Table 1 .... Storage Temperature and Humidity Conditions

Product	Short-Time Storage		24 to 72-hr Storage	
	F	Moisture	F	Moisture
Vegetables	36–42	Class 2	32–36	Class 1
Fruits	36–42	Class 2	32–36	Class 2
Meats (cut)	34–38	Class 2	32–36	Class 2
Meats (carcass)	34–38	Class 3	32–36	Class 3
Poultry	32–36	Class 2	30–35	Class 1–2[a]
Fish	35–40	Class 1	35–40	Class 1
Eggs	36–42	Class 2	31–35	Class 1
Butter, Cheese	38–45	Class 1[a]	35–40	Class 2–3[b]
Bottled beverages	35–45	Class 4	40–45	Class 4
Frozen Foods			0	Class 2

Temperatures and moisture conditions shown above give customary restaurant practice. Some variations may be expected due to different varieties of fruits or vegetables and the growing conditions in different geographical locations. For complete and detailed information, including approximate long-time storage life, on all types of foods, refer to Table 1, Chapter 23. The USDA Handbook No. 66 is another authoritative source for conditions for the long-time preservation of fruits and vegetables.

[a] If not packaged.
[b] If packaged.
[c] Freeze and hold at 0 F or below if held for more than 72 hr.

Class 1. Such products as eggs, unpackaged butter and cheese and most vegetables held for comparatively long periods of time. These products require very high relative humidity because it is necessary to effect a minimum of moisture evaporation during storage.

Class 2. Such foods as cut meats, fruits and similar products. These require high relative humidities but not as high as Class 1.

Class 3. Carcass meats and fruit such as melons which have tough skins. These products require only moderate relative humidities because they have surfaces whose rate of moisture evaporation is moderate.

Class 4. Canned goods, bottled goods, and other products which have a protective covering. These are products which need only low relative humidities or which are unaffected by humidity. Products from whose surfaces there is a very low rate of moisture evaporation or none at all, fall into this class.

venient or necessary to make use of them. This is accomplished by controlling the temperature and moisture conditions primarily, but other factors such as air flow, initial condition of the food, and the packaging or surface protection of the food must also be controlled to get optimum quality in foods held under refrigeration.

Storage requirements will vary according to the characteristics of the particular product and the length of time stored, but if the storage space is kept under proper conditions, fresh food will be on hand at all times with the assurance that its quality will be unimpaired for a reasonable period of time.

TEMPERATURES, HUMIDITY AND STORAGE CONDITIONS

As a general rule, foods not frozen should be stored between 32 and 50 F and the lower the storage temperature the longer will be the period of storage (within the maximum storage possibilities of the product in question). Current trends are to provide the optimum quality in foods, with less emphasis on maximum storage life.

In considering the important factors of temperature and humidity, it must be remembered that the food service operator has two separate and distinct problems: (1) long-time storage, where bulk or quantity lots of food can be kept refrigerated, and (2) short-time storage where many types of food can still be kept refrigerated but handled quickly and conveniently. Long-time storage in this connection is *not* to be considered the same as long-time storage for wholesale operations (as, for example, in a cold storage warehouse, where foods are frequently held for periods approaching their maximum life), but rather as a condition where foods are generally turned over in 24 to 72 hr. Short-time holding conditions are exemplified in the chef's refrigerators or salad boxes found in most restaurant kitchens. Differences in the long- and short-time applications are brought out in the subjects that follow.

Table 1 shows refrigerator temperatures for long- and short-time food service storage for such typical commodities as fresh meat, fruits, and vegetables. Storage temperatures as shown are probably the most important factor in the preservation of food and the data presented represents experience or customary limits usually prescribed for storage room temperatures and are not absolute or final. Often, more than one product will be stored in a cooler, in which case a mean of the temperature for each product, somewhere in the temperature range shown, would be chosen.

Just as different foods require different temperatures for good keeping, so do they require different amounts of moisture in the air. Too much moisture in the air will help accelerate the growth of bacteria and mold, causing sliming, discoloration and loss of flavor in some foods, while not enough moisture results in dehydration and shrinkage. Proper requirements of moisture or relative humidity could be expressed in definite percentages for all food products, but it is dangerous to rely too closely to this factor alone; other factors are involved, as the following example will show.

