[5] W. P. Chapman: Design of snow melting systems (*Heating and Ventilating*, April 1952, p. 95, and November 1952, p. 88).

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[8] P. B. Gordon: Antifreeze protection for snow melting systems (*Heating, Piping and Air Conditioning Contractors National Association Official Bulletin*, February 1950, p. 21).

[9] C. S. Cragoe: *Properties of Ethylene Glycol and Its Aqueous Solution* (National Bureau of Standards, Society of Automotive Engineers, CEC *Report* No. 9).

[10] W. P. Chapman: Are thermal stresses a problem in snow melting systems? (*Heating, Piping and Air Conditioning*, June 1955, p. 104, and August 1955, p. 92).

CHAPTER 77

EVAPORATIVE AIR COOLING

System Design; Applications for Residential, Commercial, Industrial, Equipment, and Process Cooling; Farm Building, Produce, and Greenhouse Cooling

EVAPORATIVE cooling is the oldest method used in man's attempt to produce comfort in hot climates. In biblical times,[1,2,3] wetted grass mats and porous jars utilized the evaporative process to cool air or water. The early settlers of the Southwestern United States found the Indians using the same devices. Since then evaporative cooling has been mechanized. Various devices have been developed and manufactured to utilize evaporation directly in the air stream or indirectly to cool the air in a heat exchange process. Today direct evaporative cooling represents the vast majority of installations, as indirect systems are usually too costly to justify their use.

Evaporative cooling equipment, including unitary equipment and air washers, is discussed in Chapter 38 of the 1961 GUIDE AND DATA BOOK.

SYSTEM DESIGN

Various methods for designing evaporative cooling systems are in common use. Simplified rule-of-thumb methods use an assumed air change rate as a basis. Good engineering practice however, requires an evaluation of the building heat gain, internal loads, and the cooling season wet-bulb temperature pattern. The suitability of evaporative air cooling for a particular application is in the first instance, determined by the climatic conditions. Since the lowering of the dry-bulb temperature of the air during the evaporative process is accompanied by a corresponding increase in moisture content, it follows that the greatest application of evaporative cooling for conditions of human occupancy is in areas in which the periods of high temperature are accompanied by low outdoor relative humidities. The areas in which the climate is suitable for the reliable production of optimum comfort conditions by evaporative cooling are therefore limited. Despite this, evaporative air cooling is extensively used over areas with less favorable climates as a means of improving conditions for human occupancy. It finds good acceptance also in industrial applications, particularly those in which an improvement of dry-bulb temperature can be used to advantage. Successful applications of this type are spot and area cooling in factories such as steel mills, metal casting plants and foundries. Laundries and dry cleaning plants, with large exhaust air loads may also take advantage of evaporative cooling. Electric motor cooling and turbine cooling are other examples of industrial demands for cooling where evaporative cooling is practical and economical. In agriculture, evaporative cooling has been used for cattle and poultry barn cooling with excellent results even in climates which give poor results with human occupancy. Greenhouses and common storages for fruits and vegetables use evaporative cooling to reduce temperature and raise humidity. The tobacco industry, especially cigar plants, is another example of this use for evaporative cooling. New applications continue to arise as the control of summer conditions is looked upon more as a necessity than a luxury.

The evaporative cooling process involves what is known as an adiabatic exchange of heat. The sensible heat of the air is reduced proportionally to the amount of evaporation that takes place. The water in the cooler assumes the wet-bulb temperature of the air, and cooling proceeds with the enthalpy or total heat content of the air remaining essentially constant. Humidification occurs as a result of the vapor pressure exerted by the water which is higher than that corresponding to the entering air dew point. In the process the dew-point temperature rises and the dry-bulb temperature falls with the wet-bulb temperature remaining constant. The maximum possible dry-bulb temperature reduction is the difference between the entering air dry-bulb and wet-bulb temperatures, which is usually referred to as the wet-bulb depression. If it were possible to cool the air to the wet-bulb temperature, the air would be completely saturated. Since this is not the case in actual practice, evaporative cooling systems operate at less than 100 percent effectiveness. The temperature of the air resulting from the evaporative cooling process should never be considered as the room temperature, since the latter will be several degrees higher. The temperature difference is usually called the diffusion temperature and depends upon the heat load and the amount of cool air discharged. In calculating the heat load, no attention need be paid to the latent load as the system operates on the basis of 100 percent outdoor air and any moisture pick up is exhausted. Fig. 1 is a skeleton psychro-

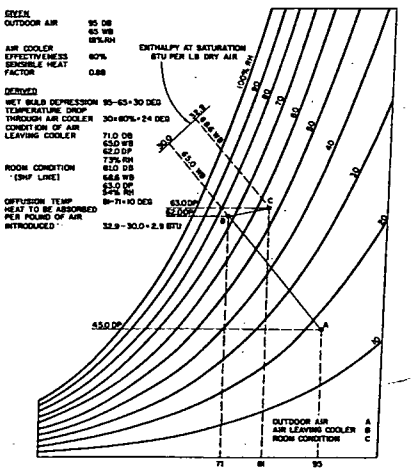


Fig. 1 Solution of *Example 1* on Psychrometric Chart