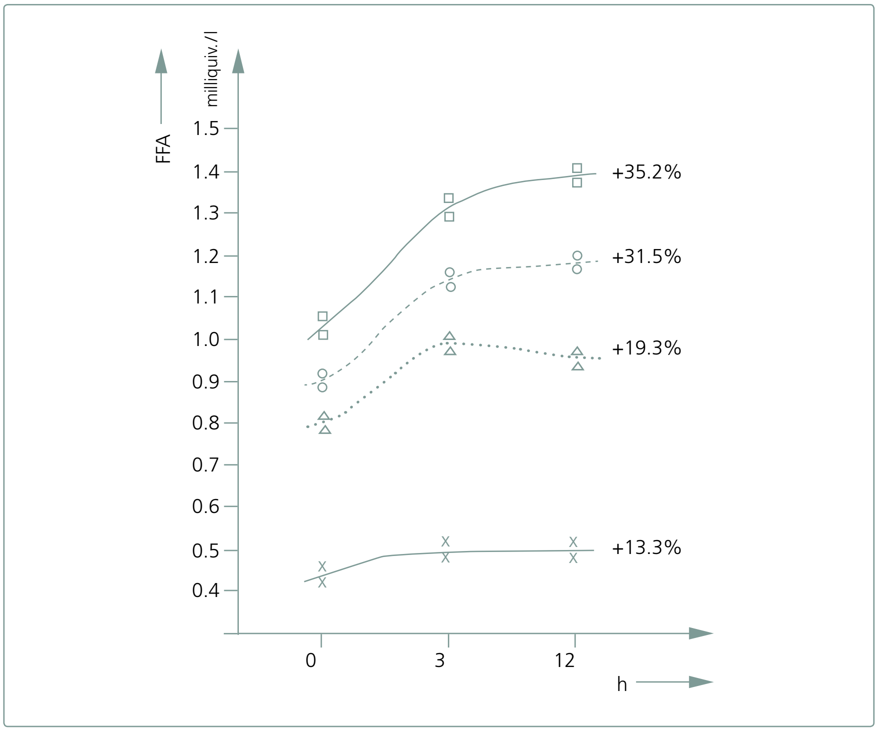


Fig. 12
FFA value as a function of the shelf life and the initial FFA value

Fig. 12 shows clearly that the results obtained depend to a great extent on the level of the initial value. The test results are thereby not reproducible.

It is quite clear even with a low FFA value that the incubation time hardly plays a part. To obtain reliable values, the incubation time should be at least 3 hours at 36 °C (97°F).

An additional factor that negatively affects the reliability of the FFA value is that the production of FFA is time dependent, because of the presence of the lipase enzyme and free fat (FF).

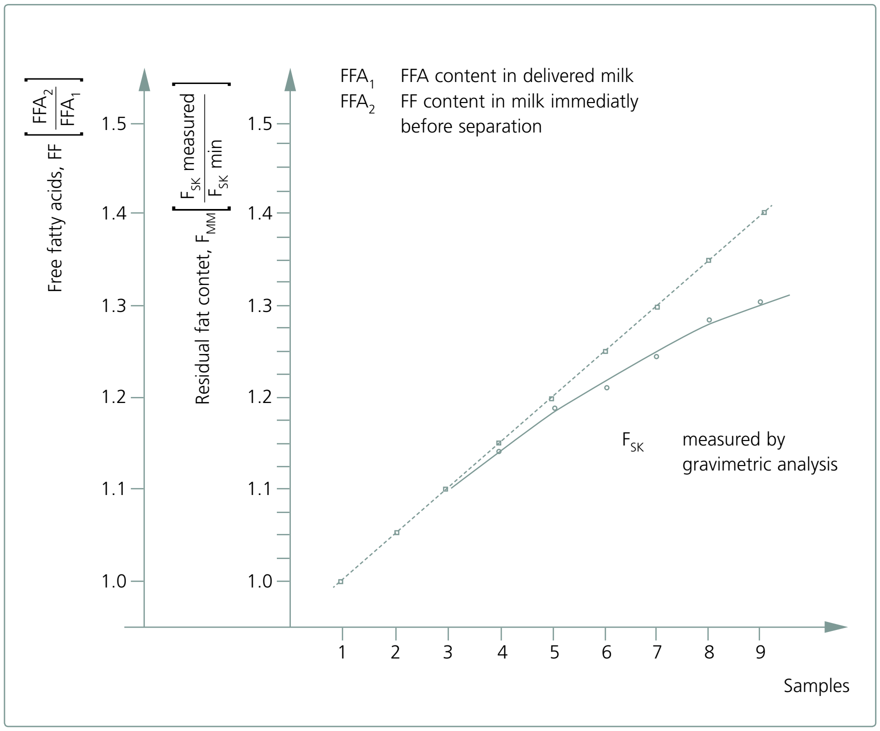
The speed of this reaction depends, among other things, on the quality of the free, or extractable fat, the amount of active lipase enzyme present and the product temperature. Consequently, the increase in FFA is not proportional to the increase in the effect on the separability of the whole milk.

As already mentioned, the product temperature has a direct influence on the reliability of the FFA values obtained. It has already been shown in fig. 8 (Milk cooling on the farm), that there are two optimum temperatures (15 °C and 40 °C or 59°F and 104°F). Moreover, the lipase enzyme is almost inactive below 10 °C (50°F) and is theoretically killed off at temperatures L 60 °C (140°F). Practical tests, however, still show negligible lipase activity above a temperature of about 50 °C (122°F).

Free fat

Methods for measuring the level of free fat (FF) which provide reliable and reproducible results have been available for some time. Two methods, the centrifugal and extraction methods can be used, however, only the extraction method gives reliable information. The difference is that the centrifugal method measures only the fat outside the fat globule membrane. With the extraction method the fat enveloped by a porous, i.e. partially damaged membrane, is also measured. The latter damage has a noticeable effect, particularly with long storage times, as the fat turns to oil with time. If active lipase is present, there is also the risk of lipolytic attack in the event of damaged membranes.

Fig. 13
Relationship between FFA values and residual fat content in the skim milk



The curve of the FFA value, (●) in Fig. 14, would lead to wrong conclusions. Test series 1 = milked by hand, shows clearly the high quality of fresh hand-milked whole milk (□). At the same time, however, there is the quite negative effect of cold storage (○,△).

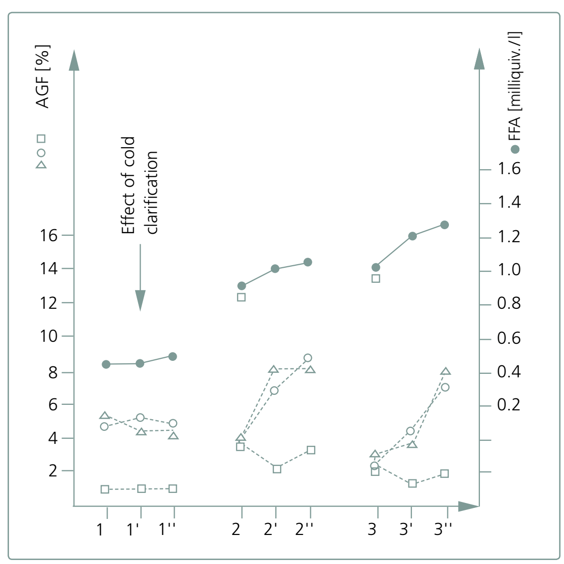
Inspection of test series (2) and (3) shows an identical tendency in the slope of the curve. This allows the following conclusions to be drawn with respect to the FF values:

- In the case of machine milked, cold-stored milk the samples must be stored for at least 24 hours at 4–6 °C (39°F - 43°F) to allow reliable testing of the FF
- An AGF value of 4 percent is given as the maximum for a still well-separated whole milk,as from 4 percent there is a steep rise in the curve to an 'upper measurement' (case 2) as early as the first basic operation (In the test the mechanical strain specifically exceeded the normal measurement)
- At 2–3 percent AGF in the initial sample the first mechanical strain (case 3) raises the FF value, but only the second takes the value from about 4 percent to the high 'upper level'

Fig. 14
Interrelation of the FF values and mechanical strain for different qualities of whole milk

1 Hand milked
2 Every 2 days from farmers i.e. 4 milkings
3 Whole milk from balance tank in dairy

□ fresh tested
○ 24 h 5–6 °C (41°F - 43°F) storage temp.
△ 36 h 5–6 °C (41°F - 43°F) storage temp.



' Mechanical basic action superposed on the milk
'' The same mechanical basic action superposed twice on the milk

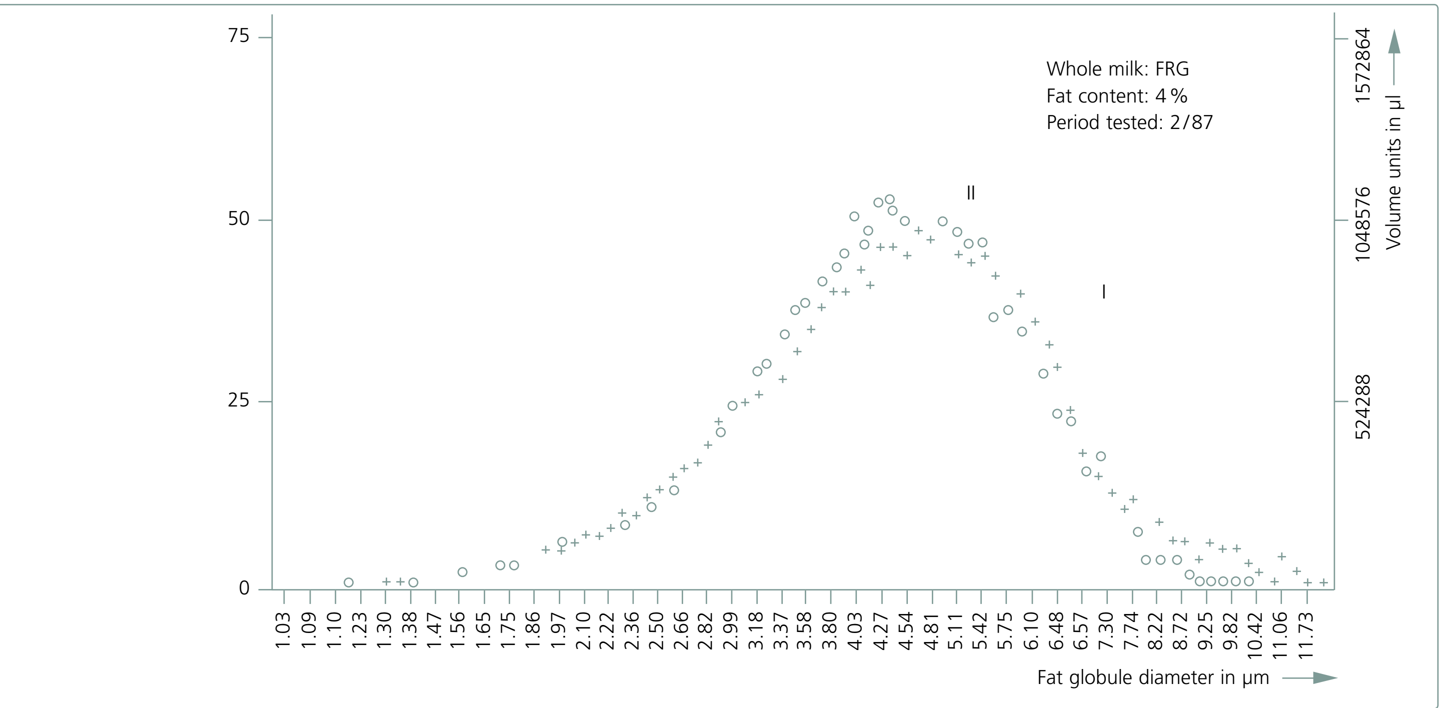


Fig. 15
Size distribution of the fat globules in the whole milk. Values I and II are for the different catchment areas.

