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CHAPTER 23

MOISTURE IN BUILDING CONSTRUCTION

Properties of Water in Air; Water in Building Materials; Vapor Transmission; Permeance and Testing; Visible Condensation; Concealed Condensation in Heated Buildings; Control of Concealed Condensation; Condensation in Cooled Structures

THE behavior of moisture is too often overlooked or given scant attention in the design and construction of buildings. It is present as a vapor in all air and as adsorbed moisture in most building materials. It may also be present at times in the free liquid state or as ice in the solid state, within the range of temperatures encountered in many buildings. Problems involving moisture may arise from changes in moisture content, from the presence of excessive moisture, or from effects associated with its changes in state.

Of particular interest is the change from the vapor to the liquid or solid state, known as condensation. This may be associated with a reduction of temperature with time, or may occur as a result of migration of water vapor to regions of lower temperature. Moisture problems involving condensation are therefore most likely to occur in buildings in any climate in which there is a source of water vapor at temperatures above normal, or in cooled structures, and in buildings in cold climates.

Most 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.[1] Another large source of water vapor is sometimes the bare earth in a crawl space or basement. Also, in new construction, moisture is added by poured concrete slabs, masonry construction and new plaster. All this water vapor must escape from the dwelling.

PROPERTIES OF WATER VAPOR IN AIR

Water vapor in air is a gas which occupies all the space, along with the air present. In many ways, the water vapor can act independently of the air, since in general its properties do not depend on the presence of the air. It exerts its own vapor pressure, and can move about through air in a space, or move through materials under differences in its own vapor pressure, independently of the air. However, when the air is moved suddenly or is heated or cooled, the water vapor present is similarly affected, so that it is usually necessary to consider it as a part of an air-vapor mixture.

The properties of mixtures of air and water vapor are relatively well known and are discussed in Chapter 3. Changes in these properties with heating and cooling can be followed readily with the aid of a psychrometric chart, shown in outline in Fig. 1. The saturation line represents the limiting concentrations of water vapor which can exist as vapor at various temperatures.

A common condition inside buildings, 70 F and 40 percent relative humidity, is represented by point A. This is a condition of partial saturation; i.e., less than 100 percent relative humidity. The vapor pressure of the water present in the air, although not shown on the chart, can be calculated readily from the vapor pressure at saturation and the relative humidity, since relative humidity is equal to the ratio of the actual vapor pressure to the saturation pressure at the existing temperature.

The increasing relative humidity accompanying cooling from the condition represented by A on the chart to point B can readily be followed. At B, however, at 44.6 F, the relative humidity becomes 100 percent, and the air-vapor mixture is said to be saturated. The temperature at which this particular air-vapor mixture, upon cooling, becomes saturated is its dew-point temperature. Upon further cooling, to 35 F, the original amount of water vapor can no longer be retained and is reduced, in this case, to the condition represented by C, from 0.0633 lb per lb dry air to 0.0427 lb per lb dry air. The process ABC is typical of that which an air-vapor mixture experiences when it comes in contact with a cool window surface. Cooling from B to C results in visible condensation on the glass surface. If the point C were below 32 F, the condensation would be in the form of frost.

Once the temperature drops below the dew point, or frost point if below 32 F, the vapor pressure at the condensing surface is also reduced, thereby establishing a gradient of vapor pressure from the room air to the window surface. This gradient will operate, in conjunction with the convective action within the room, to move water vapor continuously to the window surface to be condensed, so long as the concentration of water vapor in the room is maintained.

A common winter process is that shown by DE, showing air at 20 F, saturated, being heated to 70 F with a resulting

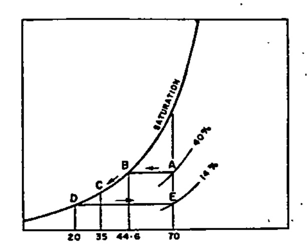

Fig. 1 . . . . Two Typical Heating and Cooling Processes in Air within Buildings Shown on Psychrometric Chart

[1] The general responsibility for this chapter is assigned to TC 2.4, Insulation and Moisture Barriers.