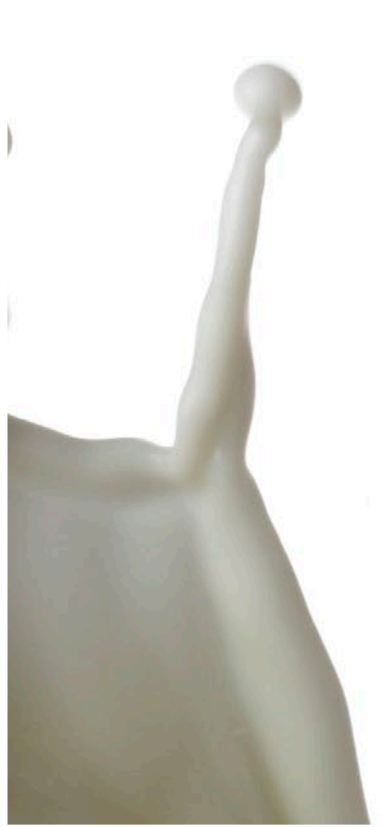




SPXFLOW
FOOD + BEVERAGE



General Milk Processing

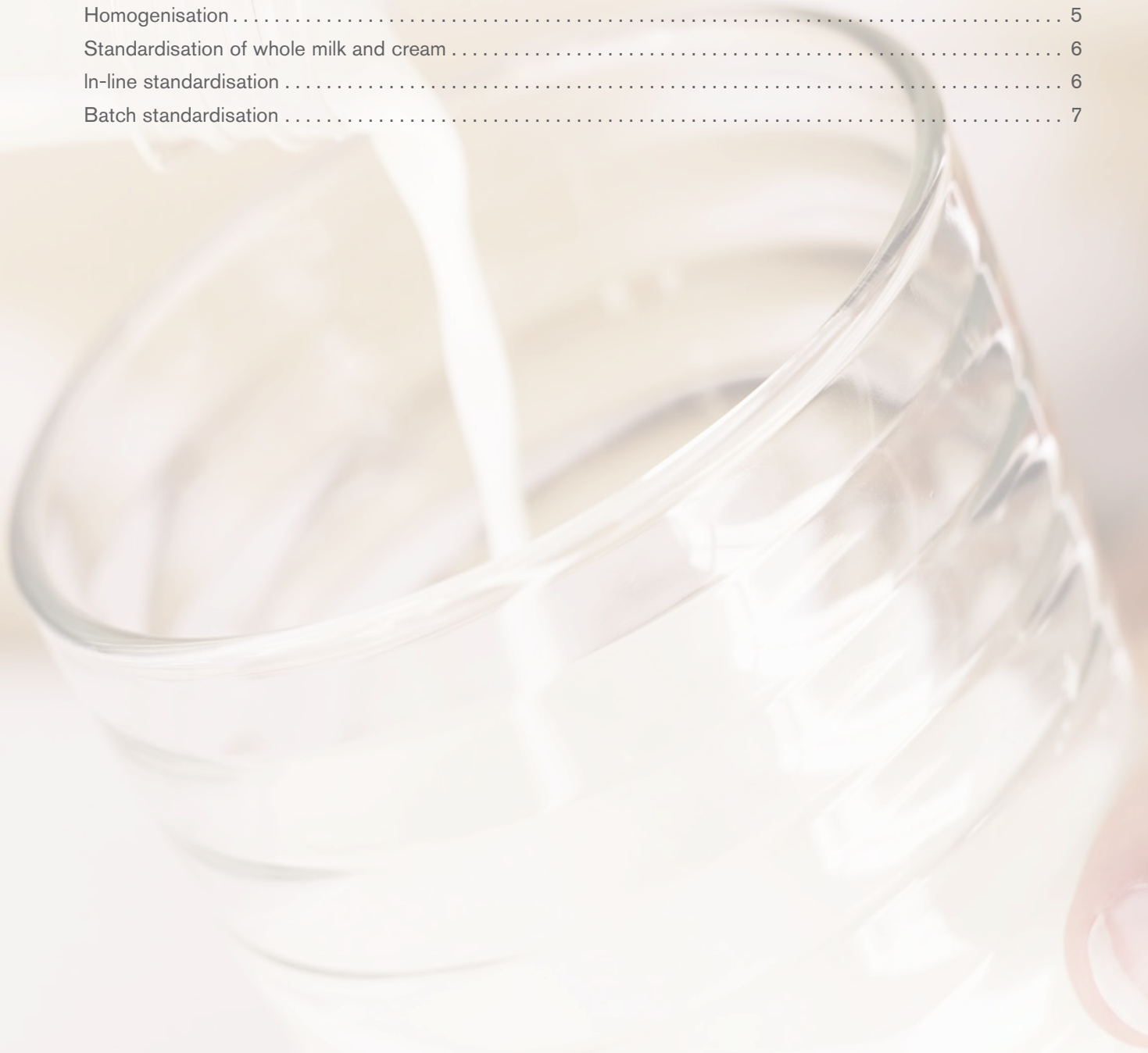


White Paper



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Introduction to SPX Flow

Vision and commitment

SPX FLOW designs, manufactures and markets process engineering and automation solutions to the dairy, food, beverage, marine, pharmaceutical and personal care industries through its global operations.

We are committed to helping our customers all over the world improve the performance and profitability of their manufacturing plants and processes. We achieve this by offering a wide range of products and solutions, from engineered components to complete process plants, all supported by world-leading engineering and application expertise.

We continue to help our customers optimise the performance and profitability of their plants throughout their life cycle with support services tailored to individual needs using our global, coordinated customer service and spare parts network.

Customer focus

APV, an SPX FLOW brand, was founded in 1910 and, for over a century, has pioneered groundbreaking technologies and set the standards in modern processing industries.

Through continuous research and development, close partnership with customers, clear understanding of application needs and the ability to visualise future process requirements, SPX FLOW continues to improve process performance and profitability for its customers

Executive Summary

General milk processing involves a number of basic processes designed to achieve the required end-product quality in terms of flavour, mouth-feel and fat content while ensuring an appropriate storage life as well as the health and safety of the consumer.

Designed for those who are not so familiar with these processes, this white paper discusses the main steps in general milk processing from milk reception and storage through heat treatment, pasteurization, homogenization and standardization.

