Chapter 4

RECEPTION OF MILK

(Milk reception in cans, Receiving section for bulk milk, Milk transport tank, Storage tank, Process tank, Standardization of milk)

MILK RECEPTION IN THE CANS

Milk is received in the processing plant from the primary producers or the milk collection centers. Usually they are transported by cans or bulk containers (milk transport tanks or vans).

Fig. 4.1 Milk can (usual capacity 20-40 litres)

- The first stage of reception involves emptying of cans over the tip tank or weigh tank. Emptying cans over the tip-tank can be done either by hand, or by hand assisted method or by mechanical methods (inverter). The process of inversion may be a serious source of contamination of the tipped milk by soil from can exteriors.
- In some canneries, the can is not completely inverted (the base of can is never directly above the surface of milk).
- After weighing and recording of consignment, the contents are discharged into a tank immediately below the tip-tank, from which the milk is pumped through a cooler to a storage tank.
- Where milk is measured volumetrically, the cans are tipped directly to the tip tank from which milk is pumped to the cooler.

Fig. 4.2 Weigh tank

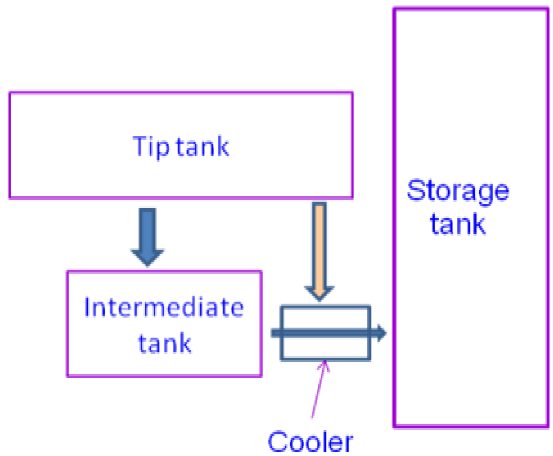


Fig. 4.3 Arrangement of tanks in milk reception section

Fig. 4.4 Bulk milk Coolers

The following approach is done for the mechanization of milk reception sections of dairy plants.

- Power driven or gravity roller conveyors are used for conveying of the milk cans.
- Tipping may be manual or completely automatic.
- The inverted can is moved in that position to the drainage rack and into can washer.

RECEIVING SECTION FOR BULK MILK

The receiving section for the bulk milk may be divided into three subsections as follows.

- Preparing to unload
- Unload
- Weigh

The different activities carried out in these subsections are shown in Fig. 4.5.

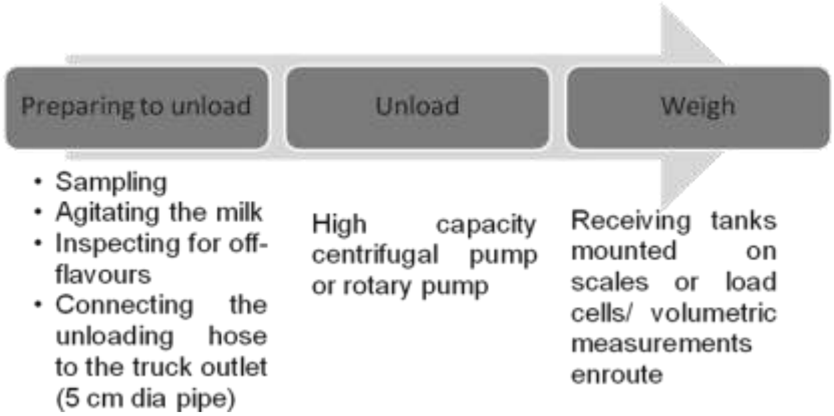


Fig. 4.5 Activities during the receiving of milk

Modern dairy plants use air operated valves to control flow in the receiving operation and CIP systems for tankers, tanks and pipelines. Unloading is done by large stationary pump. Plastic hoses are used for the purpose.

Fig. 4.5 Milk reception for bulk milk containers

Methods for measuring bulk milk

- Weighing or measuring tankers
- Weighing in receiving or storage tanks (with load cells)
- Metering
- Liquid level measurement in storage tank
- Weighing of trucks on scales before and after emptying
- Sanitary meters are used in a number of plants, in which the measurement is by determining volumetric displacement, mass flow rate or velocity.

