Table 33 .... Shade Line Factors

Direction Window Faces	Latitude, Degrees						
	25	30	35	40	45	50	55
E	0.8	0.8	0.8	0.8	0.8	0.8	0.8
SE	1.9	1.6	1.4	1.3	1.1	1.0	0.9
S	10.1	5.4	3.6	2.6	2.0	1.7	1.4
SW	1.9	1.6	1.4	1.3	1.1	1.0	0.9
W	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Note: Distance shadow line falls below the edge of the overhang equals shade line factor multiplied by width of overhang. Values are averages for five hours of greatest solar intensity on August 1.

of the overhang for each foot of overhang width. The tabulated values are the average of the shade line values for the 5 hr of maximum solar intensity on each wall orientation shown, and for a solar declination of 18 deg north (August 1). Northeast and northwest-facing windows are not effectively protected by roof overhangs, and in most cases no credit should be taken for shading of them.

Infiltration and Ventilation

Natural air leakage in residential structures is much smaller in summer than in winter. Winter air leakage in a specific structure is caused by two weather factors, the wind direction and velocity and the inside-outside temperature difference which causes the so-called chimney effect. This chimney effect is, of course, absent in summer, and wind velocities are lower in many localities.

Factors for calculating natural infiltration are shown in Table 34. These are based upon a leakage rate of one-half air change per hour, but, because of the effect of house configuration on area exposed to wind, they are tabulated in terms of Btuh per square foot of gross exposed wall area.

Mechanical ventilation may be provided in residential air conditioning systems. It is not a code requirement in most localities, and only general guidance can be given in determining its desirability. Field experience indicates that natural air leakage is adequate to provide sufficient ventilation in many installations. Nevertheless, the need for positive ventilation must be evaluated for each installation. Considerations include owner desires, entertaining by the owner, etc. In larger homes, ventilation should be provided. This ventilation air is usually introduced at the rate of about one air change per hour. It is considered desirable to install a manually operated, locking-type damper in the outdoor air duct so the owner can have the option of ventilating positively or relying on natural air leakage.

The ventilation factors of Table 34 are expressed as Btuh of sensible heat per cfm of ventilation air. Generally, ventilation will impose a greater load than will infiltration. Furthermore, positive introduction of ventilation air during the summer can substantially eliminate natural air leakage. Hence, appropriate factors for either natural infiltration or ventilation should be used in residential load calculation in most instances.

Occupancy Loads

Even though occupant density is usually lower in residences than in many other types of structures, occupancy loads must be considered in residential cooling load calculations. Loads are generated both by the occupants themselves, and by household appliances. Such loads must usually be treated in an approximate manner, since occupancy and occupant activities are varied and unpredictable.

Table 34 .... Sensible Cooling Load Due to Infiltration and Ventilation

Design Temperature, F	85	90	95	100	105	110
Infiltration, Btuh per sq ft of gross exposed wall area	0.7	1.1	1.5	1.9	2.2	2.6
Mechanical Ventilation, Btuh per cfm	11.0	16.0	22.0	27.0	32.0	38.0

Heat release per occupant of a residence is usually assumed to be 300 Btuh of sensible heat. The number of occupants must be estimated as accurately as possible, with special attention being paid to the owner's use of living or recreation rooms for entertaining large groups of guests. When the owner does not indicate the need for special provisions for entertainment, and the exact number of occupants is not known, a convenient rule-of-thumb is to assume that there will be approximately twice as many occupants as the structure has bedrooms. The occupancy load should then be distributed about equally among the living rooms of the residence. This is suggested because the period of maximum load occurs when most of the people residing in the house are occupying the living areas rather than the sleeping areas. In any case, care should be taken not to grossly overestimate the number of occupants in a residence, since this can lead to oversizing the cooling equipment. Appliance loads should be limited to the kitchen in most cases. A value of 1200 Btuh of sensible heat release by kitchen appliances has been found to be satisfactory for residential cooling load calculation. It is recognized that this does not equal the load that can be imposed by even one top burner or element of a domestic range. Nevertheless, such factors as intermittent use of appliances, flywheel effects, and use of kitchen ventilating fans make this a reasonable and practical value to use.

It may be necessary to include the loads imposed by other household equipment, particularly by laundry equipment if it is located within the conditioned space. These can be estimated from information included in Table 28 of this chapter. Appliances which are major sources of sensible and latent heat must be vented. It is all but impossible, satisfactorily and economically, to overcome the load imposed by an unvented domestic clothes dryer, for example.

Total Sensible Heat Gain

The total sensible heat gain of the structure is the sum of the sensible heat gains of all rooms. If the heat gain has been calculated treating the house as a whole rather than on a room-by-room basis, the sensible heat gain is the sum of the sensible heat gain of each component of the structure.

Latent Load

The latent portion of a residential cooling load is usually estimated as equaling thirty percent of the calculated sensible load. It is recognized that this is an approximation, yet moisture sources in a residence are both numerous and, if taken individually, difficult to evaluate precisely. Furthermore, residential cooling equipment is controlled by one or more room thermostats, and only rarely does humidity directly affect a control device.

