HVAC

Manual thermal load calculations

SHAKER CONSULTANCY GROUP

About me

Ibrahim Badawy

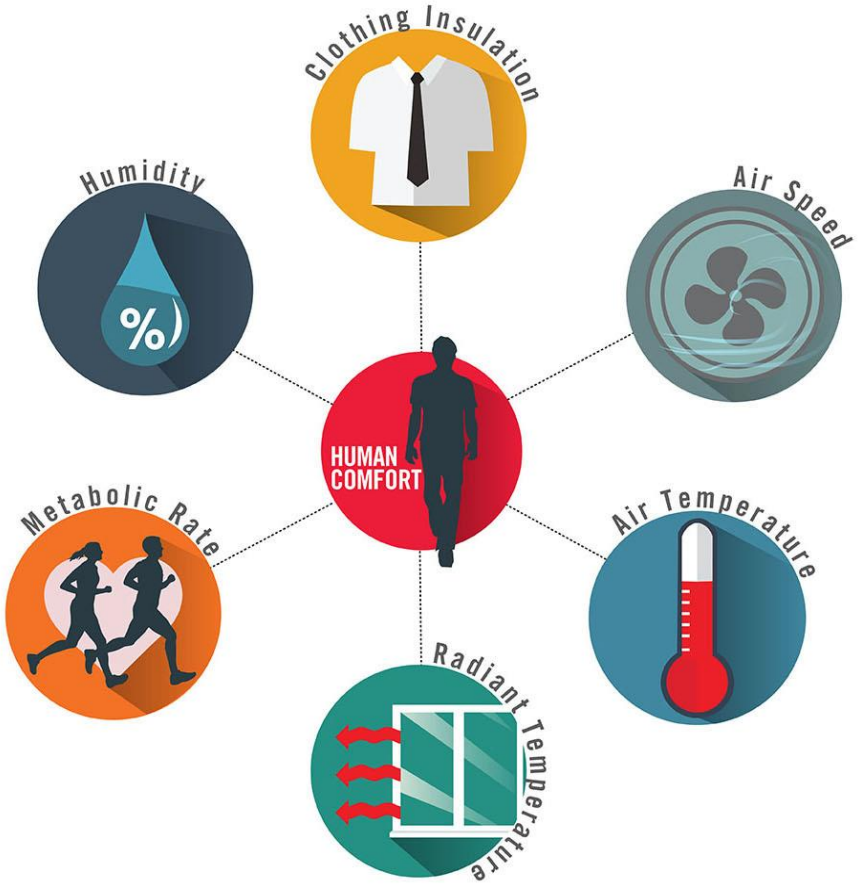
Mechanical Design,BIM-MEP, and HVAC
design engineer at SCG

B.Sc.in Mechanical Power Engineering
Faculty of Engineering , Al-Azhar Unviresty at cario
Acumulative grade : **Excellent (85%) with honor's, and first in my class.**

Ibrahim Badawy

Human Comfort

Human thermal comfort is defined as a condition of mind, which expresses satisfaction with the surrounding environment. High temperatures and humidity provide discomfort sensations and sometimes heat stress (i.e., reducing the body's ability to cool itself)



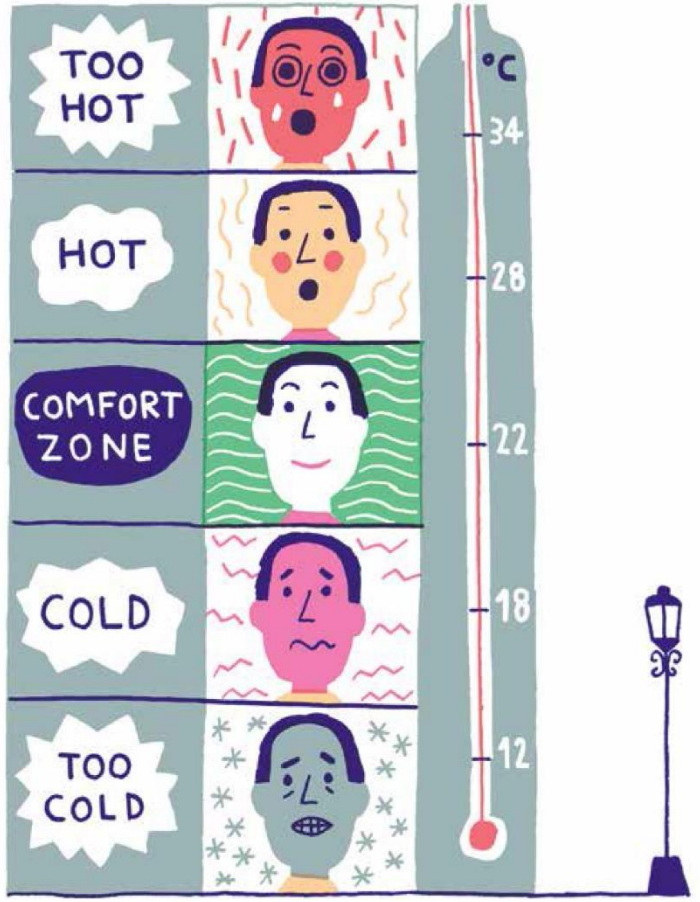
Inputs for Energy Balance

Metabolic Rate
Clothing Insulation
Air Temperature
Air Velocity
Mean Radiant Temperature
Relative Humidity

Storage = Production - Loss

PMV Index

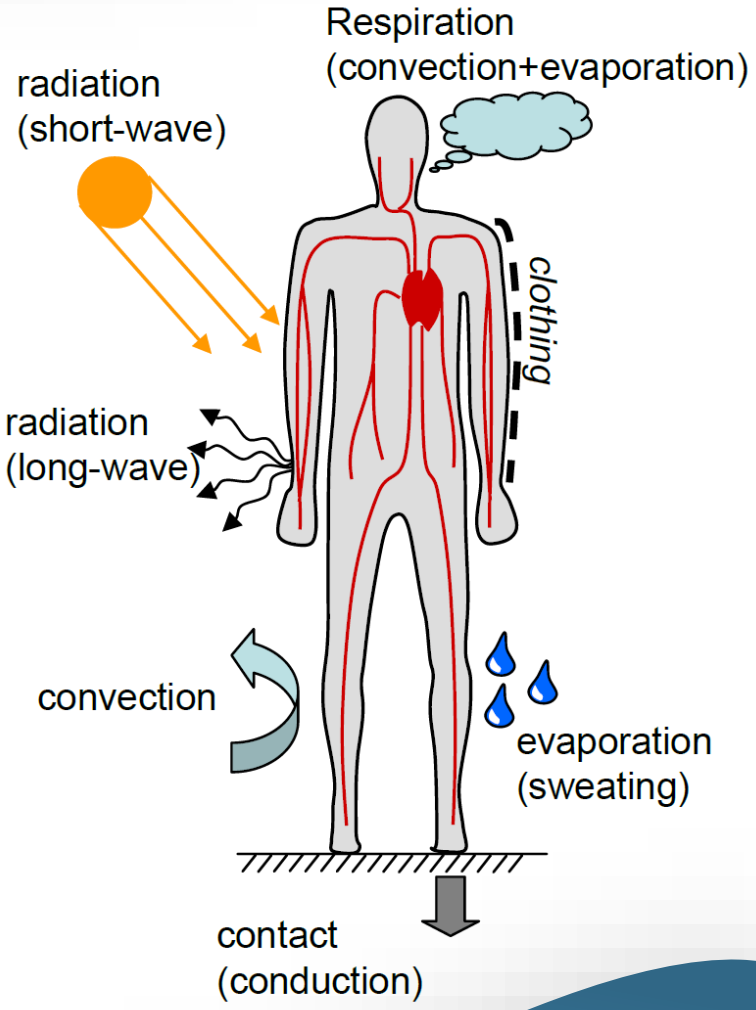
+3	Hot
+2	Warm
+1	Slightly Warm
0	Neutral (Comfort)
-1	Slightly Cool
-2	Cool
-3	Cold



WHILE EXTREMES IN TEMPERATURE, HOT OR COLD, CAN BE FATAL, EVEN MINOR FLUCTUATIONS CAN BRING PLEASURE OR DISCOMFORT.

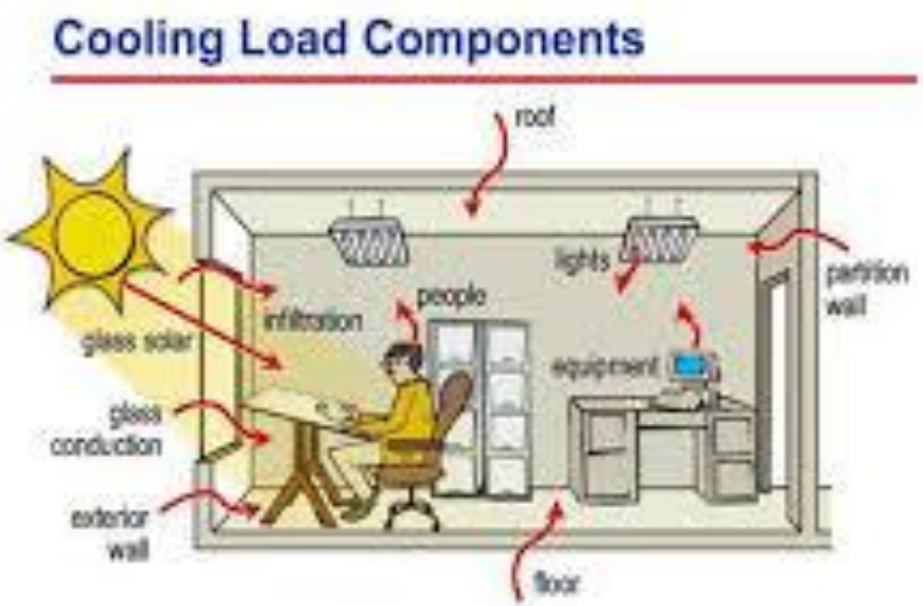
$M-W=E\pm C\pm R\pm S \quad \& \quad W=\eta M$

M=metabolic rate
W=work done
η= body efficiency
E= rate of heat loss by evaporation and respiration
R= radiation rate
C= conduction and convection rate
S= body heat storage rate



Load Estimation

Heating and cooling loads are the measure of energy needed to be added or removed from aspace by the HVAC system to provide the desired level of comfort within a space. Right-sizing the HVAC system begins with an accurate understanding of the heating and cooling loads on a space



Heat gain estimation method

Transfer Function Method (TFM)

- CLTD/SCL/CLF *
- TETD/TA *
- Radiant Time Series Method
- Admittance Method
- * Both of these methods use data that are derived from TFM

Transfer Function Method (1)

- Like heat balance method, uses conduction transfer functions to model transient conduction heat transfer:

- Unlike HBM, CTFs apply from sol-air temperature to room air temperature rather than surface temperature to surface temperature.

