Housing and Home Finance Agency for the guidance of owners, builders, and architects.[14] The dotted lines are the −20 F, 0 F, and +20 F isotherms of winter design temperature taken from Fig. 1, Chapter 12. It will be noted that there is reasonably good correlation between the zones determined by the two sets of lines. Zone I roughly includes those areas where the design temperature is −20 F or colder; zone II those for which the design temperature is zero to −20 F, and zone III those at zero and warmer. Within each zone, similar degrees of condensation trouble are to be expected, and similar corrective measures apply.

In roofs, the condensation problem is much the same as in walls. The roof covering may be even more resistant to the escape of vapor than wall

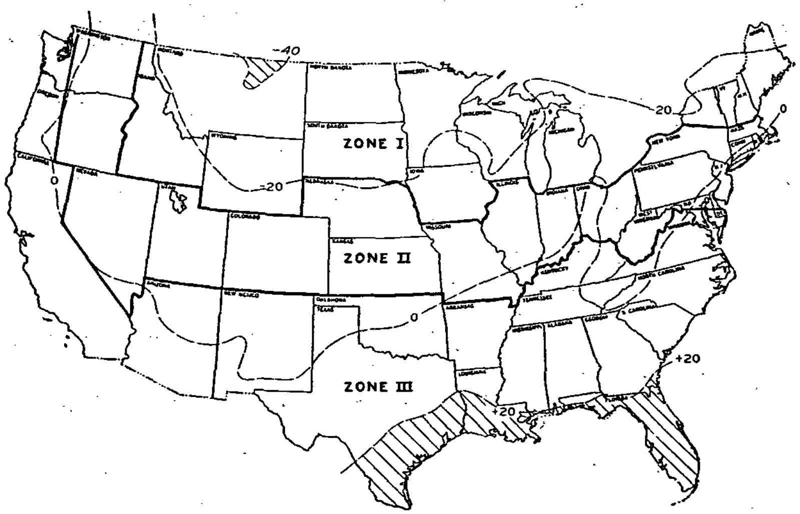

FIG. 6. CONDENSATION ZONES IN THE UNITED STATES

(Zones Include Areas with Design Temperatures about as follows: Zone I, −20 F and lower; Zone II, 0 F to − 20 F; and Zone III, above 0 F. Note that cross hatched areas are outside of Zones I and III.)

coverings such as paint; and while paint is likely to be ruptured by excessive moisture, no such relief occurs in roofs. Thus roofs furnish conspicuous examples of rapid decay in lumber.

In crawl spaces over uncovered damp ground, a large water evaporation sometimes occurs and causes condensation on the outer ends of floor joists and other members that are below the floor line and near to the outside. Water vapor from the crawl space may also enter walls, be transported by rising air in a stack effect, and even reach the attic by this route when the wall structure permits. Ventilation, as discussed later in this chapter, is an important correction factor in these cases.

Insulation in a wall or roof reduces heat loss and lowers the temperature of the outer elements of the structure, thus increasing the possibility of condensation if the vapor path to the cold surface is not blocked. Since low vapor resistance is a characteristic of fibrous insulation, the needed vapor resistance must be provided by other means. It is to be noted that,

in typical residential conditions, condensation does not occur in fibrous insulation itself, except when frost has formed on sheathing and gradually built backward among the fibers. Wet insulation may result from this condition or from liquid condensation seeping down from a higher level.

CONTROL OF CONCEALED CONDENSATION

An excessive accumulation of moisture in walls (or roofs) can be prevented by one or more of the following measures: (1) provide a vapor barrier to limit vapor entrance into the wall, (2) ventilate the building to reduce vapor pressure therein, (3) ventilate the wall cavity to remove vapor that has entered.

1. *Vapor Barrier.* A vapor barrier is the principal and most obvious correction, but each measure is more effective if aided by the effect of another. In habitations, some ventilation of the living space, either incidental or planned, is necessary. Also, a small amount of cavity ventilation is essential in cases where the vapor inflow is not completely stopped and the moisture storing capacity of the outer wall elements is slight. This applies to some prefabricated designs using metal siding.

Vapor barrier sheets are often built into the wall near the warm surface. In wood frame walls they may be applied to the inside surface of the studs. They are sometimes attached to the warm side of the insulating materials, or they may be applied on the cold side of plaster base materials. Special designs may be attached like wall paper to the inside of the wall, when satisfactory from the decorative view point. Sheet barriers often contain asphalt as the vapor resisting ingredient; metal foils, so placed that they are not too cold, may also be used.

The interior wall board or finish material may itself be vapor resistant, or a barrier coating may be applied to its concealed side when that side will not be too cold. The interior finished surface may be coated with a suitable paint having the required vapor resistance and also serving as the decorative finish, or it may be covered by another coat.

A paint coat on the interior finish, though of adequate resistance, is not likely to be so effective as a sheet barrier properly applied during the wall construction. This applies especially to houses of more than one story having cavities in ceilings which open into the outside walls. Such cavities allow vapor entering the ceiling to diffuse or be transported to the cold areas. Stoppage of this path is difficult, requiring normally the painting of the ceiling as well as the walls. Similar treatment may be required on internal partitions, or at least the first stud space adjacent to the cold wall.

The necessary barrier resistance depends on a number of factors. When the vapor flow occurs in annual cycles as in heated buildings, the requirement is not so exacting as it is for a cold storage room where there is no chance for drying out an accumulation of moisture. In a heated structure covered on the outside with materials highly resistant to water vapor such as paint or roll roofing, the winter season is a time of moisture accumulation in the cold outer elements and their safe moisture holding capacity is an important factor in determining the barrier requirement. A house without sheathing requires a better barrier; and a prefabricated design with only a sheet of metal outside of insulation requires very high barrier resistance. The interior vapor pressure and the length and severity of the winter are also important.

For typical frame dwellings with wood sheathing and siding in the northern United States, a barrier permeance of one perm or less has been found