independent of temperature for all temperature ranges. As the temperature increases at a given relative humidity, the equilibrium moisture content tends to decrease. A limiting condition exists when temperatures above the boiling point of the adsorbed liquid are encountered. In such cases, relative humidity loses its significance with regard to equilibrium moisture content, and complete dryness of most hydroscopic materials is possible, even when a large amount of vapor exists in the atmosphere. This makes possible drying by means of superheated vapors.

In the special case of the dehydration of hydrated inorganic salts, such as copper sulfate, sodium sulfate, and barium chloride, temperature and humidity are very important in obtaining the desired degree of dehydration. Thus, in the drying of wet salt crystals to obtain a product with the maximum number of molecules of hydrate water, it is necessary to dry under closely controlled conditions of air temperature and humidity. Generally, the temperature is low and the humidity is high.

The equilibrium moisture content of a hydroscopic material may be determined in a number of ways. The requirement for any method is a

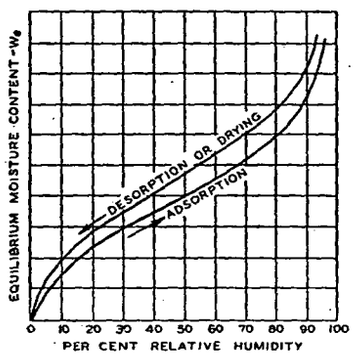

FIG. 5. TYPICAL EQUILIBRIUM MOISTURE CONTENT CURVES[1]

source of constant humidity and constant temperature air into which the sample may be placed. The determination may be made under either static or dynamic conditions, the latter being preferred if the data are to be used for drying calculations.

Probably the simplest static procedure is to place a series of samples in ordinary laboratory desiccators over sulfuric acid solutions of known concentration, which thereby produce atmospheres of known relative humidity. The sample in each desiccator is weighed periodically until a constant weight is obtained. The moisture content at this final weight represents the equilibrium moisture content for the particular relative humidity involved. The value of equilibrium moisture content so obtained will depend on whether it is reached by losing moisture, as in drying, or by gaining it, *i.e.*, whether the sample is at a moisture content higher or lower than the equilibrium value. The equilibrium moisture content reached by losing moisture, *i.e.*, by drying, is generally higher than that reached when moisture is adsorbed, as shown in Fig. 5.

The equilibrium moisture content of a solid has particular significance in drying because it represents a limiting final moisture content for specific

conditions of air humidity and temperature. Drying costs can be unnecessarily high if a material is dried to a moisture content less than that which it normally possesses in equilibrium with atmospheric air. For example, if a dryer dries a material to 1 percent final moisture, and on standing under normal atmospheric humidities it regains moisture to 5 percent, the material is considered to be overdried, so that probably the dryer would be capable of a considerably higher capacity and efficiency with a 5 percent final moisture content.

Applications of Hygrometry to Drying

Drying of a solid by hot air or hot gases may be divided into two processes: (1) transfer of heat to evaporate the water, and (2) removal of the

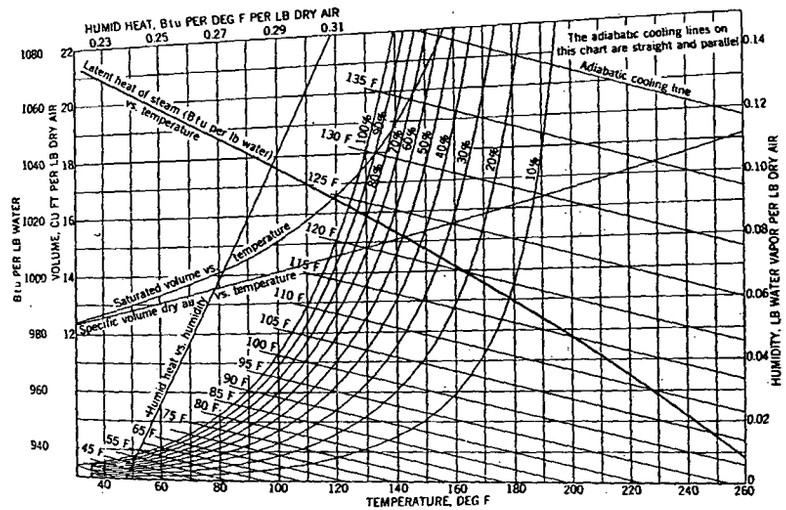

FIG. 6. PSYCHROMETRIC CHART

vapor by the air or gas stream. Likewise, two processes are involved in the *design* and *operation* of direct dryers: (1) the estimation of the drying rate or drying time, and the effect of the external variables on the drying rate; and (2) the calculation of the heat and air quantities required. The first estimates concerning drying time have been considered in the first part of this chapter. The second calculations are based on the use of the psychrometric chart, Fig. 6.

In drying, the humidity chart finds its greatest utility in analyzing the operation of existing dryers, in making design calculations, and in checking calculations of air quantities. It is equally useful in interpreting the humidity-temperature relations within the dryer. The adiabatic cooling lines on the humidity chart indicate the relation between the temperature and the humidity which are present in air passing through an adiabatic dryer, *i.e.*, one in which all of the sensible heat given up by the air in cooling is used to evaporate water from the wet stock. Referring to the section of the humidity chart shown in Fig. 7, where AB is one adiabatic saturation line, it follows that air entering an adiabatic dryer at temperature t_1