Satisfactory comfort conditions for men at work are found to vary from 40 deg to 70 deg ET, depending upon the rate of work and amount of clothing worn[31]. In hot industries, 80 deg ET is considered the upper limit compatible with efficiency, and, whenever possible, this should be reduced to 70 deg ET or less.

### Summer Comfort Zones

The summer comfort zone is much more difficult to fix than the winter zone owing to the complicating factor of sweating in warm weather. A given air condition which is comfortable for persons with dry skin and clothing may prove too cold for those perspiring, as is the case, for instance, with employees and customers in a cooled store, restaurant, or theater, on a warm summer day. The conditions to be maintained in different types of public buildings depend to a large extent upon the occupants' length of stay and upon the prevailing outdoor condition.

In Fig. 6 is shown the summer comfort zone for exposures of 3 hours or more, after adaptation has taken place. The average zone extends from 66 to 75 deg ET, with a comfort line at 71 deg ET, as determined at the Harvard School of Public Health[32]. These effective temperatures average about 4 deg higher than those found in winter when customary winter clothing was worn. The variation from winter to summer is probably due partly to adaptation to seasonal weather and partly to differences in the clothing worn in the two seasons.

The best effective temperature (for exposures lasting 3 hours or more) was found to follow the average monthly outdoor temperature more closely than the prevailing outdoor temperature. It remained at approximately the same value in July, August and September, and although the average monthly temperature did not vary much, the prevailing outdoor temperature ranged from 70 F to 99.5 F. A decrease in the optimum temperature became apparent only when the prevailing outdoor temperature fell to 66 F, which is below the customary room temperature in the United States for summer and winter.

Crowding the experimental chamber lowered the comfortable effective temperature from 70.8 deg when the gross floor area per occupant was 44 sq ft and the air space 380 cu ft, to 69.4 deg when the floor area was reduced to 14 sq ft and the air space to 120 cu ft per occupant.

The basic summer comfort zone, shown in Fig. 6 has more academic than practical significance. It prescribes conditions of choice for continuous exposures, as in homes, offices, etc., without regard to costs, prevailing outdoor air conditions, and temperature contrasts upon entering or leaving the cooled space. A great number of persons seem to be content with a higher plane of indoor temperature, particularly when the matter of first cost and cost of operation of the cooling plant is given due consideration.

According to previous investigations[33], an indoor temperature of about 80 F with relative humidities below 55 per cent, or 74.5 deg ET and lower, result in satisfactory comfort conditions in the living quarters of a residence,

[31]Loc. Cit. Note 22.
[32]Loc. Cit. Note 27.
[33]Study of Summer Cooling in the Research Residence for the Summer of 1934, by A. P. Kratz, S. Konzo, M. K. Fahnestock and E. L. Broderick (A.S.H.V.E. TRANSACTIONS, Vol. 41, 1935, p. 207).





and while this condition is not representative of optimum comfort it provides for sufficient relief in hot weather to be acceptable to the majority of users. Experience in a number of air conditioned office buildings, including the New Metropolitan Life Building in New York[34], indicates that a temperature of about 80 F with a relative humidity between 45 and 55 per cent (73 to 74.5 deg ET) is generally satisfactory in meeting the requirements of the employees.

In artificially cooled theaters, 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 to provide sufficient relief from the heat without causing sensations of chill or intense heat on entering and leaving the building.

Effective temperatures as high as 75 F at times have been found satisfactory in very warm weather. There are two schools of thought concerning the relation between temperature and humidity to be maintained. For a given effective temperature some engineers including the operators of cooling plants favor a comparatively low temperature with a high humidity as this results in a reduction of refrigeration requirements. Preliminary experiments at the A.S.H.V.E. Laboratories[35] would seem to indicate no appreciable impairment of comfort with relative humidities as high as 80 per cent, provided the effective temperature is between 70 and 75 deg.

The second school favors a higher dry-bulb temperature, according to the prevailing outdoor dry-bulb, with a comparatively low humidity (well below 50 per cent); the main purpose being to reduce temperature contrasts upon entering and leaving the *cooled* space and to keep the clothing and skin dry. This second scheme requires more refrigeration with the present conventional type of apparatus.

Current practice in theatres, restaurants, etc., follows a schedule similar to that shown in Table 2. This schedule should be used with considerable judgment depending on the occupancy and local climatic conditions. There are some indications that a definite indoor effective temperature may be applicable throughout the cooling season, but other observations seem to show that changing indoor conditions are desirable with violently changing outdoor weather conditions. It is, in fact, questionable whether entirely satisfactory air conditions could be adduced for practical use to meet the changing requirements of patrons from the time they enter to the time they leave a cooled space. Too many uncontrollable variables enter into the problem. Work now going on at the A.S.H.V.E. Laboratories and other interested institutions may throw considerable light on this complex problem.

For cooled banks and stores where the customers come and go spending

[34]The Air Conditioned System of the New Metropolitan Building—First Summer's Experience, by W. J. McConnell and I. B. Kagey (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 217).
[35]Comfort Standards for Summer Air Conditioning, by F. C. Houghten and Carl Gutberlet (A.S.H.V.E. TRANSACTIONS, Vol. 42, 1936, p. 215). Cooling Requirements for Summer Air Conditioning, by F. C. Houghten, F. E. Giesecke, Cyril Tasker and Carl Gutberlet (A.S.H.V.E. JOURNAL SECTION, *Heating, Piping and Air Conditioning*, December, 1936, p. 681).