FOOD PLANT UTILITIES

1. Industrial Water

Water is required in several food processing operations, such as steam generation, washing of raw materials, cooling & addition to food products. Water is supplied from deep wells, or from clean rivers &lakes. Water pretreatment may involve removal of suspended solids by sedimentation & filtration & break point chlorination. Potable water used as food ingredient may require some physicochemical treatment like carbon filtration, and membrane treatment

Water reuse can reduce waste water, using the above mechanical and physicochemical methods.

2. Steam Boilers

Steam boiler are an important part of the food processing plant, providing process steam for heating blanching, sterilization, peeling, cleaning, evaporation, and drying.

In some large processing plants e.g. beet sugar refineries, cogeneration installation are used, producing both process steam and electricity, with better utilization of the fuel energy and reduction of the thermal and material pollution of the environment. Two cogeneration system is used (1) the toping system, in which high pressure steam produces power, while the exhaust low presser steam is used for process applications, (2) the bottoming system in which high presser combustion gases operate gas turbines and the exhaust gases are used to produce process steam. Closed cycle gas turbines operate with high pressure air, heated by combustion of fuel gas, oil, or combustible wastes.

Process steam boilers produce 5 to 200 tons/h steam at a pressure of about 20 bars, which is reduced to about 2 bars, near the steam consumption. Steam generators are usually housed in a separate room for safety and noise reasons. In food processing, natural gas or lpg are the usual fuels, because they are clean and do not pollute the environment. The feed water for steam boilers is normally treated with chemicals, ion exchange, or membranes to remove the undesirable salts, which may cause scaling or corrosion. Production of culinary(potable) steam, used for direct injection in foods, should comply with the hygienic requirements of public health authorities.

3. Air Moving and Vacuum Equipment:

Fans and blowers are used widely in food plants to move process air in heating, cooling, drying, and air conditioning equipment. Centrifugal and coaxial fans are used for relatively low pressure drops. While blowers and compressors operate at higher pressures.

The fans are characterized by the capacity (m^3 /hr or cfm) –pressure drop (mm water or inches water) curves, which are similar to those of centrifugal pumps. Compressors for moving air are similar to those compressors used in refrigeration.

Industrial vacuum pump equipment includes steam ejectors and liquid (water) ring pumps. The water ring pumps can operate in wet environments, like vacuum evaporation and drying. Steam ejectors require high pressure steam (about 10 bars).multistage ejectors are used to create and maintain vacuum down to about 5 mbar in industrial processing equipment. Liquid ring pumps cannot reach vacuum lower than 10m bar, because of vapor pressure limitation.

Rotary mechanical pumps, similar to rotary (roots) blowers, can produce high vacuum, below 1 m bar, which is needed in freeze drying and in some vacuum distillation equipment.

Air conditioning is applied in food plants either for comfort (offices) or for storage of some products.

4. Electrical Equipment

Electrical equipment, used in food processing plants, includes electrical motors, electrical heating, illumination, and control equipment. Electrical motors are particularly important, since they operate most of the food processing equipment.

Alternating-current motors of constant or variable speed are normally used, while direct-current motors are used in some application. The voltage of motors is 220 volts for relatively small motors (up to 100 kw). Higher voltage is required, e.g., 440 v, for motors up to 250 kw.

The speed of the alternating-current motors (rpm) is related to the current frequency (Hz) and the number of poles (p), according to the equation

$$rpm = 120\ Hz/p$$

Thus, for 60 Hz current (EU) and two poles, rpm=3600. For 50-Hz current (USA), rpm=3000.

Direct-current motors operate at 115, 230, or 600 volts.

5. Waste Treatment:

Food process and design, and operating food processing plants should considers environmental polluting problems caused by liquid, gas, and solid discharge from the plants. The pollution control laws and regulations of the country and the region should be taken into consideration in selecting the appropriate measures for the specific processing plant.