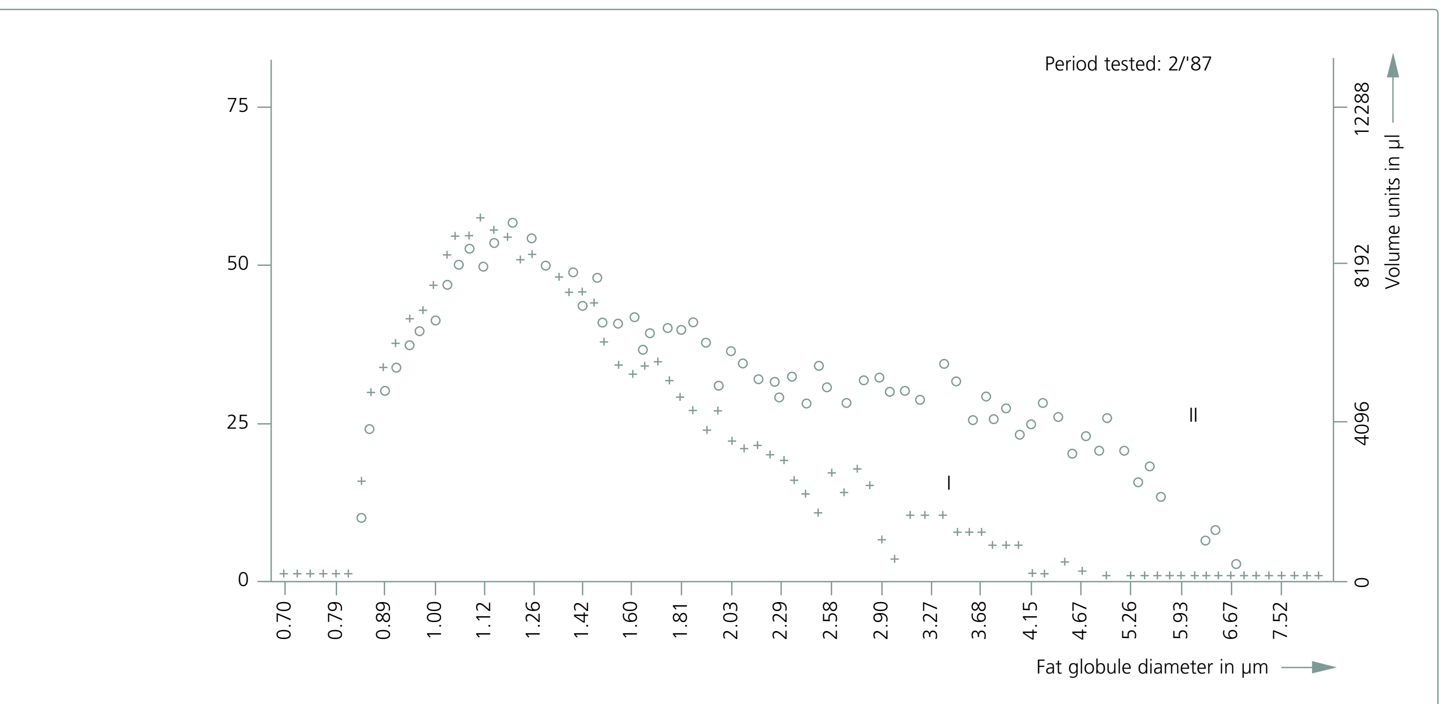


Fig. 16
Size distribution of the fat globules in the skim milk

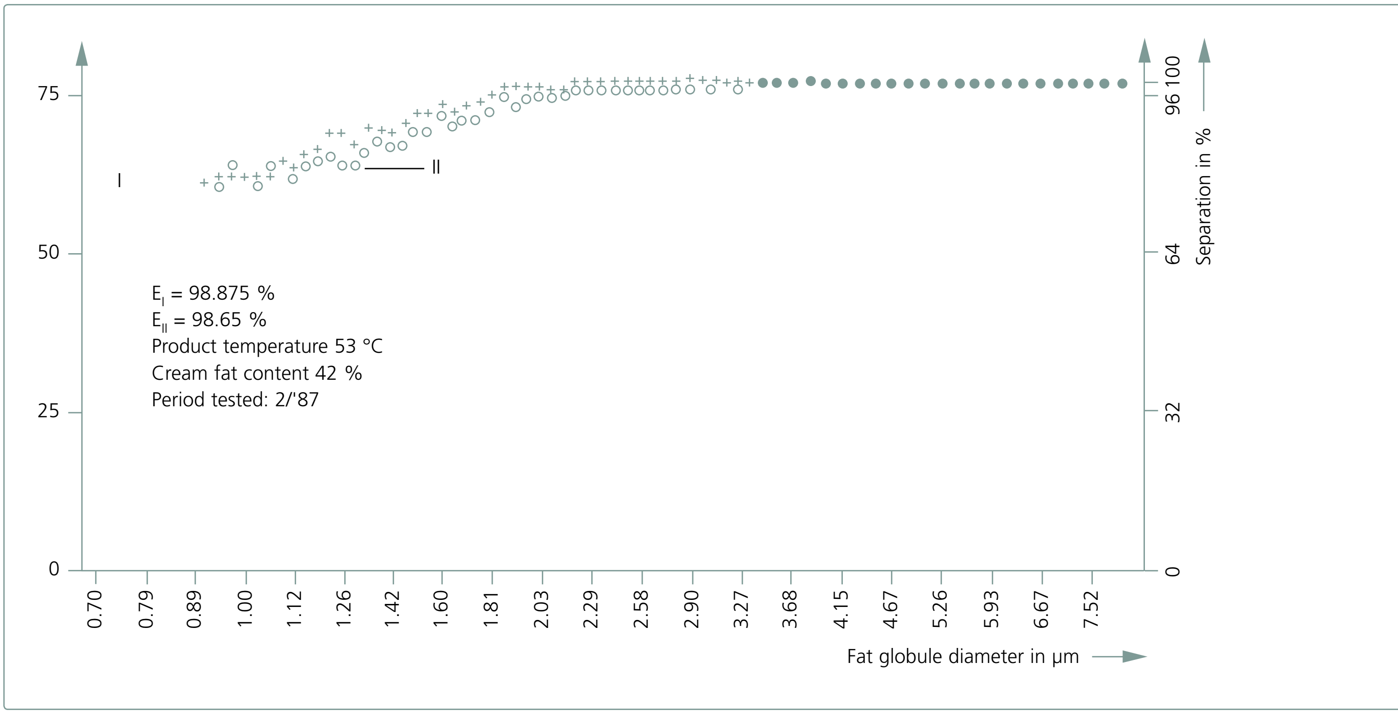


Fig. 17
Separation curves
(whole milk to skim milk)

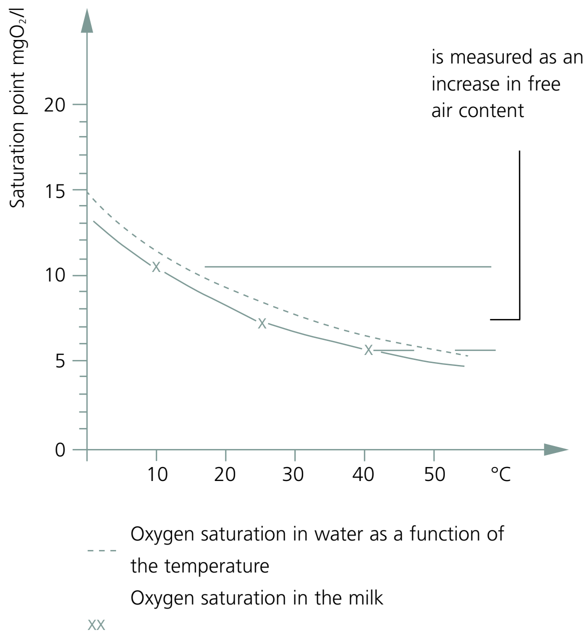
2.2.5 Size distribution of the fat globules

The relatively slight differences in the size distribution of the fat globules in the whole milk (see Fig. 15) only allow trends to be identified to a limited extent. Values I and II are for the different catchment areas. Fig. 16 shows the size distribution of the fat globules in the skim milk (SK). Curves I and II illustrate the effectiveness of the installation concepts and process parameters. However, it is possible to optimize the values in installation II. As already mentioned, the absolute residual fat content in the skim milk that would be attainable, can only be determined as a trend. By means of a particle count, the diagram in Fig. 17 shows even more clearly the difficulty of providing a reliable assessment of the quality of the separability of whole milk. Here, the size distribution of the fat globules in the whole milk and skim milk are compared. It can be seen that the separation curves I and II are almost congruent in their behavior. In comparison with Fig. 16 the skim milk II has a distinctly higher residual fat content. The residual fat levels in SK I and SK II, tested in the laboratory by the Gerber method, were 0.045 (I) and 0.054 (II).

Thus 'counting' the fat globules in the whole milk or skim milk has only limited validity. If Fig. 15 is taken for comparison, then with a clear shift of the optimum for the size distribution towards small diameters, an impairment of separability can be expected. On the other hand, the size distribution in the residual fat content of the SK (Fig. 16) does not follow the usual course. Curve II in Fig. 16, however, justifies the claim that this separation line can be optimized.

2.2.6 Effect of 'air' in the product on separation efficiency

Free air carried by the product can have a direct effect on the separation efficiency of the milk separator, in addition to the negative effect on the quality of the end product. In evaluating these effects the following should be borne in mind: whole milk generally contains a certain amount of combined 'gas'; the gas saturation point of the milk decreases with increasing temperature; gas can therefore be liberated by heat treatment.



5 mg $O_2 \triangleq$ ca. 25 mg air

$\approx 25 \cdot 10^{-6}$ kg air

This gives an air volume of:

$$V_{air} = \frac{G_L}{\varrho_L} = \frac{25 \cdot 10^{-6}}{1.293 \cdot 10^{-3}}$$

$$< 20 \cdot 10^{-3}\ dm^3$$

$$V_{air} < 20\ cm^3 \text{ (first approximation)}$$

$20\ cm^3$/Liter $\triangleq$ 2 %

Specific density of air:

$$\varrho_L = 1.293 \frac{kg}{m^3}$$

Fig. 18
Saturation point of gas in liquids as a function of temperature

If the milk is tested to ascertain the actual volumes of liberated gas, the following should be considered:

- In the case of a change in temperature, the gas absorption into the milk varies
- If the milk is exposed to vacuum, the saturation point is lowered considerably
- In the case of overpressure, the saturation point is raised only very slightly

It can be seen from the curve in Fig. 18 that with heat treatment of the whole milk in the milk separation line, gas (air) is automatically liberated. In order to be able to evaluate the 'air content' in the whole milk upstream of the separator under normal conditions.

In accordance with the diagram, approx. 5 mg O_2/l gas is liberated when the temperature of the whole milk is increased from 10 °C to 55 °C (50 °F to 131 °F). It can be assumed that the saturation behaviour of nitrogen (N_2) is similar to that of oxygen (O_2). This content of free air is not yet sufficient to impair separation efficiency.

A further increase in gas content is normally attributable to the following causes:

- The product contains foreign gas when processing commences
- The balance tanks are too small, or flow conditions in the balance tanks are unfavorable during filling and emptying
- Parts of the installation are not air-tight
- In a system under pressure, air can be drawn in without loss of product due to the injector effect
- The separator discharge pressures have not been correctly adjusted
- The pressure stages in the system are too large (a sudden drop in pressure causes 'gas' to be released)

If the volume of free air increases to values > 2.5 percent (approx. 55 °C or 131 °F), it will have a negative effect on the separability of the product in the separator.

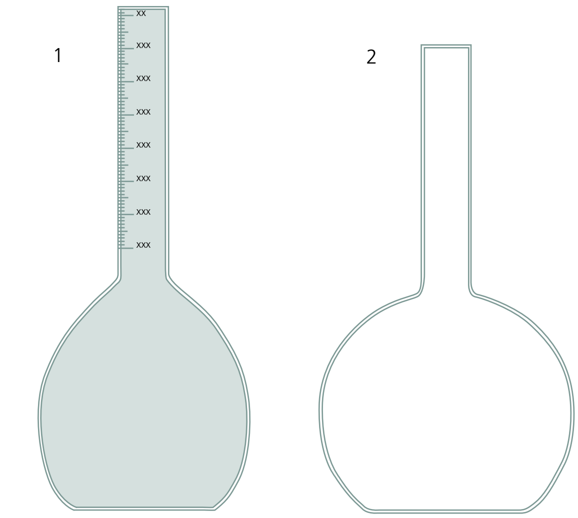


Fig. 19
Flat bottom flask
for gas tests

One reason for this is:

The dispersed air enters the disc stack of the separator with the product and, because of its low specific density, the greater part of this air is fed to the center of the bowl. Due to the falling pressure, the air bubbles expand and spread. Therefore, there is a danger if there are large amounts of air that occasional 'air blockages' will occur in the product flows, with a resulting negative effect on separation efficiency.

On the other hand, air bubbles, which bind with the membranes of the fat globules in the event of pressure changes, cause damage to the membranes. This results in an increase in FF content and impairment of separability.

Extensive testing in the years from 1985 to 1987 at the southern German Testing and Research Institute for the Dairy Industry, Weihenstephan, have confirmed the direct influence of increased air content on the separability of the whole milk.

If tests for gas are to be carried out in existing installations, the following should be considered:

- When samples are taken, no additional foreign gas must be allowed to get into the sample
- Attention must be paid to temperature when there are different sampling points
- To avoid gas bubbles, only slender sampling vessels should be used (see Fig. 19)
- The samples are placed in a water bath at the same temperature as the samples themselves. The samples are then de-gased for max. 20 min.

