

Table 2 Refrigeration Required for Pure-Pak Paper Carton Units

Model No.	Container Size	Cycles Per Min	Refrigerating Load
Midget "E"	1/4 pt to quart	20	3.0 tons*
Junior "N"	1/2 pt to quart	45	5.0 tons*
Senior "Q"	3/4 pt to quart	75	7.5 tons*
Midget "S"	1/2 gal	16	3.0 tons
Junior "R"	1/2 gal	33	6.0 tons
Senior "C"	1/2 gal	50	6.75 tons

* Refrigeration required when running quarts.

One type of paper carton machine which forms and fills the milk containers in the milk plant requires refrigeration as part of the operation. This unit handles the containers in knocked-down form, shapes the container and closes one end, dips the carton in hot paraffin to seal the end and prevent leakage, chills the carton in water to set the wax, automatically measures the quantity of milk deposited in the container, folds and seals the top and delivers the filled container to a conveyor ready to be placed in the milk crate. Refrigeration is required to chill the water used to set the wax on the containers. The unit is arranged with built-in water cooling coil so liquid and suction refrigerant lines may be connected to a separate condensing unit or to the milk plant refrigerating system. Table 2 shows the various models available and the refrigeration required for each.

BUTTERMILK

Cultured buttermilk is made from skim milk which has been pasteurized at a temperature of 180 F, or higher, for 30 min then cooled to about 70 F when starter is added and allowed to set at this temperature until fully curdled. Salt is added and the milk is agitated slowly and cooled to a temperature of about 40 F when it is bottled. The entire pasteurizing, setting and cooling process is usually handled in one vat. The buttermilk vat is usually arranged so that either hot water, city water or chilled water may be circulated through space around the lining as required for the process.

Cooling buttermilk after pasteurizing and setting is done as quickly as possible with the cooling medium available. In some areas the city water temperature or cooling tower water will be too warm to cool the milk in the vat to the setting temperature and chilled water will be used for the final stage of this cooling. Chilled water will be used for the final cooling to the bottling temperature. If a 500 gal vat is used a fluctuating load as high as 25 to 30 tons refrigeration can be thrown onto the water chilling system.

MILK STORAGE ROOM

After milk in containers is discharged from the filling equipment, the package units are placed in crates and transferred, usually by conveyor, to the cold storage room. The storage room will be maintained at a temperature not higher than 40 F and some plants prefer temperatures as low as 34 F. Milk will pass into the storage room at a temperature higher than the room temperature and should be cooled to near room temperature during the time it is held in storage. Milk will start to increase in temperature as soon as it leaves the cooling unit due to passing through uninsulated sanitary lines, surge tank, and filler bowl and will be further warmed due to the temperature of the container. After the container is filled and sealed it is passed through a spray of city water, to remove surplus milk from the outside of the container, and is further warmed.

For estimating the temperature of milk entering the cold storage room it is suggested that the following temperature rise be added to the temperature of the milk leaving the milk cooling unit, for various types of containers of quart size.

TYPE CONTAINER	TEMP RISE—F DEG
Glass Bottles	8
Preformed Cartons	6
Pure-Pak Cartons	5

These temperature increases take into consideration the specific heat of the container so that recooling the milk in the storage room need not require calculation of the heat of the containers. The refrigeration calculation for the milk storage room should include the usual heat leakage through the insulation, heat gain from lights and motors, door losses, cooling milk to the room temperature and heat added due to the milk cases.

Humidity in a milk storage room will be high and should be taken into consideration in selecting coils or diffuser units for cooling the room. Floors are continually washed down to remove milk from broken bottles or leaking cartons. The outside of the containers will be wet and the cases are usually wet due to being washed just before being filled with milk containers. Frost will collect on diffuser coils rapidly and these units should be arranged for some type of defrost or with ample surface so the coil can be shut down for air defrost approximately each six hours. For room temperatures of 35 F or below air circulation defrost will be too slow and other types of defrost should be used.

The approximate size of a milk storage room may be calculated from the volume of milk to be handled by the plant and the schedule of operation. If the plant is arranged to process milk five days per week the room should have floor area to hold the milk required for two days. Quart milk cases are usually stacked five cases high both for glass bottle cases containing 12 quarts or paper carton cases contain 20 quarts. Approximately 70 lb of milk in glass bottles or 100 lb of milk in paper quart cartons can be stored on a square foot of area. Approximately one third additional area should be allowed for aisles.

Milk in cases is usually transferred by conveyor from the storage room to the dock where it is loaded onto trucks for distribution. Ample conveyor and dock space should be allowed so trucks may be loaded quickly. For quick loading of retail trucks it is suggested that a refrigerated loading dock be used. This refrigerated dock is an insulated extension to the cold storage room arranged so trucks may back in to three sides of the room with doors spaced each eight feet, or the space required for each truck, around the dock. Sliding doors are used so the truck may back almost to the door of the room. The room is about 20 feet wide and long enough to accommodate half of the number of retail trucks at one time. A conveyor nearly flush with the floor is used for the full length of the room and the floor consists of steel deck plate so stacks of cases can be pulled into storage position from the conveyor or directly into the truck. The load for each truck is assembled at one side of the door, to be used by that truck, as it enters the cold storage room after being processed. Load for the second truck is assembled on the opposite side of the door. A plant having a refrigerated loading dock with 30 doors should be able to load 60 retail trucks in approximately 30 minutes.