Based on APV and SPX FLOW solutions, SPX FLOW offers a comprehensive platform of milk processing solutions enabling dairies to optimize product characteristics and quality at each processing stage.

The SPX FLOW Innovation Centre in Denmark offers pilot plant testing and application solution guidance services to help customers maximize the performance of their plant. Pilot testing can also be conducted on customers' own premises based on rental equipment and, if required, with support from SPX FLOW experts.

Milk reception and storage

The basic equipment requirements for a milk reception would typically include the following:

- An air eliminator to remove most of the entrained air from the product
- A high-efficiency pump to pump the milk at the highest possible flow rate in relation to product quality and cooling requirements.
- A mesh strainer to remove any large foreign bodies from the milk
- A cooler to cool the milk to an acceptable temperature
- A flowmeter to measure and record the volume of milk received
- A sampling valve to enable the operator to take a representative sample

Before allowing a tanker to offload milk into a bulk silo, it is usual for a sample to be analysed by the receiving laboratory and ensure that the microbiological quality is acceptable and to eliminate the possibility of mass contamination of the contents of the silo.

DAMAGE TO FAT CONTENT OF THE RAW MILK DURING RECEPTION

Excessive agitation may cause damage to the fat globule membranes and stimulate the naturally occurring lipase in raw milk, thus causing hydrolysis and flavour changes. It is therefore important that raw milk be handled gently to avoid such damage. This can be achieved by:

- Not exceeding recommended maximum velocities in pipes and heat exchangers (see table below)
- Proper design of reception system to avoid cavitation
- Use of high-efficiency pumps
- Use of variable speed drive on pumps to only run pump at speed necessary to achieve desired flowrate

