

the United States in which central heating of the convection type is generally used during four to eight months of the year. It does not apply to rooms heated by radiant energy, or to rooms with excessive glass area or rooms with poorly insulated or cold walls, and it has not been advocated officially for use in foreign countries where the climate, heating methods, and general living conditions are materially different from those in the United States, although several foreign workers have attempted to show that it cannot be so applied. Even in the warm south and southwestern climates, and in the very cold north-central climate of the United States, the comfort chart would probably have to be modified according to climate, living and working conditions, and the degree of acquired adaptation.

In densely occupied spaces, such as classrooms, theaters and auditoriums, somewhat lower temperatures are necessary than those indicated by the comfort line on account of counter-radiation between the bodies of occupants²² in close proximity. In rooms in which the average wall surface temperature is considerably below the air temperature, higher air temperatures are necessary. The reverse holds true in radiant or panel heating methods. (See Chapter 38.)

The sensation of comfort, in so far as the physical environment is concerned, is not absolute but varies considerably among certain individuals. Therefore, in applying the air conditions indicated by the comfort line, it should not be expected that all the occupants of a room will feel perfectly comfortable. When the winter comfort line is applied in accordance with the foregoing recommendations, the majority of the occupants will be perfectly comfortable, but there will always be a few who would feel *a bit too cool* and a few *a bit too warm*. These individual differences among the minority should be counteracted by suitable clothing.

Air conditions lying outside the average comfort zone but within the extreme comfort zone may be comfortable to certain persons. In other words, it is possible for half of the occupants of a room to be comfortable in air conditions outside the *average* comfort zone, but in the majority of cases, if not in all, these conditions will be well within the extreme comfort zone as determined experimentally.

Strictly speaking, the only authoritative comfort zone on which accurate data are available, is that for 15 to 25 fpm air movement or turbulence (often referred to as still air). In the past, the winter comfort zone has often been superimposed on effective temperature charts for various air velocities, on the assumption that air conditions of equal warmth are approximately equally comfortable. This may hold in hot industries where the workers are adapted to high temperatures and strong air currents, but it does not apply to sedentary conditions. To ascertain approximately whether a given industrial condition is reasonably comfortable, it would be necessary first to compute the effective temperature from Figs. 1, 2 or 3, and then to refer this effective temperature to the comfort chart (Fig. 5), or to refer directly to a chart or table for the proper air velocity.

The summer comfort line (71 deg ET) is applicable to the same geographic area as the winter comfort line. It is further restricted to cases in which the human body has reached thermal equilibrium with its environment. As a general rule this takes place after $1\frac{1}{2}$ to 3 hours' exposure.

When a person from outdoors enters a room cooled to 71 deg ET on a hot day (95 F or over) an intense chill is likely to be experienced which is unpleasant. However, after remaining in the room for about 2 hours, this fundamental optimum condition will prove satisfactory to the average person. The summer comfort zone, as well as the comfort line, makes proper allowance for these adaptive changes in the body, and thus applies to homes, offices, schools and other similar places where persons of sedentary occupations spend from 3 to 8 or more hours daily.

In artificially cooled theaters, department stores, restaurants, and other public buildings where the period of occupancy is short, the contrast between outdoor and indoor air conditions becomes the deciding factor in regard to the temperature and humidity to be maintained. The object of cooling such places in the summer is not to reduce the temperature to the

TABLE 2. DESIRABLE INDOOR AIR CONDITIONS IN SUMMER CORRESPONDING TO OUTDOOR TEMPERATURES

Applicable to Exposures Less Than 3 Hours

OUTDOOR TEMPERATURE (DEG FAHR)	INDOOR AIR CONDITIONS WITH DEW POINT CONSTANT AT 57 F		
	DRY-BULB	WET-BULB	EFFECTIVE TEMP
95	80.0	65.0	73
90	78.0	64.5	72
85	76.5	64.0	71
80	75.0	63.5	70
75	73.5	63.0	69
70	72.0	62.5	68

optimum degree, but to maintain therein a temperature which is temporarily comfortable to the patrons who thus avoid sensations of chill and intense heat on entering and leaving the building. The relative humidity should be low enough (about 50 per cent or less) to give a sense of comfort without chill and to induce a rate of evaporation which will keep clothing and skin dry. For exposures less than 3 hours, desirable indoor conditions in summer corresponding to various outdoor temperatures are given in Table 2.

It should be kept in mind that southern people, with their more sluggish heat production and lack of adaptability, will demand a comfort zone several degrees higher than those given here for the more active people of northern climates. Instead of the summer comfort line standing at 71 deg as here given, it was found to be much higher for foreigners in Shanghai where climatic conditions are similar to those of our gulf states. This difference in basic metabolic level of people forms a very real problem for air conditioning engineers, which they must recognize in their efforts to give proper conditions of comfort. Cooling of theaters, restaurants, and other public buildings in southern climates cannot be based on northern standards without considerable modification.