MILK TRANSPORT TANKERS

- Usually the milk tankers have capacities of more than 12000 ltr (7500-25000 ltr)
- The basic features of milk transport tanks are:

  - Inner shell of stainless steel (18% Cr and 8% Ni)
  - Intermediate thick insulation layer (cork, plastic foam, mineral wool, etc.)
  - Outer jacket (ordinary carbon steel, Al, s.s.)
  - Necessary fittings
- Stainless steel is preferred for long life, low maintenance cost, and excellent appearance, but they are costlier.
- If the milk tank incorporates a pump, hose, flow meter, or other utensils necessary for collection of milk, then it is called *bulk milk pick-up tank.*

There are three important considerations during unloading from milk transport tanks

- Safety
- Temperature
- Agitation

The agitation of milk is very important and is required when the milk is to be delivered to two or more storage tanks. Further, when the milk is stored for some time, the fat will have a tendency to settle and there will be non-uniform distribution of milk fat in the milk. In that case agitation is required for uniform butter-fat distribution. For the purpose, built in electrically driven horizontal agitators are provided in the milk tanks.

STORAGE TANKS

In a dairy plant, storage tanks are used for raw products, pasteurized products and for processed products as well.

Fig. 4.6 Different applications of storage tanks

Storage tanks for raw milk

Usually milk is held up to a maximum of 72 hours between reception and processing in the tank. The tanks may be cylindrical or oval. They may also be horizontal/ vertical.

The storage tanks are often kept outdoors with heads extended through the wall into processing room.

Main considerations

The temperature and sanitation are the two main considerations in a milk storage tank.

Temperature. Milk temperature is maintained at less than 7°C.

Sanitation

- Tanks must be designed for sanitizing, preferably for CIP.

- Surfaces must be smooth, polished and welds in particular have to be made flush, polished and pickled.
- All closed type tanks must be equipped with a manhole, either round (dia about 450 mm) or oval in shape, to permit access to the interior for cleaning and inspection. They are fitted with a swing cover.
- Head space of approximately 15 cm.

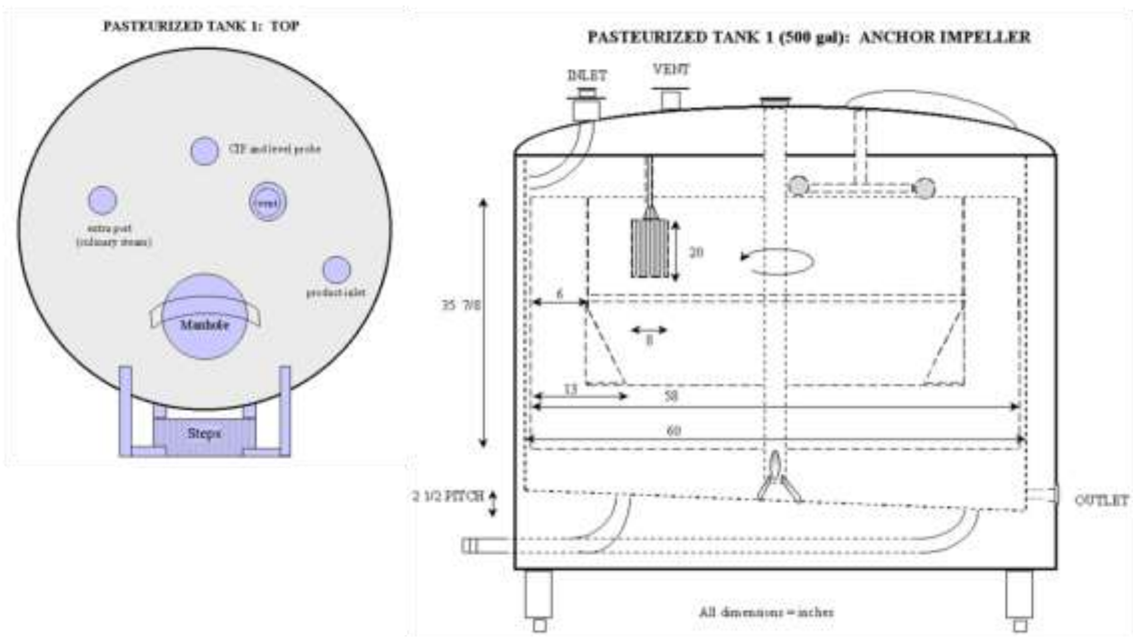


Fig. 4.7 Different parts and accessories of milk storage tanks

Storage tank- accessories

- A curved filling pipe which guides the milk towards the wall (for foam free entry of milk). It is always better to fill the tank from below.
- Viewing ports and lights, spray heads and rotating heads (for cleaning) in the head space.
- Air vent (with screen) of sufficient size to prevent excessive pressure during filling and vacuum during emptying.
- Thermometer probes
- Liquid level gauges (may be a sanitary float with external indicator)
- Agitators (for assuring uniform composition to aid in standardizing, and to improve cooling efficiency in refrigerated storage tanks- may be vertical/ horizontal).

