Sorbent methods tend to be unfavorable where:

1. Normal comfort dew-point temperatures are required with a predominantly sensible heat load and where mechanical refrigeration is required for sensible heat removal.

2. Water temperature is too high for practical sensible heat removal (above 65 F).

3. Cold water (below 55 F) is available in adequate quantities so that it can be directly used for both sensible and latent heat removal, or can be further chilled cheaply by mechanical refrigeration.

4. Electricity is low in cost compared with gas or steam.

No single unfavorable item listed will necessarily disqualify a method, but generally there will be several offsetting favorable factors required to make it the choice on a purely economic basis.

When analyzed with respect to the broadening scope of applications for air conditioning, it is now evident that sorbent dehumidification can be used, within its legitimate economic limits, for human comfort, commercial drying or storage of food products requiring low humidities, and for industrial processing and drying.

It provides an additional choice as to the type of equipment best suited to meet the requirements of special applications and conditions. Particular attention is called to those industrial and drying applications in which the dried air can be used at effluent temperature without further treatment.

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CHAPTER 39

Refrigeration

Theory and Cycle Calculations: Definitions, Simple Saturation Cycles, Complex Refrigeration Cycles, Pipe Sizes and Friction Losses, the Steam Jet System, the Absorption System, Ice Systems, Storage Systems, the Reverse Cycle; Equipment and Arrangements: Types of Compressors, Condensers, Expansion Valves, Evaporators and Coolers, Equipment Selection

WITH the increasing use of all-year comfort air conditioning installations the importance of refrigeration to the air conditioning engineer has been greatly magnified. The details of equipment operation, maintenance, and design remain problems for the refrigeration engineer, but the air conditioning engineer does retain a responsibility to the customer which requires some knowledge on his part of the different refrigeration cycles and the relative merits of each. In order to assist in meeting this need, the present chapter has been divided into two parts, the first covering the fundamental technical relationships which govern the selection and analysis of an operating cycle and the second presenting brief discussions of some of the equipment and equipment arrangements which are most commonly used.

THEORY AND CYCLE CALCULATIONS

Definitions

The *ton of refrigeration* is a quantity unit which originated in the days when harvested ice was the principal source of summer cooling. By definition the *ton* is the cooling effect realized when one ton of 32 F ice melts to water at 32 F; since the latent heat of fusion of ice is 144 Btu per pound, the *ton* represents a unit cooling effect of $144 \times 2{,}000 = 288{,}000$ Btu. In common practice the ton is usually considered a rate (rather than quantity) unit and is taken as 288,000 Btu per day (24 hours) or 12,000 Btu per hour or 200 Btu per minute. Thus for air conditioning calculations, the size of the requisite refrigeration machine, expressed in tons, can be obtained by dividing the heat gain of the structure, expressed in Btu per hour, by 12,000. In equation form:

$$H_t = (\text{Btu per hour heat gain}) \div 12{,}000 \qquad (1)$$

where

H_t = load in tons.

The *working substance*, or *refrigerant*, is the fluid which carries heat through the refrigeration cycle from the evaporator, where heat enters the refrigerant, to the condenser where the heat is discharged to some cooling medium. The great majority of modern refrigeration systems use a liquefiable vapor as the working substance. By altering the pressure of the refrigerant its boiling temperature is changed, allowing the material to *boil* in the evaporator at a temperature sufficiently lower than that of the conditioned space to insure maintenance of an effective heat transfer rate from the space (or in some cases from a secondary cooling fluid such as brine or cold water) to the refrigerant. The vapor formed in the evaporator is then raised in pressure (by a compressor, or by the absorber-generator combination of the absorption system) until its new boiling temperature exceeds the temperature of the available cooling