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 6 gives, for different temperatures, the density of saturated vapor, d_t, the weight of saturated vapor mixed with 1 lb of dry air, W_t, (at a relative humidity of 100 per cent and a barometric pressure, B, of 29.92 in. of mercury), the specific volume of dry air, and the volume of an air-vapor mixture containing 1 lb of dry air (at a relative humidity of 100 per cent and a pressure of 29.92 in. of mercury). The preceding equations or the data from Table 6 may be conveniently used in solving the following typical problems:

Example 2. Humidifying and Heating. Air is to be maintained at 70 F with a relative humidity of 40 per cent (Φ = 0.4) when the outside air is at 0 F and 70 per cent relative humidity (Φ = 0.7) and a barometric pressure, B, of 29.92 in. of mercury. Find the weight of water vapor added to each pound of dry air and the dew-point temperature of the humidified air.

Solution. From Equation 5a and Table 6,

$$W_1 = 0.622\left(\frac{0.7 \times 0.03773}{29.92 - 0.0264}\right) = 0.000548 \text{ lb per pound of dry air.}$$

$$W_2 = 0.622\left(\frac{0.4 \times 0.7386}{29.92 - 0.295}\right) = 0.00618 \text{ lb per pound of dry air.}$$

The water vapor added per pound of dry air must be ($W_2 - W_1$) or 0.005632 lb. By inspection of Table 6, W_t = 0.00618 at 44.5 F, so this is the dew-point temperature of the humidified air.

An approximation of the same result from Table 6 is

W_1 = 0.7 × 0.0007852 = 0.00054964 lb per pound of dry air.
W_2 = 0.4 × 0.01574 = 0.006296 lb per pound of dry air.

The water vapor added per pound of dry air is approximately 0.00574636 lb and the dew-point temperature is approximately 45 F. The degree of approximation is evident.

Example 3. Dehumidifying and Cooling. Air with a dry-bulb temperature of 84 F, a wet-bulb of 70 F, or a relative humidity of 50 per cent (Φ = 0.5), and a barometric pressure, B, of 29.92 in. of mercury is to be cooled to 54 F. Find the dew-point temperature of the entering air and the weight of vapor condensed per pound of dry air.

Solution. From Equation 5a and Table 6,

$$W_1 = 0.622\left(\frac{0.5 \times 1.1752}{29.92 - 0.5876}\right) = 0.01248 \text{ lb per pound of dry air.}$$

$$W_2 = 0.622\left(\frac{0.42003}{29.92 - 0.42003}\right) = 0.00887 \text{ lb per pound of dry air.}$$

Since $W_1 = W_t$ when t = 63.4 F, this is the dew-point temperature of the entering air. The weight of vapor condensed is ($W_1 - W_2$) or 0.00361 lb per pound of dry air.

An approximate result is

W_1 = 0.5 × 0.02543 = 0.012715 lb per pound of dry air.
W_2 = 1 × 0.008856 = 0.008856 lb per pound of dry air, since the exit air is saturated.

Since $W_1 = W_t$ at t = 64 F, this is the dew-point temperature of the entering air. The weight of vapor condensed is 0.003859 lb per pound of dry air. The degree of approximation is again evident.

ADIABATIC SATURATION OF AIR

The process of adiabatic saturation of air is of considerable importance in air conditioning. Suppose that 1 lb of dry air, initially unsaturated but carrying W lb of water vapor with a dry-bulb temperature, t, and a wet-bulb temperature, t', be made to pass through a tunnel containing an exposed water surface. Further assume the tunnel to be completely insulated, thermally, so that the only heat transfer possible is that between the air and water. As the air passes over the water surface, it will gradually pick up water vapor and will approach saturation *at the initial wet-bulb temperature of the air*, if the water be supplied at this wet-bulb temperature. During the process of adiabatic saturation, then, the dry-bulb temperature of the air drops to the wet-bulb temperature as a limit, the wet-bulb temperature remains substantially constant, and the weight of water vapor associated with each pound of dry air increases to $W_{t'}$, as a limit, *where* $W_{t'}$ is the weight of saturated vapor per pound of dry air for saturation at the wet-bulb temperature.

Example 4. If air with a dry-bulb of 85 F and a wet-bulb of 70 F be saturated adiabatically by spraying with recirculated water, what will be the final temperature and the vapor content of the air?

Solution. The final temperature will be equal to the initial wet-bulb temperature or 70 F, and since the air is saturated at this temperature, from Table 6, W = 0.01574 lb per pound of dry air.

In the adiabatic saturation process, since the heat given up by the dry air and associated vapor in cooling to the wet-bulb temperature is utilized in evaporation of water at the wet-bulb temperature, W. H. Carrier has pointed out[3] that the equation for the process of *adiabatic saturation*, and hence for a process of *constant wet-bulb temperature*, is:

[3]Rational Psychrometric Formulae, by W. H. Carrier (*A.S.M.E. Transactions*, Vol. 33, 1911, p. 1005.)