A further, relatively simple method of testing for entrainment of foreign gas, e.g. in complex enclosed systems, is to install sight glasses at special points on the pipelines. Then when operating with water, it is possible to observe at these points whether the water is clear or turbid. The latter indicates that free air has entered the water because of leakage.

2.2.7 Separation temperature

2.2.7.1 Warm milk separation

Other effects of product temperature on the level of the residual fat in the skim milk are described in this section. If the separation of a fat globule from its 'carrier liquid' (skim milk) in the separator bowl is considered as a physical process, then the sedimentation speed between the discs is subject to Stokes's Law.

$$v_Z = \frac{d^2 \cdot \Delta\varrho}{18 \cdot \eta} \cdot g \cdot \zeta$$

v_z = settling speed in centrifugal field [m/s]
d = diameter of fat globule [m]
$\Delta\varrho$ = $\varrho_1 - \varrho_2$
ϱ_1 = density of the skim milk [kg/m^3]
ϱ_2 = density of the fat globules [kg/m^3]
η = dynamic viscosity [kg/ms]
γ = acceleration due to gravity [9,81 m/s^2]
ζ = centrifugation coefficient $\left[\zeta = \frac{r \cdot \omega^2}{g}\right]$
r = radius [m]
ω = angular velocity $\left[\frac{1}{s}\right]$

As the equation shows, the speed of sedimentation depends on the following:

- Difference in density between the particles to be separated (e.g. fat globules)
- Particle size
- Viscosity of the liquid
- Bowl speed
- Bowl radius
- Settling area of the discs

The figures illustrate the temperature dependence of the product parameters (η and ϱ). From Fig. 20 it can clearly be seen that the optimum product temperature is around 55 °C (131°F), since the dynamic viscosity of the milk is virtually stable in this temperature range and protein precipitation must be expected at higher temperatures. At product temperatures > 60 °C (140°F) there is already 'precipitation' of proteins, which has a negative effect on separability. These proteins form a thin-film segment on the surface of the disc, and with disc interspaces of only 0.3 to 0.6 mm, these deposits have a detrimental effect on the conditions of flow. Fig. 22 shows the flow conditions of the product components being separated in a disc interspace. A fat globule is considered to have been

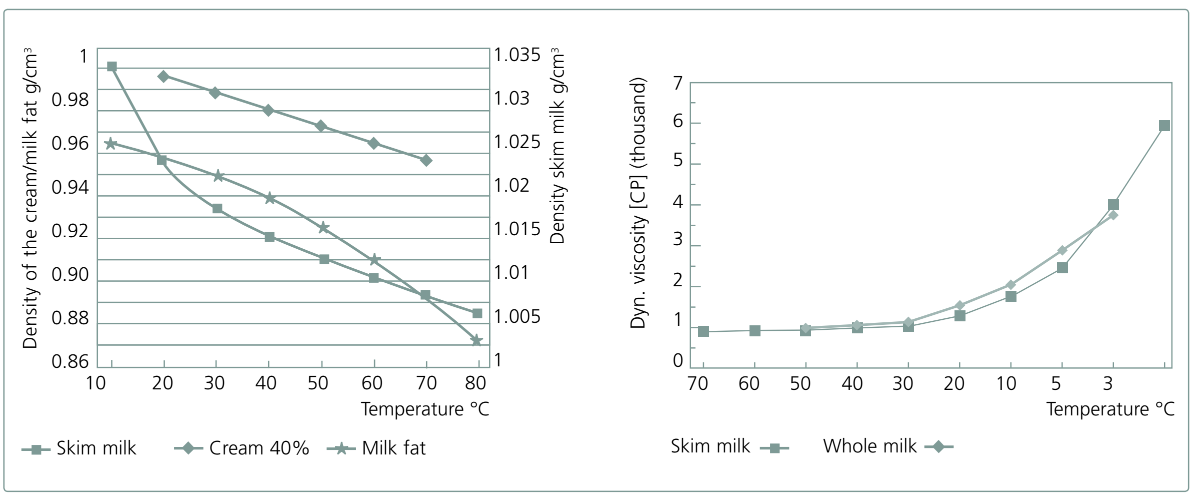


Fig. 20
Density and dynamic viscosity as a function of the temperature

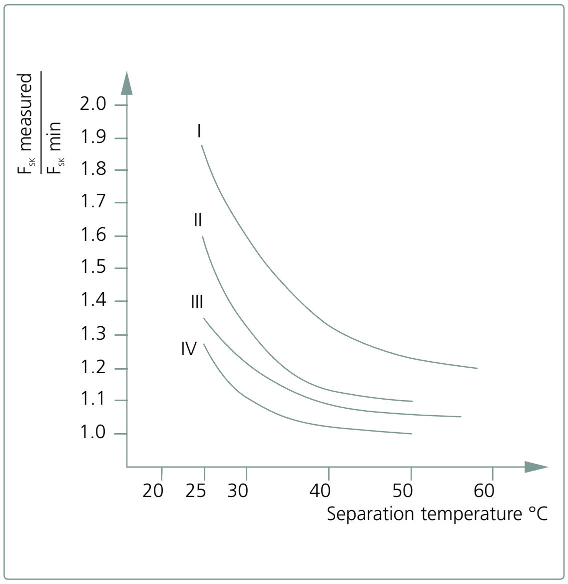


Fig. 21
Residual fat content in the skim milk at different cold-storage times of the whole milk and separator types as a function of the separation temperature

I Cooled stored milk MSA system
II Fresh milk MSA system
III Cooled and stored milk MS-.-separator with SoftStream system
IV Fresh milk MS-.-separator with SoftStream system

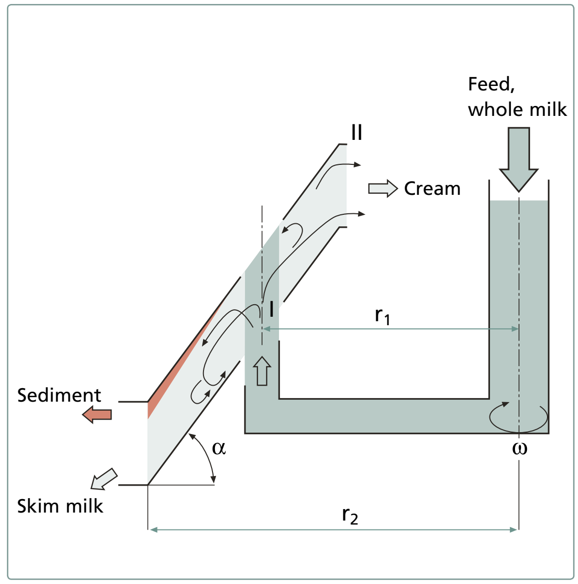


Fig. 22
Single separation space in a milk separator

removed from the liquid when it reaches the upper surface of the disc below. Due to the negative value for $\Delta\varrho$ in the formula for the sedimentation speed v_z, the fat globule moves inwards against the centrifugal field in the disc interspace towards the center of the separator bowl. A second reason is that the tendency for fat globules to agglomerate decreases drastically above 60 °C (140°F). The consequence to be drawn from this is that all process steps which significantly increase or decrease the dynamic viscosity of the liquid are to be avoided. Thus, the mixing of additives with the whole milk, such as proteins or skim milk concentrates which would increase the dynamic viscosity, is to be avoided, as this can only be compensated to a limited extent by adjustment of the separation temperature. It can also be seen that the addition of homogenized milk ('recycling') to the whole milk has an overall negative effect on the fat balance. This is because of the over-proportional accumulation of very small highly dispersed fat globules in the skim milk, which reduces the density difference $\Delta\varrho$, so that the sedimentation speed is reduced. However, the admixing of whole milk with the skim milk has a positive effect. It allows badly separated skim milk to be re-separated in the centrifuge, so that a better residual fat content can be achieved in the total balance. The reason for this is not in the significant change in the parameters of the product, as the change in $\Delta\varrho$ relates to the solids particles to be separated out, but in an improved agglomeration of the smaller fat globules to produce a larger volume density of the fat globules. Separators that have been specially designed for warm-milk separation operate with a minimum product temperature between 20 °C (68°F) and 25 °C (77°F). This is because the viscosity of the cream increases drastically with falling temperature. In addition to a reduction in the sedimentation speed, it also results in reduced fluidity of the cream. A further reduction in temperature would lead to blockage of individual flow paths. Even at 20 – 25 °C (68°F -77°F) the fat content of the cream should be adjusted to approx. 15 percent fat. It is therefore not expedient, e.g. to separate cold milk at 15 – 25 °C (59°F -77°F) under normal circumstances, as the optimum temperature for damage to the fat is 25 °C (77°F), and for the formation of FFA 15 °C (59°F). On the other hand, product temperatures of 4 – 12 °C (39°F -54°F) can be accommodated in specially designed cold-milk separators without difficulty.

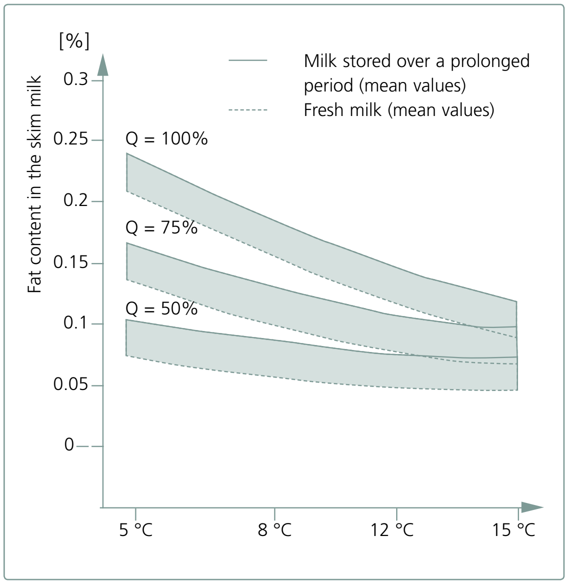


Fig. 23
Skim milk fat content according to Röse-Gottlieb as a function of the separation temperature and rated capacity

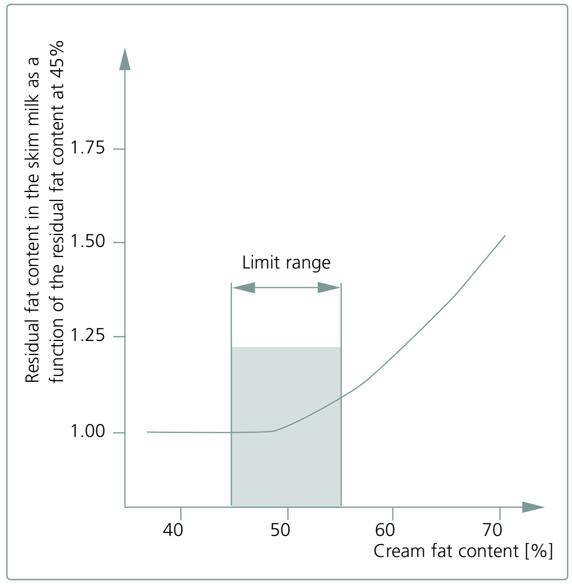


Fig. 24
Residual fat content in the skim milk as a function of the fat content in the cream

2.2.7.2 Cold milk separation

A basic mode of operation of the cold milk separator is to control the cream flow by adjusting the pressure of the product feed. By means of this pressure, the cold, 40 percent cream can be made to discharge from the center of the separator bowl under pressure, in spite of its extremely high viscosity. However this can only be achieved with the aid of hermetically-sealed product feed and cream discharge lines. When we consider the sedimentation speed in cold milk separation, we find that it is influenced by the increased dynamic viscosity. Flow characteristics of the cream are also affected, so that separability is considerably less than with warm milk separation. The relatively low residual fat content in the skim milk shown in Fig. 23 can only be achieved, however, when the period of dwell of a particle in the disc stack is increased by reduction of the feed throughput. At product temperatures < 4 °C (< 39°F) there is the disadvantage that the flow paths in the disc stack become blocked in a very short time.

2.2.8 Fat content in the cream

The adjustments of the discharge pressures necessary to control the fat content in the cream have no effect on separation efficiency up to the 'limiting range' (see Fig. 24). If this limiting range is exceeded, a slightly higher residual fat content can be expected in the skim milk. Fig. 24 shows the residual fat content in the skim milk as a function of the fat content in the cream. Within the limiting range, the residual fat content in the skim milk can be maintained at almost a constant level. This is achieved as follows: the level of fat in the cream must be kept stable. Any volume increase in the fat content of the feed results automatically in approximately a 10-fold increase in its concentration in the cream. If the fat content in the whole milk were to change from 4.0 to 4.5 percent, then, with the same settings on the separator, the fat content in the cream would increase, for example, from 45 to 50 percent.

