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CHAPTER 17

DEHUMIDIFICATION BY SORBENT MATERIALS

Moisture Content of Air, Sorbents, Liquid Absorbents, Liquid Absorption Systems, Solid Adsorbents, Solid Adsorption Systems, Sorption Dehumidifiers for Elevated Pressures

DEHUMIDIFICATION as used herein is the reduction of the water-vapor content of air or other gases. The term thus describes a special case of dehydration which covers the removal of moisture in any form from a gas. The degree of dehumidification required varies greatly with different applications, and is one of the prime considerations influencing the choice of a method.

Dehumidification may be accomplished by chilling, as described in Chapter 33 and 34, by the use of sorbents, or by compression in combination with chilling, sorbents, or both chilling and sorbents.

Within the past decade, drying of gases has become an increasingly important operation. Some of the more important commercial applications include the following:

1. Lowering the relative humidity to facilitate handling of hygroscopic materials.
2. Air conditioning for comfort (in combination with cooling, under certain design conditions, such as high moisture load in comparison to sensible heat load).
3. Drying air for wind tunnels.
4. Dehydrating natural gas.
5. Providing protective atmospheres for the heat treatment of metals.
6. Maintaining controlled humidity conditions in warehouses for storage.
7. Preserving ships of the "Mothball Fleet."
8. Drying of gases which are to be liquefied.
9. Numerous static applications in which a dry atmosphere must be maintained in a closed space or container, such as the cargo hold of a ship.

The use of sorbents for drying of refrigerants is discussed in Chapter 49, Moisture in Refrigerant Systems.

MOISTURE CONTENT OF AIR

A knowledge of air-water vapor mixtures and their thermodynamic properties is necessary for proper understanding of this chapter. The reader is, therefore, referred to Chapter 3, Psychrometrics, for definitions of terms and for thermodynamic properties of moist air (Table 1) or properties of water at saturation (Table 2).

The moisture content of air is indicated by its absolute humidity, vapor pressure, dew-point temperature or relative humidity. Moisture contents of air at one atmosphere pressure in the terms normally used in the dehumidification field are presented in the conversion chart, Fig. 1. To use this chart, merely read horizontally across to convert a given type of measurement to the one desired.

Dew-point temperature is a convenient means for measuring moisture content and is frequently used in dehumidification work. Dew-point temperature, or saturation temperature, can be defined as that temperature at which condensation of moisture begins when moist air is cooled. This temperature can be determined by observing, either visually or by means of a photoelectric cell, the condensation of water vapor on a polished metal surface that is being slowly chilled. Indirect methods for measuring moisture include wet- and dry-bulb psychrometry, adiabatic expansion, electrical resistivity, and methods which depend on the hygroscopic properties of various materials. For a discussion of these methods, refer to National Bureau of Standards Circular 512.[1]

When an air-water vapor mixture is compressed, (1) its ability to hold water is decreased, (2) water vapor will start to condense at a higher temperature, and (3) the dew point of the mixture at elevated pressure will be higher than that of the same mixture at atmospheric pressure. The effect on the dew point of compressing or expanding an air-water vapor mixture can be determined from Fig. 2. The relationship of dew-point temperature to grains of moisture per actual cubic foot of air does not change much with pressure in the range of 0 to 300 psig. Consequently, grains of water per cubic foot for elevated pressures can be read directly from Fig. 1, remembering that actual cubic feet of air are used.

SORBENTS

Sorbents are solid or liquid materials which have the property of extracting and holding other substances (usually gases or vapors, e.g., water vapor) brought into contact with them. The sorption process always generates heat, the major part of which is the result of the condensation of water vapor. The weight of water held by a substance will increase or decrease, depending upon whether the vapor pressure of the water held by the substance is less or greater, respectively, than the partial pressure of water vapor in the surrounding atmosphere. All materials are sorbents to a greater or lesser degree. As generally used, however, the term sorbents refers to those materials having a large capacity for moisture as compared to their volume and weight. Such materials are divided into two general classifications:

1. *Absorbent*—A sorbent which changes either physically, chemically, or both, during the sorption process. Calcium chloride is an example of a solid absorbent. When water is absorbed on this material, analysis shows that the calcium chloride is converted into a hydrate and reaches a saturation point at $CaCl_2 \cdot 2H_2O$, after which additional moisture tends to cause the material to lose its crystalline shape and dissolve in the water that was absorbed. With additional water there is a phase change from the solid to the liquid. Liquid absorbents include sulfuric acid, solutions of the halogen group such as lithium chloride, lithium bromide, and the ethylene glycols.
2. *Adsorbent*—A sorbent which does not change physically or chemically during the sorption process. At no time is there a phase change or solution of an adsorbent. Certain solid materials, such

The general responsibility for this chapter is assigned to TC 1.11, Sorption.