UNIT 3 MILK CHILLING AND STORAGE

Structure

3.0 OBJECTIVES

After studying this unit, we will be able to:

- state the purpose and importance of chilling of raw milk;
- outline the effect of chilling and storage on microbial growth, shelf life, quality and properties of milk;
- specify the various equipment for milk chilling;
- give the criteria for selection of location and site of a milk chilling centre;
- enumerate operational activities and devices used at milk chilling centres;
- indicate considerations in selection, construction and installation of milk storage equipment.

3.1 INTRODUCTION

Production of milk in India is very widely scattered in rural areas and at vast distances from the places of consumption i.e. urban areas. Various sources which contribute to the micro-flora in milk are containers, udder of the animal, dust and dirt particles, fodder, leaves, atmospheric air, the milker and the animal itself. The number further increases during handling, storage, transportation, processing and consuming practices prevalent in rural areas. The number and types of micro-organisms would depend upon the conditions and the sources of contamination.

As soon as microorganisms get into milk, they start growing rapidly because milk contains all the nutrients and favourable conditions required for their growth. If the growth of micro-organisms is not checked, then their growth will continue and several bio-chemical changes will take place affecting the quality of milk. Further, if milk has to be transported to longer distances, considerable time is involved between production and processing. During this period, milk must be protected from spoilage by the action of micro-organisms. Prompt cooling, i.e. chilling is one of the methods of preserving milk, after production to maintain its quality.

3.2 CHLLING OF MILK

i. Importance

Milk leaves the udder at body temperature containing only a few microorganisms. The number increases rapidly at this temperature, if growth is not checked immediately by chilling the milk. Chilling is necessary after receiving milk at collection/

chilling center. Chilled milk can easily and safely be transported without having appreciable deteriorative changes due to microbial growth. Thus, raw milk is chilled to a) limit the growth of bacteria, b) minimize micro-induced changes, and c) maximize its shelf life. However, chilling of milk involves additional expense which increases the cost of processing. Importantly, chilling process does not kill microorganisms nor it renders milk safe for human consumption. It is only a means of checking the growth of microorganisms for a certain period.

ii. Effect on Microbial Growth

Generally, milk is cooled immediately after milking to below 10°C. within 4 hours to prevent/retard the multiplication of thermophilic and mesophilic bacteria including disease producing and food poisoning organisms until the milk reaches the dairy. The extent of control of growth of microorganisms is dependent on type of organisms. Staphylococci do not grow below 10°C. Growth stops for most types of *B. coli*, *B. proteus* and M*icrococci* between 0°C and 5°C. If milk is stored cold for too long time, there can be an undesirable increase in psychrotrophic organisms which produce extremely heat resistant lipases and proteases.

The time factor is critical in arresting bacterial growth in fresh milk. As milk from the udder of healthy cows has a low bacterial count. There is a lag phase immediately after milking, for around 4 hours, before bacterial multiplication begins to grow. The quicker milk is cooled, the better the quality and in the ideal condition, milk is cooled immediately after milking to 4^{0}C or below and held at that temperature till it is processed. The effect of storage temperature on microbial growth in raw milk is shown in Table 3.1.

Table 3.1: Effect of storage temperature on microbial growth in milk

Raw milk storage temperature (°C) for a period of 18 hours	Bacterial growth factor*
0	1.00
5	1.05
10	1.80
15	10.00
20	200.00
25	1,20,000.00

* Bacterial growth factor by multiplying with the initial count of bacteria gives the final count.

iii. Effect on Keeping Quality of Milk

Fresh raw milk is cooled to 4^{0}C to extend its shelf-life (freshness). At this temperature, the activity of enzymes, the growth of microorganisms and metabolic processes are all slowed down. As a result, prolonged holding of chilled milk is bound to cause significant deteriorative alterations in keeping quality of milk. In addition, cooling causes a considerable dissociation of b-casein, calcium and phosphate ions and proteases from the casein micelles. The milk loses its suitability for cheese making, coagulation times are increased and the curd tension of the coagulum is less.