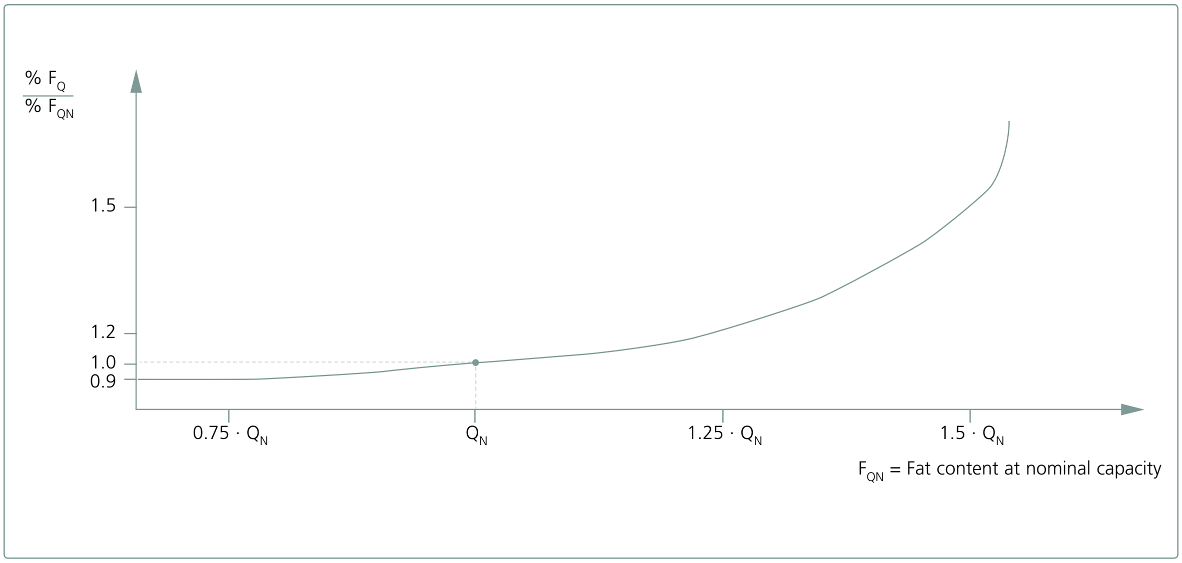


Fig. 25
Feed throughput of the separator as a function of the residual fat content in the skim milk

On the other hand, the upper range of the appropriate separation temperature (55 – 60 °C or 131-140°F) should be chosen if the fat content in the cream is high. Thus, if the cream fat content is above the limiting range, i.e. between 60 and 80 percent, a product temperature between about 60 and max. 75 °C (about 131°F and maximum 167°F) must be chosen with an increasing fat content. The production of such high-percentage creams from an initial product of (30 – 40 percent) cream or whole milk naturally has a particular effect on the residual fat content in the respective skim milk. However, this will not be further discussed in this document.

2.2.9 Throughput of the separator

Fig. 25 shows the relation between the volume of whole milk fed to the separator and the residual fat content in the skim milk. It is particularly important for perfect separation of the whole milk into skim milk and cream that the flow conditions in the bowl are maintained at a constant level. A constantly changing feed throughput means that a new static condition must be created inside the bowl. Consequently, sudden changes must be avoided.

Fig. 26 shows different systems for control of the feed throughput.

Fig. 26
System for control of the separator feed throughput

System	Flexibility	Price	Product influence	Influence on feed pump
Flow constrictor	limited	OPTIMAL	acceptable	causes pressure loss
Control valve (FIC signal)	acceptable	acceptable	acceptable	causes pressure loss
Frequency controlled pump (FIC signal)	OPTIMAL	acceptable depending kW rating of motor	OPTIMAL	operates the pump in the optimum hydraulic working range

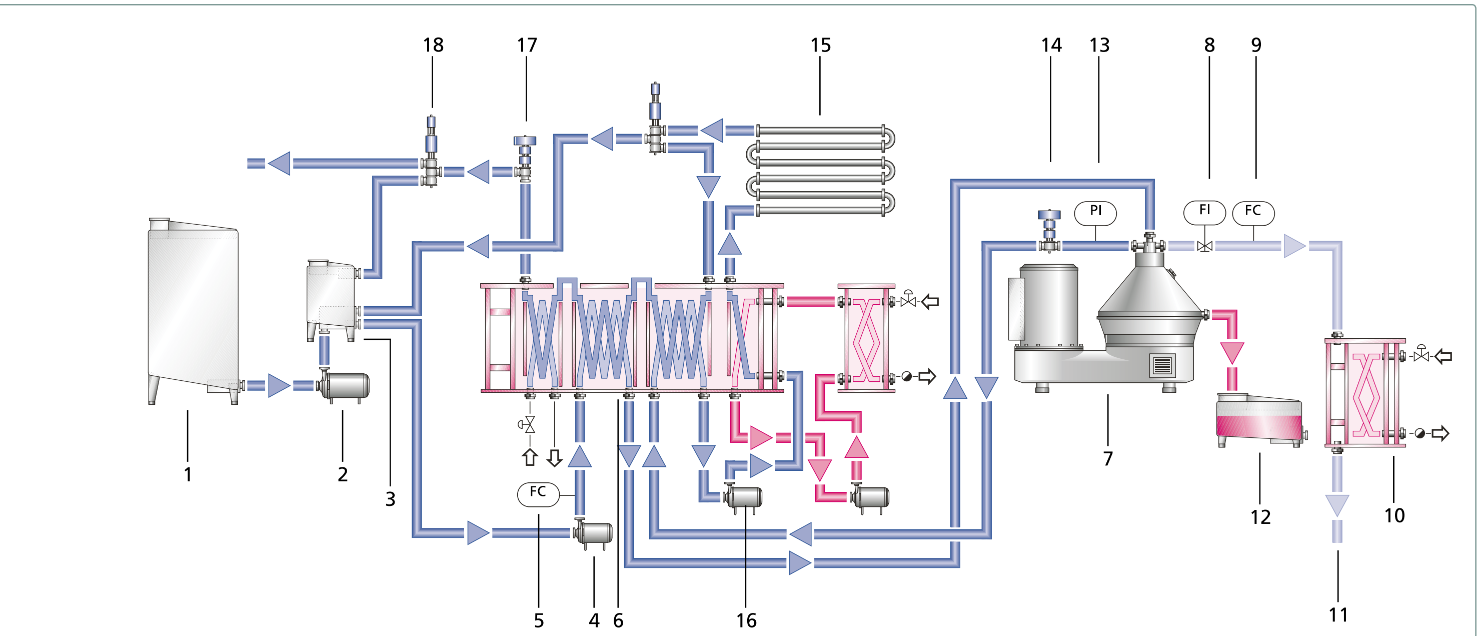


Fig. 27
Flow diagram of a milk processing line

1 Storage tank
2 Pump
3 Balance tank
4 Feed pump
5 Flow constrictor
6 Plate heat exchanger
7 Milk skimming separator
8 Flow meter
9 Adjustable flow constrictor
10 Cream heater/cooler
11 Line to cream tank
12 Solid tank
13 Pressure gauge
14 Constant pressure valve
15 Heat holding section
16 Booster pump
17 Pressure holding valve
18 Flow divertion valve

Frequently, different feed throughput capacities are necessary as defined by production requirements. In such cases, it is expedient to control the feed to the separator by frequency control of the drive of the feed pump. If, under these operating conditions the drive were to be operated at the maximum fixed speed, it is fairly safe to assume that at lower feed throughputs there would be increased damage to the fat globules. The negative consequences for the residual fat content in the skim milk have been described in the previous sections.

If a flow constrictor is installed, it is necessary to ensure that it operates correctly by a correct choice of the upstream and downstream pressures. Correct operation of the flow constrictor is only assured when:

- the Δp between initial pressure and the pressure after the flow constrictor is < 1.5 bar (< 22 psi)
- the pressure after the flow constrictor is > 0.5 bar (> 7.3 psi)

2.2.10 Design criteria for the milk processing line

Fig. 27 illustrates a processing line in simplified form for separation of warm milk.

2.2.10.1 Balance tank

The balance tank must be designed to avoid turbulence in the product. On change-over the min. level in the balance tank must be high enough to prevent air from being drawn in by pump 4. It is also important to ensure that pumps 2 and 4 do not work against each other. For example, directly facing feeds and discharges are to be avoided. Standard value for filling volume approx. 2 – 3 percent of the hourly capacity.

2.2.10.2 Pumps

Much has already been said on this subject. However, it should also be mentioned that in our opinion a great deal more attention should be paid to the design and operation of pumps than is generally the case today.

2.2.10.3 Pipeline system

In addition to the necessity for a clean-in-place (CIP) capability, it is important that sudden changes in pipeline cross-section are avoided, as otherwise pressure and expansion shocks will contribute to the increase in FF. It is also important that certain limiting values for the flow velocity of the transported liquid are neither exceeded nor unattained:

- Milk products max. 2 m/s (6.6 ft/s)
- Cream and higher percentage fat products max. 1.5 m/s (4.9 ft/s)
- Flow velocity for the CIP agent min. 2 m/s (6.6 ft/s)

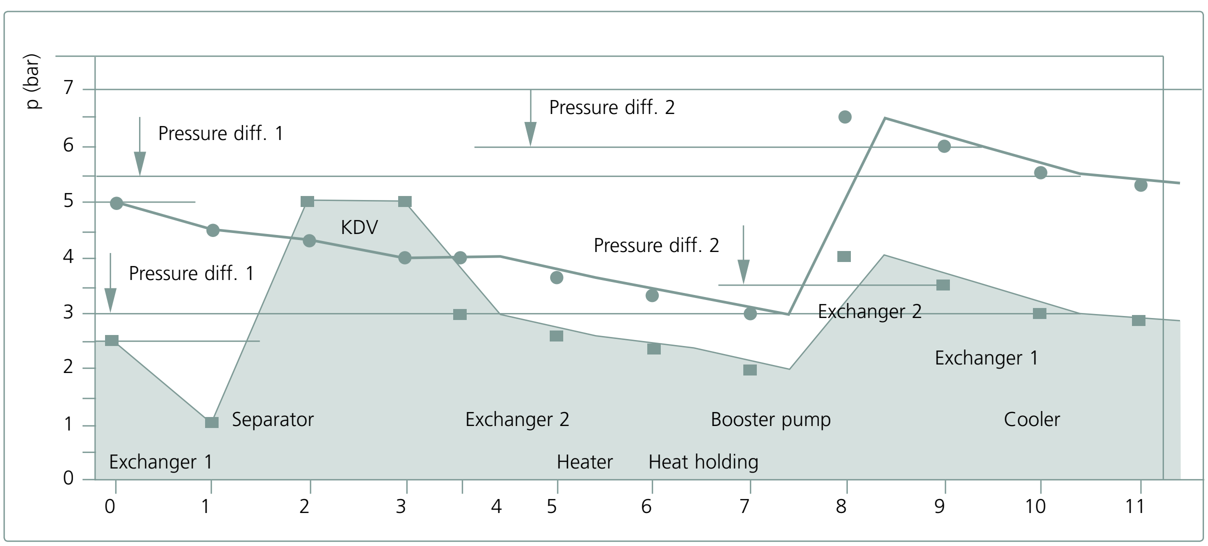
2.2.10.4 Plate heat exchangers

The plate heat exchanger for pasteurizing the milk only has an indirect effect on the separation of the milk. The legal requirements for operation of heat exchanger installations provide well-defined specifications for pressure conditions in the different sections. However, the regulations can vary from country to country. The feed pressure to the separator and the design and dimensions of the necessary pressure-boosting pump have the greatest effect on the pressure level. This is evident from the curves in Fig. 28.

In order to provide high feed-pressure separators see Fig. 28 (—●—) with a lower pressure level to reduce the pressure loading on the plate heat exchanger, a booster pump should be installed directly before the separator.

However, this pressure boosting pump adds to the mechanical strain on the whole milk and, consequently, also influences the separability of the milk.