CLTD/SCL/CLF Method (1)

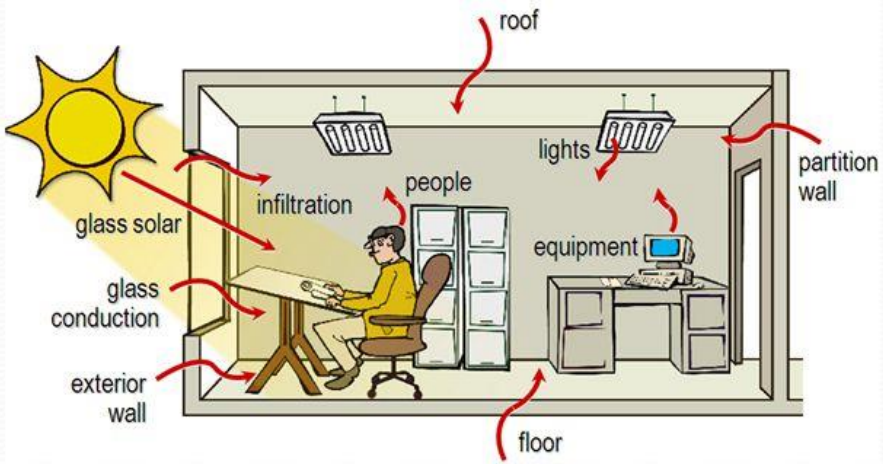
- Cooling Load Temperature Difference/Solar Cooling Load/Cooling Load Factor Method
- Transient conduction heat transfer modeled with CLTD: q=UA(CLTD)
- Accuracy depends on CLTD accuracy; if tabulated values are used, additional over prediction is included, compared to the TFM. (“Custom” CLTDs can also be generated.)

TETD/TA Method (1)

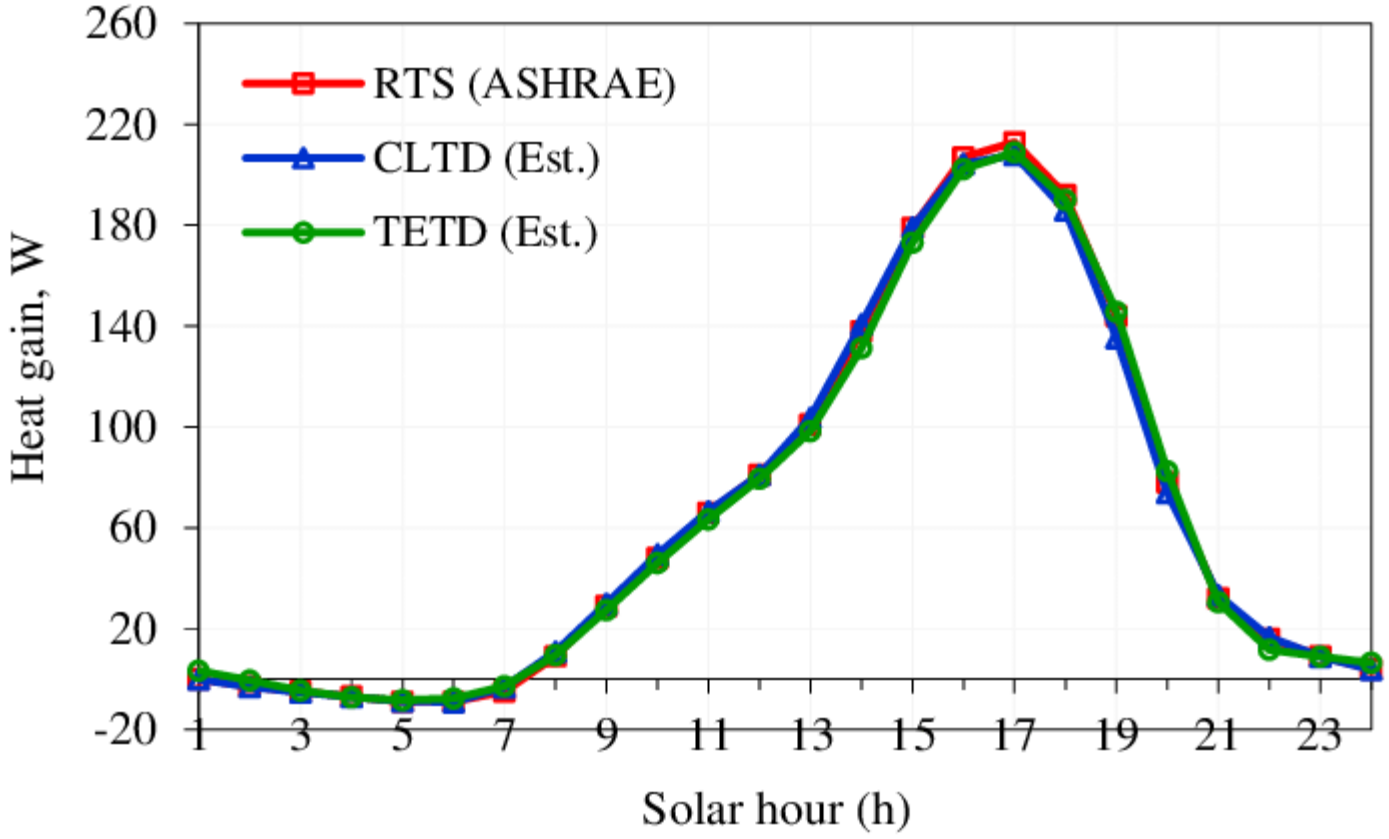
- Total Equivalent Temperature Difference / Time Averaging Method
- TETD is similar to CLTD:
- q=UA(TETD), but TETD is calculated by user based on sol-air temperature, and time lag and decrement factor for wall. (akin to single term CTF)
- Time lag and decrement factors are tabulated for the same 41 wall types and 42 roof types.

RTS Concept / Theory

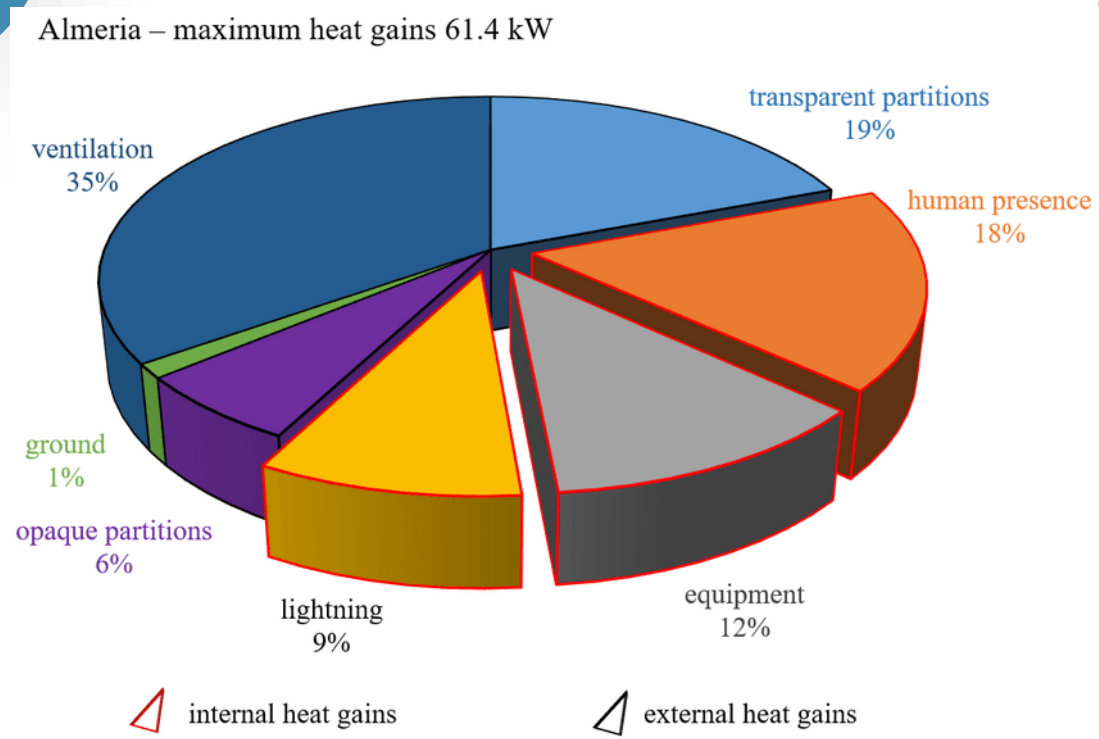
- **What Radiant Time Series does??**
  - Used to convert the radiant portion of heat gain to cooling load. (by a series of coefficients dependent on building type)