RAW MILK COOLING AND STORAGE

The milk is normally cooled to a temperature below 4°C in a plate heat exchanger in the transfer line from the reception bay to the storage tanks. The size and number of storage tanks is determined by the overall daily production capacity of the dairy processing factory. These tanks are insulated to maintain the milk

PRODUCT VELOCITIES IN STAINLESS STEEL PIPES				
PRODUCT	SUCTION LINES		PRESSURE LINES	
	25-63 mm	>76 mm	25-63 mm	>76 mm
MILK	1.5 m/s	2.0 m/s	2.0 m/s	2.5 m/s
CREAM	1.0 m/s	1.0 m/s	1.5 m/s	1.5 m/s

temperature, and may be equipped with a chilled water cooling jacket to provide additional cooling if extended storage periods are envisaged.

Raw milk tanks are usually equipped with mixers which agitate the content, either continuously or intermittently, to maintain an even distribution of the fat content in the milk, and to increase the efficiency of the cooling jacket.

Thermalisation

In some countries where the incoming microbiological count may be high, the raw milk may be thermalised by heating it rapidly to 64.50°C and holding for 16 sec. before cooling and subsequent storing before further processing.

Pasteurisation

Pasteurisation is a heat treatment applied to milk in order to avoid public health hazards arising from some pathogenic micro-organisms associated with milk such as *Mycobacterium tuberculosis*. The process also increases the shelf life of the product. Pasteurisation is intended to create only minimal chemical, physical and organoleptic changes in products to be kept in cold storage. It should be noted that pasteurisation only destroys vegetative micro-organisms and not spores.

PASTEURISATION TEMPERATURE AND TIME

The temperature/time combinations stated below are similar in effect and all have the minimum bactericidal effect required for pasteurisation.

Pasteurised milk and skim milk:

63°C/30 min. - 72°C/15 sec.

(Note that in some countries, the dairy industry has increased the holding time at 72°C to 25 sec. due to the emergence of higher resistant pathogens such as Mycobacterium Paratuberculosis.)

Pasteurised cream:

(10% fat) 75°C/15 sec.

(35% fat) 80°C/15 sec.

Pasteurised, concentrated milk, ice cream mix, sweetened products, etc.

80°C/25 sec.

The higher heat treatments necessary for higher fat products is due to the protective effect of the fat on the destruction of micro-organisms.

In each case the product is subsequently cooled to 10°C or less - preferably to 4°C. In some countries, local legislation specifies minimum temperature/time combinations.

In most countries, the phosphatase test is used as the legal determination as to whether the pasteurisation process has been carried out correctly. A negative phosphatase test is considered to be equivalent to less than 2.2 microgrammes of phenol liberated by 1 ml of sample or less than 10 microgrammes paranitrophenol liberated by 1 ml of sample. The presence of a higher level of phosphatase indicates inefficient pasteurisation or the subsequent contamination of pasteurised milk with raw product.

In order to minimise the risk of failure in the pasteurisation process, the system should have an automatic control system for:

Pasteurisation temperature

Temperature recorder and flow diversion valve at the outlet of the temperature holder for diverting the flow back to the balance tank in case of pasteurisation temperatures below the legal requirement

Holding time at pasteurisation temperature

Capacity control system which activates the flow diversion valve in case the capacity exceeds the maximum for which the holding tube is designed.

Pressure differential control

The system will activate the flow diversion valve if the pressure on the raw milk side of the regenerator exceeds a set minimum below the pressure on the pasteurised side, thus preventing possible leakage of raw milk into the pasteurised milk.

Calculation of residence time in holding tube

The mean residence time (t) in the holding tube can be calculated as follows:

$$t = \text{length of tube} \times \text{volume per metre of tube capacity per second}$$

The individual particles spend different times in the holding tube and this results in residence time variations. To avoid bacteriological problems, it is necessary to heat even the fastest particles long enough. The holding tube must have an efficiency of at least 0.8 (t_{\min}/t_{mean}) and this can best be achieved by avoiding a laminar flow, ie, ensuring a turbulent flow at a Reynolds Number >12,000 and choosing a ratio of length (m)/diameter >200 for the holding tube.

