TABLE 5. SPECIFIC ENTHALPY OF WATER VAPOR AT ZERO PRESSURE[a]

TEMP F t	SPECIFIC ENTHALPY BTU PER LB h°_w	MEAN SPECIFIC HEAT $\left[c^\circ_p\right]^t_0$	TEMP F t	SPECIFIC ENTHALPY BTU PER LB h°_w	MEAN SPECIFIC HEAT $\left[c^\circ_p\right]^t_0$	TEMP F t	SPECIFIC ENTHALPY BTU PER LB h°_w	MEAN SPECIFIC HEAT $\left[c^\circ_p\right]^t_0$
−96	1018.61	0.4425	32	1075.28	0.4435	160	1132.38	0.4455
−64	1032.76	0.4427	64	1089.51	0.4440	192	1146.76	0.4462
−32	1046.92	0.4429	96	1103.76	0.4444	224	1161.20	0.4469
0	1061.09	0.4431	128	1118.05	0.4450	256	1175.70	0.4477

[a]Prepared by John A. Goff from published data computed from spectroscopic measurements.

datum, best available information regarding latent heat, saturation pressure and second virial coefficient at 32 F has been used. The values in Table 5 do not agree exactly with those in the steam tables, but do agree with later information from the National Bureau of Standards [8].

MOIST AIR

Dalton's Law. Having accurate information regarding the thermodynamic properties of dry air and water vapor *separately*, it is desired to predict the properties of moist air which is regarded as a mixture of these two constitutents. Statistical mechanics furnishes a starting point in the form of a prediction that, at not too high pressures,

$$Pv = RT - \left[A_{aa}x^2 + 2A_{aw}\,x\,(1 - x) + A_{ww}\,(1 - x)^2\right] P \qquad (9)$$

where

P = observed pressure, pounds per square foot.
v = specific volume, cubic feet per *mol.*
A_{aa} = second virial coefficient for the dry air expressing the effect of forces between air—air molecules, cubic feet per *mol.*
A_{ww} = second virial coefficient for the water vapor, expressing the effect of forces between water—water molecules, cubic feet per *mol.*
A_{aw} = *interaction constant* expressing the effect of forces between air—water molecules, cubic feet per *mol.*
x = mol-fraction of dry air in the mixture, mols dry air per mol mixture.

Equation 9 will be recognized as a generalization of Equation 2. Both A_{aa} and A_{ww} are known; but until recently no reliable information on the interaction constant A_{aw} has been available. Preliminary results of a cooperative investigation between the A.S.H.V.E. and the Towne Scientific School, University of Pennsylvania, have indicated that the ratio $2A_{aw}/(A_{aa} + A_{ww})$ has an approximately constant value λ = 0.075 [10]. However, before attempting to make use of this information it is advisable, in the interest of simplicity, to first ignore the complications arising from intermolecular forces.

Now, in the absence of intermolecular forces, each constituent gas in a mixture such as moist air would behave exactly as if it alone occupied the volume V at the temperature T of the mixture and: (1) the observed pressure P would be the sum of individual *partial* pressures p; (2) the total enthalpy H would be the sum of the individual enthalpies. This is the essence of Dalton's Law of Partial Pressures.

Referring to dry air by the subscript a and, to water vapor by the subscript w, Dalton's Law would predict

$$V = \frac{n_a RT}{p_a} = \frac{n_w RT}{p_w} = \frac{(n_a + n_w)\,RT}{P} \qquad (10a)$$

where

$$P = p_a + p_w \qquad (10b)$$

From these equations are easily obtained,

$$\frac{n_w}{n_a} = \frac{p_w}{P - p_w} \quad \text{or} \quad \frac{p_w}{P} = \frac{n_w/n_a}{1 + n_w/n_a} \qquad (10c)$$

in which,

p_a = partial pressure of the *dry air.*
p_w = partial pressure of the *water vapor.*
P = observed pressure of the mixture.
n_a = weight of *dry air* (mols).
n_w = weight of *water vapor* (mols).

Humidity Ratio

In Equation 10c the ratio by weight of water vapor to dry air, n_w/n_a, is expressed in mols per mol. Most engineers prefer to express it in pounds per pound which can easily be done, since the molecular weights of both water vapor (18.0154 lb per mol) and of dry air (28.967 lb per mol) are known. Thus Equation 10c becomes

$$W = 0.62193\,\frac{p_w}{P - p_w} \quad \text{or} \quad \frac{p_w}{P} = \frac{W}{0.62193 + W} \qquad (11)$$

There is little doubt but that the weight ratio W is the most convenient parameter in terms of which to express the composition of moist air; but to choose a suitable name and one that would have general acceptance has always been a perplexing problem. In previous issues of the GUIDE, *specific humidity* was adopted even though it was recognized that the adjective *specific* should properly refer to weight of water vapor per pound of *mixture*, and not per pound of dry air. Various other names have been proposed from time to time including: mixing ratio, proportionate humidity, density ratio, absolute humidity. It is believed that the name *humidity ratio* is most suggestive of the meaning which it is desired to express, that it violates no well established usage as does the name specific humidity and that its adoption will avoid much confusion.

To repeat: in the case of moist air, the ratio by weight (pounds) of water vapor to dry air is called *humidity ratio* and denoted by the letter W.

Saturation

It is often stated that moist air is *saturated* when the water vapor in it is itself in the *dry saturated condition* at the given temperature. This statement would imply that the humidity ratio of saturated moist air is, in accordance with Equation 11,

$$W_s = 0.62193\,\frac{p_s}{P - p_s} \qquad (12)$$

where p_s is the saturation pressure of pure water vapor.