Specific Humidity

It simplifies many problems which deal with mixtures of dry air and water vapor to express the weight or the mass of the vapor in terms of the weight or the mass of dry air. If the weight of the water vapor in a mixture be divided by the weight of the dry air, and the weight of dry air be made unity, we have an expression of the weight of water vapor carried by a unit weight of dry air. This relation has no generally accepted name. It has been variously called: mixing ratio, proportionate humidity, mass or density ratio, absolute humidity, and specific humidity. Of all these terms *specific humidity* is the most suggestive of the meaning which it is desired to express and it has found considerable use in this sense even though it is defined in International Critical Tables as the ratio of the mass of vapor to the total mass. It will be understood here that *specific humidity* refers to the weight of water vapor in pounds carried by one pound of dry air.

The gas constant for dry air, when the partial pressure of the air is expressed in inches of Hg, is 0.753; so that the specific humidity, if represented by W, is

$$W = \frac{e}{1.21\ (t + 460)} \div \frac{B-e}{0.753\ (t + 460)}$$

$$= 0.622 \left(\frac{e}{B-e}\right) \text{ (pounds)} \tag{5a}$$

$$= 4354 \left(\frac{e}{B-e}\right) \text{ (grains)} \tag{5b}$$

where

e = actual partial pressure of vapor, inches of mercury.
B = total pressure of mixture (barometric pressure), inches of mercury.

Relative Humidity

Relative humidity (Φ) is either the ratio of the actual partial pressure, e, of the water vapor in the air to the saturation pressure, e_t, at the dry-bulb temperature, or the ratio of the actual density, δ, of the vapor to the density of saturated vapor, δ_t, at the dry-bulb temperature. That is:

$$\Phi = \frac{e}{e_t} = \frac{\delta}{\delta_t} \tag{6}$$

The relative humidity of a given mixture at a given temperature is not the same as the specific humidity, W, of the mixture divided by the specific humidity, W_t, of saturated vapor at the same temperature, for from Equations 5a and 6

$$\frac{W}{W_t} = 0.622 \left(\frac{\Phi\ e_t}{P - \Phi\ e_t}\right) \div 0.622 \left(\frac{e_t}{B\text{-}e_t}\right) = \frac{\Phi\ (B\text{-}e_t)}{B - \Phi e_t} \tag{7}$$

The specific humidity of an unsaturated air-vapor mixture cannot, therefore, be accurately found by multiplying the specific humidity of saturated vapor by its relative humidity; although the error is usually small especially when the relative humidity is high.

With a relative humidity of 100 per cent, the dry-bulb, wet-bulb, and

dew-point temperatures are equal. With a relative humidity less than 100 per cent, the dry-bulb exceeds the wet-bulb, and the wet-bulb exceeds the dew-point temperature.

RELATION OF DEW POINT TO RELATIVE HUMIDITY

A peculiar relationship exists between the dew point and the relative humidity and this is found most useful in air conditioning work. This relationship is, that for a fixed relative humidity there is substantially a constant difference between the dew point and the dry-bulb temperature over a considerable temperature range. Table 4, giving the dry-bulb and dew-point temperatures and the dew-point differentials for 50 per cent relative humidity, illustrates this relationship clearly.

TABLE 4. DRY-BULB AND DEW-POINT TEMPERATURES FOR 50 PER CENT RELATIVE HUMIDITY

Dry-bulb temperature	65.0	70.0	75.0	80.0	85.0	90.0
Dew-point temperature	45.8	50.5	55.25	59.75	64.25	68.75
Difference between dew-point and dry-bulb temperature	19.2	19.5	19.75	20.25	20.75	21.25

It will be seen from an inspection of this table that the difference between the dew-point temperature and the room temperature is approximately 20 deg throughout this range of dry-bulb temperatures or, to be more exact, the differential increases only 10 per cent for a range of practically 25 deg.

This principle holds true for other humidities and is due to the fact that the pressure of the water vapor practically doubles for every 20 deg through this range.

The approximate relative humidity for any difference between dew-point and dry-bulb temperature may be expressed in per cent as:

$$\frac{100}{2^{\frac{t-t_1}{20}}} \tag{8}$$

where

t_1 = dew-point temperature.

This principle is very useful in determining the available cooling effect obtainable with saturated air when a desired relative humidity is to be maintained in a room, even though there may be a wide variation in room temperature. This problem is one which applies to certain industrial conditions, such as those in cotton mills and tobacco factories, where relatively high humidities are carried and where one of the principal problems is to remove the heat generated by the machinery. It also permits the use of a differential thermostat, responsive to both the room temperature and the dew-point temperature, to control the relative humidity in the room.

Table 5 gives, for different temperatures, the density of saturated vapor,