Homogenisation

Milk products are usually homogenised to prevent separation during storage. Other dairy products are homogenised to improve water binding. Homogenisation takes place in a high-pressure homogeniser, which is basically a positive pump equipped with a narrow slit called the homogenising valve. The milk is forced

through the homogenising valve at high pressure and this process causes disruption of the fat globules. Advanced types of homogenising valves have been constructed for optimum homogenising efficiency in various processes

In a pasteurisation plant the homogeniser is typically placed upstream before the final heat treatment in a heat exchanger. Homogenisation of milk must take place at a temperature above the melting point of the milk fat. This means that the homogeniser is often placed after the first regenerative section. In indirect UHT milk plants the homogeniser is also generally placed upstream.

However, in indirect UHT cream systems where the fat-content is higher than approx. 10% (possibly as low as 6%), and in milk products with higher protein content, the homogeniser is preferably placed downstream. In direct UHT systems the homogeniser is always placed downstream on the aseptic side after UHT treatment.

Total homogenisation is most commonly applied for pasteurised milk and always used with UHT milk. In these cases, the fat content is standardised prior to homogenisation. Two-stage homogenisation with an SEO or XFD homogenising valve or single-stage homogenisation with an LW homogenising valve at a total pressure of 100 to 150 bar is often sufficient for the required stability of pasteurised milk. For UHT milk a total pressure of 200 to 250 bar is recommended (Fig. 1). For very high flow rates, two-stage homogenisation with a patented MicroGap homogenising valve is recommended. The MicroGap enables reduction of the total pressure by approx. 20 – 30%.

Another option is partial homogenisation in order to save operating costs. This can enable a reduction of total power consumption during homogenisation by approx. 65% as only about one third of the milk volume is passed through the homogeniser. This type of homogenisation is only applied for pasteurised milk (never for UHT milk). In partial homogenisation, one third of the volume consists of homogenised cream with up to max. 12% fat, while two thirds of the volume consists of skimmed milk, which is bypassed and added to the homogenised cream.

