

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 bulletin¹⁵, 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:

$$\frac{R_1}{R_2} = \frac{(t_1 - t_x)}{(t_1 - t_o)} \quad (6)$$

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_1 = 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 overall coefficient of heat transmission $U = 0.25$, inside air temperature 70 F, outside air temperature -20 F.

Solution:

$$R_1 = 1/f_1 = 1/1.65 = 0.606$$

$$R_2 = 1/U = 1/0.25 = 4.00$$

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 IN CONSTRUCTION

Water as a vapor is present in all air and as adsorbed moisture in building materials such as wood. Even dense materials like glass hold considerable adsorbed moisture on their surfaces. In each of these places water may be harmless or even desirable, if its quantity is not excessive. Excessive moisture in building materials may cause mould, rot, and rust. Water blistering may damage seriously the exterior paint on wood siding when the siding moisture content rises above a safe level. While excessive

moisture in building materials may be caused by rain leakage, it frequently is due to water vapor migration, a phenomenon likely to be associated with a temperature difference. Thus it may occur in the walls and roofs of heated buildings in winter, and in the enclosure of refrigerated spaces at all seasons. Water vapor released within a building, either incidentally or intentionally, may result in excessive moisture in the structure.

The behavior of water vapor is too often overlooked or given scant consideration in the design and construction of buildings and in the layout of air conditioning processes. It is an important factor to consider in the construction of residences and public buildings in cold climates and to a lesser extent 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 demand a high humidity, require buildings designed to reduce the effect of moisture on the structure.

Moisture problems in residences occur in winter and become increasingly important as homes are built smaller and tighter. Water vapor originates from such necessary living requirements as cooking, laundering, bathing and the breathing and perspiration of people. In a typical family of four, the average daily production of water vapor from these sources may be as much as 25 lb, and may be much greater where such appliances as humidifiers, automatic washers and dryers are used.¹⁶ Another large source of water vapor is sometimes the bare earth in a crawl space or basement. All this water vapor must escape from the dwelling.

Visible Condensation

Just as moisture collects on the outer surface of a glass of cold water, so does it also condense on other cold materials. In winter, visible condensation may collect on cold closet walls and attic roofs and is commonly observed on frosted window panes. Although condensation, if liquid, may enter an unpainted surface as fast as it forms and thus be unseen, any condensation on a visible surface will for convenience here be called *visible condensation* to distinguish it from *concealed condensation*. Within residences and public buildings, visible condensation occurs in winter and may damage decorative finishes and window sash.

Interior visible condensation occurs when any surface is colder than the dewpoint of the near-by air. The temperature of any such surface—wall, roof, or glass—is dependent upon the air temperature inside and outside the building and the heat transfer coefficient U of the surface structure. Based on a value of 1.65 for the inside surface conductance, Fig. 6 shows the relative humidity in a room at 70 F when visible condensation will appear at various U -values. The curves for single and double glass at their usual U -values are included. It should be noted that U -values as commonly used are an average for a large area within which there may be spots, such as the studs in an insulated wall, where the transmittance is higher. The inside surface temperature of a wall will, in general, be lower at the bottom due to such things as stratification of inside air and the effects of air leakage and of convection in walls with air spaces. Since condensation seeks the coldest spot, values from Fig. 6 can be applied only with caution. As a result, the limit of relative humidity for a non-homogeneous wall is lower than might be inferred from its average U -value.

The avoidance of interior visible condensation is partly a construction and partly an operating problem. It is accomplished by reducing the interior dew-point temperature or by raising the surface temperatures that are below the dew-point, or both. The dew-point temperature may be lowered by giving attention to the sources of the moisture, and in winter,