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Thermodynamics of Air and Water Mixtures

Dry Air, Specific Enthalpy, Water Vapor, Moist Air, Dalton's Law, Humidity Ratio, Relative Humidity, Dew-Point, Enthalpy, Thermodynamic Wet-bulb Temperature, Mollier Diagram, Typical Air Conditioning Processes, Adiabatic Saturation, Psychrometric Chart, Steady Flow Energy Equation, U. S. Standard Atmosphere

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THE working substance of the air conditioning engineer may be regarded, for the purpose of analysis, as a mixture of only two constitutents, dry air and water. The mixture may consist of two, and possibly three distinct phases, solid, liquid and vapor. The vapor phase is conveniently referred to as *moist air* and is regarded as a mixture of *dry air* and *water vapor*.

DRY AIR

Composition. Dry air is itself a mixture of several gases, but its composition is subject to such slight variation that it may be regarded as fixed. According to *International Critical Tables*, the mol-fraction composition of dry air is given by the first column of figures in Table 1. Molecular weights are given in the second column; the last figure in the third column is the *apparent* molecular weight of the mixture; the fourth column of figures gives the ordinary weight-fraction composition.

It is well known that dry air contains other gases besides those listed in Table 1; but these are present in such minute amounts that they can be grouped together as argon. Values in the lower section of Table 1 give the approximate mol-fraction composition of what is called argon in the upper portion of the table.

In physical and chemical thermodynamics, there is a distinct advantage in using a different unit of weight, the mol, for each different substance involved. A mol of oxygen weighs 32.000 lb as a matter of definition; a mol of any other substance is a weight, in pounds, equal to its molecular weight.

Specific Volume and Density

The ratio of total volume to total weight is called *specific volume*, v. In the English system, volume is expressed in cubic feet and weight in pounds; hence, specific volume is expressed in cubic feet per pound. The reciprocal of specific volume, that is, weight per unit volume is called *weight density*, d. The unit of density is the pound per cubic foot.

The earliest investigation into the relation between pressure, specific volume, and temperature for gases was made by Boyle (1661) who was able to confirm the hypothesis that the volume of a given weight of gas should vary inversely as the absolute pressure if temperature is maintained constant. Thus, within the limits of his experimental error Boyle found that at constant temperature the product pv, pressure times specific volume, has a constant value over a considerable range of pressures. These results are best visualized by plotting values of the product pv as ordinate against values of pressure p itself as abscissa. According to Boyle's experimental findings lines of constant temperature (isotherms) of a gas are *straight* and *horizontal* on this pv, p-plane.

The first rough experiments of Charles (1787) and the subsequent more refined experiments of Gay-Lussac (1802) suggested the possibility