normal operation but sufficient power must be available for the initial pull-down of a warm cabinet or overloading due to excessive freezing loads. The selection of compressor lubricating oil involves the consideration of wax precipitation at the low temperatures. Special oils which will meet this requirement should be used. Permanent dehydrators, in addition to thorough factory dehydration, are frequently included in the refrigerant circuit, because the moisture limit in these low temperature systems is extremely low.

Condenser design has followed closely the household refrigerator practice in both static and forced-draft types with some manufacturers using all or a portion of the cabinet shell as a plate condenser. As in compressor motor design the normal condenser load will be relatively small, but adequate capacity for peak loads must be provided.

Refrigerant 12 and Refrigerant 22 are used exclusively in this application. Refrigerant 22 has gained wide acceptance because the increase in refrigerating effect of this refrigerant over Refrigerant 12 for the same displacement compressor offers economic possibilities by using an available mass produced compressor to operate a larger freezer or to operate a freezer in place of a refrigerator.

Temperature controls for operating the refrigerating unit of household freezers are standard devices designed to operate at the required temperatures. The location of the temperature sensitive element requires careful consideration. A constant temperature of the stored load is highly desirable from the standpoint of preserving quality products for long periods of storage. Temperature variations due to cycling of the refrigerating unit as well as those due to changes in ambient temperature should be held to a minimum. If possible, the temperature control should automatically call for continuous operation of the refrigerating unit until fresh loads of food are frozen.

STORAGE AND FREEZING TEMPERATURES

Extensive research in the field of the quality of frozen foods versus storage time and temperature has established a temperature of 0 F as satisfactory for most foods for a storage period of six months to a year. Certain foods, particularly pork and its products, require either lower temperatures or shorter storage periods.

The effect of the rate of freezing on the quality of frozen foods has been extensively investigated. Early authorities have, perhaps, overstressed the necessity of quick freezing. A summary of the literature leads to the conclusion that high quality can be achieved with relatively slow freezing, provided that recommendations regarding the other factors in this process of food preservation are carefully followed. In the design of the household sizes of freezers, provisions should be made for the freezing of limited quantities of food in proportion to the size of the freezer, and specific instructions should be available to the user as to the proper placement of food to be frozen and the maximum quantity that may be frozen in 24 hours without seriously disturbing the stored load temperature. The maximum rise in storage temperature has been considered as 5 F deg. On the assumption that instructions are followed, the provision of such freezing facilities will insure the rapid cooling of the warm load to a point at which spoilage is avoided. Freezing by contact with horizontal refrigerated plates or by rapidly moving air offers the best possibilities for quick freezing in the household freezer. Adequate condensing unit capacity will be required to carry the recommended freezing load in addition to the normal operating load.

REFRIGERATION FAILURE

Since the financial loss through spoilage of the contents of a freezer can be serious, the problem of refrigeration failure has received considerable attention. The effects of ambient temperature, quantity of stored load, door openings, and individual cabinet heat leakage seriously affect any estimate of the time available between loss of refrigeration and the development of spoilage temperatures. In general, thawing of at least part of the food may be expected within 30 hr, and temperatures exceeding a safe limit of 50 F may occur in 75 hr. The application of dry ice is recommended as a temporary source of refrigeration.

Early knowledge of the failure of refrigeration is of primary importance in avoiding food spoilage. A variety of warning devices and temperature indicators is available. These devices are offered by many freezer manufacturers as standard equipment or as an accessory. To obtain the maximum protection the thermal element of such a device must be carefully located with regard to temperature distribution within the freezer.

TESTING AND RATING

The testing and rating of household freezers are covered by National Electrical Manufacturers Association Publication FH 1-1955 (ASA B38.3-1955, ASHRAE Standard 13), and are generally similar to those for refrigerators.