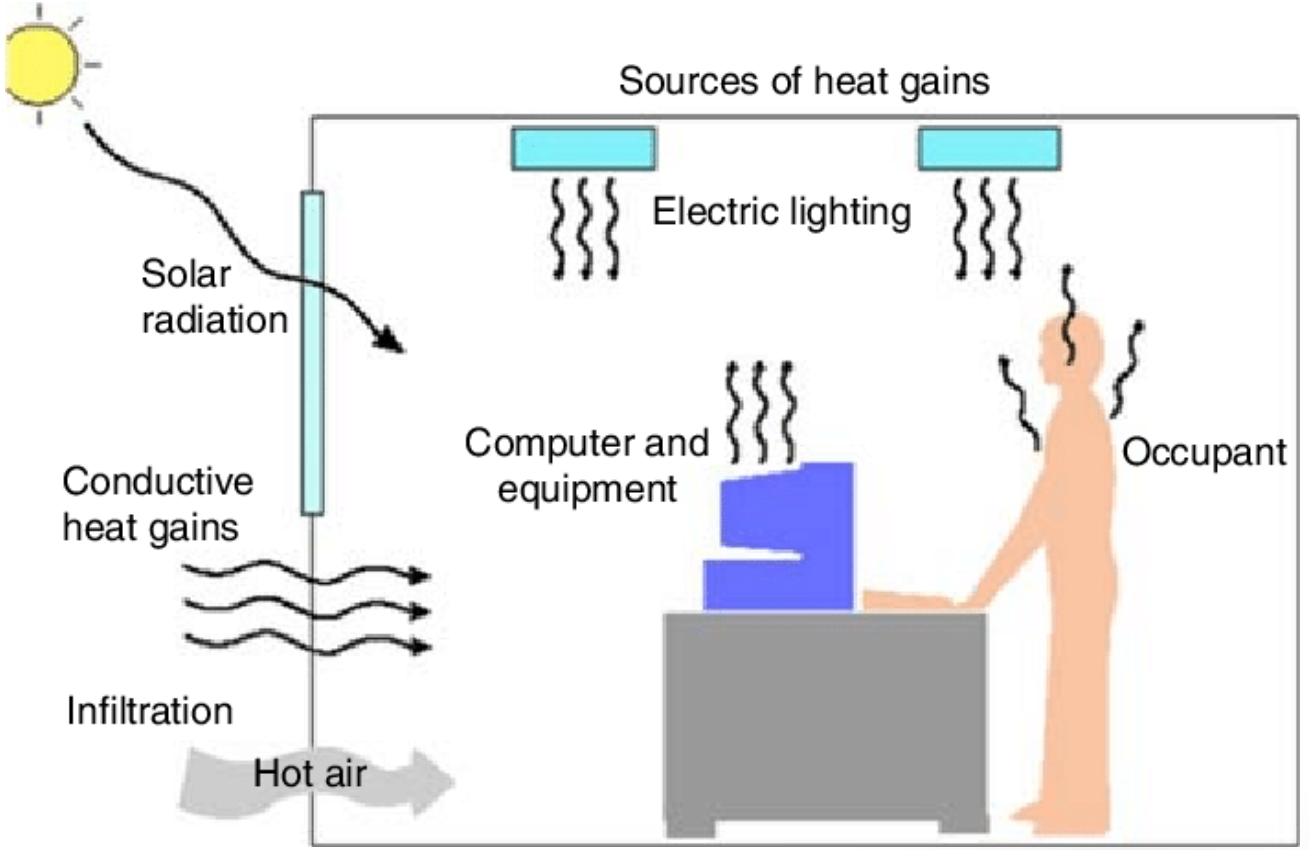


Comparison of heat gain values



Sources of heat gains





loads

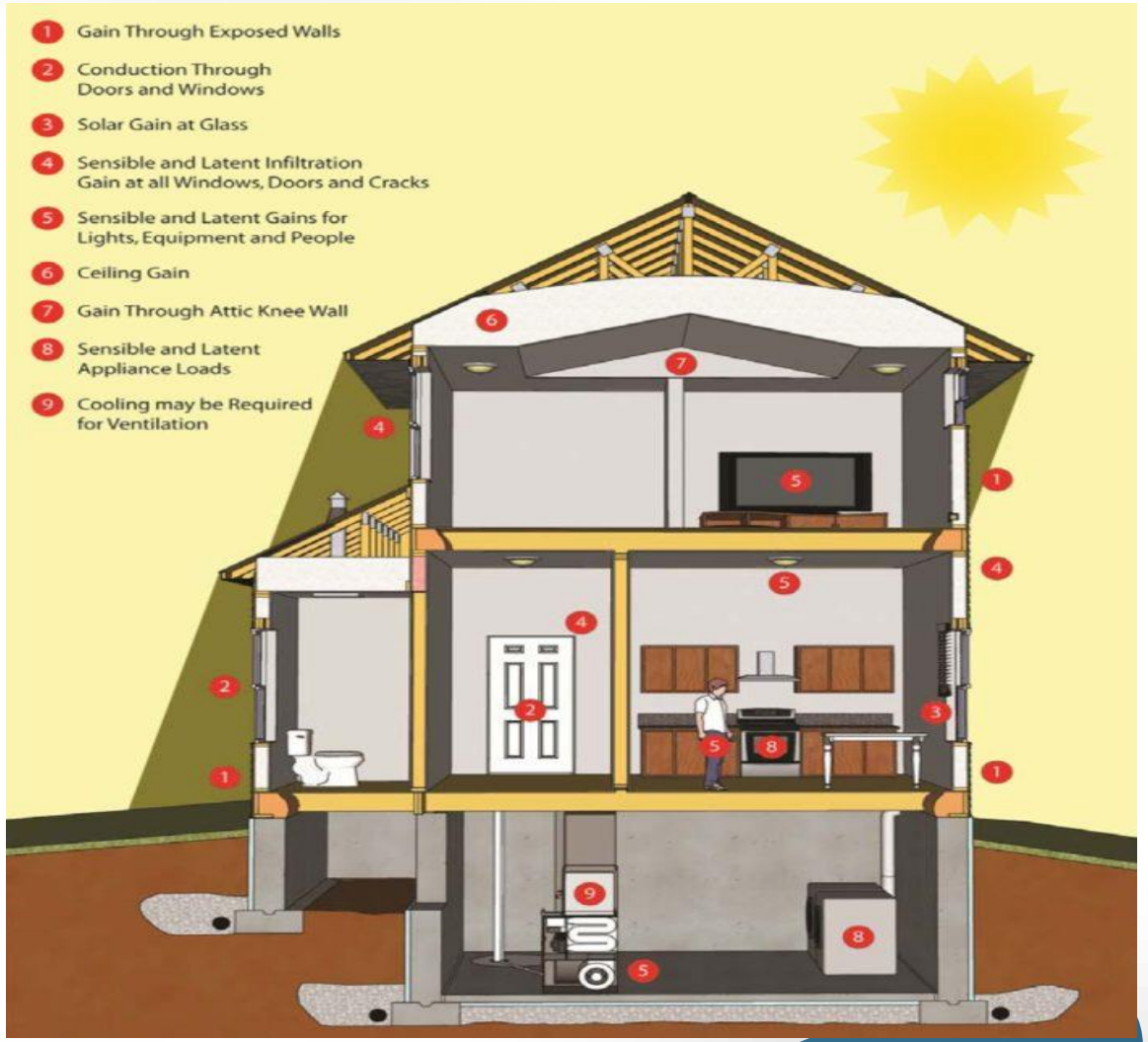
(i)External loads:

01-Walls&Roof
02-Windows.
03-Partions&floors
04-Filteration (neg.)

(ii)Internal loads:

01-People
02-lighting.
03-Equipment.

(iii)Ventilation loads



External load

- 1-Wall& Roof

Q w,r = A * U * (TETD)

- Q w,r ⟶ (BTU/hr)
- Area ⟶ (Ft^2)
- U ⟶ TRANSMISSION COEFFICIENT(BTU/hr.ft^2.f°) table(21:25)
- (TETD) ⟶ EQUIVALENT TEMPERATURE DIFFERENCE (DEG F)
- From table (19,20, and 20A)
-

Carrier manual P:1-ch-05

TABLE 19-EQUIVALENT TEMPERATURE DIFFERENCE (DEG F)

FOR DARK COLORED† , SUNLIT AND SHADED WALLS*

Based on Dark Colored Walls; 95 F db Outdoor Design Temp; Constant 80F db Room Temp;

20 deg F Daily Range; 24-hour Operation; July and 40 N. Lat.†

EXPOSURE	WEIGHTS OF WALL ‡ (lb/sq ft)	SUN TIME																								
		AM							PM											AM						
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
Northeast	20	5	15	22	23	24	19	14	13	12	13	14	14	14	12	10	8	6	4	2	0	-2	-3	-4	-2
	60	-1	-2	-2	5	24	22	20	15	10	11	12	13	14	13	12	11	10	8	6	4	2	1	0	-1
	100	4	3	4	4	4	10	16	15	14	12	10	11	12	12	12	12	11	10	9	8	7	6	6	5	5
	140	5	5	6	6	6	6	6	10	14	16	14	12	10	10	10	10	10	10	10	10	9	9	8	7	7
East	20	1	17	30	33	36	35	32	20	12	13	14	14	14	14	12	10	8	6	4	2	0	-1	-2	-3	-3
	60	-1	-1	0	21	30	31	31	19	14	13	12	13	14	13	12	11	10	8	5	4	3	1	1	0
	100	5	5	6	8	14	20	24	25	24	20	18	16	14	14	14	13	12	11	10	9	8	7	7	6
	140	11	10	10	9	8	9	10	15	18	19	18	17	16	14	12	13	14	14	14	13	13	12	12	12
Southeast	20	10	6	13	19	26	27	28	26	24	19	16	15	14	12	10	8	6	4	2	0	-1	-1	-2	-2
	60	1	1	0	13	20	24	28	26	25	21	18	15	14	13	12	11	10	8	6	5	4	3	3	2
	100	7	7	6	6	6	11	16	17	18	19	18	16	14	13	12	11	10	10	10	9	9	8	8	7
	140	9	8	8	8	8	7	6	11	14	15	16	18	16	15	14	13	12	12	12	11	11	10	10	9
South	20	-1	-2	-4	1	4	14	22	27	30	28	26	20	16	12	10	7	6	3	2	1	1	0	0	-1
	60	-1	-3	-4	-3	-2	7	12	20	24	25	26	23	20	15	12	10	8	6	4	2	1	1	0	-1
	100	4	4	2	2	2	3	4	8	12	15	16	18	18	15	14	11	10	9	8	8	7	6	6	5
	140	7	6	6	5	4	4	4	4	4	7	10	13	14	15	16	16	14	12	10	10	9	9	8	7
Southwest	20	-2	-4	-4	-2	0	4	6	19	26	34	40	41	42	30	24	12	6	4	2	1	1	0	-1	-1
	60	2	1	0	0	0	1	2	8	12	24	32	35	36	35	34	20	10	7	6	5	4	4	3	3
	100	7	5	6	5	4	5	6	7	8	12	14	19	22	23	24	23	22	15	10	10	9	9	8	7
	140	8	8	8	8	8	7	6	6	6	7	8	9	10	15	18	19	20	13	8	8	8	8	8	8
West	20	-2	-3	-4	-2	0	3	6	14	20	32	40	45	48	34	22	14	8	5	2	1	0	0	-1	-1
	60	2	1	0	0	0	2	4	7	10	19	26	34	40	41	36	28	16	10	6	5	4	3	3	2
	100	7	7	6	6	6	6	6	7	8	10	12	17	20	25	28	27	26	19	14	12	11	10	9	8
	140	12	11	10	9	8	8	8	9	10	10	10	11	12	14	16	21	22	23	22	20	18	16	15	13
Northwest	20	-3	-4	-4	-2	0	3	6	10	12	19	24	33	40	37	34	18	6	4	2	0	-1	-1	-2	-2
	60	-2	-3	-4	-3	-2	0	2	6	8	10	12	21	30	31	32	21	12	8	6	4	3	1	0	-1
	100	5	4	4	4	4	4	4	4	4	5	6	9	12	17	20	21	22	14	8	7	7	6	6	5
	140	8	7	6	6	6	6	6	6	6	6	6	7	8	9	10	14	18	19	20	16	7	11	10	9

