Table 7 . . . . Analytical Solutions for Heat Conduction in Variously Shaped Solids (Concluded)

Shape of Solid	Boundary Conditions	Data Available in Graphs
Sphere immersed in fluid. 	The temperature of the surrounding fluid suddenly changes from the initial uniform sphere temperature.	Temperature distribution as a function of time. References: (4) p. 36; (5) pp. V-21, V-35, V-44; (10) pp. 281, 282.
		Heat flow as a function of time. References: (5) p. V-21; (10) p. 281.
Rectangular bar of infinite length.	Any of the above noted boundary conditions for a slab.	Temperature distribution as a function of time. Combine solutions as indicated in Refs. 16 and 17.
Parallelopiped (rectangular).	Any of the above noted boundary conditions for a slab.	Temperature distribution as a function of time. Combine solutions as indicated in Refs. 16 and 17.
Cylinder of finite length.	Any of the boundary conditions given above for a cylinder and a slab.	Temperature distribution as a function of time. Combine solutions as indicated in Refs. 16 and 17.
Hollow cylinder of infinite exterior radius.	The temperature of the surface suddenly changes from the initial (uniform) temperature.	Temperature distribution as a function of time. Combine solutions as indicated in Refs. 16 and 17.
		Heat flow at the surface as a function of time. Reference: (10) p. 267.

most direct use in problems in which the boundaries of the two-dimensional shape are made up of isothermal and adiabatic surfaces.

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CHAPTER 6

PHYSIOLOGICAL PRINCIPLES

Chemical Vitiation of Air, Physical Impurities in Air, Thermal Interchanges Between the Body and Its Environment, High Temperature Hazards, Acclimatization, Upper Limits of Heat for Men at Work, Application of Physiologic Principles to Air-Conditioning Problems, Effective Temperature Index and Comfort Zones

VENTILATION is defined in part as *the process of supplying air to, or removing air from, any space by natural or mechanical means*. The word in itself implies quantity, but air must be of the proper quality also. The term *air conditioning* in its broadest sense implies control of any or all of the physical or chemical qualities of the air. The ASHVE *Code of Minimum Requirements for Comfort Air Conditioning*[1] defines it "as the process by which simultaneously the temperature, moisture content, movement and quality of the air in enclosed spaces intended for human occupancy may be maintained within required limits. If an installation cannot perform all of these functions, it shall be designated by a name that describes only the function or functions performed." See definition of air conditioning in Chapter 1.

CHEMICAL VITIATION OF AIR

People living indoors bring about certain physical and chemical changes in the air about them. The oxygen content of the air diminishes and the carbon dioxide increases, but these changes are too slight to be significant except in airtight spaces as in submarines. Organic matter which is usually perceived as odors, comes from the body or clothes. Moisture and heat are given off by the body. There is no evidence of any toxic volatile material given off by man to the ambient air. Stale air may be offensive because of odors and may induce loss of appetite and loss of energy. Objectionable body odors have the same effects. These reasons, whether esthetic or physiological, usually make it desirable in the design of air-conditioning systems to provide for the elimination or control of odors arising from occupancy, cooking, or other sources. This may be accomplished by introducing odor-free air in sufficient quantities to reduce odor concentrations by dilution to a level which is not objectionable. Odor-free air may be outdoor air or air which has been cleared of odors by sorption, washing, or other appropriate means.

In the case of vitiation by a few hazardous gases such as carbon monoxide from heating, cooking, and certain industrial processes, no satisfactory chemical treatment for the elimination of the impurity has been found. The only satisfactory solution is elimination at the source by local exhaust ventilation; or, if this is impossible, reduction to a safe concentration by dilution. (See Chapter 7.) In the case of contamination by other matter, including volatile vapors and gases, chemical treatment for the removal or reduction of the impurities has been made available through air cleaning methods, which are discussed in Chapter 24.

When the only source of contamination is the human occupant, and overheating is not a problem, the minimum quantity of outdoor air needed appears to be that required to remove objectionable body odors, or tobacco smoke. The concentration of body odor in a room, in turn, depends upon a number of factors, including the dietary and hygienic habits of the occupants (frequently reflecting their socio-economic status), the outdoor air supply, air space allowed per person, odor adsorbing capacity of air-conditioning processes, and temperature and relative humidity. The intensity of odor sensation has been found to vary as the logarithm of the concentration of the odoriferous substance in the air, or inversely with the logarithmic function of the amount of outdoor air supplied and the air space per person.

The relation between air supply and occupancy has been reported by the Harvard School of Public Health[2] (Table 1) and the ASHAE Research Laboratory.[3] Outdoor air require-

Table 1 . . . . Minimum Outdoor Air Requirements to Remove Objectionable Body Odors Under Laboratory Conditions[2]

Type of Occupants	Air Space per Person Cu Ft	Outdoor Air Supply CFM per Person
Heating season with or without recirculation. Air not conditioned.		
Sedentary adults of average socio-economic status	100 200 300 500	25 16 12 7
Laborers	200	23
Grade school children of average socio-economic status	100 200 300 500	29 21 17 11
Grade school children of lower socio-economic status	200	38
Children attending private grade schools	100	22
Heating season. Air humidified by means of centrifugal humidifier. Water atomization rate 8 to 10 gph. Total air circulation 30 cfm per person.		
Sedentary adults	200	12
Summer season. Air cooled and dehumidified by means of a spray dehumidifier. Spray water changed daily. Total air circulation 30 cfm per person.		
Sedentary adults	200	<4