

TABLE 1. AVERAGE MAXIMUM DESIGN DRY-BULB TEMPERATURES, DESIGN WET-BULB TEMPERATURES, WIND VELOCITIES, AND WIND DIRECTIONS FOR JUNE, JULY, AUGUST, AND SEPTEMBER (Continued)

STATE	CITY	AVERAGE MAXIMUM DESIGN DRY-BULB	DESIGN WET-BULB	SUMMER WIND VELOCITY MPH	PREVAILING SUMMER WIND DIRECTION
Texas.....	Dallas.....	99	76	9.4	S
	Galveston.....	93	79	9.7	S
	San Antonio.....	100	78	7.4	SE
	Houston.....	93	79	7.7	S
	El Paso.....	98	69	6.9	E
Utah.....	Salt Lake City.....	95	67	8.2	SE
Vt.....	Burlington.....	85	71	8.9	S
Va.....	Norfolk.....	91	76	10.9	S
Wash.....	Richmond.....	95	76	6.2	SW
	Seattle.....	83	61	7.9	S
W. Va.....	Spokane.....	89	63	6.5	SW
	Parkersburg.....	90	74	5.3	SE
Wis.....	Madison.....	89	73	8.1	SW
Wyo.....	Milwaukee.....	87	72	10.4	S
	Cheyenne.....	85	62	9.2	S

tory¹ has shown that a large error may be introduced into the calculations by failure to consider the periodical character of heat flow resulting from the diurnal movement of the sun and the heat capacity of the structure, which determine the timing and magnitude of the heat wave flowing through the wall into a building on a hot, sunny day.

Unfortunately, despite intensive study, all data on solar radiation

TABLE 2. HEAT EQUIVALENTS OF VARIOUS DEVICES, BTU

Lights and electric appliances.....	3415 per kilowatt
Motors.....	2546 per horsepower hour
Restaurant coffee urns, 10-gal capacity.....	16000 per hour
Dish warmers per 10 sq ft of shelf.....	6000 per hour
Restaurant range—4 burners and oven.....	100,000 per hour
Residence gas range.....	
Giant burner.....	12000 per hour
Medium burner.....	9000 per hour
Oven.....	1000 per cu ft of space
Pilot.....	250 per hour
Electric Range.....	
Small burner.....	3412 per hour
Medium burner.....	4100 per hour
Large burner.....	7700 per hour
Oven.....	10236 per hour
Appliance connection.....	2250 per hour
Warming compartment.....	1023 per hour

¹For further information on this subject see following A.S.H.V.E. research papers: Coefficients of Heat Transfer as Measured under Natural Weather Conditions, by F. C. Houghten and C. G. F. Zobel (A.S.H.V.E. TRANSACTIONS, Vol. 34, 1928); Absorption of Solar Radiation in Its Relation to the Temperature, Color, Angle and Other Characteristics of the Absorbing Surface, by F. C. Houghten and Carl Gutberlet (A.S.H.V.E. TRANSACTIONS, Vol. 36, 1930); Heat Transmission as Influenced by Heat Capacity and Solar Radiation, by F. C. Houghten, J. L. Blackshaw, E. M. Pugh and Paul McDermott (A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932).

through building walls are too theoretical and mathematically complicated to be of much practical value to the heating and ventilating engineer. Accordingly, the customary rule-of-thumb method of adding an arbitrary 25 F to the dry-bulb temperature difference in calculating the heat transmission through a wall or roof which may be exposed to the sun for any appreciable length of time is given as a workable solution to an exceedingly complex problem.

Solar Radiation

Fig. 1 shows the total amount of solar energy in Btu per square foot per hour received during the day by a surface normal to the rays of the sun, by a horizontal surface, and by east, west, and south walls. The curves are drawn from A.S.H.V.E. Laboratory data obtained by pyrheliometer, are based on sun time, and are for a perfectly clear day on August 1 at a north latitude of 40 deg. Data from these curves may be used with little error for most United States latitudes and for all of the hotter months of the year.

The absorption of solar radiation by an interior surface depends upon the character of the surface, the angle of the surface with respect to the direction of the radiation, and the angle and type of glass through which the radiant rays pass. The heat absorption by a black oilcloth surface perpendicular to the sun's rays was found to be as high as 273 Btu per square foot per hour, based on tests conducted by the A.S.H.V.E. Research Laboratory in Pittsburgh². Lamp black, red brick dust, and aluminum bronze painted surfaces perpendicular to the sun's rays showed respectively 94.0, 63.4, and 28.2 per cent as high a rate of absorption as the black oilcloth.

Transmission Through Glass

In considering the effect of glass on heat absorption, several factors must be considered. As the sun's rays impinge against and pass through an intervening sheet of glass, some radiation is reflected directly from each of the two glass surfaces, and some is absorbed by the glass depending upon its character and thickness. All of the heat reflected by the glass surfaces and most of that absorbed within the glass is stopped from passing through the glass into a room.

The A.S.H.V.E. tests indicated that a single pane of double strength glass absorbs from 8.9 to 16.5 per cent of the solar radiation passing through it when the impingement is normal. For smaller angles of impingement, the glass retards percentages of the total radiant energy approximately in proportion to the sine of the angle. Experiments³ indicate a glass absorption of 16.7 per cent for one pane of glass and 37.5 per cent for two ¼-in. panes separated by a 1¾-in. air space.

In a recent paper by the A.S.H.V.E. Research Laboratory⁴ it was shown

²Absorption of Solar Radiation in Relation to the Temperature, Color, Angle, and Other Characteristics of the Absorbing Surface, by F. C. Houghten and Carl Gutberlet (A.S.H.V.E. TRANSACTIONS, Vol. 36, 1930).

³Field Studies of Office Building Cooling (A.S.H.V.E. Research Paper), by J. H. Walker, S. S. Sanford, and E. P. Wells (A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932).

⁴Radiation of Energy Through Glass by J. L. Blackshaw and F. C. Houghten (A.S.H.V.E. Journal Section, Heating, Piping and Air Conditioning, October, 1933).