Take time at 3 pm

TABLE 20-EQUIVALENT TEMPERATURE DIFFERENCE (DEG F)

FOR DARK COLORED†, SUNLIT AND SHADED ROOFS*

Based on 95 F db Outdoor Design Temp; Constant 80 F db Room Temp; 20 deg F Daily Range;

24-hour Operation; July and 40° N. Lat.†

CONDITION	WEIGHTS OF ROOF‡ (lb/sq ft)	SUN TIME																								
		AM							PM												AM					
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
Exposed to Sun	10	-4	-6	-7	-5	-1	7	15	24	32	38	43	46	45	41	35	28	22	16	10	7	3	1	-1	-3
	20	0	-1	-2	-1	2	9	16	23	30	36	41	43	43	40	35	30	25	20	15	12	8	6	4	2
	40	4	3	2	3	6	10	16	23	28	33	38	40	41	39	35	32	28	24	20	17	13	11	9	6
	60	9	8	6	7	8	11	16	22	27	31	35	38	39	38	36	34	31	28	25	22	18	16	13	11
	80	13	12	11	11	12	13	16	22	26	28	32	35	37	37	35	34	34	32	30	27	23	20	18	14
Covered with Water	20	-5	-2	0	2	4	10	16	19	22	20	18	16	14	12	10	6	2	1	1	-1	-2	-3	-4	-5
	40	-3	-2	-1	-1	0	5	10	13	15	15	16	15	15	14	12	10	7	5	3	1	-1	-2	-3	-3
	60	-1	-2	-2	-2	-2	2	5	7	10	12	14	15	16	15	14	12	10	8	6	4	3	2	1	0
Sprayed	20	-4	-2	0	2	4	8	12	15	18	17	16	15	14	12	10	6	2	1	0	-1	-2	-2	-3	-3
	40	-2	-2	-1	-1	0	2	5	9	13	14	14	14	14	13	12	9	7	5	3	1	0	0	-1	-1
	60	-1	-2	-2	-2	-2	0	2	5	8	10	12	13	14	13	12	11	10	8	6	4	2	1	0	-1
Shaded	20	-5	-5	-4	-2	0	2	6	9	12	13	14	13	12	10	8	5	2	1	0	-1	-3	-4	-5	-5
	40	-5	-5	-4	-3	-2	0	2	5	8	10	12	13	12	11	10	8	6	4	2	0	-1	-3	-4	-5
	60	-3	-3	-2	-2	-2	-1	0	2	4	6	8	9	10	10	10	9	8	6	4	2	1	0	-1	-2
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
		AM							PM												AM					
		SUN TIME																								

Take time at 3 pm

TABLE 20A-CORRECTIONS TO EQUIVALENT TEMPERATURES (DEG F)

OUTDOOR DESIGN FOR MONTH AT 3 P.M. MINUS ROOM TEMP (deg F)	DAILY RANGE (deg F)																
	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
-30	-39	-40	-41	-42	-43	-44	-45	-46	-47	-48	-49	-50	-51	-52	-53	-54	-55
-20	-29	-30	-31	-32	-33	-34	-35	-36	-37	-38	-39	-40	-41	-42	-43	-44	-45
-10	-19	-20	-21	-22	-23	-24	-25	-26	-27	-28	-29	-30	-31	-32	-33	-34	-35
0	- 9	-10	-11	-12	-13	-14	-15	-16	-17	-18	-19	-20	-21	-22	-23	-24	-25
5	- 4	- 5	- 6	- 7	- 8	- 9	-10	-11	-12	-13	-14	-15	-16	-17	-18	-19	-20
10	1	0	- 1	- 2	- 3	- 4	- 5	- 6	- 7	- 8	- 9	-10	-11	-12	-13	-14	-15
15	6	5	4	3	2	1	0	- 1	- 2	- 3	- 4	- 5	- 6	- 7	- 8	- 9	-10
20	11	10	9	8	7	6	5	4	3	2	1	0	- 1	- 2	- 3	- 4	- 5
25	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
30	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5
35	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
40	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15

External load

- 2-Partions& Floors

$\mathbf{Q}_{p,f} = A * U * (\Delta T)$

- $Q_{p,f}$ ⟶ (BTU/hr)
- Area ⟶ (Ft^2)
- U ⟶ TRANSMISSION COEFFICIENT(BTU/hr.ft^2.f°) table(26)
- ΔT ⟶ temperate difference (DEG F).

ΔT conditions

الجار مكيف	الجار غير مكيف	الجار غير مكيف و محمل
ΔT = 0	ΔT= $Tdb_{neig.}$ – Tdb_{room}	ΔT= $Tdb_{neig.}$ – Tdb_{room}

2 spaces conditioned with the same temp.

$Tdb_{neig.}$ = Tp"out" -10°F

$Tdb_{neig.}$ = Tp"out"

External load

- 3-i-Windows

(i) Q w = A * U * (ΔT)

- Q w ⟶ (BTU/hr)
- Area ⟶ (Ft^2)
- U ⟶ TRANSMISSION COEFFICIENT(BTU/hr.ft^2.f°) table(33)
- ΔT ⟶ temperate difference (DEG F).

External load

- 3-ii-Windows

(ii) Q W = A * SHG* F

- Q w ⟶ (BTU/hr)
- Area ⟶ (Ft^2)
- SHG ⟶ Solar heat gain (BTU/hr. Ft^2) table 15
- Latitude, timing, and direction
- F ⟶ Solar heat gain factor (more applicable 0.8) table 16
- Curtains, glass type

TABLE 15—SOLAR HEAT GAIN THRU ORDINARY GLASS (Contd)

30° Btu/(hr) (sq ft sash area) 30°

30° NORTH LATITUDE		AM						SUN TIME				PM			30° SOUTH LATITUDE	
Time of Year	Exposure	6	7	8	9	10	11	Noon	1	2	3	4	5	6	Exposure	Time of Year
JUNE 21	North	33	29	18	14	14	14	14	14	14	14	18	29	33	South	DEC 22
	Northeast	105	139	130	97	55	19	14	14	14	14	12	10	5	Southeast	
	East	108	156	161	143	98	44	14	14	14	14	12	10	5	East	
	Southeast	42	75	90	90	73	44	17	14	14	14	12	10	5	Northeast	
	South	5	10	12	14	15	19	21	19	15	14	12	10	5	North	
	Southwest	5	10	12	14	14	14	17	44	73	90	90	75	42	Northwest	
	West	5	10	12	14	14	14	14	44	98	143	161	156	108	West	
	Northwest	5	10	12	14	14	14	14	19	55	97	130	139	105	Southwest	
	Horizontal	19	61	131	180	217	240	250	240	217	180	131	61	19	Horizontal	
JULY 23 & MAY 21	North	22	20	14	13	14	14	14	14	14	13	14	20	22	South	JAN 21 & NOV 21
	Northeast	93	131	123	89	46	16	14	14	14	13	12	9	4	Southeast	
	East	100	155	164	145	99	44	14	14	14	13	12	9	4	East	
	Southeast	42	82	100	100	83	53	22	14	14	13	12	9	4	Northeast	
	South	4	9	12	14	20	27	30	27	20	14	12	9	4	North	
	Southwest	4	9	12	13	14	14	14	53	83	100	100	82	42	Northwest	
	West	4	9	12	13	14	14	14	44	99	145	164	155	100	West	
	Northwest	4	9	12	13	14	14	14	16	46	89	123	131	93	Southwest	
	Horizontal	15	66	123	176	214	236	246	236	214	176	123	66	15	Horizontal	
AUG 24 & APR 20	North	6	8	11	13	13	14	14	14	13	13	11	8	6	South	FEB 20 & OCT 23
	Northeast	55	108	100	66	27	14	14	14	13	13	11	8	2	Southeast	
	East	66	147	165	148	102	46	14	14	13	13	11	8	2	East	
	Southeast	37	98	127	129	112	82	39	15	13	13	11	8	2	Northeast	
	South	2	8	13	27	47	58	63	58	47	27	13	8	2	North	
	Southwest	2	8	11	13	13	15	39	82	112	129	127	98	37	Northwest	
	West	2	8	11	13	13	14	14	46	102	148	165	147	66	West	
	Northwest	2	8	11	13	13	14	14	14	27	66	100	108	55	Southwest	
	Horizontal	6	47	107	161	200	225	235	225	200	161	107	47	6	Horizontal	
SEPT 22 &	North	0	5	10	12	13	14	14	14	13	12	10	5	0	South	MAR 22 &
	Northeast	0	74	90	40	15	14	14	14	13	12	10	5	0	Southeast	
	East	0	124	158	144	103	48	14	14	13	12	10	5	0	East	
	Southeast	0	98	131	152	141	113	67	25	13	12	10	5	0	Northeast	
	South	0	9	18	60	82	98	105	98	82	60	18	9	0	North	