Chemical and biochemical processes are considerably slowed down by cooling. However, milk, which has been stored, sometime has a bitter off-flavour. Enzymes and microorganisms can cause chemical changes which are accompanied by a lower pH value and change in nitrogen-containing compounds. Psychrophilic microorganisms cause proteolysis of casein and, together with enzymes, also that of albumin. Protein breakdown products (polypeptides) are formed. Certain bacteria are responsible for the hydrolysis of fats causing rancid flavour development. Several enzymes such as oxidase, catalase and reductase are active for a long time, even at 0° C. Hence, if the time between milk reception and processing is 2 to 3 days, the storage temperature should be kept between 2° C to 5° C for minimum effect on keeping quality of milk.

iv. Effect on Physico-chemical Properties of Milk

The effect of rapid cooling and storage at low temperatures on the physico-chemical properties of the milk components are being discussed below:

- **Failure to rennet/acid coagulation:** The failure of casein to coagulate at 2°C either at pH 4.7 or after rennet treatment has been utilized in the development of continuous cheese making process, where the milk is either acidified or renneted at 2°C and the temperature is subsequently raised to about 15.6°C or 30°C to effect coagulation.
- **Failure to coagulate at isoelectric point:** Milk fails to coagulate at 2° C after adjusting to the isoelectric point (pH) of casein. At 2-3° C there is an increase in the diffusible inorganic salts and a change in the casein micelle structure. Some micellar casein is converted to a non-micellar or soluble form (e.g. b-casein). At 2°C, the pH of the milk has to be reduced to 4.3 to effect complete casein coagulation, whereas at 30°C the recovery of the casein at pH 4.6 was nearly complete. Also the properties of casein obtained by acid precipitation at 2° C and pH 4.3, and at 30°C and pH 4.6 were found slightly different.
- **Increase in viscosity:** Storage of milk at 2^0 to 5°C, both raw and pasteurized caused an increase in the viscosity of the product which may be related to changes in the protein system, since viscosity is influenced largely by the colloidal components of milk. Probably, conversion of colloidal calcium partly to soluble form may uncoil the casein micelle. The change in viscosity with storage at low temperature (2 to 5°C) was greatest during the first 24 hours and reaches maximum after about 72 hours.
- **Decrease in cheese curd firmness:** The cold aging of milk increased the rennet coagulation time at 30°C. The increased coagulation time was inversely related to the ratio of colloidal calcium-phosphate, and could be reversed by heating to 40°C for 10 minutes or by addition of calcium chloride to the milk prior to cold aging.
- **Increased hydrolytic rancidity:** Cold storage of milk below 7°C is associated with an increase in the rate of development of rancidity. Cooling tends to dissociate the casein micelle and increases the total available lipase in the milk system. Subsequent treatment to milk (warming, agitation, etc.) bring lipases into contact with fat globules and liberate free fatty acids to produce rancidity in milk.
- **Increased Foaming:** Cold milk foams readily. Milk proteins concentrate in the lamellae of the foam where b-lactoglobulin acts as a surface active agent. Foams are formed by the preferential adsorption of surface active materials at an air-liquid interface with orientation of the material to form an air bubble.
- **Physical structure of fat globules:** Crystal structure and size vary as a function of both cooling rate and cooling temperature and regulate the hardness of the milkfat. More fat passes into the solid state by direct cooling than by stepwise cooling. The sensitivity of the fat globule membrane to shear and subsequent release of free fat is greater in milk that has a higher proportion of solid to liquid fat. Thus, milk rapidly cooled, 0-5°C, is more sensitive to shear damage than that is cooled more slowly and in a stepwise manner.

i) **Increased clustering of fat:** When milk is stored at low temperature (0-5°C), change in the surface characteristic of fat globule membrane results in more rapid creaming due to increased fat globule clustering effected by concentration of "agglutinin" on the fat globule surface.

ii) **Migration of substances:** Cooling milk to 4°C leads to migration of some membrane proteins, phospholipids, xanthin oxidase, natural copper, etc. from fat globule membrane to milk plasma.

v. Equipment and Methods of Chilling

Cooling is the predominant method of maintaining milk quality during collection. The most important factor next to hygienic production of milk is the time between completion of milking and reducing the temperature low enough to restrict bacterial growth. Whatever the method of cooling, the faster the temperature is reduced from 37°C at milking, the better will be the resultant milk quality. Selection of a suitable method and equipment for prompt cooling i.e. chilling milk is dependent upon the available facilities at the moment keeping in view the volume of milk handling and time for cooling and keeping it cold till reaches for processing. Various methods of cooling of milk are described below:

- **Can (container) Immersion:** The fresh milk immediately after milking, is placed in a container (preferably metal) which is gently lowered into a tank/ trough of cooling water. Cooling of milk will slowly take place and if the water is cold enough, the milk temperature will be reduced low enough to allow the milk to be marketed/processed. The milk inside the cans may be stirred with the help of plunger for uniform quick cooling.
- **Surface Cooler:** An improvement of water cooling is a metal surface cooler, where water flows through the inner side and milk flows over the outer surface in a thin layer. A well designed water cooler will reduce milk temperature almost instantaneously. The cooled milk is received below in a receiving trough, from which it is discharged by gravity or a pump.
- **Plate Heat Exchanger:** This is the most widely used very effective equipment for chilling of milk by the commercial dairy plants. Several stainless steel plates are mounted on a solid stainless steel frame in which the milk to be chilled and chilling water flow alternatively and counter-currently. The number and size of plates in the exchanger depend upon the capacity of the plant which may vary as per requirement. This method of chilling is more efficient, more hygienic, involves less manual labour and cost effective.
- **Tubular Cooler:** This consists of two concentric tubes, inner tube usually carries the milk to be chilled while cold water is passing through the hollow space in between the pipes. The length and diameter of both the tubes are determined according to the capacity of the plant. The flow of the milk and chilled water is in opposite direction, i.e. counter-current. The tubular cooler is efficient,, where milk is not exposed to atmosphere.
- **Bulk Milk Coolers:** These consist of a double jacketed vat fitted with a mechanical agitator. It also has provision for circulation of chilled water which comes from the chilled water tank. Normally, milk is chilled and subsequently stored at low temperature until transported to processing units for further processing. Bulk milk coolers are generally installed at chilling centres.
- **Rotor Freeze:** Rotor freeze provides spray of chilled water outside the cans obtained by mechanical refrigeration system and passing through the perforated tubes around the neck of the can. With this system, milk temperature is brought down to 10°C from 35°C within 15 minutes.

Brine Cooling: The direct expansion coil is used to cool brine which is then circulated by a pump around the product to be cooled. Brine system of cooling may be of a) brine circulating type, b) brine storage type, and c) congealing-tank type. This system has the advantages of being safe with ammonia and of causing less damage in case of a leakage and the temperature can be easily controlled. It also allows the storing up of refrigeration in the cold brine and therefore, allows heavy refrigerating loads of short duration to be carried with a system having a much smaller compressor than direct expansion system used. The overall thermal efficiency of a brine system is usually less than the direct expansion system on account of the one extra heat transfer and the added radiation losses.

Ice Cooling: Ice, produced by commercial ice plants, is used in some countries to cool milk. The use of ice for cooling is generally fairly expensive and not particularly effective due to the problems in getting an optimum and rapid heat transfer from the liquid milk to the solid ice. Different methods of cooling milk by ice are:

- **Putting Ice Around Metal Cans of Milk:** It is the simplest form of cooling milk in which ice slabs are stacked around the metal cans of milk on the delivery vehicle and the system relies on heat transfer by contact.
- **In Can Cooling:** In this method, ice is placed in a metal container, known as ice gum or ice cone, which is inserted into the can of milk. This permits a more effective heat exchange rate by giving off latent heat of ice and sensible heat of melted water but reduces the volume of milk that can be carried in the milk can. When ice is completely melted in the ice cone and there is no more heat transfer, the water is thrown and fresh ice pieces are put in. The process of cooling milk by this method continues even during transportation from collection centres to processing unit.
- **Direct Addition of Ice:** Sometimes cooling of milk is done by direct putting ice into the milk. While this achieves an effective transfer of energy, and reasonably rapid cooling, it has a major disadvantage of diluting the milk with water, which will require removal at subsequent processing or the sale of adulterated milk.
- **Mechanical Cooling:** Mechanical refrigeration system is the most effective means of arresting bacterial growth by lowering milk temperature to around 4^0C. This system of cooling can be utilized in the following manners:
- **Household Refrigerator:** This is a practical method for small volume of milk (say from 1 or 2 animals, approx. 5 litres) where the farmers has a refrigerator. The milk in metal container immediately after milking, is placed in a domestic household refrigerator where the milk will slowly cool to the temperature of the refrigerator.
- **Surface/Immersion Cooler:** Under direct expansion system, a mechanical refrigerator compressor and condenser (usually air cooled) produces a liquid refrigerant (freon or ammonia) which when passing through an expansion system causes a rapid reduction in temperature.
- **Expansion Bulk Tank:** Direct expansion bulk tank, ranging in size from 500 L to 20,000 L, is an energy efficient system of cooling the milk to 4^0 C within the acceptable period of 4 hours. It is used directly on farms where, medium to large sized herds are milked or at collection/chilling centre.
- **Ice Bank:** The ice bank is a widely used for fast cooling of milk. This method of cooling reduces the size of the refrigeration compressor (hence, power requirement) by building up a reserve of ice over a long period. In ice bank, cooling is done through a plate heat exchanger or a surface type cooler with chilled water being the cooling medium. The chilled water is pumped from the ice bank through the heat exchanger and back to the ice bank. Ice banks have considerable flexibility in size and range from a small, self-contained portable unit to a large, using a multiple ammonia compressors, water condensers and associated cooling towers.