Wastes pollution is the major problems in food processing, since large amounts of water are used in washing the raw materials, in cleaning, and in cooling operations. Air pollution is important in some food plants with particulate and odorous emissions. Management of solids wastes concerns several food processing plants.

Water and solids wastes from small food processing plants, located near agril. land, can be disposed to the fields by spray irrigation and soil mixing. If the waste load is not excessive. And if no toxic substances are present. Disposal of waste water to municipal treatment plants is an alternative, if treatment cost is acceptable.

A. Wastewater Treatment

Large quantities of water are used in the washing of fruits and vegetables prior to processing. Waste water may contain significant amounts of organic compounds (BOD, COD), suspended solids, and oils. Clean water regulations impose strict limits on the pollutants discharged into rivers, lakes, seas.

Waste water may require pretreatment, primary, secondary, and tertiary treatment. Before it is discharged to the environment or reused. Pre treatment includes neutralization and removal of oils. Primary treatment involves sedimentation, screening, and filtration. Secondary (biological) treatments involve bio-oxidation of organic compounds in ponds, activated sludge, or bio filters. Tertiary treatment may include adoption and membrane separation.

The equipment used in waste water treatment is similar to some of the food processing equipment, described here. Examples are filters, membrane systems (MF, UF, RO), gas absorption and adsorption. Economic, high capacity systems are required in waste water treatment, in contrast to the specialized, more expensive and efficient used in food processing.

B. Solid Wastes

Reduction of solid wastes from food processing plants is of primary importance, e.g., by using more efficient peeling processes. Solid wastes can be used in composting and biogas (methane) production. Production of dehydrated food by products for animal feed is economical alternative, e.g., wastes from sugar, citrus, and fish processing. Land disposal of nontoxic solid wastes may be applied, if the food processing plants is located in an agril. area, away from populated areas.

C. Gas Pollution

Gas and vapor exhausts may create air pollution problems in the environment of food processing plants, especially if the plant is located to residential areas. For example,

particulate (dust) pollution from spray dryers can be reduced and prevented by proper design of separation equipment, such cyclones and bag filters.

Odorous gas discharges from edible oil plants and fish processing (e.g., fish meal drying) can be treated in wet scrubbers, using water or alkaline solution. Offensive fish odors require special scrubbing solutions, such as chlorine compounds.

PILOT MILK PROCESSING PLANT:

Introduction:

Milk is a valuable nutritious food that, if untreated, will spoil within a few days. However, there are a number of preservation techniques that can be used at a small scale to extend its shelf life by several days, weeks or months. Some of these processing methods also produce foods that have different flavours and textures, which can increase the value of the milk when these products are sold. This gives an overview of the types of dairy processing that are possible at a small scale of operation of the very high costs of equipment and the specialist technical knowledge required.

Some Examples of Milk Products:

Dairy Ambient; white milk & cream, formulated products ex. flavoured milk, fermented milk products, concentrated and condensed milk and ice cream mix.

Dairy Chilled; ESL - products, yoghurt, drinking yoghurt, milk/flavoured milk and recombined products.

Prepared food; soups, sauces, tomato, rice and cereal based applications, beans and fruit preparations.

Beverages; juices, soft drinks, soya based beverages, malt products, juice/milk and juice/soya products

Description:

It is important that a suitable room is set aside as a dairy and it is only used for processing. The size of the room depends on the amount of milk being processed, but typically a small-scale unit that processes 100-500 litres per day requires an area of approximately 50 m^2.The room should be hygienically designed and easily cleaned to prevent contamination of products by insects, birds, rodents or micro-organisms. A paneled ceiling should be fitted rather than exposed roof beams, which would allow dust to accumulate that might contaminate products. There should be no holes in the ceiling or roof, and no gaps where the roof joins the walls, which would allow birds and insects to enter.