DISTRIBUTION

Refrigeration of some type is necessary for the trucks used for distribution of milk and milk products if they are to be

delivered to the retail outlets or ultimate consumer in the best condition after being carefully processed in the dairy plant. Many plants now use insulated truck bodies with integral refrigerating systems either arranged with power takeoff from the engine of the truck or plug-in to remote power source at night. Another method of truck refrigeration for insulated bodies is the use of cold plates filled with a solution having a lower freezing temperature than that desired in the refrigerated space and arranged with hose connections to a remote refrigerating system. Plants using refrigerated trucks can eliminate the need for a large milk storage room by loading milk directly onto the truck from the filling equipment and holding the product overnight for delivery in the morning.

Ice is used in uninsulated milk delivery trucks in the form of crushed block ice or manufactured chip or snow ice. The ice is usually placed over the top crate of a stack in the truck and is allowed to drop down as cases are emptied. A separate insulated cabinet with a top shelf for ice is used for trucks which also distribute butter, eggs, cottage cheese and other items requiring refrigeration. For estimating the ice requirements for truck distribution during the summer months it is suggested that an average of five pounds of ice per case of milk be used as the basis for calculation of total requirement.

WATER CHILLING EQUIPMENT

A large portion of the refrigeration capacity in a milk plant is required for the water chilling equipment. Chilled water is usually used for cooling pasteurized milk and other dairy products and may be used for precooling incoming milk and holding or lowering the temperature in milk storage tanks. Chilled water is refrigerated at a central source and recirculated by pumps through the various pieces of dairy equipment which require cooling of the product. Refrigeration may be by flash cooling equipment or by circulation through an ice bank. Some plants use both systems.

Flash cooling of chilled water involves refrigerating equipment large enough to recool the water as fast as it is circulated for the product cooling load. The refrigerating compressor should be large enough to carry the peak load and the flash type water chiller should have ample heat exchange surface to match the compressor capacity. The flash type water chiller may be arranged as a bank of coils having the circulated water sprayed over the coils, it may be banks of coils or plates arranged so water flows over the coils by gravity from distributing pipes or troughs, it may be a vertical open shell and tube chiller with the water flowing down the inside of the vertical tubes, or it may be arranged with refrigerated coils submerged in a water tank having rapid circulation of the water around the coils. A closed shell-and-tube type or shell-and-coil type chiller should not be used due to the low temperature of water required and the danger of freezing the water circulation tubes.

Flash type water chilling equipment is generally used in larger plants for cooling pasteurized milk and for other uniform and continuous cooling loads required at the same time. Other high peak cooling loads in large plants are usually handled by an ice bank type chilling system. To maintain a uniform chilled water supply temperature of about 34 F in a flash system, sufficient water should be circulated so the temperature rise of the water returning will not be greater than 10 F deg. Refrigerant temperatures in the flash chiller will depend on the design of unit but are usually maintained at about 28 F. Flash type water chillers are recommended for plants of any size which process and cool pasteurized milk for more than eight hours per day.

The ice bank type water chiller is recommended for the entire water chilling load of small plants operating less than

eight hours per day, and for the high peak cooling loads of large plants. The ice bank system permits the use of a refrigerating system having considerably less capacity than is required for the peak cooling load by building ice on the refrigerated surface during the time that chilled water is not required. When chilled water is required the melting of the ice provides the refrigerating effect required in addition to that supplied by the refrigerating system.

The ice-bank type water chiller consists of an insulated tank containing refrigerated coils or plates submerged in the water and spaced so ice can build up on the refrigerated surface to a depth of about two inches. The tank should be provided with agitation and baffles so the water will be kept in motion over the surface of the ice. The agitator may be a motor-driven propeller type to circulate water around the baffles and over the coils at a rate of five times the amount of water being pumped for product cooling or agitation may be by means of compressed air. For air agitation perforated pipes are extended along the bottom of the tank located under each stand of pipe coils so the air bubbles rising will cause the water to move over the surface of the ice.

In an ice-bank type water chiller using 1 1/2 in. steel pipe coils with ice build up on the pipe to 5-in. diameter there will be 7 lb of ice per ft of pipe or 1000 Btu available refrigeration per foot of pipe due to melting of the ice. With good agitation the water for process cooling will leave the tank at a temperature of 33 to 34 F as long as ice remains on the refrigerated surface. Warm water returning to the tank should be discharged near the bottom of the tank or at the inlet to the agitator. Water from the tank for process cooling should be taken from near the top of the tank. The refrigerant temperature in the ice-bank system will vary from 5 to 15 F and is usually operated from the refrigerating system without pressure control. Automatic thermostatic control is available to limit the thickness of ice build-up in the tank. In selecting or designing an ice-bank type water chilling system it is suggested that sufficient refrigerated surface and ice build-up capacity be provided to handle the entire chilled water requirements for the full day without taking into consideration the refrigerating effect supplied by the refrigerating system while chilled water is being supplied to processing equipment. This selection will provide a surplus in capacity to take care of losses in insulation and circulating piping, allow for unusual peak operating conditions, and for some expansion in the volume of dairy products being processed.

PART III: BUTTER MANUFACTURE

Butter is an important food commodity in North America, Europe, Australia and New Zealand. Creameries in 27 different countries manufactured 7.1 billion lb of butter in

Table 3 Production of Creamery Butter by Region 1958*

Region	Lb Butter
North Atlantic	36,244,000
East North Central	392,995,000
West North Central	723,438,000
South Atlantic	9,251,000
South Central	51,112,000
Mountain	60,024,000
Pacific	61,073,000
United States	1,333,623,000

* Source: U. S. Department of Agriculture