Take time at 3 pm

TABLE 16-OVER-ALL FACTORS FOR SOLAR HEAT GAIN THRU GLASS

WITH AND WITHOUT SHADING DEVICES*

Apply Factors to Table 15

Outdoor wind velocity, 5 mph-Angle of incidence, 30 – Shading devices fully covering window

	GLASS FACTOR NO SHADE	INSIDE VENETIAL BLIND* 45° horiz. or vertical or ROLLER SHADE			OUTSIDE VENETIAN BLIND 45° horiz. slats		OUTSIDE SHADING SCREEN† 17° horiz. slats		OUTSIDE AWNING‡ vent. sides & top	
		Light Color	Medium Color	Dark Color	Light Color	Light on Outside Dark on Inside	Medium** Color	Dark§ Color	Light Color	Med. or Dark Color
ORDINARY GLASS	1.00	.56	.65	.75	.15	.13	.22	.15	.20	.25
REGULAR PLATE (1/4 inch)	.94	.56	.65	.74	.14	.12	.21	.14	.19	.24
HEAT ABSORBING GLASS††										
40 to 48% Absorbing	.80	.56	.62	.72	.12	.11	.18	.12	.16	.20
48 to 56% Absorbing	.73	.53	.59	.62	.11	.10	.16	.11	.15	.18
56 to 70% Absorbing	.62	.51	.54	.56	.10	.10	.14	.10	.12	.16
DOUBLE PANE										
Ordinary Glass	.90	.54	.61	.67	.14	.12	.20	.14	.18	.22
Regular Plate	.80	.52	.59	.65	.12	.11	.18	.12	.16	.20
48 to 56% Absorbing outside; Ordinary Glass inside.	.52	.36	.39	.43	.10	.10	.11	.10	.10	.13
48 to 56% Absorbing outside; Regular Plate inside.	.50	.36	.39	.43	.10	.10	.11	.10	.10	.12
TRIPLE PANE										
Ordinary Glass	.83	.48	.56	.64	.12	.11	.18	.12	.16	.20
Regular Plate	.69	.47	.52	.57	.10	.10	.15	.10	.14	.17
PAINTED GLASS										
Light Color	.28									
Medium Color	.39									
Dark Color	.50									
STAINED GLASS‡‡										
Amber Color	.70									
Dark Red	.56									

TRANSMISSION COEFFICIENT

- **More applicable**

- Heat transmission from walls
- U = 0.3 Btu/hr.ft^2
- Heat transmission from windows
- U = (0.6) Btu/hr.ft^2
- Heat transmission from partitions
- U = (0.33:0.4)Btu/hr.ft^2
- Heat transmission from roof
- U = (0.1:0.2) Btu/hr.ft^2

Internal load

- 1-People: (sensible, latent)

- Qs = no. of person * sensible heat gain for each person
- Ql = no. of person * latent heat gain for each person

Internal load

- No. of people:

1. From Arch. Plan.
2. From ANSI/ASHRAE Standard 62.1

TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone

(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/ person	L/s· person	cfm/ft^2	L/s·m^2		#/1000 ft^2 or #/100 m^2	cfm/ person	L/s·person	
Correctional Facilities									
Cell	5	2.5	0.12	0.6		25	10	4.9	2
Dayroom	5	2.5	0.06	0.3		30	7	3.5	1
Guard stations	5	2.5	0.06	0.3		15	9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4	2
Educational Facilities									
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6	2
Daycare sickroom	10	5	0.18	0.9		25	17	8.6	3
Classrooms (ages 5–8)	10	5	0.12	0.6		25	15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3		65	8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3		150	8	4.0	1
Art classroom	10	5	0.18	0.9		20	19	9.5	2
Science laboratories	10	5	0.18	0.9		25	17	8.6	2
University/college laboratories	10	5	0.18	0.9		25	17	8.6	2
Wood/metal shop	10	5	0.18	0.9		20	19	9.5	2
Computer lab	10	5	0.12	0.6		25	15	7.4	1
Media center	10	5	0.12	0.6	A	25	15	7.4	1
Music/theater/dance	10	5	0.06	0.3		35	12	5.9	1
Multiuse assembly	7.5	3.8	0.06	0.3		100	8	4.1	1
Food and Beverage Service									
Restaurant dining rooms	7.5	3.8	0.18	0.9		70	10	5.1	2

Internal load

- Sensible, latent heat gain for each person:

1. It depends on type of application. From table 48 (Carrier)
2. From ASHRAE Handbook—Fundamentals CH:18

TABLE 48-HEAT GAIN FROM PEOPLE

DEGREE OF ACTIVITY	TYPICAL APPLICATION	Met-abolic Rate (Adult Male) Btu/hr	Aver-age Ad-justed Met-abolic Rate* Btu/hr	ROOM DRY-BULB TEMPERATURE									
				82 F Btu/hr		80 F Btu/hr		78 F Btu/hr		75 F But/hr		70 F Btu/hr	
				Sensible	Latent	Sensible	Latent	Sensible	Latent	Sensible	Latent	Sensible	Latent
Seated at rest	Theater, Grade School	390	350	175	175	195	155	210	140	230	120	260	90
Seated, very light work	High School	450	400	180	220	195	205	215	185	240	160	275	125
Office worker	Offices, Hotels, Apts., College	475	450	180	270	200	250	215	235	245	205	285	165
Standing, walking slowly	Dept., Retail, or Variety Store	550											
Walking, seated	Drug Store	550	500	180	320	200	300	220	280	255	245	290	210
Standing, walking slowly	Bank	550											
Sedentary work	Restaurant†	500	550	190	360	220	330	240	310	280	270	320	230
Light bench work	Factory, light work	800	750	190	560	220	530	245	505	295	455	365	385
Moderate dancing	Dance Hall	900	850	220	630	245	605	275	575	325	525	400	450
Walking, 3 mph	Factory, fairly heavy work	1000	1000	270	730	300	700	330	670	380	620	460	540
Heavy work	Bowling Alley‡ Factory	1500	1450	450	1000	465	985	485	965	525	925	605	845

Table 1 Representative Rates at Which Heat and Moisture Are Given Off by Human Beings in Different States of Activity

Degree of Activity	Location	Total Heat, Btu/h		Sensible Heat, Btu/h	Latent Heat, Btu/h	% Sensible Heat that is Radiant[b]	
		Adult Male	Adjusted, M/F[a]			Low *V*	High *V*
Seated at theater	Theater, matinee	390	330	225	105		
Seated at theater, night	Theater, night	390	350	245	105	60	27
Seated, very light work	Offices, hotels, apartments	450	400	245	155		
Moderately active office work	Offices, hotels, apartments	475	450	250	200		
Standing, light work; walking	Department store; retail store	550	450	250	200	58	38
Walking, standing	Drug store, bank	550	500	250	250		
Sedentary work	Restaurant[c]	490	550	275	275		
Light bench work	Factory	800	750	275	475		
Moderate dancing	Dance hall	900	850	305	545	49	35
Walking 3 mph; light machine work	Factory	1000	1000	375	625		
Bowling[d]	Bowling alley	1500	1450	580	870		
Heavy work	Factory	1500	1450	580	870	54	19
Heavy machine work; lifting	Factory	1600	1600	635	965		
Athletics	Gymnasium	2000	1800	710	1090		

Internal load

- 2-light: ‘sensible
- 1-Electrical drawing
- 2- Electrical engineer
- 3- Range ‘ Assumption
- Residential (20-25 W/m^2)
- Malls (25-30 W/m^2)
- Factories (35 W/m^2)

From ASHRAE Handbook—Fundamentals CH:18

TABLE 49 – HEAT GAIN FROM LIGHT

TYPE	HEAT GAIN* Btu/hr
Fluorescent	Total Light Watts×1.25†×3.4
Incandescent	Total Light Watts×3.4

*Refer to Tables 12 and 13, pages 35-37 to determine actual cooling load.

†Fluorescent light wattage is multiplied by 1.25 to include heat gain in ballast.