All internal walls should be plastered or rendered with concrete that has no cracks that

could harbour dirt or insects. The lower parts of walls should either be tiled to at least 1.5 metres above the floor, or painted with waterproof white gloss paint. Higher parts of walls can be painted with good quality emulsion paint if tiling is too expensive. Windows should be screened with mosquito mesh. Thin metal chains or strips of plastic can be hung from door lintels to deter flying insects, or alternatively, mesh door screens can be fitted. The floor should ideally be tiled with floor tiles. However, these are expensive and may be slippery when wet. Good quality concrete, smooth finished and without cracks can be used instead. Vinyl-based floor paints can be used to protect floors, but they are expensive. Red wax household floor polishes should not be used because they wear away easily and could contaminate products.

Proper drainage prevents pools of stagnant water forming, which would allow insects and micro-organisms to breed. The floor should have a 2-3% slope to drain water to a drainage channel, which is covered with a metal grating that can be removed to clean the drain. A wire mesh cover should be fitted over the drain exit to prevent rodents and crawling insects getting into the building through the drain. This should also be easily removed for cleaning. An adequate supply of clean water of drinking quality should be available from taps in the processing room (2-5 litres of water are required to process one litre of milk at a small scale of operation). Hosepipes with pistol grip adjustable sprays should ideally be used for washing down floors and equipment. If necessary, water should be treated to remove bacteria. The cheapest and easiest way is to use bleach (also known as ‘chlorine solution’ or ‘hypochlorite’). Bleach is cheap and effective against a wide range of micro-organisms. Water for cleaning should contain about 200 ppm (mg/litre) of chlorine, made by mixing 1 litre of bleach into 250 litres of water. Commercial treatment units that use ultra-violet light to destroy micro-organisms in water are suitable for larger-scale processors that use a lot of water.

Equipment:

All dairy equipment should be designed and constructed so that it can be easily dismantled for cleaning.

Description of Pilot Plant Equipments

S. No.	EQUIPMENT	DESCRIPTION
1	Raw milk silos	Refrigerated storage tanks for raw milk.
2	Cold Milk Separator	Separate cream from raw milk with a skim milk fat

		content of .10 %
3	Tri-Blender	Disperse dry ingredients at high shear rate into liquid flow stream.
4	HTST (High Temperature Short Time) Pasteurizer	Pasteurize milk and ice cream mixes with homogenization unit. (HTST is a legally sealed unit by the State of California and PMO)
5	Cream Processing Vat	Pasteurization of cream and fluid milk products.
6	Batch Tank	Fluid milk fortification/additions with dry or liquid ingredients. Ice cream mixes, chocolate milk.
7	Nimco Carton Filler	Gable top carton filler
8	Process Holding Tanks	Non-jacketed holding tanks
9	Hoyer Frigus SF 600 N Continuous Ice Cream Freezer	equipped with a self-contained freon refrigeration unit and a vertical freezing cylinder. A piston pump meters ice cream mix and air intake. The frozen ice cream is discharged from the cylinder by means of a constant pressure valve.
10	Hoyer Addus FF 2000°C Ingredient Feeder	for continuous and accurate injection of free fl owing granulates or highly viscous ingredients with inclusions. It is manually controlled, the operator selects the speed of the dosing screw for constant fl ow of ingredients into the lamella pump.
11	Ice Cream Cup Filler	Piston feed, rotary table.
12	Emery Thompson Batch Ice Cream Freezer	For batch ice cream manufacturing.
13	Ice Cream Process Mix Tank	Ice cream mix process/holding tank with two additional flavor vats
14	Blast Hardening and Traditional Freezer Storage	Storage of frozen products
15	Cheese Vats	Open cheese vats with traveling agitation paddles.
16	Salt Brine Tank	Submersion of cheese blocks into a salt brine solution.
17	Universal Pilot Plant	Small scale High Temperature Short Time (H.T.S.T) with two 15-gallon process tanks with heating and cooling capability, 2-stage homogenizer, swept surface agitations