Check your progress 1

1. Why is chilling of milk essential within stipulated time after production?

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2. How does chilling arrest the microbial growth and enhance keeping quality of milk?

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3. Describe, in short, the effect of chilling and cold storage on physico-chemical properties of milk.

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4. What are the methods of chilling raw milk?

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3.3 CHILLING CENTRE

i. Purpose

When the producer has no possibility for any mode of primary cooling, the objective should be to deliver the milk in the shortest possible time to the processing plant or collection centre. If no cooling facilities exist at the centre, its main objective is to receive all the milk from producers as quickly as possible and transport it for processing to chilling centre. The chilling centre pools, accepts and weighs the supplies of the milk from different sources, and checks the condition and quality of milk supplies. Milk is chilled immediately and stored till supplied it to the market or processor. So wherever, there is no possibility of raw milk to reach processing plant within 4 hours of production, a chilling centre is required to be established to save the milk from deterioration. This requires enforced time schedules for receiving milk at the primary collection point and a reliable delivery system to the market, processor or chilling centre. Where milk is to be mechanically cooled prior to further transportation, the most important pre-condition is also time. The arrival of milk at the chilling centre should be short for the better milk quality.

Installation of chilling center is done with the following objectives:

- Accepting, weighing and pooling the supplies of milk.
- Preserving the quality of raw milk supplies.
- Providing easy transport of chilled milk to the processor.

ii. Criteria for Selection of Site and Location

Selection of a suitable site and location for establishing a milk chilling centre is guided by:

- Location of main dairy or market,
- Within area of adequate milk production,
- Availability of adequate potable water supply,
- Sufficient electric supply,
- Proximity to a good road and/or railway station.
- Facilities of waste/sewage disposal, and
- Easy availability of human resources and infrastructural facilities.

iii. Operational Procedure

Essentially, this is the same as in a small dairy. On arrival, the milk is graded for acceptance/rejection, weighed, recorded, sampled for testing, cooled and stored at low temperature until dispatched to the market or processor.

Reception and Receiving Devices: Normally, milk is brought in cans to the chilling units from milk collection centers by different modes of transportation. In some small chilling centres, milk is also received directly from the producers. Depending on quantum of milk received, sources of supplies, type of milk supply containers, etc. receiving procedures and devices are provided at the reception dock.

Chilling and Storage: As soon as the milk is received and dumped, it is pumped to storage tank through a chiller. The chilling system, that enables rapid cooling to reduce temperature to the desired level, is preferred. An ice bank system, using chilled water circulating through a plate heat exchanger to cool the milk immediately after reception, is more effective than immersing cans in chilled water, placing in a cold storage or cooling in jacketed vat with chilled water etc. The milk should be kept cold until it is despatched to processing plant. For this purpose, insulated bulk storage tanks mounted with motor-agitator and cooled by chilled water or refrigerant are the most effective.