Assume that a refrigeration application requires a 90 percent relative humidity to protect the foods against dehydration and shrinkage. However, 90 percent relative humidity produced in a room with gravity cooling units may not produce the same results, insofar as optimum food storage conditions are concerned, as 90 percent relative humidity produced by forced-air cooling units. This is so because the additional velocity of the air passing over the food as created by the forced-air cooling unit tends to dry out the food more than when using gravity coils. As a simple analogy, every housewife knows that clothes dry quickly on a windy day. This same principle applies to the use of forced air as opposed to gravity circulation for food refrigeration. Therefore, relative humidity, expressed in percentages, can be very misleading when applied to refrigeration. A more practical answer is found if relative humidities are considered in terms of the over-all moisture conditions in the storage area.

It is the function of the refrigeration engineer to classify any product according to its moisture requirements and to design the refrigeration equipment to provide those conditions. Where two or more types of products are stored in one refrigerator, a compromise favoring the product most subject to dehydration should be made.

Desired moisture conditions must be obtained by properly designed refrigeration equipment. The choice of the correct differential between storage fixture temperature and the evaporating refrigerant in the cooling unit, to provide the proper balance in the system, is the simplest, least expensive and most practical method to achieve this end.

FROZEN FOODS

In addition to fresh foods, many restaurants are making generous use of frozen food products. Ice cream, of course, has been known and accepted for many years. Many varieties of frozen pre-cooked meals and pre-cooked portions of meals which need only minutes in the oven before serving are rapidly finding a place in the commercial food industry. As a result, adequate freezer storage capacity is essential.

The latest information available indicates that frozen fruits and vegetables should be stored at approximately 0 F, especially if they are to be kept for periods of three months or longer. Above this temperature they will suffer appreciable losses of Vitamin C and possibly lose some of their color, aroma and flavor. Certain mold organisms also grow at temperatures of about 15 F and above. Just as important as having 0 F in the storage area is the necessity for keeping the temperature as nearly constant as possible. Fluctuating temperatures, which may be caused either by poor design of the refrigeration system, or placing warmer products in the storage area, may damage the product and shorten its storage life. Fluctuation of more than 2 to 3 F deg should be avoided. Frozen foods should be properly packaged or wrapped, otherwise, they desiccate rapidly and their storage life is materially reduced.

In general, no damage, whether caused by temperature rise, desiccation, or any other cause, can ever be repaired. Storage at 0 F or any other temperature will not improve a poor product that has been damaged mechanically or physically in shipment or handling, or was of inferior quality before freezing.

REACH-IN REFRIGERATORS

By far the largest category of refrigerated equipment in the food service field is that of reach-in refrigerators. According to all available statistics, the reach-in refrigerator comes closer to being a fundamental requirement in every food service establishment than any other refrigerator.

Although all refrigerators except walk-ins are technically reach-ins, the industry has generally confined the term to upright cabinets with straight, vertical fronts, and hinged or sliding doors. The reach-in refrigerator is usually about 2½ to 3 ft deep, about 6 ft high, and ranges in width from about 3 ft to about 10 ft. In net capacity, the range is from about 20 to 90 cu ft. These capacities and dimensions refer to cabinets that are available as standard from the manufacturers. Other shapes, sizes and capacities are available on special order. There are reach-in refrigerators used in other industries besides food service, but the food service types are distinguished by their requirement for heavy duty use and specialized features.

Types of Construction

Reach-in refrigerators are available in two basic types of construction. First is the older method of making a wood frame substructure clad with a metal interior and exterior. The second, a newer method, calls for a welded assembly of the exterior panels and inserting an insulation liner. Both methods have advantages and both have drawbacks. A well-designed and properly constructed cabinet can be satisfactory in use, whichever method of construction is used. Generally speaking, those manufacturers that concentrate on stock models have standardized on welded construction and those whose lines are more flexible have stayed with wood framing, or use both. In either case, the importance of the frame is in providing solidity and rigidity to the structure, square, true door openings with strong door-hanging arrangement and a simple, effective and lasting base for the vapor-proofing seal that is so necessary to the exterior shell.

