characteristic of the adsorbent being used, the temperature of the air and the bed, the vapor pressure of the water vapor in the air being passed through it, and its final vapor pressure or moisture content.

As the bed of material adsorbs moisture, its vapor pressure approaches that of the contacting air and the efficiency of adsorption gradually decreases. Equilibrium throughout the whole bed will not be reached for an extended period depending on bed thickness. Because of this diminishing efficiency of adsorption, commercially designed systems do not approach the state of equilibrium, but generally operate on a predetermined cycle or contact time and at partial saturation.

As the process of adsorption goes on heat is liberated in the bed. The total heat so liberated consists of the latent heat of the water vapor condensed together with the so-called heat of wetting of the adsorbent. For silica gel, the total heat of adsorption will amount to approximately 1293 Btu per pound of water vapor adsorbed from the air-vapor mixture being passed through the bed. The heat of wetting varies with the substance used as adsorbent while the latent heat of condensation depends only on the temperature and pressure of the water vapor.

Since the adsorptive ability of an adsorbent depends on the temperature of the bed and on the vapor pressure difference between the pores and the air-vapor mixture, it is important to know the pressures and temperatures at which pressure equilibrium is reached.

Evidently the equilibrium conditions represent the limits beyond which adsorption of vapor cannot continue. This relationship for one commercial silica gel of 0.70 specific gravity is shown graphically in Fig. 1. These curves indicate the general manner in which adsorbents may be expected to perform, though the exact form and values of the curves will vary for each specific adsorbent and may vary even within the same generic group.

As an example in the interpretation of the chart consider the case when moist air at a temperature of 80 F and a partial vapor pressure of 0.5 in. of mercury flows through a bed of silica gel which is at a temperature of 80 F. The chart indicates that the equilibrium of pressure between the air-vapor mixture and the bed is reached when the dry bed has adsorbed moisture to the extent of 30 per cent of the weight when dry. When this happens the bed can adsorb no more moisture unless its temperature is decreased or the air vapor pressure increased.

The effect of temperature upon the adsorptive capacity of silica gel may be observed by following the 59 F dew-point line in Fig. 1. At 80 F gel temperature equilibrium is reached at 30 per cent moisture concentration while at 120 F and 200 F equilibrium is reached at 12 and 6.6 per cent moisture respectively.

Under normal reactivation temperatures the residual water content of silica gel is between 5 and 6 per cent.

In practice, the temperature rise in the dehumidified air caused by the adsorption heat is approximately 10 F for each grain of moisture removed per cubic foot of air at atmospheric pressure. This temperature rise occurs progressively through the adsorbent bed and is an important consideration in predetermining the performance of a given design of apparatus. Data such as these together with information covering other characteristics, such as specific heat, resistance to air flow, etc., are of value in the basic design of adsorption apparatus. In the solution of air conditioning problems, however, reference must be made to performance data on established apparatus designs such as are presented later in this chapter.

Absorbents

Any absorbent substance may be used as a dehumidifying agent if it has a vapor pressure lower than the vapor pressure in the air-vapor mixture from which the moisture is to be removed.

Solid Absorbents. The substances used are in general the solid forms of the liquid absorbents. Calcium chloride is frequently used because of low cost. At present they are used principally in small dessicating chambers, and in small dryers of the cartridge type, through which air is forced under pressure.

Liquid Absorbents. These are characteristically water solutions of materials in which

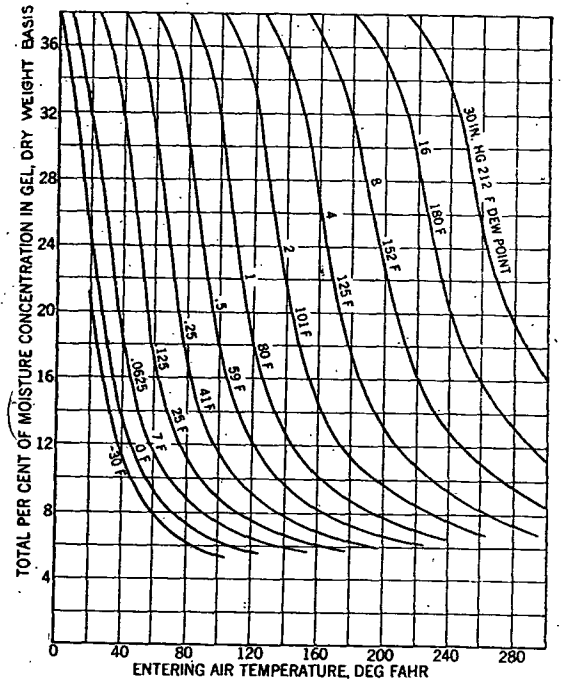

FIG. 1. TEMPERATURE—VAPOR PRESSURE—CONCENTRATION RELATION FOR A SILICA GEL BED AT CONSTANT TEMPERATURE

the vapor pressure is reduced to a suitable level by governing the concentration and temperature of the dehydrating solution. In addition to having suitable vapor pressure characteristics a practical absorbent must also be widely available at economical cost, be non-corrosive, odorless, non-toxic, non-inflammable, chemically inert against any impurities in the air stream, stable over the range of use and especially it must not precipitate out at the lowest temperature to which the apparatus is exposed. It must have low viscosity and be capable of being economically regenerated or concentrated after having been diluted by absorbing moisture.

Water solutions, or brines, of the chlorides or bromides of various inorganic elements such as lithium chloride and calcium chloride are the absorbents most frequently used in connection with air conditioning applications and detailed attention is confined to these two in this chapter.

The application consists of bringing the air-vapor stream into intimate