Dispatch of Milk to Main Dairy: Once the milk is chilled, it is stored chilled in storage tank at the chilling centre till despatched to the main dairy. The chilled milk is drawn from the storage tank and filled either in cans or in road/rail milk tankers and, despatched. Before filling, each can and/or road/rail milk tanker is inspected carefully for cleaning and sanitization. Then, proper filling is ensured reducing loading and unloading time. The following steps are observed to ensure satisfactory despatch by tanker:

- The level of milk and recorded temperature are noted.
- Working of agitator is ensured.
- The milk delivery line is connected from the tank to the milk pump in the tanker through the flow meter. Wherever flow meters are not provided, the quantity of milk dispatched is ascertained by tele-gauges or dipstick.
- The outlet valve of the storage tank is opened, the milk pump is started and the milk is released into the tanker.
- The rate of flow using any of the devices is recorded when the flow has become steady.
- Milk is allowed to flow in the tanker to the prefixed optimum level, taking care to avoid excessive foam due to sudden rush of milk in the tanker compartments.
- Milk pump is stopped, the tanker covers are closed and secured by locking them.

- The milk delivery valve of storage tank is closed.
- After the operation, all connected milk delivery line is dismantled, sanitized and kept ready for next day use.
- A sample of milk is drawn and analyzed. Result is also recorded in the dispatch challan along with other information.
- The number of cans and quantity of milk kept in cold storage for dispatch are checked.
- If the milk is held in a storage tank, the necessary pipe line is connected and cans are filled.
- A composite sample is drawn as per the laid down procedure, analyzed and recorded.
- Satisfactory sealing of individual can is ensured to prevent tampering.
- Wherever, ice-cooled cans are used, the recommended precautions are observed.

Sampling and Testing of milk: At a chilling centre, milk is to be sampled at 3 stages:

- At milk reception dock for acceptance/rejection of milk and making payment to individual suppliers.
- After bulking and chilling of milk kept in storage tank/vat and /or milk cans for record and verification.
- At the time of dispatch to verify the quality of milk with the record of the receiving dairy.

Quality of milk on the reception dock is assessed by performing the platform tests. Further, milk samples are analyzed in the laboratory for chemical and microbiological quality of all accepted milk for making payments, maintaining records etc.

Check Your Progress 2

1. Give reasons for establishing a chilling centre.

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2. Describe operations carried out at a chilling centre?

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3.4 STORAGE OF MILK

i. Purpose

The purpose of storage of milk at different operational points is described below:

At Production/Collecting/ChillingCentre:

- For pooling and bulking from small producers until it is transported to chilling centres/processing plants.
- For chilling and holding at chilling centres until picked up by tankers.

- To handle milk from large producers.

At Processing Centre

- For storing raw milk as received from chilling centres till taken up for processing.
- For storing processed milk till taken up for packaging or bulk dispensing.
- For storing milk products in liquid state during manufacturing.
- Intermediate storage between processes.

For Transportation in bulk by road tankers

- For transportation of pre-cooled milk from collection and chilling centres located in rural areas of production to processing plants located in urban areas of high density consumption.
- For transportation in container service from process plant to bulk dispensing centres.

For Transportation in bulk by rail tankers

- For transportation of pre-cooled milk comparatively large quantity of raw milk from chilling centers located close to rail tracks to processing plants.
- For transporting processed milk from area of high production to cities located at vast distances.

Modern dairy plants hold both raw and pasteurized milks. Normally the milk storage capacity is equal to one day’s intake. So, large milk tanks & silos are being installed at dairy plants with the following objectives:

- To maintain milk at a low temperature so as to prevent any deterioration in quality prior to processing /product manufacture.
- To facilitate bulking of raw milk supply to ensure uniform composition.
- To allow for uninterrupted operation during processing.
- To facilitate standardization of milk.

ii. Storage Equipment

Guidelines Deciding Suitability of Storage Facilities: The following guidelines are observed while deciding the suitability of storage facility for specific purposes:

Modern dairy operations necessitate storage facilities to allow continuous (uninterrupted) operation, for extended period of time, during processing. The type of storage facility to be provided depends on various factors. When large volume of milk is processed, the present trend is to install Silo type of tanks of capacity as large as 1,00,000 liters each. This will reduce the cost of building, capital cost of tanks as well as operation, cleaning and maintenance costs, since the number of unit required for any desired capacity is considerably few. The total capacity of raw milk storage tanks will be, under normal circumstances, equal to daily intake at the plant. With a coordinated programme of rate and time of receiving at the plant, and the rate of processing, some raw milk storage capacity could be reduced. Storage facilities at intermediate stages of processing such as for manufacturing operations like separation, standardization, clarification, products manufacturing as ice-creams, butter, cheese, evaporated milk, milk powder, etc. have to be studied for each stage independently. While deciding on the number and size of tanks, for each facility, the length of storage time as well as the time required to clean and sterilize the tank before the next filling starts, has to be taken into consideration. Installing standard sizes, storage for different products, helps in flexibility with respect to alternative use and future expansion. The horizontal or the vertical design consideration must include economy of construction and housing, suitability and space availability.

Material of Construction: The material of construction of the storage equipment and road/rail milk tankers should conform to IS:739-1965. All product contact surfaces must be made of non-corrosive & non-reactive materials such as stainless steel (SS-304 or 316 grades) or aluminum or its suitable alloys. Other parts not coming in the direct contact must be decided based on requirements like appearance, heat transfer properties, strength and surrounding environment. Suitable fittings like ladder (internal and external) for inspection and cleaning should be provided. Suitable provision for milk inlet and out-let along with looking glass or manhole for manual cleaning or maintenance should be considered. The appropriate quality of gasket also needs considerations. The internal ladder could be made of stainless steel. The road /rail milk tankers must have provision of enclosures and locking of valves to prevent theft or sabotage.

Design Considerations: There has been in recent years, an increasing change away from open vats or vats with lids to closed cylindrical tanks. Vats previously in general use, which were rectangular, round or oval, are today used only in some instances such as in milk reception and more commonly in the cheese manufacturing plants. Cylindrical tanks are used either in an upright position or horizontally depending upon the space available. To compensate for irregularities in the floor, when tanks are erected, they are fitted with adjustable legs with levelling screws.

Today tanks, vessels or vats are made almost invariably of stainless steel. Aluminium has largely been replaced in the vessel construction industry. To be suitable for use in the dairy industry, the surfaces of vessels which are in contact with product must be smooth and, the welds in particular have to be made flush and polished during manufacture. Sharp angles where bases and sides meet in flanges and pipe inlets must be avoided. In vessels, corners which connot be properly cleaned must also be avoided. The specific design considerations for cans, tanks and tankers have been discussed below:

Milk can: The centre of gravity of full cans should be conveniently placed. It should be made rollable. The angles of shoulders of the can should allow quick and easy drainage of contents and provide enough strength along with ease of cleaning and inspection. The can should be fitted with handles to assist easy handling by workers. The neck width should allow good stability to hold it up-right in inverted position. Therefore, the design consideration should have angle of balance when upright of 30 degree, spill point greater than 30 degree, shoulder angle 45 degree and angle of balance when inverted 15 to 20 degree with respect to vertical surface.

Storage tanks/vessels: Inner shell is usually made of stainless steel or aluminium alloys with all welded points conforming to IS:2812-1964. Joints are well dressed and ground, smooth and free from visible porosity and brittleness. All inside surfaces are made to drain directly to outlet nozzle. Bottom slope is 1 in 15 to horizontal for vertical tanks and 1 in 12 for horizontal tanks, both in the longitudinal and transverse directions. Internal corners should have a radius of not less than 25 mm. Thickness of plate for shell wall and bottom plate vary according to size of tank and its capacity. A minimum 2 mm thickness for shell and 5 mm thickness for bottom plate is considered for lowest capacity tank/vat.

Jacketed space surrounds the inner shell and used for circulation of steam, hot water, chiller water, brine or direct expansion refrigerant for heating in case of vats and for cooling as well as for maintenance of low temperatures of products in storage.

Insulation layer surrounds the inner vessel for ordinary vessels that are not refrigerated or surrounds the outer wall of jacketed space and is provided by vapour barrier on the outer surface. Outer shell surrounds the insulation layer. The material of this shell may be stainless steel, aluminium, galvanized iron or mild steel of not less than

3 mm thickness provided with vent hole to drain any condensation of moisture inside.

Road/Rail Tankers: These are made with or without compartments to transport different quality milk and also reduce churning and foaming during transportation. Maximum number of compartment per tanker is three. If a tank is made with compartments, the baffles require special care in installation and routine cleaning. Inner vessel of stainless steel of not less than 2 mm and outer shell of mild steel of not less than 3 mm thickness is considered in normal design.

