cal. Keep the air in constant movement while products are being frozen. Reduce product temperature below 20 F within six hours, if possible. Under no circumstances should the product remain above 24 F for more than 24 hr. Temperature of bread products should be approximately 0 F upon removal for shipment. The product should not rise above 20 F during shipment.

For further information on frozen breads and rolls, see Chapter 34, Bakeries.

Cakes and Cookies. Nearly all kinds of cakes can be frozen and thawed without noticeable change. Researchers still differ as to which freeze and store with less change; batters or the pre-baked cakes. Few batters produce cakes of good volume, texture and flavor when baked after six months storage, even at temperatures below 0 F. Many kinds of cakes retain their acceptability almost perfectly during storage for this period or longer.

Frozen batters have two disadvantages: (1) most frozen batters have a relatively short storage life; (2) they require baking, and in some instances both thawing and baking.

Cakes, both plain and iced, should be packaged in moisture-vapor-proof sheeting prior to freezing. Moisture-proof cellophane, polyethylene and pliofilm sheetings are satisfactory. The sheeting should be heat-sealed, and the cake either placed directly on a tray, or the wrapped cake put into a bleached sulfite carton. In either case, the wrapped, or wrapped and packaged cakes, are placed on trays on a wheeled rack, which is pushed into an airblast freezer for freezing at 0 F or below.

One packer recommends wrapping cakes in polyethylene, packaging in bleached sulfite boxes and freezing at 5 F. Lower temperatures do not produce a better product and may cause trouble from moisture condensation when the cakes are removed from storage.

Because of a relatively low moisture content of most cakes their freezing rate is faster than breads and rolls.

Most cookies may be frozen and thawed several times without noticeably affecting quality. It is important to package them in moisture-vapor-proof packages so they will not dry out in storage nor lose their crispness because of condensation during thawing.

Nearly all cookies remain fresh for long storage periods, if held at low temperatures. Christmas tree cookies, coconut molasses cookies, small bridge cookies, almond macaroons and chocolate chip cookies retain acceptability for 14 months stored at −15 F.

For further information on frozen cakes and cookies, see Chapter 34, Bakeries.

Pies. Frozen, unbaked pies are available in a wide assortment: apple, apricot, blueberry, boysenberry, cherry, mince, peach and pineapple, pumpkin, raisin, raspberry, rhubarb, and strawberry; cream pies—blackbottom, chocolate, coconut, lemon, strawberry, and pineapple; deep dish pies—apple, cherry, and blueberry. Meat and poultry pot pies and pizza pies are also popular.

Racks of unbaked pies are pushed into an airblast freezer, where they are frozen, at −20 F or below. When the interior of the pies has been cooled to 0 F or lower (about six hours), the racks of pies are pushed out of the freezer into a cold room maintained at about 20 F. Here the pies are packed in moisture-vapor-proof packages and placed in corrugated fiberboard containers for shipment or storage.

Refrigerated plates are also satisfactory for freezing pies, but more labor may be required in handling the pies.

For further information on frozen pies, see Chapter 34, Bakeries.

Fruits. Not only may certain fruits be preheated before freezing, but apples, blueberries, raspberries, blackberries and plums are superior, provided proper methods of heating and suitable packages are used. Preheated fruits should be solid packed, without air spaces, in leak-proof moisture-proof containers. Storage temperatures of −10 F prevent loss of flavor.

A great variety of prepared and precooked fruit products are frozen, such as pies, sherbets and ices, baby foods, cobblers, fritters, jellies and spreads, pectinized purées, pie fillings, shortcakes, relishes, toppings or sundae sauces, confections, sauces, and specialty items such as baked apples. Freezing retains the color and flavor of many prepared and precooked fruits far better than does canning.

For further information on frozen fruits, see Chapter 38, Frozen Fruits and Vegetables.

Foods Eaten Frozen

This group includes all kinds and types of ice creams, sherbets and ices, ice cream cakes, frozen éclairs and parfaits.

Most of these foods are hardened at −10 to −30 F with or without forced air. They should be stored at 0 F or lower. For service, they must be held at room temperature until they can be easily spooned or dipped. Defrosting time will vary with the size and type of frozen dessert.

For further information on ice cream, see Chapter 43, Ice Cream.

IMPORTANCE OF UNIFORMLY LOW TEMPERATURE STORAGE

It is said that the speed of chemical reactions is increased two and one half times when the temperature is raised 18 F. In the case of precooked foods, assuming the products are held solidly frozen, most of the deterioration and change is caused by these chemical reactions. When the temperature is raised 18 F, the permissible storage period is more than cut in two. If this chemical rule is assumed to hold for frozen foods, then a product may retain its fresh quality for two and one half years at −36 F, or be kept for one year at −18 F, or about five months at 0 F, and for only two months at 18 F. Actually, the rate of deterioration about triples for every 18 F rise in temperature. If a food retains its fresh quality for three years at −18 to −20 F, it can be held in good condition for one year at 0 F, but only for six months at 10 F.