Milk silo

The milk silos are usually of the capacities of 50,000-100000 tonnes. The silos are useful in that they can hold large amount of product in less area. Other considerations are

- Bottom slope 6%.
- Control panel to show temperature, pressure, etc.
- Electrode at the drainage line to indicate when tank becomes empty.

Fig. 4.8 Milk Silos

The milk silos should be provided with some device for agitation to avoid cream formation. The following points should be considered while providing the agitators in the tank.

- Agitation should be smooth. Vigorous agitation causes aeration of milk and fat globule disintegration. Aeration also exposes the fat to lipase in the milk.
- Propeller agitator is preferred.
- For very tall tanks, two agitators may be provided at different levels.

Refrigerated storage tank

- Must cool the milk to a required temperature in a specified time.
- Must maintain the milk below a specified temperature.
- Must maintain the milk below a designated maximum when milk is added.
- In most cases, there is a jacket around the tank for circulation of chilled water or refrigerant.

Process tanks

- Used for treatment of product.
- Examples are ripening tanks for butter cream and for cultured products such as yoghurt, and crystallization tanks for whipping cream, and tanks for preparing starter culture.

Aseptic tank

- Used to store UHT processed milk if it is necessary to have an intermediate tank between sterilizing plant and packaging machine.

- When part of a plant is out of operation (for instance when it has to be cleaned or because there has been a breakdown), a total shut down is not necessary.
- Should have strong and thick walls (as it has to be sterilised together with product pipes by dry steam at pressure of 3 to 5 kg/cm², before it can be used).
- There should be cooling jacket for cooling the milk immediately after steam sterilization.
- Before the UHT milk enters the tank, it must be ventilated with sterile air to drain away any condensate which may have formed.

Fig.4.9 Processing tanks for milk

STANDARDIZATION OF MILK

Standardization of milk can be defined as the process of adjusting the fat concentration of milk. As we have discussed earlier, in India the standardized milk has 3% fat and 8.5% SNF. So it is usual that when the dairy plant receives milk with higher fat content, they take out some of the fat by the process of cream separation and send the 3% fat milk to market. In certain situations, the cream and SNF are added to skim milk to prepare milk with desired fat content. We will discuss about the standardization process with some examples.

Case I. You have received 100 kg of cow milk with 4.5% fat. How much water is to be added to it to make it to 3% fat?

By using mass balance equation, you can calculate the amount of water to be removed.
The raw material has 4.5% fat and the final fat requirement is 3%.
Let the amount of water added be ‘x’
So, we have, $100 \times 4.5\% = (100+x)3\%$, i.e. $100(0.045)=(100+x)(0.03)$
or, $100 + x = 4.5 \div 0.03 = 150$
or, $x = 50$ kg
Hence, 50 kg of water is to be added to make the fat to 3%.

Case II. You have 100 kg of cow milk with 4.5% fat, if you add 20 kg of water in that, what will be the final fat percentage?

You have 4.5% fat in 100 kg milk
Now, you have added 20 kg of water to it,

So, the final fat percentage = (4.5÷120) × 100 = 3.75%.

Case III. You are having 100 kg of the milk with 2% fat. What should you do to get the final fat of 3%?

In 100 kg, you have got 2% fat.

The final fat percentage will be 3%, so you must remove some water from it or add some cream to it.

If you will be removing water, then as per mass balance

$100 x 0.02 = (100-x) \times 0.03$

So, $100 - x = 66.6$

So, $x = 33.4$ kg

That is you will have to remove 33.4 kg of water from the milk to bring it up to 3% fat.

Remember that in all the above cases we have used the mass and component balance equations as

$$F = P+V \qquad (A)$$

$$F.X_f = P.X_p \qquad (B)$$

Case IV. What should be the ratio of the milk with 4.5% fat and water to be added so that the final milk is of 3% fat?

In this case we can directly apply the mass (in this case, fat) balance equations.

$$(F_1 \times X_{F1}) + (F_2 \times X_{F2}) = P \times X_P$$

Here F_1 corresponds to 4.5% fat milk, F_2 corresponds to water and P corresponds to final milk.

So, we have to calculate $F_1 : F_2$

Also, $F_1 + F_2 = P$.

We can write the above equation as

$$(F_1 \times X_{F1}) + (F_2 \times X_{F2}) = (F_1+F_2) \times X_P$$

or, $(F_1 \times 0.045) + (F_2 \times 0) = (F_1+F_2) \times 0.03$

$0.015 F_1 = .03F_2$

or, $F_1:F_2 = 2:1$

Case V. What should be the ratio of milk with 3% fat and cream with 45% fat to get the final milk with 4.5% fat?