Fig. 28
Pressure curve in the pasteurizer for a given throughput capacity
(Representation based on the German milk regulations)



Separator with low feed pressure

Separator with high feed pressure

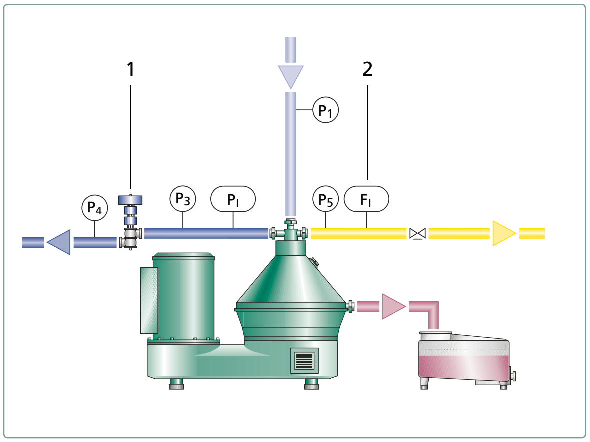


Fig. 29
Control and measuring device for the separator feed and discharge

1 Constant pressure valve
2 Flowmeter

p_1 Feed pressure ≈ 1.0 bar (14.5 psi)
p_3 5 bar (73 psi) discharge pressure of skim milk from separator
p_4 max. 4.5 bar (65 psi) pressure of downstream apparatus
p_5 5,2 bar (73, 29 psi) discharge pressure of cream from separator

2.2.10.5 Separator settings

One of the most important requirements for achieving a low residual fat content in the skim milk is correct adjustment of pressure on the separator. Key pressures for separation efficiency on the skim milk side are p_3 and p_4 (see Fig. 29). p_3 determines the separation zone in the disc stack of the separator and has a crucial effect on separability. For this reason it can also be seen that pressure fluctuations at p_3 will have a negative effect. To allow the individual fat globules the longest possible settling path in the disc stack, the p_3 pressure must be set to a level that just prevents an overflow from occuring on the skim milk side. In practice this pressure is approximately 0.5 bar (7.3 psi) less than the overflow pressure. To prevent pressure fluctuations in the equipment downstream of the separator from affecting p_3, a constant pressure valve (2) is installed on the skim milk side. To ensure correct operation of the constant pressure valve, pressure p_4, 4.5 bar (65 psi) in the example, must not be exceeded. If the pressure is higher, it is necessary to install a booster pump in the downstream apparatus to provide pressure relief. The max. cream pressure p_5 depends on pressure p_3. The cream fat content can be adjusted by means of a hand control valve.

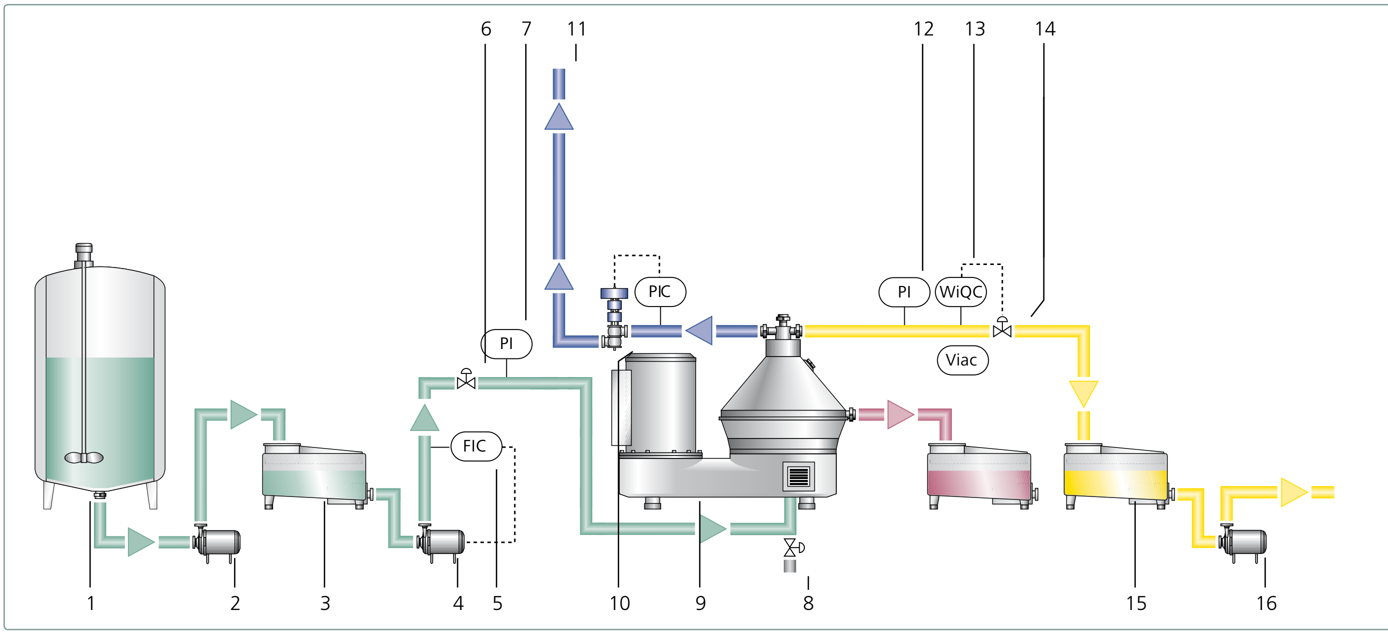


Fig. 30
Installation diagram for cold milk separation

1 Storage tank (whole milk)
2 Pump
3 Balance tank
4 Feed pump
5 Inductive flowmeter
6 Automatic valve
7 Pressure gauge
8 Vent
9 Cold milk separator
10 Control valve (skim milk)
11 Line to tank (skim milk)
12 Pressure gauge
13 Mass flow meter
14 Control valve
15 Cream storage tank
16 Pump

2.2.10.6 Installation of cold milk separators

The cold whole milk is fed into balance tank (3) by pump (2) or under gravity (see fig. 30). The balance tank must be adequately dimensioned so that there is always sufficient milk in the vessel to prevent foreign air from being drawn in by the pump (4). The adjustable positive displacement pump (4) conveys the milk into the separator (9). The speed of pump (4) is controlled by the measuring signal of inductive flow meter (5). The product flowing to the separator is thus maintained constant. The separator feed pressure, which depends to a great extent on the throughput, is 3 – 4 bar (44-58 psi). The concentration of the discharging cream is directly determined by the skim milk discharge pressure. When adjusting the fat content of the cream it is necessary to proceed as follows: set a pressure of 5 – 2 bar (73-29 psi) with constant pressure valve (10) in accordance with the feed throughput, so that thin cream discharges (approx. 30 percent). By gradually reducing the skim milk pressure and, at the same time, controlling the cream fat content, the desired cream fat content can be adjusted.

Fine adjustment is carried out by slightly throttling the cream discharge with the fine adjusting valve (14). The pressure in the cream discharge line, from throttling or from the cream line itself, must not exceed 2 bar (29 psi).

The adjustment of the fat content in the cream can be partially automated. The measuring signals from the inductive flowmeter in the cream line and from the flowmeter in the feed line (in the case of varying feed rates) are compared in a control unit.

For this to function satisfactorily, the fat content in the incoming whole milk must be constant. The cream is collected in a tank situated in the vicinity of the separator and conveyed further with a positive displacement pump.

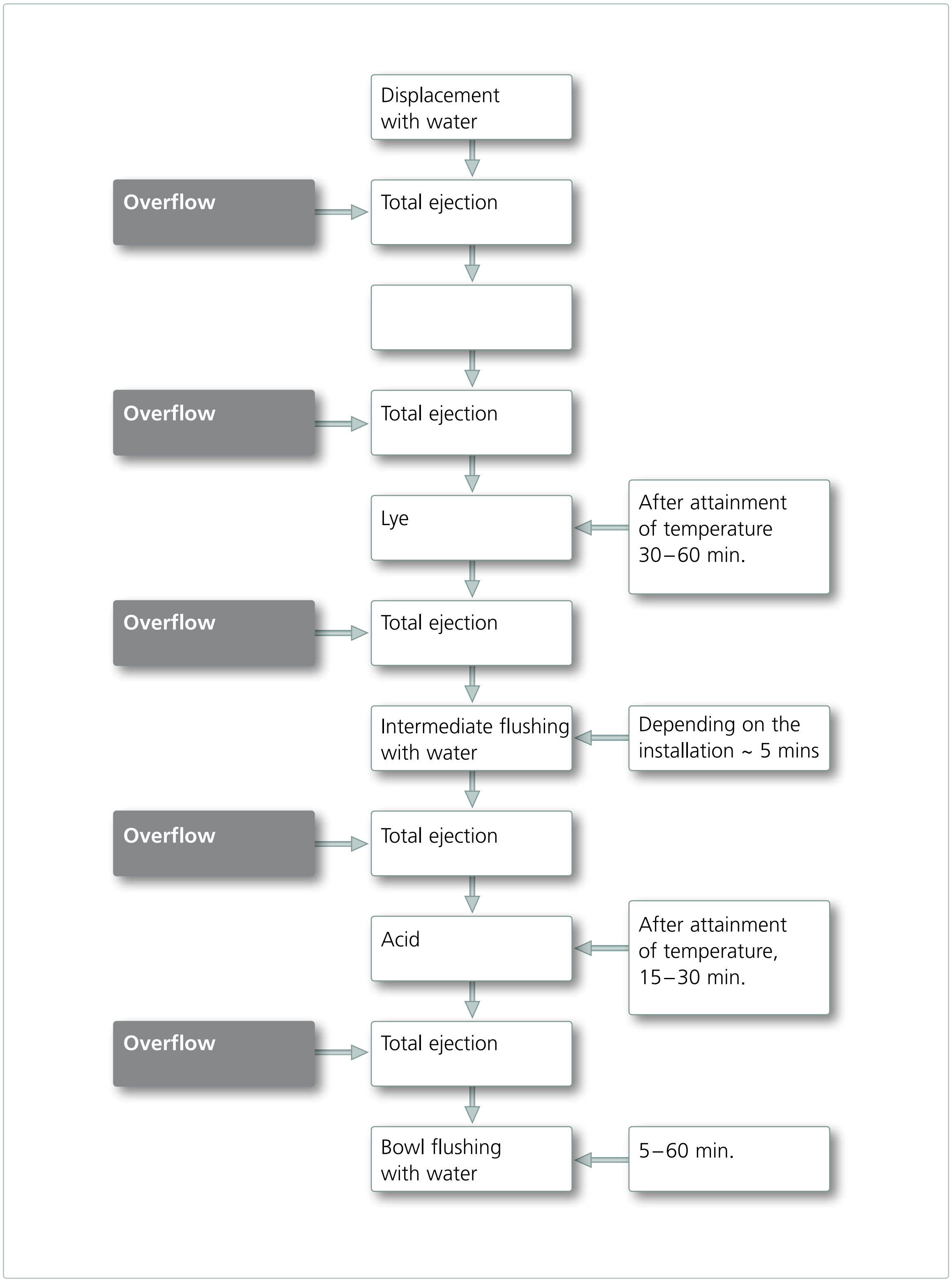


Fig. 31
CIP program for
milk separators

Automatic overflow
after each total ejection

2.2.11 Cleaning-in-place (CIP)

With the ever longer production cycles between cleaning processes usual today, it is of particular importance that the CIP process is optimally tailored to the individual components of the installation.

During cleaning-in-place, the solids are removed from the cleaning solution in the separator and are then automatically ejected during the ejection process.

Fig. 31 shows the CIP program for separators recommended by GEA Westfalia Separator. Depending on the process and plant, other programs may be required in consultation with GEA Westfalia Separator.

The recommendations of the manufacturer should be followed for the temperature and concentration of the cleaning solution.

As a rule one should start with the following parameters:

Lye: Temperature 70 – 80 °C (158– 176°F)
Concentration 1.5 – 2.0 percent

Acid: Temperature 55 – max. 60 °C
(131–max 140°F)
Concentration 0.5 – 1.0 percent

Here we would like to refer to the DIN technical report No. 18: Dairy installations, Cleaning and Disinfection in CIP Processes, published by the Beuth Verlag, 1988.

These brochures cover all relevant questions relating to cleaning-in-place of dairy installations.

3. Milk Separators

3.1 Type of construction

Two basic types of construction are used for milk separators. Separators with solid-wall bowl are used for discontinuous processing and separators with self-cleaning bowl for continuous processing.

3.1.1 Separators with solid-wall bowl

The solids holding space in the discontinuously operating separators is formed by the solid bowl wall. Solids which are separated out of the milk or milk product accumulate on the inner wall of the bowl in the solids holding space. For chemical cleaning, the bowl must be dismantled after each production phase and cleaned manually. The duration of one production phase depends on the amount of separated solids, i.e. the solids content in the product feed. Production must be halted and the bowl cleaned by the time the solids reach the edge of the disc stack.

3.1.2 Self-cleaning separators

These separators are for applications that require continuous processing. Separation takes place in the disc stack; the solids are separated out in the solids holding space. The solids holding space is of double conical form and incorporates ejection ports which can be opened and closed by hydraulically lowering and raising the sliding piston.

During production the accumulated solids can be ejected instantaneously at preset intervals by lowering the sliding piston. At the end of the production phase the separator is automatically cleaned in place. Operation can be fully automated by installing suitable control units.