SEO = is a single stage valve, used on a one and two-stage machine

XFD = Extra fine valve - used in one and two-stage machines

LW = homogenisation valve with integrated second stage

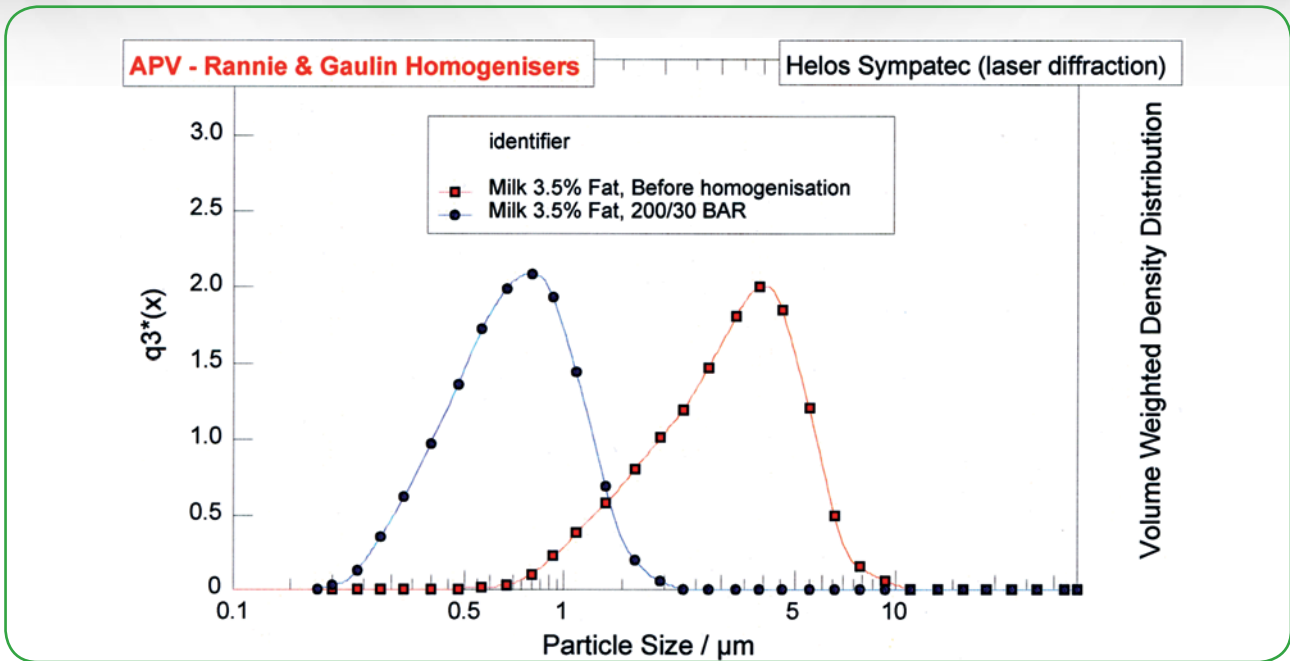


Fig. 1: The particle size distribution of fat globules in milk before and after homogenisation at 200 bar total pressure with 30 bar on the 2nd stage (volume weighted distributions).

Standardisation of whole milk and cream

In many countries, milk and cream sold for consumption must contain a legally fixed fat percentage, although slight variations are usually allowed. Typically for example the fat content of heat-treated whole milk must be 3.5%, in low-fat milk 1.8%, and in skim-milk 0.1%. The various types of cream might be specified to have a fat content of 18 or 38%. In order to comply with these regulations, it is necessary to standardise the fat content of both the milk and the surplus cream.

This can be done in various ways depending on the stage at which standardisation is carried out.

Standardisation before or during heat treatment is to be preferred as the danger of subsequent contamination is thereby reduced. Standardisation will normally take place automatically during the separating and pasteurising process. Alternatively it may be done manually as a batch process.

In-line standardisation

For in-line standardisation the following equations may be used:

To obtain Z kg standardised milk, use Y kg whole milk

$$Y \text{ kg whole milk} = \frac{Z (\% \text{ fat in surplus cream} - \% \text{ fat required})}{\% \text{ fat in surplus cream} - \% \text{ fat in whole milk}}$$

$$X \text{ kg surplus cream} = Y - Z$$

To obtain X kg surplus cream, use Y kg whole milk.

$$Y \text{ kg whole milk} = \frac{Z (\% \text{ fat in cream} - \% \text{ fat in standardised milk})}{\% \text{ fat in whole milk} - \% \text{ fat in standardised milk}}$$

$$Z \text{ kg standardised milk} = Y - X$$

Y kg whole milk used will result in Z kg standardised milk and X kg surplus cream.

$$Z \text{ kg standardised milk} = \frac{Y (\% \text{ fat in surplus cream} - \% \text{ fat in whole milk})}{\% \text{ fat in surplus cream} - \% \text{ fat in standardised milk}}$$