Total Cooling Load

The total cooling load is the sum of the sensible load and the latent load. Inasmuch as latent load does not enter directly into residential load calculation, total load is usually

calculated as 1.3 times the calculated sensible load. Design of the distribution system and equipment selection, if all ducts are located within the conditioned space, is based upon the total calculated cooling load of each room.

Whenever the distribution system is located outside of the conditioned space—in attics, crawl spaces, or unconditioned rooms—heat gains to the ducts or pipes must be included as an equipment load and must be considered in equipment selection.[55]

Another factor affecting equipment selection is the effect of outside conditions on the Btuh capacity of unitary cooling equipment. The rated capacity of unitary equipment is affected by standard test conditions, and the properties and quantities of the fluids passed through the evaporator and condenser. One standard combination of test conditions cannot be considered to provide a capacity rating that is meaningful for all outside design conditions of dry-bulb temperature and daily temperature range. Furthermore, the inside design temperature swing materially affects the equipment capacity requirement.

The load calculation procedure is predicated on an inside temperature swing of three degrees. Engineers are not unanimous on the maximum acceptable temperature swing, but 3 deg is viewed as a practical minimum. Others, including 4½ deg and 6 deg, have been responsibly recommended. Despite apparent reported acceptance of greater indoor temperature swings, for engineered jobs a three degree swing and equipment capacity selection on this basis are recommended. Equipment capacity installed must, therefore, be based upon three considerations: calculated heat gain of the structure, heat gain to the distribution system, and the effects of inside temperature swing and outside design conditions. Equipment capacity multipliers which relate outside design conditions to total equipment load (structure plus distribution system) and inside temperature swing are given in the publications of Reference 57 for unitary equipment utilizing air-cooled, evaporatively cooled, or water-cooled condensing units. These are equipment capacity multipliers which, when multiplied by the calculated equipment load, determine the equipment capacity requirement in terms of its standard rating.[57]

LETTER SYMBOLS USED IN CHAPTER 27

α = fraction of incident solar radiation absorbed, dimensionless; subscripts D, d, and t refer to direct, diffuse and total, respectively.
β = solar altitude, degrees.
γ = wall solar azimuth, degrees.
θ = incident angle, degrees.
ϕ = solar azimuth, degrees.
ψ = wall azimuth, degrees.
A = area across which heat is being transferred, square feet.
b = fraction of air passing through coil which does not contact surfaces, coil bypass factor.
F_D, F_d = ratio of the solar heat gain to the incident solar radiation for direct and diffuse solar radiation, respectively, dimensionless.
F_U = usage factor = 0.50.
F_R = radiant heat factor = 0.32.
F_{FL} = flue loss factor = 1.6.
f = unit surface conductance, Btu per (hour) (square foot) (Fahrenheit degree). Subscripts c, r, o, and i refer to convection, radiation, outdoor, and indoor, respectively.
h = enthalpy of air per pound of dry air, Btu per pound. Subscripts i, o, and s refer to indoor, outdoor, and supply air, respectively.
I = incident solar radiation, Btu per (hour) (square foot). Subscripts D, d, Dn, and t refer to direct, diffuse, direct normal, and total solar radiation, respectively.
K = cosine of angle of incidence for direct solar radiation striking a surface, dimensionless.
M = the permeance of the specimen in *perms* or grains per (square foot) (hour) (inch of mercury vapor pressure difference).
Q = rate of entry of outdoor air, cubic feet per minute.
Q_m = required air quantity through conditioning equipment, cubic feet per minute.
q/A = instantaneous rate of total heat transfer, Btu per (hour) (square foot).
q = instantaneous rate of heat transfer, Btu per hour.
q_a = heat gain from appliance, Btu per hour.
q_l = instantaneous latent heat load, Btu per hour.
q_{il} = instantaneous space latent ventilation load, Btu per hour.
q_{el} = instantaneous rate of heat gain from electric lights, Btu per hour.
q_{em} = instantaneous rate of heat gain from electric motors, Btu per hour.
q_{ol} = instantaneous latent ventilation load which does not become a part of space load, Btu.
q_i = rated input of appliance, Btu per hour.
q_m = latent heat load due to moisture transmission through materials, Btu per (hour) (square foot).
q_s = instantaneous sensible heat load, Btu per hour.
q_{is} = instantaneous space sensible ventilation load, Btu per hour.
q_{os} = instantaneous sensible ventilation load which does not become a part of space load, Btu per hour.
$q_t = q_s + q_l$, also $q_{il} + q_{ol} + q_{is} + q_{os}$, Btu per hour.
S = shading coefficient for fenestration being considered.
t_b = temperature of air in adjacent space, Fahrenheit.
t_e = sol-air temperature, Fahrenheit.
t_i = indoor air temperature, Fahrenheit.
t_o = outdoor air temperature, Fahrenheit.
t_s = room supply air dry-bulb temperature, Fahrenheit.
U = overall coefficient of heat transfer of a structural section, Btu per (square foot) (hour) (Fahrenheit degree).
W = humidity ratio, pounds moisture per pound of dry air. Subscripts i, o, and s refer to indoor, outdoor, and supply air, respectively.

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