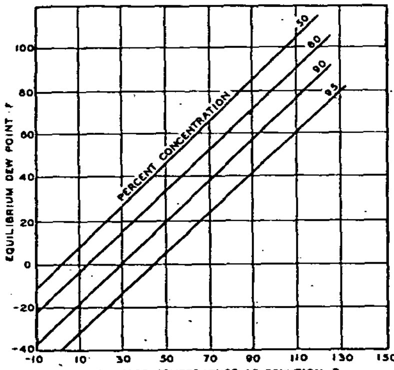

Fig. 1 .... Temperature—Equilibrium Dew-Point Characteristics for Typical Organic Absorbent

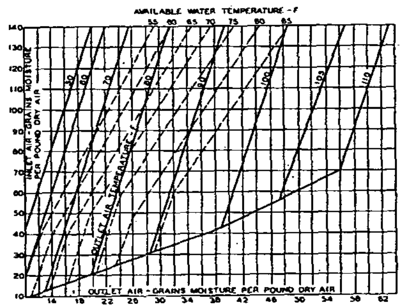

Fig. 3 .... Performance Data for Liquid-Absorbent Dehumidifier Using Lithium Chloride

dry-bulb temperature of the air leaving the dehumidifier will be within 1 to 5 deg of the liquid absorbent temperature.

Cooling and heating coils are installed in the ductwork after the dehumidifier if the air is to be cooled or heated.

The liquid absorbent is maintained at the proper concentration for moisture removal by automatically removing from the liquid the water vapor absorbed from the air. A small percentage of the solution, usually 10 to 20 percent of the flow to the contactor coils, is passed over the regenerator coil where the liquid is heated with steam or other heating medium. The liquid absorbents commonly used may be regenerated with steam at 2 to 25 psig. The vapor pressure of the liquid absorbent at temperatures corresponding to 2 psig steam is considerably higher than that of the outdoor air. The hot solution at the relatively high vapor pressure is in contact with outdoor air in the regenerator where water is absorbed from the solution by the scavenger air due to the vapor-pressure difference between the outdoor air and the hot solution. The hot-moist air from the regenerator is discharged to the outdoors and the concentrated solution flows to the sump where the process is repeated.

The steam flow to the regenerator coil is regulated by a control responsive to the concentration of the solution circulated over the contactor coils. This may be a level control, specific gravity control, boiling point control, or a similar instrument.

For humidifying operations the liquid absorbent is maintained at the required temperature by adding heat in proportion to the water absorbed by the air from the solution. Water is automatically added to the solution to maintain the proper concentration.

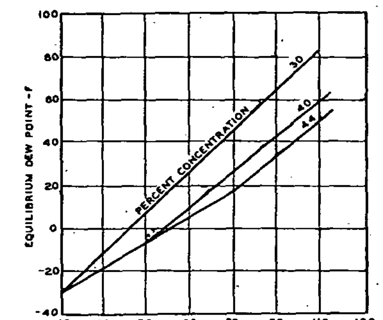

Fig. 2 .... Temperature—Equilibrium Dew-Point Characteristics for Typical Inorganic Absorbent

SOLID ADSORPTION SYSTEMS

Solid Desiccants

The ability of an adsorbent (desiccant) to remove water vapor from a gas is explained by the fact that the vapor pressure of the water in the adsorbent (when in the reactivated condition) is less than the partial pressure of the water vapor in the surrounding atmosphere. For instance, when an active adsorbent is brought into contact with a gas of high humidity, there is a tendency for the vapor pressure of the water in the adsorbent to reach equilibrium with the partial pressure of the water in the surrounding gas, with the result that water is extracted by the adsorbent and its weight increased, while the moisture content of the gas is correspondingly reduced. (The adsorbent is said to be saturated for a given condition when equilibrium is attained.) The weight of water a given adsorbent will extract is dependent upon the relative humidity (ratio of the partial pressure in the gas to the saturation pressure at a given temperature) and the temperature of the adsorbent. The process is reversible; if the temperature of the adsorbent is raised until the vapor pressure of the adsorbed water becomes greater than the partial pressure of the vapor in the surrounding atmosphere, water will be released by the adsorbent. After the adsorbent cools to room temperature, for instance, the vapor pressure of the water in the adsorbent falls below the partial pressure of the vapor in the atmosphere, and the adsorbent will again start extracting water. The elimination of water by the addition of heat is known as reactivation, and is a means of regenerating the adsorbent so that it may be used repeatedly.