These generalizations can be applied only to temperatures at which foods remain substantially completely frozen. If the food contains a high percentage of sugar or other water-soluble solids, when the temperature is raised to the point where all or a portion of the food is liquid or semi-liquid, deterioration occurs at a greater rate.

When under fluctuating temperature, if the maximum temperature to which a frozen food is subjected is sufficiently low so that the product remains solidly frozen and no liquid separates, the rate of deterioration of many foods (except cream sauces and thickened gravies) is about the same as that which occurs when the product is held uniformly at the mean temperature. If the temperature of a food fluctuates between −6 and 5 F, then the rate of deterioration is approximately the same as that which would occur if the food were held at a constant temperature of 0 F.

Fluctuating storage temperatures are considerably more detrimental to white sauces, thickened gravies, corn starch and custard puddings than a constant temperature, which is the mean of the maximum and minimum temperatures.

CHAPTER 45

REFRIGERATED WAREHOUSE PRACTICE

Building Location, Design, and Size Determination; Insulation; Construction Types; Roof and Floor Constructions; Cold Storage Doors; Fire Protection; Utility Space; Load Determination; Refrigeration System Selection; Room Cooling Equipment; Defrosting Methods; Room Coil Installations; Freezing Facilities; Refrigeration Plant Equipment; Warehouse Costs

A refrigerated warehouse is any building or section used for storage at temperatures controlled by refrigeration. There are two basic storage conditions commonly in use: (1) cooler facilities, which protect fresh foods at temperatures usually above 32 F, and (2) freezers, operating under 32 F to prevent spoilage. Freezer storage for many years covered almost any temperature below 32 F, but today it is recognized that frozen foods should be kept below 0 F, preferably at −10 to −15 F.

Refrigerated warehouses may be operated for and by an individual company or for public use, or as a combination of the two. Whether private or public, they are needed at: (1) point of processing; (2) intermediate points for general or long term storage; (3) the final distributor or distribution point.

BUILDING LOCATION

The location of private refrigerated space is dictated by other operations of the owner and is usually adjacent to, or in the same building with, the other operations. The storage is an expensive structure and must be considered as a permanent building. The selected location must fit in with long range planning of production operations, traffic and general storage and plant expansion.

Public space should be located to meet a definite need to serve a producing area, a transit storage point, a large consuming area, or various combinations which will develop a good average occupancy. In addition, it should have:

1. Convenient location for producers, shippers and distributors, but with consideration to present tendency towards decentralization and avoidance of unduly congested areas.
2. Good switching facilities and service with minimum switching charges from all trunk lines to the plant's tracks.
3. Easy access from main highway truck routes as well as for local trucking, but avoiding location on congested streets.
4. Location where ample land is available for trucks, truck movement and for plant utility space.
5. Location where the cost of land will not result in excessive overall cost.
6. Adequate power and water supply.

Recent tendency has been to locate plants farther from congested areas or even outside city limits where some increase in trucking distance is offset by better plant layout possibilities, better or lower priced labor supply, or other economies of operation.

BUILDING DESIGN SELECTION

Most recent refrigerated warehouses are single story structures. Ceiling heights are from 16 to 25 ft with piling heights from 14 to 20 ft. Small columns on wide centers permit palletized storage with comparatively little lost space. This building usually provides the additional highway truck unloading space required by today's traffic. The single story design does have characteristics which must be considered carefully: (1) horizontal distances which to some extent offset the vertical transportation required in the multi-story building; (2) difficulty of utilizing the piling height with many commodities, or with small lot storage and movement of goods; (3) the necessity for treatment of the floor below freezers to give economical protection against possible ground heaving (see later section Floor Construction); and (4) high land cost for capacity of the building. A one story design for moderate or low piling heights would result in excessive cost for capacity because of the high ratio of roof and insulated areas, additional land cost, and refrigeration load. Fig. 1 shows a typical one story layout.

A modified one story design is used in some cases to reduce the horizontal distances and the land costs associated with the single story design. The building is extended to two high ceiling stories. Provision for economical low piled storage may be by a balcony or mezzanine in part of the high ceiling area,

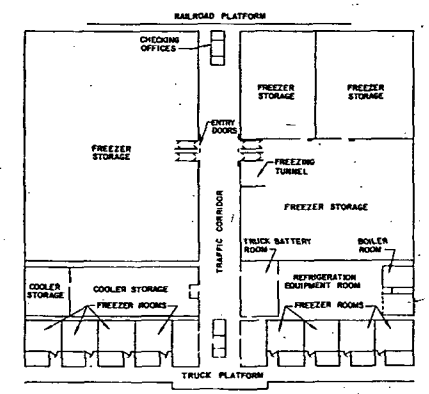

Fig. 1 .... Typical Plan of One Story Warehouse