Using the mass balance equation,

$$(F_1 \times X_{F1}) + (F_2 \times X_{F2}) = P \times X_P$$

Here $X_{F1} = 0.03$, $X_{F2}=0.45$ and $X_P=0.045$

We have to calculate $F_1 : F_2$

Also, $F_1 + F_2 = P$.

Now, $F_1 (0.03) + F_2(0.45) = P(0.045)$

Substituting $P = F_1 + F_2$

$$F_1 (0.03) + F_2(0.45) = F_1(0.045)+F_2(0.045)$$

$$0.405\ F_2 = 0.015\ F_1$$

Or, $F_1:F_2 = 0.405 : 0.015$

i.e. $F_1:F_2 = 27 : 1$

Case VI. If I add 27 kg of 3% fat milk with 1 kg of 45% fat milk, then what will be the final fat percentage?

This is the case to check whether the calculations made in the previous case are correct.

As per the mass balance equation,

$27 \times (0.03) + 1(0.45) = 28 \times X_P$

$X_P = (0.81+0.45)/28 = 0.045$ or 4.5%

So, the final percentage of fat is 4.5%.

Case VII. What should be the ratio of milk with 1.5% fat (doubled toned milk) and 80% cream to get the final milk with 3% fat?

Using the mass balance equation,

$$(F_1 \times X_{F1}) + (F_2 \times X_{F2}) = P \times X_P$$

Here $X_{F1} = 0.015$, $X_{F2}=0.8$ and $X_P=0.03$

We have to calculate $F_1 : F_2$

Also, $F_1 + F_2 = P$.

Now, $F_1 (0.015) + F_2(0.8) = P(0.03)$

Substituting $P = F_1 + F_2$

$$F_1 (0.015) + F_2(0.8) = F_1(0.03)+F_2(0.03)$$

$$0.77\ F_2 = 0.015\ F_1$$

Or, $F_1:F_2 = 0.77 : 0.015$

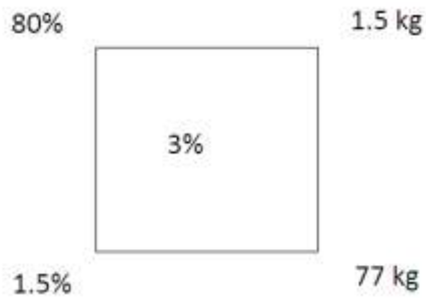
i.e. $F_1:F_2 = 51.333 : 1$

The above problems in case V and VII can be solved easily by another method as follows.

The steps are as follows.

1. First we draw a square as shown below.
2. On the left top and bottom corners, we write the fat percentage of the raw materials.
3. At the centre of square we write the final fat percentage.
4. Then we write the differences in between the fat percentages on the other corners.
5. The values that we get on the opposite corners are the ratios of the materials to be added.

As an illustration, let us resolve the case VII.



The values will be as shown in Figure. Remember that on the extreme right top corner 1.5 is the difference between 1.5 and 3, and the right bottom corner value 77 is the difference between 80 and 3. Thus the ratio of 1.5% milk and 80% cream will be 77:1.5 or 51.33:1.
In this case 77 kg of 1.5% fat milk will be added to 1.5 kg of 80% cream to make 78.5 kg of 3% fat milk.

This method is known as Pearson's square method.

Case VIII. What should be the ratio of 3% fat milk and 65% cream to make a product of 5% fat milk?

We can solve this type of problem by using "Pearson's square" method.

So after writing all the values in the square, we can straight away write that 60 kg of 3% fat milk will be added to 2 kg of 65% fat cream to give 62 kg of 5% fat milk.

Case IX. What should be the ratio of 3% fat milk and 88% cream to make a product of 3.5% fat milk?

You may draw the figure accordingly to find that 84.5 kg of 3% fat milk will be added to 0.5 kg of 88% cream to get 85 kg of 3.5% fat milk.

CHECK YOUR PROGRESS

1. Write short notes on
    a) Milk reception by cans
    b) Receiving of bulk milks
    c) Milk transport tanks
    d) Accessories in storage tank (explain and indicate why they are essential)
    e) Sanitation of milk storage tank
2. What are the methods for measuring bulk milk?
3. What are the important considerations during unloading of bulk milk tanks?
4. Explain the different types of milk silos.
5. What should be the ratio of skim milk (0.5% mf) and 82% cream to make a product of 3% fat milk?
6. In the above example, what will be the proportions, if we want to make 2.5% fat milk.