

to-air coefficients. Heat losses through basement walls below grade should be based on the floor and wall coefficients for surfaces in contact with the soil and on the proper ground temperature.

HEAT LOSSES THROUGH CEILINGS AND ROOFS

The transmission heat loss through top floor ceilings, attics and roofs may be estimated by either of two methods:

1. By substituting in Equation 1 the ceiling area (A), the inside-outside temperature difference ($t - t_o$) and the proper value of (U):
 - a. *Flat roofs.* Select the coefficient of transmission of the ceiling and roof from Table 11, Chapter 4.
 - b. *Pitched roofs.* Calculate the combined roof and ceiling coefficient by means of Equation 4, Chapter 4, where this formula is applicable as explained in Chapter 4.
2. By estimating the attic temperature (based on the inside and outside design temperature) by means of Equation 4, and substituting for t_o in Equation 1, the value of t_a thus obtained, together with the ceiling area (A) and the ceiling coefficient (U). This applies to *pitched roofs*. In the case of *flat roofs* it is not necessary to calculate the attic temperatures as the ceiling-roof heat loss can be determined as per paragraph 1a.

SELECTION OF WIND VELOCITIES

The effect of wind on the heating requirements of any building should be given consideration under two heads:

1. Wind movement increases the heat transmission of walls, glass, and roof, affecting poor walls to a much greater extent than good walls.
2. Wind movement materially increases the infiltration (inleakage) of cold air through the cracks around doors and windows, and even through the building materials themselves, if such materials are at all porous.

Theoretically as a basis for design, the most unfavorable combination of temperature and wind velocity should be chosen. It is entirely possible that a building might require more heat on a windy day with a moderately low outside temperature than on a quiet day with a much lower outside temperature. However, the combination of wind and temperature which is the worst would differ with different buildings, because wind velocity has a greater effect on buildings which have relatively high infiltration losses. It would be possible to work out the heating load for a building for several different combinations of temperature and wind velocity which records show to have occurred and to select the worst combination; but designers generally do not feel that such a degree of refinement is justified.

It has been the practice for many years in estimating air leakage by the crack method to use the *average* wind velocity during the months of December, January and February. Although this practice is still followed by some engineers, data are not as yet available to substantiate this assumption. This *average* wind velocity may not necessarily correspond with that occurring during periods when the outside design temperature prevails, the latter being not an *average* but rather a near extreme, that is, a specified number of degrees above the lowest temperature recorded in the locality involved. Therefore instead of using the aforementioned *average* wind velocity, it is the practice of some designers to use in all cases a wind velocity of 15 mph together with the proper design tem-

perature. Although a 15 mph wind velocity is higher than the general average wind velocity during December, January and February in various United States cities, this and higher wind velocities frequently occur during periods of outside temperature corresponding to the design temperature. Because of the unpredictable and intangible nature of this variable there appears to be ample justification for this assumption. It should be added that this wind velocity also corresponds with that on which the heat loss coefficients in Chapter 4 are based, although the effect of variations in wind velocity on the infiltration losses is generally much greater than the effect of wind velocity on the heat loss by transmission through walls, except in the case of single pane windows or other materials and constructions having a high rate of heat transfer. Therefore, pending further investigation of this subject, either the average during December, January and February or a 15 mph wind velocity may be used at the discretion of the designer, the actual wind velocity used however to be specified in each case.

Exposure Factors

In the past many designers have used empirical *exposure factors* which were arbitrarily chosen to increase the calculated heat loss on the side or sides of the building exposed to the prevailing winds. It is also possible to differentiate among the various exposures more accurately by calculating the infiltration and transmission losses separately for the different sides of the building, using different assumed wind velocities. Recent investigations show, however, that the wind direction indicated by Weather Bureau instruments does not always correspond with the direction of actual impact on the building walls, due to deflection by surrounding buildings.

The exposure factor, which is still in use by many engineers, is usually taken as 15 per cent, and is added to the calculated heat loss on the side or sides exposed to what is considered the prevailing winter wind. There is a need for actual test data on this point, and pending the time when it can be secured, the question must be left to the judgment of the designing engineer. It should be remembered that the values of U in the tables in Chapter 4 are based on a wind velocity of 15 mph and that the infiltration figures are supposed to be selected from the tables in Chapter 5 to correspond to the wind velocities given in Table 2 of the present chapter.

AUXILIARY HEAT SOURCES

The heat supplied by persons, lights, motors and machinery should always be ascertained in the case of theaters, assembly halls, and industrial plants; but allowances for such heat sources must be made only after careful consideration of all local conditions. In many cases, these heat sources should not be allowed to affect the size of the installation at all, although they may have a marked effect on the operation and control of the system. In general, it is safe to say that where audiences are involved, the heating installation must have sufficient capacity to bring the building up to the stipulated inside temperature before the audience arrives. In industrial plants, quite a different condition exists, and heat sources, if they are always available during the period of human occu-