leaves in a saturated state. Equipment delivering air at a dry-bulb temperature above the wet-bulb temperature is termed *partially* saturating.

Evaporative cooling is being used advantageously in many parts of the country. It is particularly applicable (1) in districts where the normal maximum wet-bulb temperature remains sufficiently low during the cooling season, and (2) in applications where the cooling load is principally sensible heat.

Dehumidification of air means to decrease the density of water vapor in the space. This may be accomplished by the condensation of water vapor from air due to its contact with a chilled medium (see Cooling). This type of energy exchange invariably includes temperature reduction due to removal of sensible heat. When moisture removal is the prime consideration it is frequently necessary to cool air to a greater extent than can be balanced by normal sensible heat gain in order to remove the required amount of water vapor by condensation. In this case it is necessary to restore sensible heat to the dehumidified air stream by re-heating.

Dehumidification may also be accomplished by contact with a dehumidifying agent. The primary distinction between these two methods is in the manner in which the required vapor pressure at the surface of the contacting medium is obtained. In the case of dehumidification by condensation this surface vapor pressure is always the same as that which would be exerted by a body of water (or ice) at that same surface temperature. In the case of a dehumidifying agent, the surface vapor pressure is always *lower* than that exerted by water at the same temperature, and the effectiveness of the medium as a dessicant is largely a function of the amount by which this vapor pressure can be lowered at the working temperature involved.

Thus it is evident that the primary function of a dehumidifying agent is to maintain a vapor pressure lower than that of the water vapor in the air in order to secure a removal of moisture from the air. In its simplest form the process is essentially an adiabatic one in which the latent heat lost by the mixture is converted to sensible heat which raises the temperature of the air and medium by an equivalent amount. This process is therefore an energy exchange, similar to, but the reverse of, adiabatic saturation or evaporative cooling.

Combination Methods. It is evident that two or more of the above processes—cooling, evaporative cooling, and dehumidification—may be combined by the proper application of interchangers in sequence. Such combinations are dictated by the availability of prime sources and cost of energy as well as the requirements of the particular application in question.

This chapter discusses in detail the engineering and economic principles involved in dehumidification by the use of sorbents. For similar discussion of the other processes, refer to the following material: Cooling and dehumidification by the use of surface interchangers (cooling coils), see Chapter 25. Cooling, dehumidification and evaporative cooling with air washers, see Chapter 26. For sources of cooling involving city and well water and cooling towers, see Chapter 26, while for mechanical refrigeration and ice, refer to Chapter 24. For the thermodynamics of evaporative cooling, see Chapter 1.

SORBENTS

Sorbents may be divided into two general classifications:

1. *Adsorbent*—A material which has the ability to hold water or other vapors on its internal surfaces without itself being permanently changed physically or chemically. Certain solid materials, such as silica gel, and activated alumina have this property. Adsorbents also show an affinity for vapors other than water and this action is frequently selective. Thus, in a mixture of water vapor and organic gases, silica gel will effectively remove the water vapor and charcoal will remove the organic gases. The selective property of adsorbents is used in the removal of some contaminating gases. (See Chapter 28.)

2. *Absorbent*—A material which has the ability to take up water vapor but which changes physically, chemically, or both, during the cycle. Calcium chloride is an example of a solid material while liquid materials include solutions of lithium chloride, calcium chloride, lithium bromide and the ethylene glycols.

Adsorbents

These substances contain a vast number of sub-microscopic pores which afford a tremendous internal surface to which water adheres or is adsorbed. In spite of a porous structure these substances retain sufficient mechanical strength to resist the wear and handling to which they are subjected. To be suitable for dehumidification purposes such substances must fulfill the following requirements:

1. Possess suitable water vapor pressure characteristics.
2. Be available at a reasonable cost.
3. Adsorb sufficient moisture per pound of material to avoid excessive bed dimensions.
4. Be chemically stable, resisting contamination from impurities.
5. Be physically rugged to resist breakdown from handling, abrasion, etc.
6. Be able to withstand breakdown from indefinitely repeated reactivation cycles.
7. Be capable of reactivation at reasonable temperatures.

Activated Aluminum Oxide (Alumina) is a porous, amorphous form of aluminum oxide and is called by the common name Activated Alumina. Commercial activated alumina commonly used for dehumidification contains about 92 per cent of Al_2O_3 combined with hydrated aluminum oxide. It is available in granules ranging from a fine powder to pieces approximately 1.5 in. in diameter. It has high adsorptive capacity per unit of weight and is non-toxic. It may be repeatedly re-activated after becoming saturated with adsorbed moisture without practical loss of its adsorptive ability. In the grade frequently used for air drying the re-activation may be accomplished at temperatures between 350 and 600 F. Specific gravity is 3.25 and the pores are reported to occupy 51 per cent of the volume of each particle. For most estimating purposes the volume-weight relation on a dry basis may be taken as 50 lb per cubic foot although in the smaller sizes the packed weight may be as much as 64 lb per cubic foot.

Silicon Dioxide (Silica), in a prepared form obtained by suitable mixing of sulphuric acid with sodium silicate, is another solid adsorbent and is commonly called silica gel. Its capillary structure is exceedingly small, so small that its exact structure has to be deduced as it cannot be observed. It has high adsorptive capacity per unit of weight; it is non-toxic, and may be repeatedly re-activated at temperatures up to 600 F without practical deterioration. Re-activation is generally accomplished with air or other gases at temperatures not over 350 F. Volume of the capillary pores is reported to be from 50 to 70 per cent of the total solid volume. Silica gel is available commercially in a wide variety of sizes of graded granules ranging from 3 to 8 mesh granules to impalpable powder (through 325 mesh). The 6 to 16 mesh granules are generally used in dehumidification applications and will vary in density from 40 to 45 lb per cubic foot.

There are other solid substances having marked adsorbent properties, but details concerning them are not available. Most adsorbents have the ability to absorb some gases and condensible vapors other than water vapor, a property sometimes useful in air conditioning applications, and one which accounts for the extensive use of adsorbent materials in the field of chemistry.

Air to be dehumidified is drawn or blown through a screened bed of dry, solid adsorbent and the water vapor in the air-vapor mixture is caught and retained in the pores of the medium. The exact nature of the process which goes on during adsorption is not known but it is stated that the action is brought about by surface condensation, and also by a difference between the vapor pressure of the water condensing inside the pores and the partial pressure of the water vapor in the air-vapor mixture. The adsorbing process in the bed can continue until the vapor pressures reach equilibrium. The amount of vapor adsorbed will depend on the