3.2 Warm milk separators

3.2.1 General

Design engineers have mathematical models available for the design of milk separators. For the separation efficiency of a warm milk separator, the so-called K_1 factor, based on Stokes's Law, is the most important mathematical computational base.

$$K_1 = \frac{3}{\omega}\sqrt{\frac{Q_M}{(r_2^3 - r_1^3) \cdot \tan\alpha}}$$

ω = Angular velocity of bowl [1/s]
r_2 = Effective outside radius of disc [cm]
r_1 = Mean radius relative to position of rising channels [cm]
α = Angle of discs to horizontal
Q_M = Flow of feed milk per sec. [cm^3/s] and disc interspace

As the above K_1 equation shows, the geometry of the discs, the speed of the bowl and, thereby, the centrifugal acceleration have a crucial bearing on separation efficiency. In addition to the observance of mathematical relations, it is of particular importance, if the highest separation efficiency is to be attained, that the treatment of milk flows inside the bowl is as gentle and preserving as possible.

When designing separators, particular attention is paid to the avoidance of vacuum and shear forces which might act on the product. Depending on their relative magnitude, shear forces, and vacuum are capable of destroying agglomerates of fat globules, as well as causing partial damage to the membranes.The result is an increase in FF, an increase in the number of fine fat globules and, consequently, an increase in the residual fat content in the skim milk.

This problem can only be avoided if the distributor chamber, the center of the separator bowl, is constantly filled. Constructionally, this is achieved by hermetically sealing the separator feed and discharge lines with the rotating bowl by means of mechanical seals.

By this means, a reliable seal is assured at high speeds of rotation and radial movement of the bowl. However, these systems also require cooling and 'lubricating' systems, as well as an expensive control system. As a rule, this system also requires an extremely high feed pressure – a disadvantage, among other things, when integrating these separators in a pasteurizing line. With the Westfalia Separator hydro**soft** inlet, we present a system which ensures constant filling of the distributor without the need for mechanical seals.

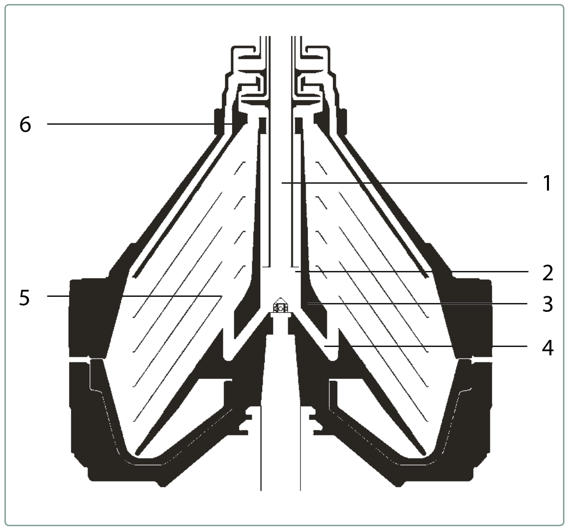


Fig. 32 Schematic of the separator

1 Feed tube
2 Bore
3 Distributor
4 Bore
5 Rising channel
6 Cream centripetal pump

3.2.2 Skimming separators with the Westfalia Separator hydro**soft** feed system

The feed system from GEA Westfalia Separator combines the advantages of the SoftStream system with those of the hydrohermetic feed system. Combining these systems allows very gentle acceleration of the product at a low pressure level. The system offers a high degree of flexibility in terms of feed capacity. Owing to the cream centripetal pump (6) situated above the system, which is immersed in the cream during production, the inlet chamber is hydrohermetically sealed off from the outer air. Air intake into the product is therefore not possible.

The stationary feed tube (1) allows the product to flow into the centrally-located bore (2) of the rotating distributor (3). The central bore has no ribs so it avoids a shearing effect on the product. The product is gently fed through the radially arranged bores (4) into the inner rising channels (5) of the disk stack where it is separated into skim milk and cream.

3.2.3 Westfalia Separator® hy**vol**® **pro**plus separators with integrated Westfalia Separator **pro**plus system

Westfalia Separator hy**vol** **pro**plus brands the new separator generation which combines the excellent features of both systems.

In addition to the high separating efficiency, this entirely new approach gives dairies additional protein and hence a higher yield. At the same time, costs are cut as a result of a lower water requirement and less waste water.

Added value though increasing the protein content

Previously, all research on skimming separators focused on skimming efficiency and consequently on the recovery of the valuable cream or skim milk. Normally, milk separators eject every 20 to 30 minutes, discharging a solid mixture comprising proteins and non-milk constituents. However, the previously discarded protein is also a valuable substance. GEA Westfalia Separator has succeeded in substantially reducing the protein content in the solids and significantly extending the ejection cycles by applying a new design concept and fluid mechanics model. Each gram of additional protein in the skim milk means hard cash for a cheese dairy, for example. There was also a further positive side effect. The ejection intervals have been extended two-fold to three-fold. This in turn results in huge savings in water consumption and lower disposal costs – a major benefit for the environment. The decisive added value factor, however, remains the increase in the protein content in the skim milk and hence the generation of additional revenue without increasing the milk capacity.

Tested under high-performance conditions

To verify the economic effect, GEA Westfalia Separator tested the new process under high-performance conditions in several dairies. The field test results with a skimming separator type MSE 500 with the Westfalia Separator hy**vol** **pro**plus system at a capacity of 50,000 l/h (13,200 gal/h) confirmed the expectations. The additional revenue generated totaled 70,000 Euros/year. The environment likewise benefits. Up to 300,000 l/year (79,000 gal/year) water can be saved due to the longer ejection intervals. The solids to be disposed of shrink to around a quarter of the original volume. The new Westfalia Separator hy**vol** **pro**plus separators with integrated Westfalia Separator **pro**plus system naturally combine the excellent features of the hy**vol** separators in terms of high availability, gentle product treatment, service-friendliness, long service life and consistently high economy.

New investment or plant optimisation

The dairy industry can benefit from the Westfalia Separator hy**vol** **pro**plus separators in milk separation and the bacterial clarification of milk in two ways. The first option is naturally a new installation of a new separator with the system. Thanks to the modular construction, however, it is also possible to retrofit the Westfalia Separator **pro**plus system on separators already in operation. The perfectly coordinated components ensure full exploitation of the decisive plus in protein recovery in retrofits, too. Fast payback times are therefore guaranteed. The innovative Westfalia Separator **pro**plus system concentrates this holistic benefit in milk processing and, at the end of the day, results in a boost in profits throughout the entire life cycle of the separators.

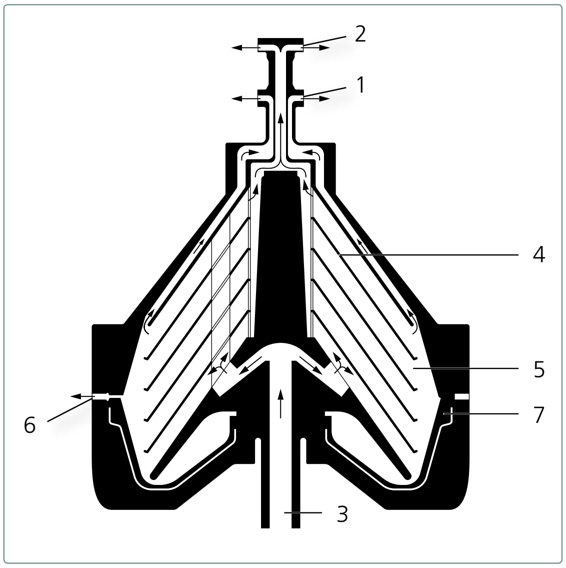


Fig. 33 Cold milk separator

1 Heavy phase discharge
2 Light phase discharge
3 Feed
4 Disc stack
5 Sediment holding space
6 Solids ejection ports
7 Sliding piston

3.3 Cold milk separators

Fig. 33 shows the semi-hermetic cold milk separator. The product flows through feed pipe (3) into the bowl and is separated into light and heavy liquid phases in the disc stack (4). The light liquid phase flows to the center of the bowl from where it is discharged foam-free and under pressure at outlet (2). The heavy liquid phase is conveyed foam-free under pressure to outlet (1).

The separated solids are collected in the sediment holding space (5) from there they are instantly ejected at periodic intervals through ports (6) by means of the hydraulically operated sliding piston (7), whereby the closing liquid is fed through the piston valve. The ejection cycles are initiated via the control unit.

Feed and discharge of the product are effected through an enclosed pipeline system, whereby the feed and discharge of the light liquid phase are connected to the rotating bowl by means of hermetic seals. The two liquid phases are discharged under pressure. The operating pressure for adjustment of the separator is set by means of a control valve in the discharge line of the heavy liquid phase. The two liquid phases are discharged under pressure. The operating pressure for adjustment of the separator is set by a control valve in the discharge line of the heavy liquid phase.

The discharging light liquid phase is also adjusted by a control valve.

During start up and run down of the separator, and in the event of any interruption during production, cooling water must be fed to the rotating seals in the feed and discharge lines of the light liquid phase. This is effected automatically by the control program for the separator.

3.4 Hydraulic system for automatic bowl ejection

Separators with self-cleaning bowls eject the separated solids automatically at pre-selected intervals while the bowl is rotating at operating speed. During partial ejections the product feed to the separator is not interrupted. In this mode of operation, the separation process is assured 24 hours a day.

Depending on the processing conditions and the properties of the milk or milk product, self-cleaning separators can be set to carry out partial or total ejection.

For partial ejection the bowl ejection ports are only opened briefly, so that only a pre-determined volume of solids is ejected. The liquid phase remains in the bowl. With total ejection the ejection ports are fully opened and remain open until the total contents of the bowl have been ejected. In this case the product feed to the separator must be interrupted.

Mention has already been made of the necessity for constant flow conditions. In this respect particular attention must be paid to the ejection mechanism, as each ejection of the bowl leads to turbulence. To meet the requirements for extremely fast and volumetrically small, but exactly reproducible partial ejections (PE), a double piston valve with metering system was developed which works in conjunction with an optimally configured sliding piston.

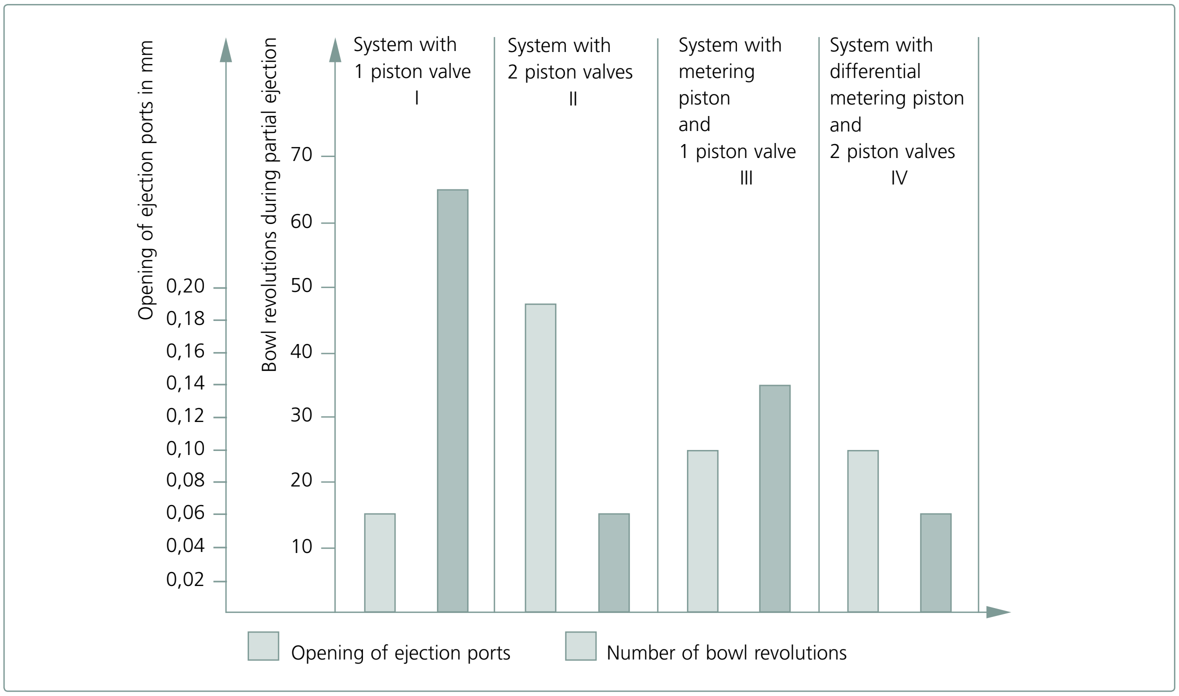


Fig. 34
Development stages of the hydraulic system for automatic bowl ejection

Fig. 34 illustrates the different development stages leading to the system in use today. Item. IV shows the widest possible opening of the ports in the shortest possible time. This allows a partial ejection to be carried out in only a few revolutions of the bowl. It also allows the smallest possible partial ejection to be carried out with precision. As a result there is of course an impairment of the flow conditions, but looked at over the complete separator line, it is only of short duration and consequently of minimal effect.

