Table 10 . . . . Summary of Heat Losses of Insulated Residence (*Btu Per Hour*)

Room or Space	*Walls*	*Ceiling and Roof*	*Floor*	*Glass and Door*	*Infil-tration*	*Totals*
Bedroom A	2620	2770	. . .	1530	2310	9,230
Bedroom B	1720	1870	. . .	1530	1560	6,680
Bedroom C	1260	1470	. . .	1030	1340	5,100
Bedroom D	1300	1220	790	770	1010	5,090
Bathroom 1	330	610	. . .	540	670	2,150
Bathroom 2	870	280	250	340	430	2,170
Living Room	3630	. . .	. . .	1910	5730	11,270
Dining Room	1830	. . .	. . .	3300	3270	8,400
Kitchen	1430	. . .	. . .	1040	2440	4,910
Lavette	1520	. . .	. . .	1160	590	3,270
Entrance Hall	430	960	. . .	680	1700	3,770
Garage	−580[a]	−1040[b]	1180	4120	2120	5,800
Recreation	950	. . .	720	770	3080	5,520
Design Totals	17,310	8,140	2,940	18,720	26,250	73,360
Operating Totals[c]	17,310	8,140	2,940	18,720	13,130	60,240
Percentages[d]	28.7	13.5	4.9	31.1	21.8	100.0

[a] Wall heat loss of 1080 Btuh minus wall heat gains of 680, 370, and 610 Btuh.
[b] Heat gains 790 and 250 Btuh. [c] Based on ½ computed infiltration.
[d] Based on operating totals.

instance, the *glass* and *door* transmission heat losses of 19.8 percent are relatively small. The infiltration losses of 14.0 percent are also comparatively small because the storm windows are equivalent to weatherstripping. In this problem, the wall, ceiling, and floor transmission losses comprise 66.2 percent of the total.

Example 7: Calculate the heat loss of residence shown in Fig. 1, based on the same conditions as in *Example 6*, but having construction improved or insulated to obtain coefficients as follows:

Walls, 0.13; *Walls of Dormer over Garage*, 0.12; *Attic Walls*, 0.28; *Walls Adjoining Garage*, 0.18; *Basement Walls (Recreation Room)*, 0.10.

Roof, 0.53.

Ceiling (Second Floor), 0.15.

Windows (Same as in *Example 6*).

Floor (Bedroom D), 0.18.

Solution: The procedure for calculating the heat losses is similar to that for *Example 6*. A summary of the results is given in Table 10.

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CHAPTER 27

AIR-CONDITIONING COOLING LOAD

COMMERCIAL AND INDUSTRIAL COOLING LOAD CALCULATIONS: Design Conditions; Instantaneous Heat Load; Solar Radiation; Periodic Heat Flow; Tables for Calculating Solar Heat Gain Through Walls, Roofs, and Glass; Instantaneous Heat Gain vs Cooling Loads; Load from Interior Partitions, Ceiling, and Floors; Load from Outdoor Air, Ventilation and Infiltration; Effect of Outdoor Air on Load; Heat Sources Within Conditioned Space; Moisture Transfer Heat Load; Miscellaneous Heat Loads; Apparatus Dew Point and Required Air Quantity Through Conditioning Equipment; Minimum Entering Air Temperature; Example Cooling Calculation; RESIDENTIAL COOLING LOADS: Interpretation of Data; Design Temperatures; Equivalent Temperature Differentials; Heat Gains; Infiltration and Ventilation; Occupancy Loads; Total Cooling Load

THIS chapter discusses the methods and data used for calculation of air-conditioning cooling loads for both comfort and process applications. Part I deals with the loads for commercial and industrial buildings and processes. Part II deals with the load for residential cooling.

PART I: COMMERCIAL AND INDUSTRIAL COOLING LOADS

The variables affecting cooling load calculations are numerous, often difficult to define precisely, and always intricately interrelated. Many of the components of the cooling load vary in magnitude over a wide range during a 24-hour period, and as the cyclic changes in load components are not usually in phase with each other, careful analysis is required to establish the resultant maximum cooling load for a building or zone. A zoned system must often handle peak loads in different zones at different hours.

Economic considerations must be of particular influence in the selection of equipment for cooling season operation in comfort air conditioning, and this fact, coupled with present inadequacies in available data and knowledge of the air-conditioning art, places a premium on the experienced judgment essential to successful design or practice. Variations in the weather, building occupancy, and other factors affecting load, necessitate carefully coordinated controls to regulate simultaneously the components and the equipment in order to maintain the desired room conditions.

The calculation procedures presented in this section deal with the various instantaneous rates of heat gain, both sensible and latent, in a conditioned space. There may be an appreciable difference between the *net instantaneous rate of heat gain* and the *total cooling load* at any instant. This difference is caused by the storage and subsequent release of heat by the structure and its contents. This *thermal-storage effect* may be quite important in determining an economical cooling equipment capacity. This effect has been demonstrated by investigators using thermal circuit techniques and computers.[1–15] The lack of any adequate means of treating this storage analytically in its entirety for a complete structure must be recognized in judging the procedures and data presented for calculating individual components of the net rate of instantaneous heat gain.

Solar heating calculations involve the same principles as cooling load calculations. Many of the data on solar radiation given in this section can be used in calculations for solar heating.

The general responsibility for this chapter is assigned to TC 2.1, Load Calculation Data and Procedures; TC 2.2, Weather Data and Design Conditions; and TC 2.5, Fenestration.

COOLING LOAD CALCULATIONS

Summer cooling load calculations, whether for industrial or comfort applications, require consideration of:

1. *Design Conditions:* (a) indoor conditions, (b) outdoor conditions (Table 1), (c) ventilation rate (Table 2).
2. *Instantaneous Heat Load, Sensible and Latent:* (a) load from solar radiation, sky radiation, and from outdoor-indoor temperature differential for glass areas and exterior walls and roofs, modified by periodic heat flow or lag factors, depending on the type of structure, (b) load due to heat gain through interior partitions, ceilings, and floors, (c) load due to ventilation, either natural or mechanical (d) load due to heat sources within the conditioned space such as people, lights, power equipment, and appliances, (e) load due to moisture transfer through permeable building materials, and (f) miscellaneous heat sources.
3. *Determination of Air Quantity and Apparatus Dew Point.*

These factors will be discussed in turn. The material presented leads to an illustrative procedure for a cooling load calculation, and a numerical example is given to demonstrate the calculations involved.

DESIGN CONDITIONS

Indoor Conditions

Indoor air conditions for human health and comfort continue to be the subject of discussion and research.

Research at the ASHRAE Research Laboratory[16] concludes that, for inactive individuals, lightly clothed in still-air conditions, the line of optimum comfort ranges from 77.6 F at 30 percent relative humidity to 76.5 F at 85 percent relative humidity. It is only slightly dependent on humidity. This research was based on 3-hr exposures to constant conditions in a room where the walls were held at room air temperatures; whereas earlier research resulting in the Effective Temperature Chart was based on subjective reactions to sudden temperature change.

Indoor design conditions, for which summer air-conditioning equipment is selected, should preferably be chosen at 75 F dry-bulb, with a relative humidity of 50 percent for the average job in the United States and Canada. In arid climates, a design relative humidity of 40 percent should be chosen.

The 75 F design dry-bulb temperature, which is slightly lower than the optimum range of 76.5 to 77.6 (with walls at room temperature), will partially compensate for the higher mean radiant temperatures normally encountered in comfort cooling applications. For brief occupancy only, a higher dry-bulb temperature may be chosen, although complaints of discomfort may be expected with continuous occupancy.

(Continued on p. 494).