cases as in sun rooms, greenhouses, and some panel heated rooms, or where there is an unusual amount of air motion in the vicinity of the glass. Although based on zero outdoor air, the values change only slightly with different design temperatures, being about 5 percent greater for a 30 F outdoor design temperature.

In computing the Table 20 values, consideration of the dependence of the indoor surface conductances upon temperature and direction of heat flow leads to surface conductances averaging about 1.50 for block and vertical glass, and about 1.80 for horizontal glass, as compared to the value of 1.65 used in computing U values given in other tables in this chapter. These values should therefore be used in estimating the temperature at which condensation on glass surfaces will occur.

The application factors given in Section D of Table 20 are based upon hot box tests summarized in a research bulletin[16], and are approximate only. In practice, some variation in heat flow through windows having the same ratio of glass to sash area, may be expected because of difference in construction details and in air space edge effects.

CALCULATING SURFACE TEMPERATURES

In many heating and cooling load calculations it is necessary to determine the inside surface temperature or the temperature of the surfaces within the structure. As the resistance of any path of heat flow is expressed in Fahrenheit degrees per (Btu) (hour) (square foot), the resistances through any two paths of heat flow would be proportional to the temperature drop through these paths, and can be expressed as follows:

$$\frac{R_1}{R_2} = \frac{(t_i - t_x)}{(t_i - t_o)} \qquad (6)$$

where

R_1 = the resistance from the inside air to any point in the structure at which the temperature is to be determined.

R_2 = the overall resistance of the wall from inside air to outside air.

t_i = inside air temperature.

t_x = temperature to be determined.

t_o = outside air temperature.

Example 2. Determine the inside surface temperature for a wall having an overal coefficient of heat transmission U = 0.25, inside air temperature 70 F, outside air temperature −20 F.

Solution:

$$R_1 = 1/f_i = 1/1.65 = 0.606$$
$$R_2 = 1/U = 1/0.25 = 4.00$$

Then, by Equation 6

$$\frac{0.606}{4.00} = \frac{70 - t_x}{70 - (-20)}$$

$$t_x = 56.4 \text{ F}$$

The same procedure can be used for determining the temperature at any point within the structure.

A chart for determining inside wall surface temperature is given in Fig. 12 of Chapter 23, Panel Heating.

WATER VAPOR AND CONDENSATION

Water vapor is an important factor in the design and construction of many types of buildings, and in processes where controlled air conditions are essential. It must often be considered in the construction of residences, or public buildings located in cold climates and, to a lesser extent, in those located in warm climates. It is extremely important to consider the moisture problem in the construction of cold storage and low temperature rooms. Manufacturing processes which require a high humidity often require buildings designed with consideration of the effect of moisture on the building.

The moisture problem in residences may also be important. Water vapor is derived from many sources such as cooking, laundering, dishwashing, bathing (particularly use of showers), and the use of appliances such as humidifiers, automatic washers and dryers. The smaller size and compactness of the newer housing units, together with reduced air leakage due to use of weather stripping, insulation and tighter construction, tend to increase the relative humidity of modern homes to high values. There are, likewise, many processes which in themselves create moisture problems that become the major consideration in either the construction of the building or the method of plant operation.

These water vapor problems make it necessary to understand the laws governing water vapor and its relation to air conditioning processes, as well as its effect on different types of structures.

Water Vapor

The theory governing water vapor is well known, and yet it is too often overlooked or given scant consideration in the construction of buildings and the layout of air conditioning processes. Water vapor is present in all air; it occupies the space and has the same properties that it would have if the air were not present. It is steam at low pressure and temperature. Thus, in an air vapor mixture at 80 F, the density of the water vapor may be 0.00158 lb per cu ft, providing that it is saturated and the vapor pressure would be 1.0323 in. Hg. These are the same conditions that would be obtained in a cubic foot of saturated steam at 80 F, and it is spoken of as 100 percent relative humidity air. If this same volume of air contained only one-half of the original moisture or 0.00079 lb per cu ft, it would be only 50 percent saturated, or the relative humidity would be 50.1 percent. In the first case, the vapor pressure would be 1.0323 in. Hg, and in the second case, it would be 50.1 percent of this, or 0.5172. In the first case, the vapor would be saturated and the dew-point, or condensing temperature, would be 80 F. In the second case, the vapor would be superheated and the dew-point, or condensing temperature, would be about 60.2 F. When the vapor in a space is cooled, either by contact with cold surfaces, or otherwise, to a temperature below its dew-point temperature, some of the vapor will be condensed and form either free water or frost, depending upon the condensing temperature.

Surface Condensation

If water vapor comes in contact with surfaces of materials which have temperatures below its dew-point temperature, condensation will take place. This process is seen in the accumulation of moisture on surface of a glass of cold water, or on cold water pipes. In cold storage systems condensation occurs on the cooling surfaces.