		and high shear agitators. Manual temperature control for variable product heat treatments. Continuous ice cream freezer attached to unit.
18	Marriot Walker Rising Film Evaporator	Single effect evaporator, for removal of water and solids concentration of fluid milk products.
19	Blentech Process Cheese Cooker	Steam jacketed, variable speed, counter rotating twin screw augers.
20	Suprema Pasta Filata System	Cheese curd, cooker stretcher and molder. Temperature controlled wash water. Dual screw augers in contained temperature controlled housing.
21	Koch Vacuum Packaging System	Vacuumed sealed plastic wrap packages
22	4 Groen Process Steam Kettles	: Steam jacketed mixing tanks with swept surface and high speed lighting mixers.
23	2 APV Conical Bottom Swept-surface Processors	Jacketed process tank with swept surface agitators. Cooling and heating capability.
24	R-12 Universal Membrane System	A membrane system containing one or two commercial size spiral-wound membranes. The system can be configured for RO, NF, UF or MF depending on the type of membranes and pumps employed. Membranes are in parallel when two elements are used.
25	Niro Filterlab Spray Dryer	A gas fired spray dryer with nozzle core and orifice. The system has co- current, countercurrent and two fluid drying capabilities. The spray dryer can remove approximately 150 lbs water/hr.
26	Egli Continuous Butter Churn	Continuous butter churn with attached crystallization tank with heating and cooling capabilities for cream tempering. Variable speed motor controls for beater blade, buttermilk removal cylinder, first stage working, and second stage working cylinders. Programmable heating and cooling profile for cream tempering.
27	Ceramic Micro Filtration Unit	A filtration system using ceramic elements for UF/MF. The system uses one element with 2.2 ft2 of filtration

		area. The unit can tolerate operating temperatures up to 150 F and meets sanitary design standards.
28	Cold storage	Cheese Room Storage (48 to 52degrees F) Fluid Milk Storage (34 to 38 degrees F)
29	DDS Ultra Filtration System	single membrane housing
30	Micro Thermics UHT/HTST Direct and Indirect Processing System with an Inline Homogenizer and Clean-Fill Hood with Sterile Product Outlet	Includes Direct/Indirect Heat Exchange, Vacuum flash cooler, Clean Fill Hood, Fluke Data Acquisition System and Recorder, sterilizable, variable speed homogenizer (.8 L – 3.3 L/min), extra holding tube from 30 – 60 sec., s It is capable of processing pudding, cheese sauces, juices, broths, purees, dairy fluids
31	Silverson High Shear Mixer	Used for pilot batching and reconstitution of ingredients. This piece of equipment handles liquids with varying viscosities and rapidly produces a homogenous product while minimizing aeration. It's unique design makes it ideal for dissolving powders and stabilizers as well as mix, emulsify, and homogenize liquids in one single operation. It is mounted on a floor stand making it flexible in various applications in the pilot plant.

Cleaning and sanitation:

Good sanitation is essential in all dairy processing. Equipment should be thoroughly cleaned after each day's production, using a cleaning schedule that indicates which equipment is to be cleaned, who is responsible for cleaning it, how it should be cleaned, how frequently it is done, and who is responsible for checking that cleaning has been done properly. All equipment should be washed with hot water and a cleaning agent that is recommended for use with dairy products, and then rinsed with chlorinated water. Equipment and surfacesshould be allowed to dry in the air, because wiping with cloths can recontaminate them. If they are available, brushes with coloured bristles are preferred because the coloured material can be seen easily if they are lost in machinery or in the product. At the end of a working day,a slight 'chlorine' odour in the processing room indicates that it has been properly cleaned.

Legislation:

The legislation covers all aspects related to the operation of a dairy and the

microbiological and chemical quality of products. In most countries, the legislation for dairy foods is more stringent than for many other types of food.

Quality assurance of milk supply:

Because milk has a high risk of causing food poisoning, it is essential that processors pay great attention to the quality of milk that they buy. Two types of danger exist:

- Infection from the living animal (e.g. Brucellosis) that are passed to the milk.
- Incoming milk in the dairy should be cooled to below 4oC (see below). It should be tested by contamination of the milk.