Table 2 Lighting Power Densities Using Space-by-Space Method

Common Space Types*	LPD, W/ft²	Building-Specific Space Types*	LPD, W/ft²	Building-Specific Space Types*	LPD, W/ft²
Atrium		Automotive		Library	
First 40 ft in height	0.03 per ft (height)	Service/repair	0.67	Card file and cataloging	0.72
Height above 40 ft	0.02 per ft (height)	Bank/office		Reading area	0.93
Audience/seating area—permanent		Banking activity area	1.38	Stacks	1.71
For auditorium	0.79	Convention center		Manufacturing	
For performing arts theater	2.43	Audience seating	0.82	Corridor/transition	0.41
For motion picture theater	1.14	Exhibit space	1.45	Detailed manufacturing	1.29
Classroom/lecture/training	1.24	Courthouse/police station/penitentiary		Equipment room	0.95
Conference/meeting/multipurpose	1.23	Courtroom	1.72	Extra high bay (>50 ft floor-to-ceiling height)	1.05
Corridor/transition	0.66	Confinement cells	1.10	High bay (25 to 50 ft floor-to-ceiling height)	1.23
Dining area	0.65	Judges' chambers	1.17	Low bay (<25 ft floor-to-ceiling height)	1.19
For bar lounge/leisure dining	1.31	Penitentiary audience seating	0.43	Museum	
For family dining	0.89	Penitentiary classroom	1.34	General exhibition	1.05
Dressing/fitting room for performing arts theater	0.40	Penitentiary dining	1.07	Restoration	1.02
Electrical/mechanical	0.95	Dormitory		Parking garage	
Food preparation	0.99	Living quarters	0.38	Garage area	0.19
Laboratory		Fire stations		Post office	
For classrooms	1.28	Engine room	0.56	Sorting area	0.94
For medical/industrial/research	1.81	Sleeping quarters	0.25	Religious buildings	
Lobby	0.90	Gymnasium/fitness center		Audience seating	1.53
For elevator	0.64	Fitness area	0.72	Fellowship hall	0.64
For performing arts theater	2.00	Gymnasium audience seating	0.43	Worship pulpit, choir	1.53
For motion picture theater	0.52	Playing area	1.20	Retail	
Locker room	0.75	Hospital		Dressing/fitting room	0.87
Lounge/recreation	0.73	Corridor/transition	0.89	Mall concourse	1.10
Office		Emergency	2.26	Sales area	1.68
Enclosed	1.11	Exam/treatment	1.66	Sports arena	
Open plan	0.98	Laundry/washing	0.60	Audience seating	0.43
Restrooms	0.98	Lounge/recreation	1.07	Court sports arena—class 4	0.72
Sales area	1.68	Medical supply	1.27	Court sports arena—class 3	1.20
Stairway	0.69	Nursery	0.88	Court sports arena—class 2	1.92
Storage	0.63	Nurses' station	0.87	Court sports arena—class 1	3.01
		Operating room	1.89	Ring sports arena	2.68
		Patient room	0.62	Transportation	
		Pharmacy	1.14	Air/train/bus—baggage area	0.76
		Physical therapy	0.91	Airport—concourse	0.36
		Radiology/imaging	1.32	Waiting area	0.54
		Recovery	1.15	Terminal—ticket counter	1.08
		Hotel/highway lodging		Warehouse	
		Hotel dining	0.82	Fine material storage	0.95
		Hotel guest rooms	1.11		
		Hotel lobby	1.06		
		Highway lodging dining	0.88		

Internal load

- 3- Equipment's: ‘sensible’
- Qs = total wattage of equipment's * 3.4
- From ASHRAE Handbook—Fundamentals CH:18

Internal load

- Miscellanies Equipment's: ‘sensible, latent’:
- Qs = sum [sensible load for each equipment's].
- Ql = sum [latent load for each equipment's]
- From tables (50-52) carrier
- From ASHRAE Handbook—Fundamentals CH:18

TABLE 50-HEAT GAIN FROM RESTAURANT APPLIANCES

NOT HOODED*-ELECTRIC

APPLIANCE	OVERALL DIMENSIONS Less Legs and Handles (In.)	TYPE OF CON-TROL	MISCELLANEOUS DATA	MFR MAX RATING Btu/hr	MAIN-TAIN-ING RATE Btu/hr	RECOM HEAT GAIN FOR AVG USE		
						Sensible Heat Btu/hr	Latent Heat Btu/hr	Total Heat Btu/hr
Coffee Brewer-1/2 gal Warmer-1/2 gal		Man. Man.		2240 306	306 306	900 230	220 90	1120 320
4 Coffee Brewing Units with 41/2 gal Tank	20X30X26 H	Auto.	Water heater—2000 watts Brewers—2960 watts	16900		4800	1200	6000
Coffee Urn--3 gal --3 gal --5 gal	15 DiaX34H 12X23 oval X21H 18 Dia X37H	Man. Auto. Auto.	Black finish Nickel plated Nickel plated	11900 15300 17000	3000 2600 3600	2600 2200 3400	1700 1500 2300	4300 3700 5700
Doughnut Machine	22X22X57H	Auto.	Exhaust system to outdoors-1/2 hp motor	16000		5000		5000
Egg Boiler Food Warmer with Plate Warmer, per sq ft top surface	10X13X25H	Man. Auto.	Med. ht. –550 watts Low ht—275 watts Insulated, separate heating unit for each pot. Plate warmer in base	3740 1350	 500	1200 350	800 350	2000 700
Food Warmer without Plate Warmer, per sq ft top surface		Auto.	Ditto, without plate warmer	1020	400	200	350	550
Fry Kettle--111/2 lb fat	12 DiaX14H	Auto.		8840	1100	1600	2400	4000
Fry Kettle—25 lb fal	16X18X12H	Auto.	Frying area 12"X14"	23800	2000	3800	5700	9500
Griddle, Frying	18X18X8H	Auto.	Frying top 18"X14"	8000	2800	3100	1700	4800
Grille, Meat	14X14X10H	Auto.	Cooking area 10"X12"	10200	1900	3900	2100	6000
Grille, Sandwich	13X14X10H	Auto.	Grill area 12"X12"	5600	1900	2700	700	3400
Roll Warmer	26X17X13H	Auto.	One drawer	1500	400	1100	100	1200
Toaster, Continuous	15X15X28H	Auto.	2 Slices wide--360 slices/hr	7500	5000	5100	1300	6400
Toaster, Continuous	20X15X28H	Auto.	4 Slices wide					

Table 5A Recommended Rates of Radiant and Convective Heat Gain from Unhooded Electric Appliances During Idle (Ready-to-Cook) Conditions

Appliance	Energy Rate, Btu/h		Rate of Heat Gain, Btu/h				Usage Factor F_U	Radiation Factor F_R
	Rated	Standby	Sensible Radiant	Sensible Convective	Latent	Total		
Cabinet: hot serving (large), insulated*	6,800	1,200	400	800	0	1,200	0.18	0.33
hot serving (large), uninsulated	6,800	3,500	700	2,800	0	3,500	0.51	0.20
proofing (large)*	17,400	1,400	1,200	0	200	1,400	0.08	0.86
proofing (small 15-shelf)	14,300	3,900	0	900	3,000	3,900	0.27	0.00
Coffee brewing urn	13,000	1,200	200	300	700	1,200	0.09	0.17
Drawer warmers, 2-drawer (moist holding)*	4,100	500	0	0	200	200	0.12	0.00
Egg cooker	10,900	700	300	400	0	700	0.06	0.43
Espresso machine*	8,200	1,200	400	800	0	1,200	0.15	0.33
Food warmer: steam table (2-well-type)	5,100	3,500	300	600	2,600	3,500	0.69	0.09
Freezer (small)	2,700	1,100	500	600	0	1,100	0.41	0.45
Hot dog roller*	3,400	2,400	900	1,500	0	2,400	0.71	0.38
Hot plate: single burner, high speed	3,800	3,000	900	2,100	0	3,000	0.79	0.30
Hot-food case (dry holding)*	31,100	2,500	900	1,600	0	2,500	0.08	0.36
Hot-food case (moist holding)*	31,100	3,300	900	1,800	600	3,300	0.11	0.27
Microwave oven: commercial (heavy duty)	10,900	0	0	0	0	0	0.00	0.00
Oven: countertop conveyorized bake/finishing*	20,500	12,600	2,200	10,400	0	12,600	0.61	0.17
Panini*	5,800	3,200	1,200	2,000	0	3,200	0.55	0.38
Popcorn popper*	2,000	200	100	100	0	200	0.10	0.50
Rapid-cook oven (quartz-halogen)*	41,000	0	0	0	0	0	0.00	0.00
Rapid-cook oven (microwave/convection)*	24,900	4,100	1,000	3,100	0	1,000	0.16	0.24
Reach-in refrigerator*	4,800	1,200	300	900	0	1,200	0.25	0.25
Refrigerated prep table*	2,000	900	600	300	0	900	0.45	0.67
Steamer (bun)	5,100	700	600	100	0	700	0.14	0.86
Toaster: 4-slice pop up (large): cooking	6,100	3,000	200	1,400	1,000	2,600	0.49	0.07
contact (vertical)	11,300	5,300	2,700	2,600	0	5,300	0.47	0.51
conveyor (large)	32,800	10,300	3,000	7,300	0	10,300	0.31	0.29
small conveyor	5,800	3,700	400	3,300	0	3,700	0.64	0.11
Waffle iron	3,100	1,200	800	400	0	1,200	0.39	0.67

*Items with an asterisk appear only in Swierczyna et al. (2009); all others appear in both Swierczyna et al. (2008) and (2009).

Ventilation load

- $Q_s = 1.08 * CFM * \Delta T$
- $Q_l = 0.68 * CFM * (\Delta Gr \setminus lb)$
- $Q_T = 4.5 * CFM * \Delta H$

Ventilation load

- CFM (Min. required of fresh air)
- no. of persons * CFM per person Or area * CFM per sq.feet
- From table 45 carrier
- From ANSI/ASHRAE Standard 62.1

TABLE 45-VENTILATION STANDARDS

APPLICATION	SMOKING	CFM PER PERSON		CFM PER SQ FT OF FLOOR
		Recommended	Minimum*	Minimum*
Apartment { Average	Some	20	15	-
Apartment { De Luxe	Some	30	25	.33
Banking Space	Occasional	10	7½	-
Barber Shops	Considerable	15	10	-
Beauty Parlors	Occasional	10	7½	-
Broker's Board Rooms	Very Heavy	50	30	-
Cocktail Bars	Heavy	30	25	-
Corridors (Supply or Exhaust)	-	-	-	.25
Department Stores	None	7½	5	.05
Directors Rooms	Extreme	50	30	-
Drug Stores†	Considerable	10	7½	-
Factories‡§	None	10	7½	.10
Five and Ten Cent Stores	None	7½	5	-
Funeral Parlors	None	10	7½	-
Garage‡	-	-	-	1.0
Hospitals { Operating Rooms‡**	None	-	-	2.0
Hospitals { Private Rooms	None	30	25	.33
Hospitals { Wards	None	20	15	-
Hotel Roms	Heavy	30	25	.33
Kitchen { Restaurant†	-	-	-	4.0
Kitchen { Residence	-	-	-	2.0
Laboratories†	Some	20	15	-
Meeting Rooms	Very Heavy	50	30	1.25
Office { General	Some	15	10	-
Office { Private	None	25	15	.25
Office { Private	Considerable	30	25	.25
Restaurant { Cafeteria†	Considerable	12	10	-
Restaurant { Dining Room†	Considerable	15	12	-
School Rooms‡	None	-	-	-
Shop Retail	None	10	7½	-

