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; (2) load due to heat gain through interior partitions, ceilings and floors; (3) load due to ventilation, either natural or mechanical; (4) load due to heat sources within the conditioned space such as people, lights, power equipment, and appliances; (5) load due to moisture transfer through permeable building materials; (6) miscellaneous heat sources.

C. *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 have been and continue to be the subject of much discussion and research.

The effective temperature index, explained in Chapter 6 is probably the best available source of design criteria for comfort air conditioning systems for buildings or enclosures in which the air and inside surface

Table 1. Typical Commercial Design Room Conditions for Summer Average Peak Load in Comfort Air Conditioning[a]

| Type of Installation | Dry-Bulb Temp | Wet-Bulb Temp[b] | Relative Humidity Per Cent | Grains Per Lb[b] | Effective Temp[c] |
|---|---|---|---|---|---|
| Deluxe Application | 78 | 65 | 50 | 72.7 | 72.2 |
| Normal Application | 80 | 67 | 51 | 78.5 | 74.0 |
| 15 to 40 min Occupancy | 82 | 68 | 49 | 80.0 | 75.3 |

[a] Values in Table 1 are for *peak load* conditions. It is general practice to operate a system at approximately 76 F and 50 percent relative humidity at other than peak load.

[b] Psychrometric data for standard barometric pressure.

[c] Fig. 10, Chapter 6, air movement 15 to 25 fpm.

temperatures remain substantially equal; a condition that can safely be assumed for most ordinary comfort air conditioning installations. Other sources of design specifications are to be found in the requirements of codes and ordinances, and in the varied long-term experiences of manufacturers, contractors, and engineering specialists.

Past experience, cumulative over many years, indicates that indoor design conditions for which summer air-conditioning equipment is selected, should not exceed a temperature of 80 F or a relative humidity of 50 percent for the average job in the United States. If these conditions are exceeded, complaints of discomfort may be expected, especially with continuous occupancy. For very brief occupancy only, a slightly higher peak-load design temperature may be employed. In regard to the lower limit of humidity, complaints are not encountered for store installations operated down to 35 percent relative humidity or, for office jobs, somewhat lower. These observations apply to normal commercial practice in this country only; for extremes, such as tropical or very hot regions, it is regarded as more practicable to design for a peak-load outdoor-indoor temperature difference of about 15 to 20 F.

Table 1 offers typical design conditions for average requirements encountered. The *deluxe* figures would also apply in general for localities having a summer outdoor design temperature of 90 F or less; and the *15 to 40 min* occupancy values, or even somewhat higher dry-bulb temperatures, would indicate acceptable conditions for very hot localities. Table 1 *is to be used with good judgment*, for there is no universal rule which may be applied to indoor design conditions.



Guarantees of conditions to be maintained for summer operation are based upon a definite set of load conditions. At other than the guarantee load, the conditions produced by a system are determined by the balance of imposed load and equipment capacity, and by the method adopted for regulating the system operation. Complete specifications of indoor design conditions would include part-load and overload operation, particularly from the viewpoint of economy.

In the field of *industrial air conditioning*, indoor design conditions are established by the requirements of goods and processes, in addition to the comfort and efficiency of the workers. No generally-applicable specifications are possible, as each job has its own special requirements. Table 2 offers illustrative general information.

Table 2. Illustrative Temperatures and Relative Humidities Applicable to Industrial Air Conditioning[a]

| Classification | Materials, Location or Process | Temperature F | Relative Humidity % |
|---|---|---|---|
| Employee Efficiency | General Machine Shop Work | 78–80 | 50 |
| | Drafting Rooms | 78–80 | 50 |
| | Offices | 78–80 | 50 |
| Storage Prior to Manufacturing | Rough Castings | 80 | 50 |
| | Ceramic Materials | 60–80 | 50 |
| | Pharmaceutical Powders | 70–80 | 15–35 |
| | Sugar | 80 | 35 |
| | Paper | 75–80 | 35 |
| | Electrical Goods | 60–80 | 35–50 |
| | Flour | 60–75 | 55–65 |
| | Rubber | 60–75 | 40–50 |
| | Grains | 60 | 30–45 |
| | Hardened Aluminum Alloys | 0 to −30 | |
| Manufacturing Process | Machine Tool Oil Cooling | 70–90 | |
| | Precision Parts Honing Machinery | 75–80 | 40–55 |
| | Ceramic Molding | 80 | 60 |
| | Manufacturing of Electrical Wiring | 60–80 | 35–50 |
| | Assembly Line | 65–80 | 40–50 |
| | Gage Rooms | 78 | 50 |
| | Instrument Calibration | 68 | 50–55 |
| | Match Manufacturing | 72–74 | 50 |
| Research and Development | Paper Testing Laboratory | 60–80 | 55–65 |
| | Textile Testing Laboratory | 70 | 65 |
| | Special Process Temperature Boxes | −100 to +170 | |
| | Chemical Laboratories | 78 | 50 |
| | Fibres and Plastics | 70–75 | 50–65 |
| | Drafting | 78–80 | 45–50 |
| | Temperature Shock Tests | −80 to +150 | |

[a] Taken from the article, "Indoor Climate and Refrigeration for Post-War Industry," by E. K. Heglin, *Cleveland Engineering*, Vol. 40, No. 27, July 3, 1947, p. 5.

The indoor design conditions suggested have had reference to conditions to be maintained at the level of occupancy. For extremely high ceilings in public or industrial buildings, only the zone from 10 to 15 ft above the floor may be cooled to the full extent. The air temperature at the ceiling would be much higher, and this should be kept in mind when calculating the convective portion of the roof heat gain. A reduction of outdoor-to-indoor air temperature differential may be assumed in such instances; radiation from the inner roof surface is not diminished.

### Outdoor Conditions

Summer climatic conditions and suggested design wet-bulb and dry-bulb temperatures are given in Table 3 for various locations in the United