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CHAPTER 61

WATER CHILLERS AND COOLERS

UNITARY WATER CHILLERS: Selection Requirements, Design, Construction Standards, Compressors, Condensers, Coolers, Refrigerant Piping, Controls, Testing and Rating; DRINKING WATER COOLERS: Types, Refrigeration Systems, Stream Regulators, Ratings, Standards and Codes

THIS chapter discusses unitary equipment for water chilling (Part I), and for cooling of drinking water (Part II).

PART I: UNITARY WATER CHILLERS

The unitary water chiller is a factory prefabricated assembly (not necessarily shipped as one package) of one or more reciprocating compressors, condensers, and water coolers, with electrical controls, interconnections, base and accessories.

The water-cooled condenser is commonly included as an integral part of the unit, whereas the air-cooled and evaporative condensers are most frequently provided for remote installation. A unitary water chiller may be used to cool liquids other than water, but this chapter will discuss only applications involving the cooling of water.

Unitary water chillers are used in air-conditioning systems for residential, commercial, and industrial applications, as well as for cooling water in industrial processes.

Chillers used in residential systems are generally of the sealed-system type with readily replaceable components. Units of this type are designed for economy with replaceable rather than repairable parts. Residential units are generally available with capacities ranging from 12,000 to 60,000 Btuh.

For small commercial applications, chillers are available with capacities from 60,000 to over 180,000 Btuh. Many of these units are of the sealed, repairable type, using semi-hermetic compressors. Service valves, gage connections, and accessories are provided for testing and checking. The smaller sizes of these units often are used in larger residential systems.

Chillers used for industrial and large commercial applications generally have capacities ranging from 180,000 to 3,000,000 Btuh. These units usually are provided with some means of capacity reduction. Reduced voltage starting equipment may be furnished.

SELECTION REQUIREMENTS

Selection requirements to be considered include application (air conditioning or process cooling), design temperature requirement, availability of power, space limitation, economic limitations, and load variations. The selection of the unitary water chiller is a part of the design of an overall system since in most cases the chiller is only a component of a complete system and does not perform the entire cooling function within itself.

The load to be imposed upon the water chiller is obtained by calculating the cooling requirements and converting to gpm of water for a specific cooling range (see Chapter 43). The load is indirect in that it is obtained from other heat exchangers which are removing heat from the space or fluid to be cooled. The unit should therefore be selected to be able to handle the peak loads of the system and operate to balance the system at a condition favorable to the operation of all components.

The water being cooled normally requires make-up water only in small quantities to replace that which is bled off in air vents throughout the water system. Because of this, and also because the temperature of the cooled water does not tend to induce scaling, low scaling factors are used in determining the operation of the cooler. Common practice is to use a scaling factor of approximately 0.0005 for this fouling resistance. As a contrast, the water-cooled condenser has a fouling resistance which varies within greater limits to accommodate the various types of water normally used. The reader is referred to Part I, Water-Cooled Condensers, of Chapter 42 for information on these values.

A significant requirement of a unit is the ability to vary the capacity as required by changes in the load. These load fluctuations are normal and can be handled on most equipment by the use of various capacity reducing means. A common method of capacity reduction is by means of internal or external unloaders on the compressor, responsive to the suction pressure or in some cases controlled by external temperatures. This allows the unit to cycle from a fully loaded condition to some condition near unloaded without stopping. On units having two or more compressors, it is common to vary the capacity of the unit by starting and stopping one or more compressors in sequence.

On those installations requiring year round operation or during seasons in which the outside temperature falls below 80 F, the system should be designed to regulate the condensing capacity to maintain sufficient high-side pressures. (See Chapter 42.)

DESIGN

The range of sizes available for use generally follows the motor horsepower sizes with nominal capacities of about 1 ton per horsepower in the range from approximately 2 tons up to as high as 250 tons. The arrangement of the unitary water chiller is generally dictated by the size of the individual components and desirable weight distribution for noise isolation and structural economics. Normally, it is desirable to maintain the heavy compressor component in the lowest part

The general responsibility for this chapter is assigned to TC 8.3, Drinking Water Coolers, and TC 9.2, Liquid Heat Exchangers.