$$X \text{ kg surplus cream} = Y - Z$$

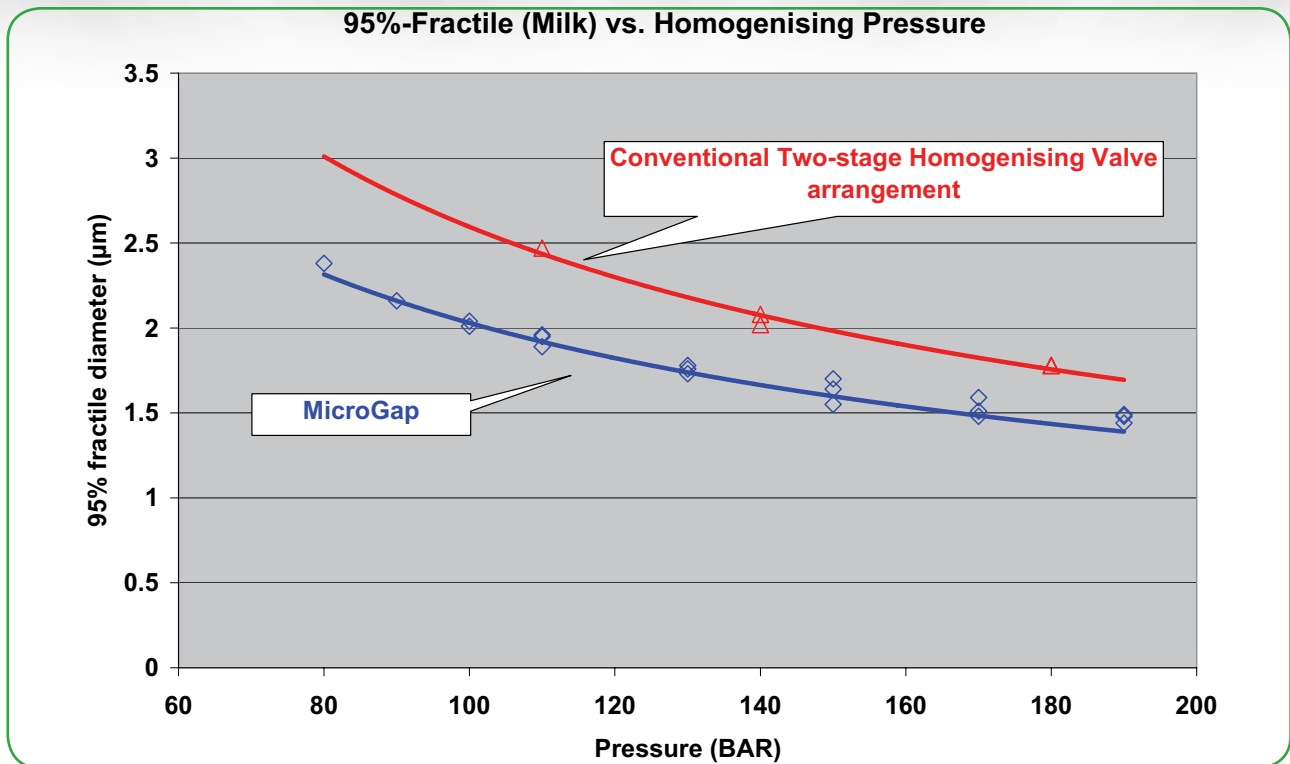


Fig. 2: Micro-Gap valve compared with conventional two-stage valve arrangement (95%-Fractile from volume-weighted particle size distributions, analysed by Helos Sympatec particle sizer).

Batch standardisation

For batch standardisation the following equations may be used:

Fat content to be reduced

To reduce the fat content in Y kg whole milk, add X kg skim milk.

Where X kg skim milk =
$$\frac{Y (\% \text{ fat in whole milk} - \% \text{ fat required})}{\% \text{ fat required} - \% \text{ fat in skim milk}}$$

To obtain Z kg standardised milk, mix Y kg whole milk with X kg skim milk.

Y kg whole milk =
$$\frac{Z (\% \text{ fat required} - \% \text{ fat in skim milk})}{\% \text{ fat in whole milk} - \% \text{ fat in skim milk}}$$

X kg skim milk = Z - Y

Fat content to be increased

To increase the fat content in Y kg low-fat milk, add X kg cream (or high-fat milk).

X kg cream =
$$\frac{Y (\% \text{ fat required} - \% \text{ fat in low-fat milk})}{\% \text{ fat in cream} - \% \text{ fat required}}$$

To obtain Z kg standardised milk, mix Y kg low-fat milk with X kg cream (or high-fat milk).

Y kg low-fat milk =
$$\frac{Z (\% \text{ fat in cream} - \% \text{ fat required})}{\% \text{ fat in cream} - \% \text{ fat in low-fat milk}}$$

X kg cream = Z - Y



Based in Charlotte, North Carolina, SPX FLOW, Inc. (NYSE: FLOW) is a multi-industry manufacturing leader. For more information, please visit www.spxflow.com

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