TABLE 6.2.2.1 Minimum Ventilation Rates in Breathing Zone
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/ person	L/s·person	cfm/ft^2	L/s·m^2		#/1000 ft^2 or #/100 m^2	cfm/ person	L/s·person	
Correctional Facilities									
Cell	5	2.5	0.12	0.6		25	10	4.9	2
Dayroom	5	2.5	0.06	0.3		30	7	3.5	1
Guard stations	5	2.5	0.06	0.3		15	9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4	2
Educational Facilities									
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6	2
Daycare sickroom	10	5	0.18	0.9		25	17	8.6	3
Classrooms (ages 5–8)	10	5	0.12	0.6		25	15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3		65	8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3		150	8	4.0	1
Art classroom	10	5	0.18	0.9		20	19	9.5	2
Science laboratories	10	5	0.18	0.9		25	17	8.6	2
University/college laboratories	10	5	0.18	0.9		25	17	8.6	2
Wood/metal shop	10	5	0.18	0.9		20	19	9.5	2
Computer lab	10	5	0.12	0.6		25	15	7.4	1
Media center	10	5	0.12	0.6	A	25	15	7.4	1
Music/theater/dance	10	5	0.06	0.3		35	12	5.9	1
Multiuse assembly	7.5	3.8	0.06	0.3		100	8	4.1	1
Food and Beverage Service									
Restaurant dining rooms	7.5	3.8	0.18	0.9		70	10	5.1	2

Cooling Load Components

cooling load components	sensible load	latent load	space load	coil load
conduction through roof, walls, windows, and skylights	✓		✓	✓
solar radiation through windows, skylights	✓		✓	✓
conduction through ceiling, interior partition walls, and floor	✓		✓	✓
people	✓	✓	✓	✓
lights	✓		✓	✓
equipment/appliances	✓	✓	✓	✓
infiltration	✓	✓	✓	✓
ventilation	✓	✓		✓
system heat gains	✓			✓

Figure 13

Input data

- Outdoor Design condition (DBT&WBT)
- Indoor Design condition (DBT&RH)
- (Walls& Windows) Area, Exposure
- (Roof& floor) Area
- Overall heat transfer coefficient
- No.of people
- Lighting
- Equipment
- Ventilating

Manual load calculation

Internal load

Spaces	Area (m^2)	Area (ft^2)	People			Lighting			Equpments	
			NO.	Qs (BTU/hr)	Ql (BTU/hr)	W/ft²	Area (ft^2)	Qs (BTU/hr)	Qs (BTU/hr)	Ql (BTU/hr)
Open work (L1099)	300.4	3232.304	55	13750	11000	0.98	3232.304	3167.65792	20308.8	0
Manger (L1030)	16.3	175.388	6	1500	1200	1.11	175.388	194.68068	423.1	0
Manger (L1031)	16.5	177.54	6	1500	1200	1.11	177.54	197.0694	423.1	
Manger (L1027)	33.8	363.688	10	2500	2000	1.11	363.688	403.69368	423.1	
Print room(L1088)	6	64.56	3	750	600	0.72	64.56	46.4832	3616.87	
GSM (L1018)	5.5	59.18	2	500	400	0.95	59.18	56.221	938.4	
Open work (L1121)	195	2098.2	40	10000	8000	0.98	2098.2	2056.236	15231	
Manger (L1116)	30.8	331.408	10	2500	2000	1.11	331.408	367.86288	423.1	
Phone (L1115)	2.8	30.128	1	250	200	0.87	30.128	26.21136	432.1	
Phone (L1114)	2.8	30.128	1	250	200	0.87	30.128	26.21136	432.1	
Manger (L1117)	12	129.12	3	750	600	1.11	129.12	143.3232	423.1	
Manger (L1118)	12	129.12	3	750	600	1.11	129.12	143.3232	423.1	
Manger (L1119)	12.5	134.5	3	750	600	1.11	134.5	149.295	423.1	
Manger (L1120)	12.5	134.5	3	750	600	1.11	134.5	149.295	423.1	
Manger (L1133)	12.5	134.5	3	750	600	1.11	134.5	149.295	423.1	
Print (L1035)	6	64.56	3	750	600	0.72	64.56	46.4832	3616.87	
Phone (L1036)	2.8	30.128	1	250	200	0.87	30.128	26.21136	432.1	
Phone (L1037)	2.8	30.128	1	250	200	0.87	30.128	26.21136	432.1	
CBE (L1098)	52	559.52	12	3000	2400	1.23	559.52	688.2096	4654.1	
CBE (L1099)	52	559.52	12	3000	2400	1.23	559.52	688.2096	4654.1	
Manger (L1028)	19.1	205.516	6	1500	1200	1.11	205.516	228.12276	423.1	
Open work(L1100)	94.2	1013.592	23	5750	4600	0.98	1013.592	993.32016	4231	
IDF (1003)	14.3	153.868	2	500	400	0.95	153.868	146.1746	938.4	
Elec.room(1002)	16.6	178.616	2	500	400	0.95	178.616	169.6852	938.4	
Manger 1101	26.7	287.292	10	2500	2000	1.11	287.292	318.89412	423.1	
Manger 1103	13.9	149.564	6	1500	1200	1.11	149.564	166.01604	423.1	
Manger 1104	13.9	149.564	6	1500	1200	1.11	149.564	166.01604	423.1	
Manger 1105	13.9	149.564	6	1500	1200	1.11	149.564	166.01604	423.1	
Women prayer (1106)	6.7	72.092	10	2500	2000	1.53	72.092	110.30076		

Internal load

TABLE 6-1 MINIMUM VENTILATION RATES IN BREATHING ZONE *(continued)*
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/person	L/s·person	cfm/ft²	L/s·m²		#/1000 ft² or #/100 m²	cfm/person	L/s·person	
Office Buildings									
Office space	5	2.5	0.06	0.3		5	17	8.5	1
Reception areas	5	2.5	0.06	0.3		30	7	3.5	1
Telephone/data entry	5	2.5	0.06	0.3		60	6	3.0	1
Main entry lobbies	5	2.5	0.06	0.3		10	11	5.5	1
Miscellaneous Spaces									
Bank vaults/safe deposit	5	2.5	0.06	0.3		5	17	8.5	2
Computer (not printing)	5	2.5	0.06	0.3		4	20	10.0	1
Electrical equipment rooms	–	–	0.06	0.3	B	–			1
Elevator machine rooms	–	–	0.12	0.6	B	–			1
Pharmacy (prep. area)	5	2.5	0.18	0.9		10	23	11.5	2
Photo studios	5	2.5	0.12	0.6		10	17	8.5	1
Shipping/receiving	–	–	0.12	0.6	B	–			1
Telephone closets	–	–	0.00	0.0		–			1
Transportation waiting	7.5	3.8	0.06	0.3		100	8	4.1	1
Warehouses	–	–	0.06	0.3	B	–			2
Public Assembly Spaces									
Auditorium seating area	5	2.5	0.06	0.3		150	5	2.7	1

جدول رقم (2 - 8)

رقم	المكان المكيف	الحد الأدنى لمعدل الهواء النقى	
		ل / ث لكل فرد	ل / ث لكل م2
1	الشقق السكنية الحمامات المطابخ	لاتقل عن 7.5 25 استخدام متقطع 50 استخدام متقطع	0.35تغير الهواء فى الساعة – –
2	الأسواق المركزية أماكن خاصة أماكن البيع أماكن أخرى	13 8 8	– – –
3	الكافتيريا	10	
4	المطاعم	10	–
5	البارات	15	–
6	الملاهى الليلية والكازينوهات	15	–
7	المطابخ	8	لاتقل عن7.5 للهواء المطرود
8	المكاتب	10	–
9	المكتبات	8	–
10	المتاحف	8	–
11	غرف التليفونات	10	–
12	مكاتب التلغراف	10	–
13	استوديوهات الأذاعة والتليفزيون	10	–
14	الجراج	–	7.5
15	المساجد والكنائس	8	–
16	السينما	8	–
17	الأوبرا	8	–