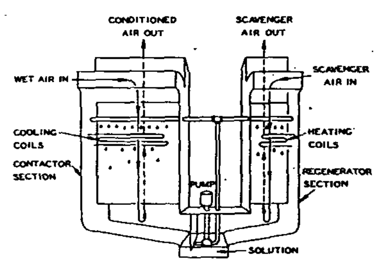

Fig. 4 .... Flow Diagram for Typical Liquid-Absorbent Dehumidifier

Adsorption is proportional to the amount of surface (internal and external) of the sorbent. The materials that are used commercially as solid adsorbents have a porous structure of submicroscopic dimensions, which gives them extensive surface area. An adsorbent should meet the following requirements in order to be satisfactory for dehumidification purposes:

1. Have a high adsorptive capacity under normal atmospheric conditions.
2. Be chemically stable, resisting contamination from impurities.
3. Be physically rugged to resist breakdown from handling and use.
4. Be capable of reactivation at temperatures generally obtainable.
5. Be heat-stable at reactivation temperatures.
6. Have a weight per unit volume such as to avoid excessive bulk.
7. Be available at reasonable cost.

There are a number of solid adsorbents available, which are used in solid adsorption systems. The reader is referred to the various manufacturers for detailed information regarding performance of the various desiccants. These include activated aluminas and bauxites, silica gels, and alumino-silicates marketed under various trade names. Reactivation temperatures for these desiccants are generally between 200 and 600 F.

Machine Operation and Design

Dehumidification by a solid desiccant such as silica gel or activated alumina may be performed either under static or dynamic operation. As the name implies, the static method entails no artificial means for circulating the gas to be dried into or through the desiccant. Instead, the air immediately surrounding the adsorbent is initially dried and subsequently, through convection and diffusion, water vapor from spaces and objects further away pass into the air surrounding the desiccant and then to the desiccant where it is adsorbed. Obviously this type of dehumidification is best suited for small containers. This method of preservation was used extensively by the armed services during World War II for overseas shipments and domestic storage.

On the other hand, dynamic dehumidification entails the forced passage of the air being treated through the desiccant bed. This method is used in installations such as dehumidified warehouses and ships of the "Mothball Fleet" where large volumes of air must be dried.

The only requisites for a dynamic dehumidifier are a desiccant bed, a fan to force the humid air through this bed, and a heater to periodically reactivate the adsorbent. As the air passes into the activated desiccant, it surrenders a certain amount of its water vapor. The rate of moisture pickup and the humidity condition of the leaving air are functions of a great many variables, some of which will be discussed later. The ratio of the amount of water adsorbed by the desiccant in a given time to the amount of water vapor in the air entering the desiccant bed during that time is known as *adsorption efficiency*. A characteristic of adsorbents in dynamic use is that this adsorption efficiency remains constant and at a relatively high level from the beginning of an adsorption cycle until some later point in the cycle at which time the efficiency begins to drop. This point is known as the *breakpoint*, and the time from the beginning of adsorption to this point is known as the *breakpoint time*. In the ideal case the breakpoint would coincide time-wise with the sudden rise in the dew-point temperature of the effluent air. Although additional drying can be effected beyond the breakpoint, good commercial practice dictates that the desiccant be regenerated at or near this point. Adsorption carried beyond the breakpoint continues at an increasingly slower rate until the adsorbent is completely saturated. This point is known as *completion*.

Adsorbents, such as silica gel and activated alumina, contain, even when reactivated, a small amount of water. This is usually about 5 to 7 percent of the dry weight of the desiccant and is known as residual moisture. Attempts to remove it result in a physical change in the substance and a reduced adsorptive capacity. The term *useful concentration* is used to designate the percent of moisture in the adsorbent over and above the residual quantity. It is generally based on the dry weight of the desiccant.

When regeneration of the adsorbent is desired, the heater is energized and the direction of air flow through the bed is usually reversed. The dry-bulb temperature of the effluent air rises rapidly at first, and then virtually levels off for a period of time. This period of level or slowly increasing temperature represents the period during which the major portion of the heat input is being used to boil off the adsorbed water. This temperature pattern continues until most of the water contained in or on the desiccant is released. When the latent heat requirements begin to diminish, the heat input goes into sensible heat gain to the passing air stream. This is reflected in a rather sharp increase in the dry-bulb temperature of the effluent air. This period, measured from the beginning of desorption, has been designated *temperature-rise time*. Although additional regeneration (at a slower rate) can be attained by continuing the heat addition process beyond the temperature-rise time, once again good commercial practice calls for reactivation to be ended near this point. Regeneration past this point until the adsorbent is in moisture equilibrium with the air stream is known as *complete desorption* or *desorption to completion*. The energy expended in the heater per unit weight of water desorbed for any given time is called *economy of desorption* and usually has the dimensions of kilowatt hours per pound of water desorbed.