Capacity Determination: Capacity of a storage tank is the volume of milk holding when filled to a level of 60 mm below top edge of inner vessel. Determination of capacity of a storage tank is dependent upon the products to be processed and milk operation procedure. This facilitates continuous processing of product, once the operation starts. Adequate storage facilities help independence of unloading of tankers from processing of milk.

iii. Parts of Storage Tank

Lid or manhole: Usually located at top or side portion of tank. In case of over head tank, manhole is located at the front end (in-side the process room). In silos, it is positioned near the bottom at suitable working height or at top. Usually the manholes are made of minimum 400 mm diameter, round or rectangular in shape and fitted with gasket around rim.

Product inlet: Inlet provision is made for pouring /loading the product through a bend from top of tank to the side so that milk will gently flow down the sidewall. In vertical silos inlet is given at the bottom to prevent foaming and air incorporation.

Product outlet: Outlet is fitted at the lowest point of bottom and installed to flush and provide proper drainage of product from the tank. In vertical silos, inlet also serves as outlet. Flanges type openings of minimum 50 mm diameter with bend of at-least 55 mm radius are considered most suitable.

Indicating thermometer: Pocket for indicating thermometer of range upto 40°C is provided at least 15 cm above the bottom of inner shell. Remote indicating and automatic temperature control and recording system may be installed for large size tanks and vats.

Opening: An opening is provided at the top of tank for chemical cleaning device of minimum 38 mm size.

Air vent: Air vent at top of tank is provided with screen to prevent entry of foreign materials and of sufficient size to prevent build up of pressure during filling and vacuum condition during rapid draining.

Agitator: Mechanical or pneumatic type agitator devices are provided to prevent cream-line formation during holding. It improves cooling efficiency and maintains uniform temperature and composition. It may be mounted on the lid of the tank near the manhole to facilitate dismantling for cleaning and inspection. Mechanical agitation device consists of motor driven agitator made of stainless steel, whereas pneumatic type has devices for introducing pressurized, clean and moisture/ oil free air into the silo.

Sight and light glass: One each with clear glass and diameter of not less than 100 mm is provided, effectively sealed to prevent ingress of foreign materials from the surroundings. These are shaped and mounted in such a way that inner surfaces drain inversely and is easily removable for cleaning and inspection. Each of these is mounted on opposite ends of top cover.

Sampling cock: size 50 or 63.5 mm

Measuring scale or dip-stick: Made of stainless steel and graduated to tank volume.

Ladder: Ladder, made of stainless steel or aluminum, is used inside and/or outside. It could be made of mild steel for external use.

High and low level cutoff: Large tanks are provided for automatic stoppage of pump motor, together with alarm bells and indicating lamps at the control panel to prevent accidental over filling or low level at outlet and consequent damage to pump material due to dry running.

Like storage tanks, the Road/Rail tankers also have provisions of lid or man-hole, vent, inlet connection and ladder for their specific purposes. Outlet is provided at the rear end of a road tanker, whereas in rail tanker it is at the centre of compartment. Each compartment may have separate outlet. The tanker alignment has sloping towards the outlet point for easy drainage of content. The outlet is provided with two way valve and its size is normally 63.5mm. Preferably flanged on tank end and union connection on the outlet end for hose connection is provided. Other special fittings include:

- Housing for valve: Stainless steel box with locking arrangement is provided for the safety during transportation.
- Rear Cabinet: Provision of rear cabinet is made to accommodate milk pump, metering equipment, sampling cock, unloading device and emergency spares such as gaskets, etc.

iv. Cleaning and Sterilization

For effective cleaning and sterilizing, the quality of the construction, finish and installation of equipment is of primary importance. Places such as dead ends, bends, etc. must be dismantled and cleaned manually. It is to be ensured that cleaning/ sanitizing solution is not trapped in the equipments and pipe lines. Specific methods for cleaning and sterilizing of storage equipments have been discussed below:

Cans: Immediately after emptying, milk cans are turned upside down on a conveyor or rack and transported through several treatment stages such as drain, pre-rinse, caustic rinse, hot water rinse, hot air drying /steam sterilization and cold air treatment. The liquids are jetted into the can from below. Empty cans are also cleaned manually, steam sterilized and allowed hot drying.

