This indicates departures from Dalton's Law of the order of 0.5 per cent. The data in Table 6 which are based on an assumed value of unity for the Dalton factor have not been revised pending final results on the measurement of the interaction constant [10].

Relative Humidity

The ratio of actual humidity ratio W to the saturation humidity ratio W_s corresponding to the actual temperature and the observed pressure is denoted by the symbol μ and may be called alternatively *degree of saturation* or *per cent saturation;* thus,

$$W = \mu W_s \tag{14}$$

Example 4. Air is to be maintained at 70 F, 40 per cent saturation when outside air is at 0 F, 70 per cent. The observed pressure may be taken to be 29.921 in. Hg. Find the weight of water to be added to each pound of dry air using Table 6.

Solution. The desired humidity ratio is $0.40 \times 0.01574 = 0.006296$ while that of outside air is $0.70 \times 0.0007852 = 0.000550$. Hence the weight of water to be added is $0.006296 - 0.000550 = 0.005746$ lb per pound dry air.

Under Dalton's Law the water vapor exerts a partial pressure p_w which may be calculated from the given humidity ratio W and the observed pressure P by means of Equation 11. The ratio of this partial pressure p_w to the saturation pressure of pure water p_s corresponding to the actual temperature is called *relative humidity* and may be denoted by the symbol Φ; thus,

$$\Phi = \frac{p_w}{p_s} \tag{15}$$

The relation between μ and Φ is obtained directly from Equations 11 and 12 and is

$$\mu = \left(\frac{P - p_s}{P - p_w}\right)\Phi \tag{15a}$$

whence it is clear that for ordinary temperatures where p_s and therefore p_w are small compared with P, the two are approximately equal.

As an aid in quickly translating degree of saturation μ into relative humidity Φ, the following empirical equation may be substituted for Equation 15a:

$$\Phi = \mu + C\mu(1 - \mu) \tag{15b}$$

where C depends upon temperature *for standard atmospheric pressure*, as shown by the values in Table 7.

Within the limits of accuracy of (15b) this may also be written

$$\mu = \Phi - C\Phi(1 - \Phi) \tag{15c}$$

and used to translate relative humidity Φ into degree of saturation μ.

For example, corresponding to 40 per cent saturation at 100 F, the relative humidity is $0.40 + 0.0667 \times 0.40 \times 0.60 = 0.416$ or 41.6 per cent (15b). Conversely, corresponding to a relative humidity of 41.6 per cent, the degree of saturation is $0.416 - 0.0667 \times 0.416 \times 0.584 = 0.400$ or 40 per cent (15c).

TABLE 7. VALUES OF THE CONSTANT C IN EQUATIONS 15b AND 15c

Temp F t	Per Cent C	Temp F t	Per Cent C	Temp F t	Per Cent C	Temp F t	Per Cent C
5	0.16	30	0.55	55	1.47	80	3.51
10	0.21	35	0.68	60	1.76	85	4.14
15	0.27	40	0.83	65	2.10	90	4.86
20	0.34	45	1.01	70	2.50	95	5.70
25	0.44	50	1.22	75	2.97	100	6.67

Dew-Point

If moist air is cooled at constant humidity ratio W and constant observed pressure P, a temperature will be reached at which the air just becomes saturated and formation of a liquid (or solid) phase just commences. This temperature is called the *dew-point* corresponding to the given humidity ratio and observed pressure.

Example 5. Find the dew-point of the humidified air of Example 4.

Solution. The given humidity ratio is 0.006296 which is the saturation value at 44.96 F (Table 6, assuming the total pressure to be 29.921 in. Hg). This is therefore the dew-point of the humidified air.

Example 6. Find the degree of saturation of air having a temperature of 90 F, a dew-point of 60 F.

Solution. Assuming the total pressure to be 29.921 in. Hg, the humidity ratio is given in Table 6 as 0.01103 lb per pound dry air. The saturation humidity ratio at 90 F is 0.03102 lb per pound dry air; hence the degree of saturation is $0.01103 \div 0.03102 = 0.355$ or 35.5 per cent.

Volume

The volume of moist air *per pound of dry air* contained in it is a very useful quantity. It should not be called specific volume; for the adjective *specific* should properly refer to volume per pound of *mixture.* Using Equations 10a and 14 an expression for the volume per pound of dry air is obtained, namely,

$$v = \frac{B_a T}{P} + \mu\left(\frac{W_s B_w T}{P}\right) \tag{16}$$

Example 7. Find the volume (per pound of dry air) of the humidified air of Example 4.

Solution. $v = \left(\frac{53.35 \times 529.7}{29.92 \times 0.49115 \times 144}\right) + 0.40\left(\frac{0.01574 \times 85.78 \times 529.7}{29.92 \times 0.49115 \times 144}\right)$

$= 13.354 + 0.40 \times 0.338 = 13.489$ cu ft per pound dry air.

Equation 16 is linear in degree of saturation μ and of the form

$$v = v_a + \mu v_{as} \tag{17}$$

where v_a denotes specific volume of dry air at temperature T and pressure P; and v_{as} denotes the difference between this and the volume of the saturated mixture per pound of dry air v_s. Strict linearity is, of course, a result of the use of Dalton's Law; but it is expected that it can be retained as a very close approximation even when the abandonment of Dalton's Law becomes possible.

Example 8. Work Example 7 using Table 6.

Solution. $v = 13.34 + (0.40 \times 0.34) = 13.48$ cu.ft per pound dry air.

By putting $\mu = 1$ (100 per cent saturation) in Equation 16 an expression for v_s, the volume of saturated air per pound of dry air, is obtained. Values for standard atmospheric pressure (29.921 in. Hg) are listed in Table 6. Often it is preferred to express this information in terms of *density*, that is, weight of saturated air per unit volume. This can easily be done by dividing v_s (volume of saturated air per pound of dry air) *into* $(1 + w_s)$ (*weight* of saturated air per pound of dry air). Thus, at 100 F, 29.921 in. Hg, the density of saturated air is, from Table 6, $1.04293 \div 15.07 = 0.06921$ lb per cubic foot.