Milk should be bought using quality specifications and agreements with farmers. It is important that dairy farmers ensure that:

- Udders are washed using a clean cloth and clean water before milking. They should boil the cloth each day to sterilise it and dry it by hanging on a line in the sun.
- All milking equipment should be thoroughly cleaned and disinfected and after each use.
- People milking animals should wash their hands using clean water, because any bacteria on their hands can contaminate the milk.
- Animals should be inspected each day for disease (especially for mastitis) to prevent bacteria from an infected animal being passed by hands to healthy animals or into the milk.
- Personal hygiene rules are observed (see Technical Brief: *Hygiene and safety rules in food processing*).
- Milk is kept in containers that are covered and it is cooled as quickly as possible.
- Milk is transported to collection centres in shortest time possible.

Methods of processing:

There are four main methods used to process milk that are suitable for small-scale operation:

- Cooling fresh milk to extend the shelf life by a day or two, or freezing It.(also making ice cream).
- Heating milk to destroy both contaminating micro-organisms and naturally occurring enzymes that change the flavour of milk.
- Methylene blue dye is a powder that may be available from pharmacies or specialist suppliers in the capital city.
- Different times may be used in local dairy regulations and these should be consulted

at the Bureau of Standards

- Making the milk acidic to slow down or prevent the growth of spoilage bacteria or food poisoning bacteria (this also changes the milk to a curd).
- Reducing the amount of water in milk products to slow down or prevent the growth of bacteria. This may be combined with adding sugar (to make milk confectionery) or salt (in cheese or butter production), both of which also prevent bacteria from growing.

Cooling:

Cooling does not destroy bacteria or enzymes but it slows down their activity. Cooled raw milk keeps its quality for a few days before it is processed. Milk products such as yoghurt'cheese, butter and pasteurised milk are also cooled to ensure they have the required shelf life for distribution to shops and retail storage. At the smallest (micro-) scale of operation, a refrigerator set at 4-5oC can be used to cool milk, but most dairy processors use a milk cooler or cold store to cool milk in bulk before it is processed. Finished products should be stored in a separate dispatch store at 4°C +/- 2°C, or for frozen milk and ice cream, frozen in a freezer operating at below -18°C.

Heating:

There are regulations in most countries that specify the time and temperature that milk should be heated to pasteurise it. Most specify that milk should be heated to 63°C for 30 minutes (see Technical Brief: *Pasteurisation of milk*). Higher temperatures and shorter times are used in larger commercial operations but the equipment needed to do this is more expensive.

Acidifying:

Acid is produced in milk by the growth of certain types of harmless bacteria called 'lactic acid bacteria'. They are normally present in milk and are also used as starter cultures in the production of yoghurt (Technical Brief: *Soured milk and yoghurt*). Lactic acid bacteria convert milk sugar (lactose) into lactic acid, which increases the acidity of the milk and prevents the growth of harmful bacteria. The removal of lactose means that these products can be eaten by people who suffer from lactose intolerance. The acid also creates the characteristic curd of yoghurt. The shelf life is extended by several days and the changes in flavour and texture make this a popular product in most regions.

Removing water:

Separating milk fat from the watery part of milk produces cream. This can be made as aproduct for sale, but care is needed because there is a greater risk of cream causing food

poisoning. Production of cream is not recommended except by the most experienced smallscale dairies. However, cream is also used to make butter and ghee: which have lower moisture contents and are much safer. When butter is prepared and stored correctly, it can have a shelf life of several months. Clarified butter (ghee) also has a shelf life of several months. Both are high-value products and have a good market in most countries. In cheese-making .a curd is produced and the watery part of milk is separated as ‘whey’. ‘Cottage’ cheese or simple curd cheeses are relatively easy to make at a small scale, but hard cheeses require greater levels of investment, and more skill and expertise:

Another process is ***boiling milk*** to evaporate water and produce a brownish gel that is eaten as a snack food or sweet. The product has a shelf life of a few weeks and may have ingredients such as sugar, colour, spices, fruits or nuts added to give a variety of products.