wide variation in basic design of structure, in type and extent of insulation, and in type and capacity of refrigerating equipment for the refrigerated volume. This transition from the traditional multistory warehouse has resulted in an unusually wide spread in unit costs. Available data shows costs per cubic foot of refrigerated space are from about $1.00 to $1.50 or more. This wide variation precludes any rule-of-thumb estimates and indicates the need for evaluation of the many factors discussed in this chapter before reasonably close estimates may be made. The cost of a multistory building is probably in the upper range of the above cost estimate of refrigerated space.

CHAPTER 46

COMMODITY STORAGE REQUIREMENTS

THIS chapter presents information on the essential average storage requirements of most of the important perishable foods that enter the market on a commercial scale. Also included is a short discussion on the use of refrigeration in the mushroom industry as well as information on the storage of furs and fabrics. The statements made are derived from scientific experimentation and from the best commercial practice at the present time. The data given in Table 1 are based on the storage of high quality commodities shortly after harvest. When products are transported from a distance, or are deteriorated, appropriate allowances should be made.

The temperatures recommended are the optimum temperatures for long storage and are actual commodity temperatures rather than air temperatures. For short storage, higher temperatures are often satisfactory. Conversely: products subject to chilling injury can sometimes be held at a lower temperature for a short time without injury. Exceptions are bananas, cranberries, cucumbers, eggplant melons, okra, pumpkins and squash, white and sweet potatoes, and tomatoes. Recommended temperatures for these products should be strictly adhered to.

The values given for water content and freezing points are, the result of actual laboratory determinations, but it should be realized that, at best, they can be only approximate because of the great variability in plant and animal tissues and the products thereof. The optimum storage temperature for many foods has been found to be just above their freezing point. Knowledge of freezing points is useful to the cold storage industry in determining how the various commodities should be handled in storage. The highest temperature at which freezing may occur is generally given. In previous editions the average freezing point was given, which may be somewhat lower. It is felt that the highest freezing point is a better guide for commodities that are damaged by freezing.

Values of the water content of foods are useful to the refrigerating engineer as a basis for calculating specific heats and the latent heat of freezing. Specific heat is usually calculated by Siebel's formula:

$$S = 0.008a + 0.20$$

where S signifies the specific heat of a substance containing a, the percent of water; 0.20 is the value representing the specific heat of the solid constituents of the substance.

Necessary additional information for some of the items in Table 1 is given in the text.

The values for the freezing points, water content, rate of evolution of heat (heat of respiration) above and below freezing and for latent heat as given in Table 4 of Chapter 65 in the 1961 GUIDE AND DATA BOOK do not always agree exactly with the data given in Tables 1, 2 and 4 of this chapter. The composition of foods varies to some extent, depending upon water content, where grown and other factors. It is also possible that in tables compiled by different editors, slightly different formulae have been used in making calculations to determine both specific and latent heat. The values given in either of these tables can safely be used for refrigeration load calculations. When in doubt, it is suggested that the higher values be used. For more precise work, the specific heat and other values should be determined for the specific sample in question.

It is important to remember that fresh fruits and vegetables in storage are alive and carrying on, within themselves, processes characteristic of living things. In particular, the heat of respiration must always be considered a part of the refrigeration load in storage handling. The approximate rate of heat evolution for various commodities is given in Table 2.

Sealed polyethylene box liners are extensively used commercially for pears and sweet cherries. The slight accumulation of carbon dioxide and depletion of oxygen extend the storage life of pears at 31 F by one or two months and of sweet cherries by several days.

Non-sealed film liners are used extensively to maintain freshness and prevent excessive moisture loss of Golden Delicious apples, rose bushes and strawberry plants. There are indications that similar liners would be beneficial to other crops (such as parsnips) susceptible to excessive weight loss during storage or marketing. Reduction of frost accumulation on refrigerating coils is another advantage of polyethylene liners.

Apples—See Chapter 47

Asparagus

Asparagus deteriorates very rapidly at temperatures above 32 F and especially at ordinary room temperature. It loses sweetness, tenderness, and flavor, and later decay develops. Asparagus is not ordinarily stored except temporarily, but at 32 F with a high relative humidity, it can be kept in salable condition for 3 to 4 weeks. But after a long haul to market, even under refrigeration, it cannot be expected to keep longer than 1 to 2 weeks.

Bananas—See Chapter 47

Beans, Green or Snap

Green or snap beans are probably best stored at 45 F where they may keep for 8 to 10 days. When stored at 40 F or below for 3 to 6 days, surface pitting and russet discoloration may appear in a day or two following removal for market. The russeting will be especially noticeable in the centers of the