In descending order of cost, the materials used on exteriors and interiors are stainless steel, porcelain enamel on steel, synthetic enamel on steel, and aluminum. The requirements, of course, are for a material that matches or blends with that used on nearby equipment; is easy to keep clean; is not discolored or etched by commonly-used cleaning materials; is strong enough to resist denting, scratching and abrasion; and provides the necessary frame strength. The material that is chosen by the individual purchaser will to a large extent depend on layout and budget.

Temperature Ranges

Reach-in refrigerators are available for medium or low temperature range. The medium temperature range has a maximum of 45 F and a minimum of 32 F, with the most desirable average temperature being close to 38 F. The low temperature range need not be below − 10 F and should not exceed + 10 F. The desirable average is 0 F for frozen foods and − 5 F for ice cream. Both ranges are available in cabinets of many sizes, and there are some that combine both ranges in one cabinet.

Another type of cabinet of recent development that is becoming very popular in the food service field, is the dual temperature *refrigerator-warmer*, one part of which is refrigerated while the other part is heated.

Remote refrigeration systems are often used when the cabinet is to be installed in a hot or otherwise unfavorable location, with several other refrigerators and the noise or heat of the condensing units would be objectionable, where every possible cubic inch of refrigerated space is needed and under various other special circumstances that call for remote location of the condensing unit.

The location of condensing units close to the equipment which they serve minimizes installation costs and permits high operating efficiency. However, this consideration should never cause units to be installed in rooms used for food storage. Ideally, remote condensing units should be installed in rooms designed for the purpose, and if the units are air-cooled, the rooms should be mechanically ventilated.

Self-contained systems having the condensing unit and controls built into the refrigerator structure are of two general types. The first type has the condensing unit beneath the cabinet. In some designs the condensing unit compartment takes up the entire front of the refrigerator, while in others the compartment occupies only a corner at one lower end. The second general type has the condensing unit on top. There is no important advantage in locating a self-contained condensing unit beneath the refrigerator. Although the air near the floor is generally cooler and thus beneficial to the condensing unit, it is usually dirtier. Location of the condensing unit on top of the cabinet allows full use of cabinet space, and, although the air passing over the condenser may be warm, it is clean and more abundant. In addition, top mounting permits the use of refrigeration *plugs* (see next section).

REFRIGERATION SYSTEMS

Refrigeration systems are of two basic types, with several variations.

1. *Direct expansion with gravity air circulation.* This system is used almost exclusively in low-temperature cabinets. Evaporators are usually plate type, and thus are used as shelves, or they may be wall or ceiling mounts. This type of refrigeration has the disadvantage of requiring periodic manual defrosting, but has the advantage of slow air movement, which lessens dehydration of bakery and similar products.

2. *Direct expansion with forced-air circulation.* This system is used in almost all medium-temperature cabinets and in all automatic defrosting low-temperature cabinets. Coil housings, which are sheet metal enclosures of appropriate shape to which are attached evaporators, expansion devices, heat exchangers, air circulating fans, fan motors, defrost water drain pans and other minor parts, are mounted either horizontally in the upper part of the cabinet or vertically against the back wall or between the door openings. The horizontal, or top mounted installation, is adequate for small cabinets where complete circulation of air is almost automatically achieved, but must be used with care in the larger sizes because of the danger of short-circuiting the air when the upper shelves are loaded. The vertical unit uses the housing as a duct, and usually takes air in at the top and discharges it at the bottom, thus automatically providing complete air circulation from top to bottom within the cabinet.

A variation of the above systems is embodied in the so-called *plug* system, which consists of a removable section of the insulated cabinet top having a coil and expansion device attached to the inside and connected through to the condensing unit on the outside. The entire refrigeration system is completely sealed and readily removable and replaceable. When the *plug* is in place, the coil fits into a housing attached to the cabinet, thus providing top-to-bottom air circulation.