Tanks, vats and vessels: Small tanks and vats can be cleaned manually. After a pre-rinse with lukewarm water, manual cleaning by hand brushes is done. Since there is inadequate lighting and soiling matter removal is dependent on the judgement of individuals, manual cleaning is not so effective. The spray lance of 1m to 1.5m long is directed by hand to the appropriate places of cleaning.

With the development of automatic Cleaning-in-Place (CIP), efficient cleaning and sterilizing results are obtained even in large size vessels. Especially designed spray arms and nozzles (turbine or ball spray) are normally used to ensure uniform spraying of detergent and sanitizing solutions over the surface in programmed manner.

Road/Rail Tankers: In addition to the manual cleaning and sanitization of road/ rail tankers, programmed C.I.P. with spray ball or rotating turbine type arrangement for each compartment is used. For 20,000 L tankers, two spray balls and for 40,000 L, four spray balls are provided.

Check Your Progress 3

1. What guidelines are observed in deciding the suitability of storage facilities?

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2. Describe the various constructional aspects of storage equipment to facilitate sanitary handling of milk.

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3.5 LET US SUM UP

It is essential to restrict the growth of microorganisms in raw fresh milk. This can be achieved by means of prompt cooling or chilling of milk to below 10^0C within 4 hours of milking and, holding it cold till processed or marketed. Chilling of milk is a surest means of controlling growth of pathogenic and non-pathogenic organisms but it does not render safe for human consumption until processed. Chilling can be done at the farm, collection centre, chilling centre or main dairy by several methods. However, long storage of chilled milk at low temperature (below 4°C) causes changes in microbial population and some physico-chemical properties affecting its keeping quality. Several containers of varying size, shape, type and capacity are used for chilling and storage of milk. The material and constructional design of equipment and utensils are most important for milk chilling and its storage.

3.6 KEY WORDS

Brine	:	A solution of salt such as sodium or calcium chloride
Chilling	:	Rapid cooling to below 10°C
Cleaning	:	The irreversible removal of the soil from the surface
Conveyor	:	Mechanical device used to assist in the movement of articles or products from one location to another without using a vehicle.
Firm	:	Solid, compact textural properties.
Off-flavour	:	Abnormal flavour, detracting from characteristic flavour
Retard	:	Slow down
Rinsing	:	To remove any loosely adherent milky and other residual matter by washing lightly from surface of equipment.
Sanitizing	:	Cleaning plus disinfecting
Sterilizing	:	The act or process mostly by heat of killing all living cells.

3.7 SOME USEFUL BOOKS

Anantakrishnan, C.P. and Simha, N.N. (1987), Technology and Engineering of dairy Plant operations, Lakshmi Publications, Ansari Road, New Delhi.

De, Sukumar (1980), Outlines of dairy technology. Oxford University Press, Delhi.

Khan, A.Q. and Padmanabhan, P.N. (1991), The Technology of milk processing. Shri Lakshmi Publications, Chennai10

3.8 ANSWERS TO CHECK YOUR PROGRESS

Your answer should include the following points:

Check Your Progress 1

1) i. Milk is contaminated by microorganisms and microbes-multiply rapidly. Milk is chilled to arrest growth of microbes.

2) i. Chilling lowers down rate of biochemical changes, quality deterioration takes more time, keeping quality increases.

3) i. Effect on, rennet / acid coagulation rate, shift of isoelectric point, viscosity, hydrolytic rancidity, foaming, fat globules and fat globule membranes-clustering of fat, migration of FGM materials, etc.

4) i. Chilling by cold water, ice bank system and mechanical cooling.

Check Your Progress 2

1) i. Collection points have no mode of cooling milk and dairy plant is at far off places, to improve keeping quality

2) i. Unloading, conveying, grading, tilting, weighing, recording, sampling, dumping, pumping, chilling, storage, dispatching.

Check your progress 3

1) i. Per day handling capacity of dairy, operational convenience,location in the dairy stage of processing, length of storage-process schedule, varieties of products, manufactured, constructional material, size, number and design-standardization of size and shape.

2) i. Material of construction, sanitary design, sanitary and standard fittings.