Fig. 35 shows the operation diagram of the hydraulic system of the milk separator. When a partial ejection is initiated, opening water valve (7) opens and the amount of water preset in the metering chamber (6) is fed instantly under pressure into the opening chamber of the bowl. The closing operation begins automatically when the required amount of opening water flows away through the piston valves. Closing water (3) is fed in throughout the process.

Before the ejection, the metering chamber is filled by opening of the filling water valve (4) at pre-selectable time intervals. Finally, by opening of valve (2), air pressure is applied to the piston in the metering device, so that the water fed for the next partial ejection is under a defined pressure.

3.5 Separator types and feed capacities

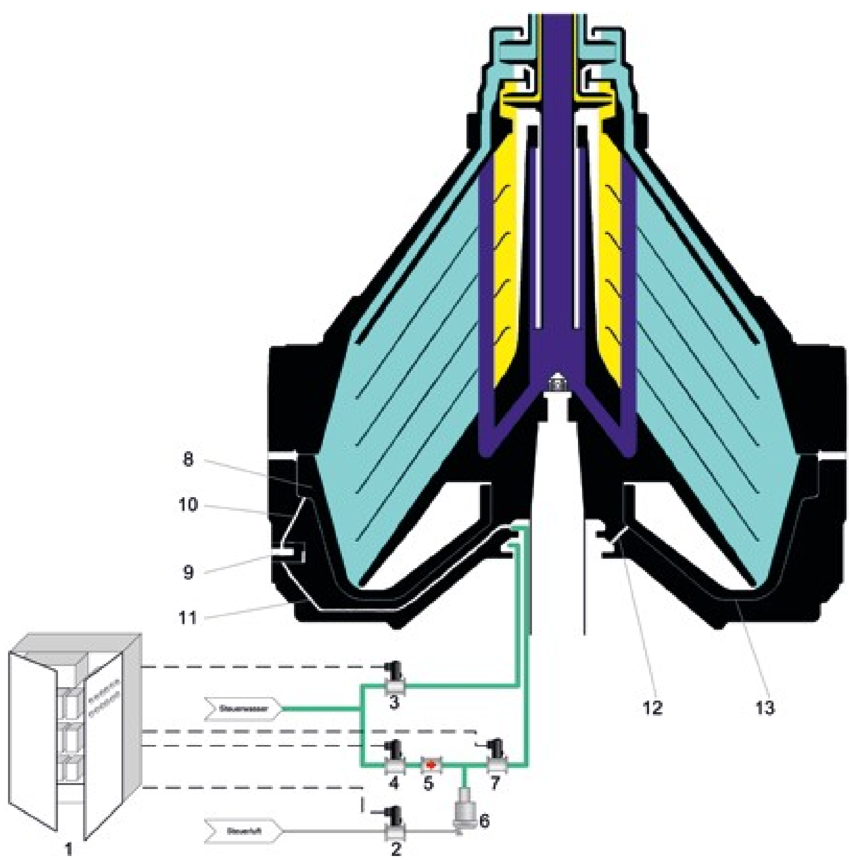
GEA Westfalia Separator supplies hot milk skimming separators with rated capacities from 600 to 60,000 l/h (160 to 15,900 gal/h) or 3,000 to 70,000 l/h (790 to 18,500 gal/h) for standardization. The models with capacity specifications can be found in the technical data sheet.

GEA Westfalia Separator supplies cold milk skimming separators with rated capacities of 10,000 to 50,000 l/h (2,600 to 13,200 gal/h). The models with capacity specifications can be found in the technical data sheet.

Separator type	Rated capacity [l/h]	Standardising capacity [l/h]	proplus system
Warm milk			
MTC 3-03-107	600 (160 gal/h)		No
MTE 15-00-007	2000 (530 gal/h)		No
MSE 25-01-177	3000 (790 gal/h)	4000 (1,100 gal/h)	No
MSE 55-01-177	5000 (1,320 gal/h)	7500 (2,000 gal/h)	No
MSE 75-01-177	7500 (2,000 gal/h)	10,000 (2,600 gal/h)	No
MSE 85-01-177	10,000 (2,600 gal/h)	12,500 (3,300 gal/h)	No
MSE 100-01-177	15,000 (4,000 gal/h)	20,000 (5,300 gal/h)	Yes
MSE 140-01-177	20,000 (5,300 gal/h)	25,000 (6,600 gal/h)	Yes
MSE 180-01-777	25,000 (6,600 gal/h)	30,000 (7,900 gal/h)	Yes
MSE 230-01-777	30,000 (7,900 gal/h)	35,000 (9,200 gal/h)	Yes
MSE 350-01-777	35,000 (9,200 gal/h)	40,000 (10,600 gal/h)	Yes
MSE 400-01-777	40,000 (10,600 gal/h)	45,000 (12,000 gal/h)	Yes
MSE 500-01-777	50,000 (13,200 gal/h)	55,000 (14,500 gal/h)	Yes
MSE 600-01-777	60,000 (15,900 gal/h)	65,000 (17,200 gal/h)	Yes
Cold milk			
MSE 500-48-777	20,000 (5,300 gal/h)	50,000 (13,200 gal/h)	No

Fig. 36

Results obtained in the separation of warm milk and cold milk



1 Control unit
2 Pilot valve
3 Closing water valve
4 Filling water valve
5 Non-return valve
6 Metering unit
7 Opening water valve
8 Sliding piston
9 Piston valve
10 Closing water drain hole
11 Opening water hole
12 Closing water hole
13 Closing water chamber

Fig. 35

Operation diagram of the hydraulic system for opening and closing the bowl

4. Special Processes

4.1 Buttermilk separation

In buttermilk separation, the type of buttermilk must be taken into consideration when selecting the separator model.

4.1.1 The product as a criterion for selecting the right separator model

There are four main types:

- Buttermilk from sweet cream
- Buttermilk from sour cream
- Buttermilk from neutralized cream
- Buttermilk from the cask churning process

Self-cleaning separators and separators with solid-wall bowl (not self-cleaning) can be used for the separation of sweet cream buttermilk. This is owing to the relatively small amount of coagulated protein which is separated out. This also applies to the separation of buttermilk produced from churning neutralized cream or buttermilk recovered from the cask churning process.

For the separation of sour cream buttermilk only self-cleaning separators can be used. The coagulated protein is separated out and accumulates in the sediment holding space. It is automatically ejected through ports at pre-set intervals.

4.1.2 Process parameters

The process diagram is shown in Fig. 37. The buttermilk is pumped from the buttermaking machine (1) to the silo (5). The buttermilk should be stored at a temperature of 6 – 8 °C (43°F–46°F). In a plate heat exchanger (7), sweet cream buttermilk is heated to 30 – 40 °C (86°F–104°F) and sour cream buttermilk to 32 – 35 °C (90°F–95°F). The buttermilk from the neutralized cream churning and cask churning processes can be treated in the same way as sweet cream buttermilk. The separator throughput capacity should be approx. 50 percent of the rated capacity for sour cream buttermilk and up to 100 percent of the rated capacity for sweet cream buttermilk. The cream flows from the separator into a cream collecting tank (10). The butterfat content in the cream must be adjusted with the aid of a fine adjustment valve to approx. 25 percent. The construction of the disc stack depends on the type of buttermilk to be processed.

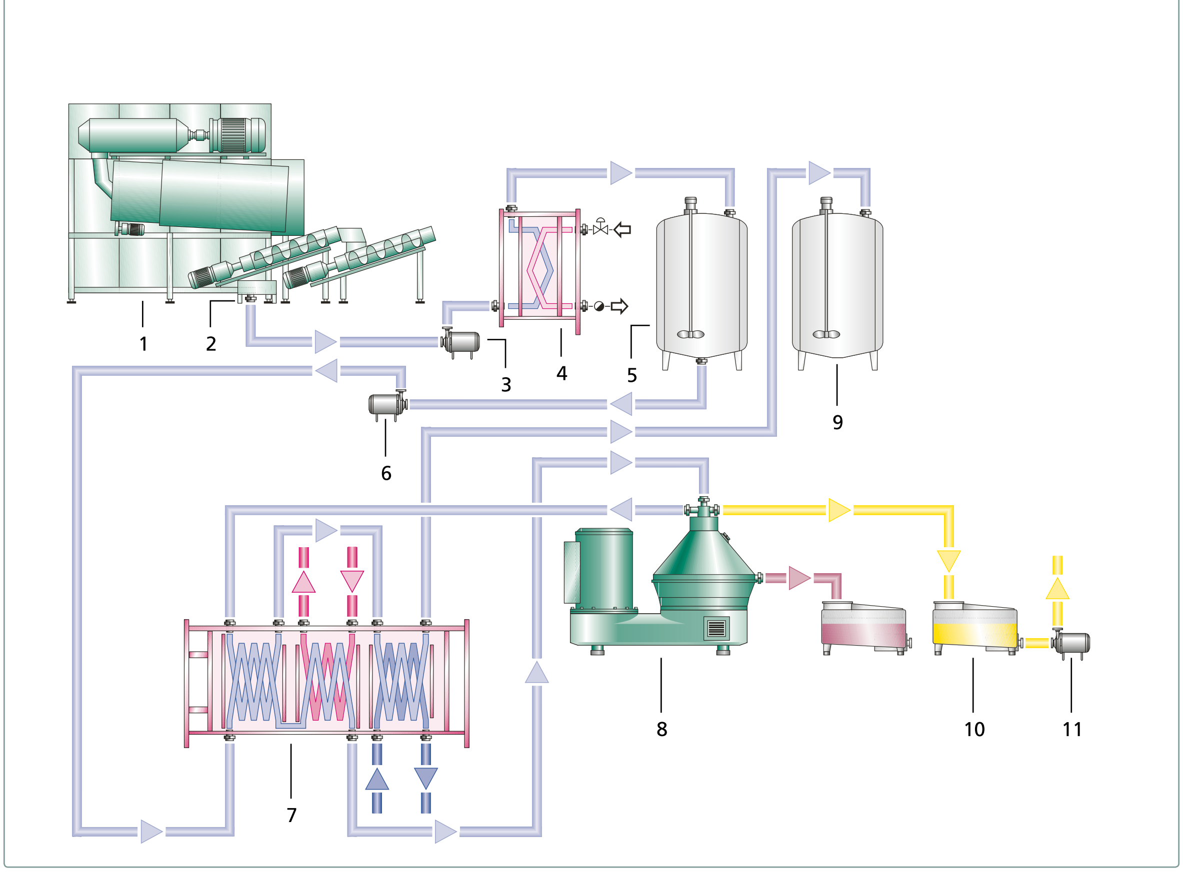


Fig. 37
Installation diagram for buttermilk separation

1 Buttermaking machine
2 Buttermilk collecting vat
3 Pump
4 Cooler
5 Storage tank
6 Pump
7 Plate heat exchanger
8 Milk separator
9 Storage tank for separated buttermilk
10 Cream collecting tank
11 Pump

4.1.3 Separation efficiency

The residual butterfat content in the separated buttermilk can only be estimated as lying somewhere between 50 and 70 percent of the initial butterfat content unless extensive tests are carried out. This is due to important parameters in the buttermaking process such as cream treatment, type of buttermaking machine and butter production process. These technical and technological parameters affect the separability and hence the residual fat content in the buttermilk. However, if the initial butterfat content is known, the residual fat content in the separated buttermilk can be estimated with a fairly high degree of accuracy.

Fig. 38 illustrates the butterfat yield as a function of the initial butterfat content. The separability of buttermilk from the cask churning process deviates from the pattern illustrated in Fig. 40. A fat recovery yield of 20 percent can be considered as the upper limit.

GEA Westfalia Separator supplies buttermilk skimming separators with a large capacity range. Details of the models and their capacities are available on request.

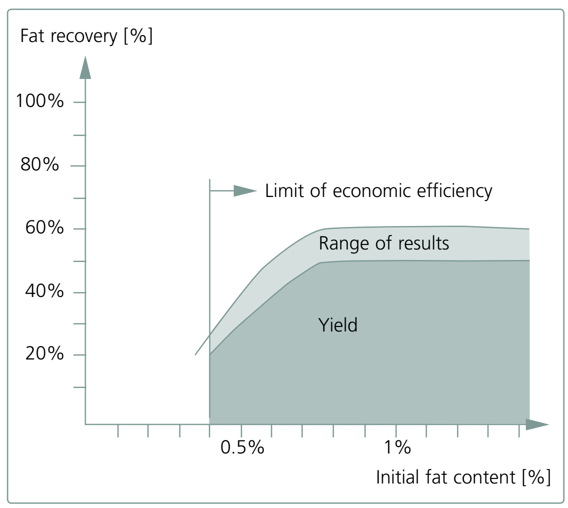


Fig. 38
The butterfat yield as a function of the initial butterfat content

4.2 Whey separation

Here we would like to refer the reader to our whey brochure in which all relevant questions are discussed[2)].

4.2.1 Criteria for designing a whey separation line

Westfalia Separator supplies whey skimming separators with a large capacity range. Details of the models and their specifications are available on request.

4.3 Whey concentrate separation

The limiting factors affecting the separability of whey concentrate are the level of concentration, the product temperature and the content in centrifugable sediment.

Optimum values can only be attained when the following conditions are met:

- The degree of concentration in the evaporator is m 1:4, corresponding to a max. dry matter content of 25 percent DM
- Separation temperature is between 40 and 60 °C (140°F)
- Feed throughput to the separator is between 60 and 70 percent of the respective milk separation feed capacity

Difficulties are encountered with separation of whey concentrate when, with increasing temperature during concentration, whey proteins are already precipitated out or, because of excessive vacuum, too many fat globules are already damaged. Here, we would also like to refer the reader to our whey brochure.

4.4 Retentate separation

To improve the quality of the whey protein concentrates (WPC's), part of the concentrated fat can be removed by re-separation. This can be employed, for example to bring the final fat content of an 80 percent WPC to approx. 5 percent. Without re-separation the final fat content would be 7 percent under optimum conditions.

Generally the following assumptions can be made for re-separation of retentate (whey protein concentrate):

- Feed to the separator is approx. 50 percent of the feed throughput for separation of milk in the appropriate separator
- Separation temperature is approx. 55 °C (131°F)
- Dry matter content in the retentate is 10 – 30 percent DM
- Separable solids are max. 0.4 – 0.8 percent V/V

Depending on the whey and type of membranes, reductions in the initial fat value of 20 – 30 percent can be achieved.

4.5 Cream concentration

4.5.1 Concentration of low cream content 40 – 50 percent

This process is employed in plants where cream with a low concentration (approx.15 percent) is obtained, e.g. during re-separation of skim milk, separation of buttermilk or whey concentrate and washing of cream. If cream is to be churned into butter by the process described earlier, then concentration is possible in warm milk separators specially modified for this purpose. The concentration capacity corresponds to about half the rated capacity for warm milk separation.

4.5.2 Increasing the concentration of 40 percent cream

Without destabilization

A basic requirement for production of a highly concentrated, high quality cream is extremely gentle treatment in a separator in hydrohermetic design. The increase in viscosity with rising fat content defines the limit for the cream fat content. Fat levels between 75 and 78 percent are quite possible. Modified warm or cold milk separators are used for concentration of the cream. The throughput capa-cities achievable depend on the degree of concentration and the permissible residual fat content in the skim milk. In most cases the feed capacity is half the rated capacity of a milk separator.

With destabilization

Destabilization of the cream is carried out when a cream concentration > 80 percent is to be obtained. Before the cream is concentrated the fat globules are reduced in size by homogenizing, whereby a higher dispersion of the fat is obtained at the same density. More detailed information is contained in the document on production of butteroil.

5. Measuring Methods for Determining the Residual Fat Content of the Skim Milk

Naturally, the method selected for determining the residual fat content in the skim milk has no direct influence on the fat content. However, there can be an influence on the separability of the milk if misinterpretation of the values obtained leads to wrong decisions being taken.

This exposition will deal with some typical differences between the measuring methods (see Fig. 40) in use. The most important difference in the measuring methods is in analysis by weight and volume. In the case of analysis by volume the phospholipids in the skim milk are not detected, whereas with the weight analysis method (e.g. by Röse-Gottlieb) they are detected. In the case of fat content specifications, the method of analysis must always be stated.

The residual difference defined in Fig. 40 normally exhibits a relatively constant magnitude when the residual fat content in the skim milk obtained in separation of whole milk is measured. However, it can vary markedly in other separation processes, such as the production of high percentage creams (70 – 80 percent).

Fig. 41 below illustrates the greatest differences between the measuring methods.

How delicate these comparisons are can be seen from the tests between Mojonnier and Röse-Gottlieb methods in Fig. 41. The sole difference is that different measuring flasks are used. If the Mojonnier flask shown in Fig. 39 is used for the Röse-Gottlieb test, then the results of the Röse-Gottlieb and Mojonnier methods will correspond.

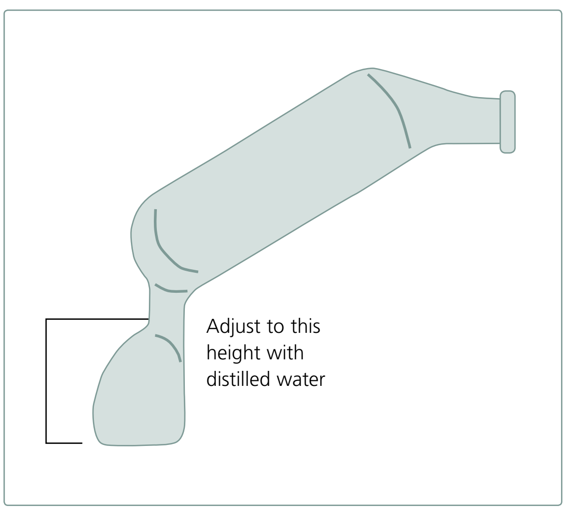


Fig. 39
Mojonnier-measuring flask

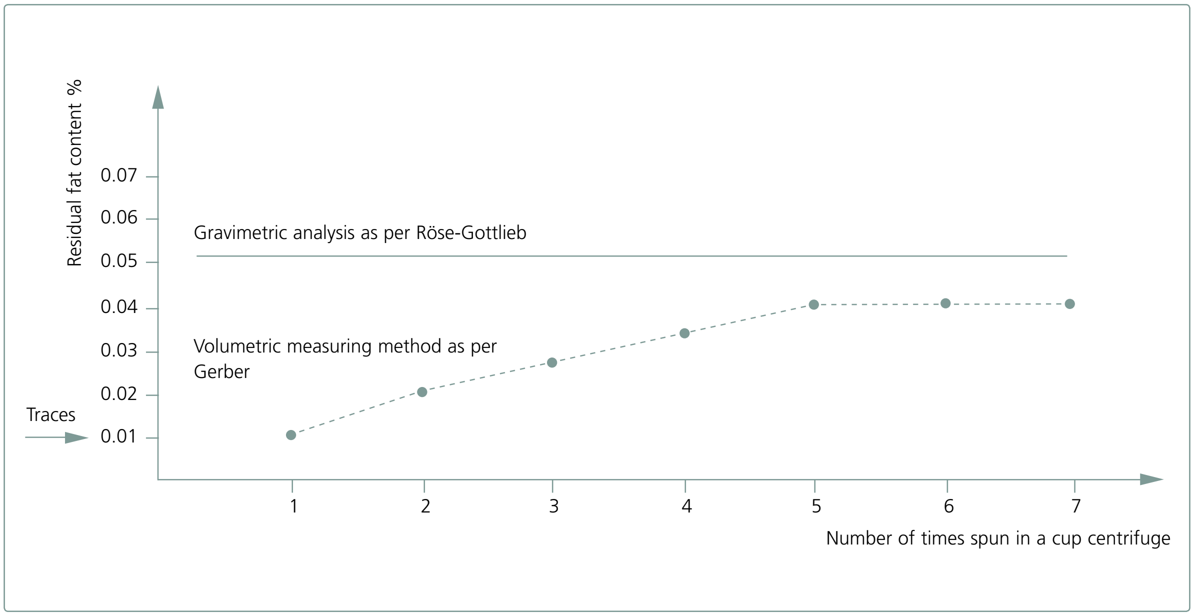


Fig. 40
Comparison of
measuring methods

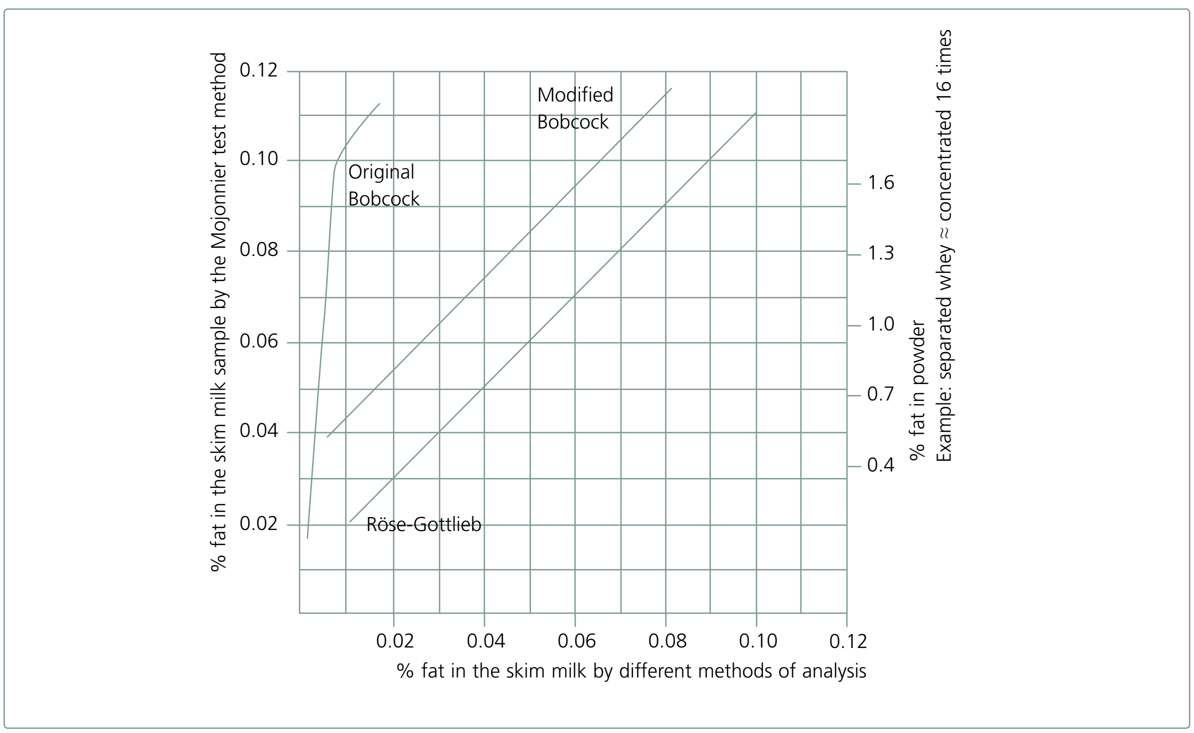


Fig. 41
Comparison of
different fat
testing methods

6. Automatic Fat Standardizing Installations

Milk and cream standardization is a process for adjusting the butterfat content of the milk or cream to a predetermined value. Exceeding the maximum butterfat content means a financial loss for the dairy.

The tendency today is for consumers to prefer milk with a low fat content. Consequently, it is necessary to market a wide range of products, e.g. milk with a fat content of 0.5 percent, 1.5 percent, 2.6 percent, 3.0 percent and 3.5 percent.

Control system

With all models, the cream fat content is determined via density measurement in a mass flow meter. The cream fat control is effected by variation of the cream flow. Control procedures adapted to the different operating conditions (start up, production, bowl discharge, shut down) take into account the specific requirements of the separator. For standardizing, a part of the cream flow is controlled via an inductive flow meter and dosed back into the skim milk. The control components for the skim milk backpressure are integrated on the Westfalia Separator® **standomat** base unit. For all milk applications a control signal is supplied for the feed flow to the separator.

Models

Depending on the application and the control task, different Westfalia Separator® **standomat** models are available. Further information is given in the technical data sheets for standardizing units.

Fig. 42
Westfalia Separator **standomat**

- Beverage Technology
- Dairy Technology
- Renewable Resources
- Chemical / Pharmaceutical Technology
- Marine
- Energy/Power
- Oil & Gas
- Environmental Technology
- Engineering
- Factory Reconditioned Machinery
- Original Manufacturer's Service

GEA Mechanical Equipment US, Inc.

GEA Westfalia Separator Division

Headquarters:
100 Fairway Court
Northvale, NJ 07647
201-767-3900

Midwest:
725 Tollgate Road, Suite B
Elgin, IL 60123
630-503-4700

South:
4725 Lakeland Commerce Parkway, Suite 4
Lakeland, FL 33805
863-603-8900

Southwest:
2408 Timberloch Place, Suite C-4
The Woodlands, TX 77380
281-465-7900

West Coast:
Western Region Customer Support Center
555 Baldwin Road
Patterson, CA 95363
209-895-6300

GEA Mechanical Equipment Canada, Inc.

GEA Westfalia Separator Canada Division

835 Harrington Court
Burlington, ON L7N 3P3
289-288-5500

Toll-Free: 800-722-6622
24-Hour Technical Help: 800-509-9299
www.wsus.com

2350