External load

P	Q	R	S	T	U	W	X	Y	Z	AA	AB	AC	AD	AE	AG	AH	AI	AJ	AK
Walls						Windows									Wall partitions				
Direction	Area (m^2)	Area (ft^2)	U value (BTU/hr.ft².f°)	TETD (f°)	Q (BTU/hr)	Direction	Area (m^2)	Area (ft^2)	U value (BTU/hr.ft².f°)	SHG (BTU/hr.ft²)	ΔT (f°)	S.C	Qc (BTU/hr)	Qr (BTU/hr)	Area (m^2)	Area (ft^2)	U value (BTU/hr.ft².f°)	ΔT (f°)	Q (BTU/hr)
E	5.4	58.104	0.227	26	342.929808	E	26.1	280.836	0.57	14	26	0.8	4161.98952	3145.3632					
W	5.4	58.104	0.227	23	303.360984	W	26.1	280.836	0.57	99	26	0.8	4161.98952	22242.2112	38.15	410.494	0.4	10.8	1773.33408
S	14.58	156.8808	0.227	36	1282.029898	S	70.5	758.58	0.57	20	26	0.8	11242.1556	12137.28					
W	2.4	25.824	0.227	23	134.827104	W	11.6	124.816	0.57	99	26	0.8	1849.77312	9885.4272		0	0.4	0	0
W	2.4	25.824	0.227	23	134.827104	W	11.6	124.816	0.57	99	26	0.8	1849.77312	9885.4272		0	0.4	0	0
E	5.04	54.2304	0.227	26	320.0678208	E	24.4	262.544	0.57	14	26	0.8	3890.90208	2940.4928		0	0.4	0	0
		0	0.227		0			0	0.57		26	0.8	0	0		0	0.4	0	0
		0	0.227		0			0	0.57		26	0.8	0	0	7.35	79.086	0.4	10.8	341.65152
S	14.16	152.3616	0.227	36	1245.098995	S	68.44	736.4144	0.57	20	26	0.8	10913.66141	11782.6304		0	0.4	0	0
S	4.56	49.0656	0.227	36	400.9640832	S	21.46	230.9096	0.57	20	26	0.8	3422.080272	3694.5536		0	0.4	0	0
W	2.4	25.824	0.227	23	134.827104	W	11.6	124.816	0.57	99	26	0.8	1849.77312	9885.4272					
W	1.38	14.8488	0.227	23	77.5255848	W	6.7	72.092	0.57	99	26	0.8	1068.40344	5709.6864		0	0.4	10.8	0
W	1.38	14.8488	0.227	23	77.5255848	W	6.7	72.092	0.57	99	26	0.8	1068.40344	5709.6864	4.55	48.958	0.4	10.8	211.49856
		0	58.1	0	0			0	0.57		26	0.8	0	0	8.05	86.618	0.4	10.8	374.18976
		0	0.227	0	0			0	0.57		26	0.8	0	0	8.05	86.618	0.4	10.8	374.18976
		0	0.227	0	0			0	0.57		26	0.8	0	0		0	0.4	0	0
		0	0.227	0	0			0	0.57		26	0.8	0	0		0	0.4	0	0
		0	0.227	0	0			0	0.57		26	0.8	0	0	14	150.64	0.4	10.8	650.7648
		0	0.227		0			0	0.57		26	0.8	0	0	18.2	195.832	0.4	10.8	845.99424
		0	0.227		0			0	0.57		26	0.8	0	0		0	0.4	0	0
		0	0.227		0			0	0.57		26	0.8	0	0	34.7	373.372	0.4	10.8	1612.96704
		0	0.227		0			0	0.57		26	0.8	0	0	9.45	101.682	0.4	10.8	439.26624
		0	0.227		0			0	0.57		26	0.8	0	0		0	0.4	0	0
E	2.64	28.4064	0.227	26	167.6545728	E	12.76	137.2976	0.57	14	26	0.8	2034.750432	1537.73312		0	0.4	0	0
E	60	645.6	0.227	26	3810.3312	E	29	312.04	0.57	14	26	0.8	4624.4328	3494.848	28.7	308.812	0.4	10.8	1334.06784
		0	0.227		0			0	0.57		26	0.8	0	0	31	333.56	0.4	10.8	1440.9792
		0	0.227		0			0	0.57		26	0.8	0	0	25.2	271.152	0.4	10.8	1171.37664
E	4.08	43.9008	0.227	26	259.1025216	E	19.7	211.972	0.57	14	26	0.8	3141.42504	2374.0864		0	0.4	0	0
		0	0.227		0			0	0.57		26	0.8	0	0		0	0.4	0	0
		0	0.227		0			0	0.57		26	0.8	0	0	9.8	105.448	0.4	10.8	455.53536
		0	0.227		0			0	0.57		26	0.8	0	0	18.2	195.832	0.4	10.8	845.99424
		0	0.227		0			0	0.57		26	0.8	0	0	11.2	120.512	0.4	10.8	520.61184

Cooling load | Heating load | Sheet5

External load (wall)

TABLE 19-EQUIVALENT TEMPERATURE DIFFERENCE (DEG F)

FOR DARK COLORED† , SUNLIT AND SHADED WALLS*

Based on Dark Colored Walls; 95 F db Outdoor Design Temp; Constant 80F db Room Temp; 20 deg F Daily Range; 24-hour Operation; July and 40 N. Lat.†

EXPOSURE	WEIGHTS OF WALL‡ (lb/sq ft)	SUN TIME																						
		AM							PM												AM			
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
Northeast	20	5	15	22	23	24	19	14	13	12	13	14	14	14	12	10	8	6	4	2	0	-2	-3	-4	-2
	60	-1	-2	-2	5	24	22	20	15	10	11	12	13	14	13	12	11	10	8	6	4	2	1	0	-1
	100	4	3	4	4	4	10	16	15	14	12	10	11	12	12	12	11	10	9	8	7	6	6	5	5
	140	5	5	6	6	6	6	6	10	14	16	14	12	10	10	10	10	10	10	10	9	9	8	7	7
East	20	1	17	30	33	36	35	32	20	12	13	14	14	14	12	10	8	6	4	2	0	-1	-2	-3	-3
	60	-1	-1	0	21	30	31	31	19	14	13	12	13	14	13	12	11	10	8	5	4	3	1	1	0
	100	5	5	6	8	14	20	24	25	24	20	18	16	14	14	14	13	12	11	10	9	8	7	7	6
	140	11	10	10	9	8	9	10	15	18	19	18	17	16	14	12	13	14	14	14	13	13	12	12	12
Southeast	20	10	6	13	19	26	27	28	26	24	19	16	15	14	12	10	8	6	4	2	0	-1	-1	-2	-2
	60	1	1	0	13	20	24	28	26	25	21	18	15	14	13	12	11	10	8	6	5	4	3	3	2
	100	7	7	6	6	6	11	16	17	18	19	18	16	14	13	12	11	10	10	10	9	9	8	8	7
	140	9	8	8	8	8	7	6	11	14	15	16	18	16	15	14	13	12	12	12	11	11	10	10	9
South	20	-1	-2	-4	1	4	14	22	27	30	28	26	20	16	12	10	7	6	3	2	1	1	0	0	-1
	60	-1	-3	-4	-3	-2	7	12	20	24	25	26	23	20	15	12	10	8	6	4	2	1	1	0	-1
	100	4	4	2	2	2	3	4	8	12	15	16	18	18	15	14	11	10	9	8	8	7	6	6	5
	140	7	6	6	5	4	4	4	4	4	7	10	13	14	15	16	16	14	12	10	10	9	9	8	7
Southwest	20	-2	-4	-4	-2	0	4	6	19	26	34	40	41	42	30	24	12	6	4	2	1	1	0	-1	-1
	60	2	1	0	0	0	1	2	8	12	24	32	35	36	35	34	20	10	7	6	5	4	4	3	3
	100	7	5	6	5	4	5	6	7	8	12	14	19	22	23	24	23	22	15	10	10	9	9	8	7
	140	8	8	8	8	8	7	6	6	6	7	8	9	10	15	18	19	20	13	8	8	8	8	8	8
West	20	-2	-3	-4	-2	0	3	6	14	20	32	40	45	48	34	22	14	8	5	2	1	0	0	-1	-1
	60	2	1	0	0	0	2	4	7	10	19	26	34	40	41	36	28	16	10	6	5	4	3	3	2
	100	7	7	6	6	6	6	6	7	8	10	12	17	20	25	28	27	26	19	14	12	11	10	9	8
	140	12	11	10	9	8	8	8	9	10	10	10	11	12	14	16	21	22	23	22	20	18	16	15	13
Northwest	20	-3	-4	-4	-2	0	3	6	10	12	19	24	33	40	37	34	18	6	4	2	0	-1	-1	-2	-2
	60	-2	-3	-4	-3	-2	0	2	6	8	10	12	21	30	31	32	21	12	8	6	4	3	1	0	-1
	100	5	4	4	4	4	4	4	4	4	5	6	9	12	17	20	21	22	14	8	7	7	6	6	5
	140	8	7	6	6	6	6	6	6	6	6	6	7	8	9	10	14	18	19	20	16	7	11	10	9
North (Shade)	20	-3	-3	-4	-3	-2	1	4	8	10	12	14	13	12	10	8	6	4	2	0	0	13	-1	-2	-2
	60	-3	-3	-4	-3	-2	-1	0	3	6	8	10	11	12	12	12	10	8	6	4	2	-1	0	-1	-2
	100	1	1	0	0	0	0	0	1	2	3	4	5	5	5	8	7	6	5	4	3	1	2	2	1
	140	1	1	0	0	0	0	0	0	0	1	2	3	4	5	6	7	8	7	6	4	3	2	2	1
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
		AM							PM												AM			
		SUN TIME																						

Equation: Heat Gain Thru Walls, Btu/hr = (Area, sq ft) × (equivalent temp diff) × (transmission coefficient U, *Tables 21 thru 25*)

*All values are for the both insulated and uninsulated walls.

†For other conditions, refer to corrections on *page 64*.

‡"Weight per sq ft" values for common types of construction are listed in *Tables 21 thru 25*.

For wall constructions less than 20 lb/sq ft, use listed values of 20 lb/sq ft.

TABLE 20-EQUIVALENT TEMPERATURE DIFFERENCE (DEG F)

FOR DARK COLORED†, SUNLIT AND SHADED ROOFS*

Based on 95 F db Outdoor Design Temp; Constant 80 F db Room Temp; 20 deg F Daily Range; 24-hour Operation; July and 40° N. Lat.†

CONDITION	WEIGHTS OF ROOF‡ (lb/sq ft)	SUN TIME																						
		AM							PM												AM			
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
Exposed to Sun	10	-4	-6	-7	-5	-1	7	15	24	32	38	43	46	45	41	35	28	22	16	10	7	3	1	-1	-3
	20	0	-1	-2	-1	2	9	16	23	30	36	41	43	43	40	35	30	25	20	15	12	8	6	4	2
	40	4	3	2	3	6	10	16	23	28	33	38	40	41	39	35	32	28	24	20	17	13	11	9	6
	60	9	8	6	7	8	11	16	22	27	31	35	38	39	38	36	34	31	28	25	22	18	16	13	11
	80	13	12	11	11	12	13	16	22	26	28	32	35	37	37	35	34	34	32	30	27	23	20	18	14
Covered with Water	20	-5	-2	0	2	4	10	16	19	22	20	18	16	14	12	10	6	2	1	1	-1	-2	-3	-4	-5
	40	-3	-2	-1	-1	0	5	10	13	15	15	16	15	15	14	12	10	7	5	3	1	-1	-2	-3	-3
	60	-1	-2	-2	-2	-2	2	5	7	10	12	14	15	16	15	14	12	10	8	6	4	3	2	1	0
Sprayed	20	-4	-2	0	2	4	8	12	15	18	17	16	15	14	12	10	6	2	1	0	-1	-2	-2	-3	-3
	40	-2	-2	-1	-1	0	2	5	9	13	14	14	14	14	13	12	9	7	5	3	1	0	0	-1	-1
	60	-1	-2	-2	-2	-2	0	2	5	8	10	12	13	14	13	12	11	10	8	6	4	2	1	0	-1
Shaded	20	-5	-5	-4	-2	0	2	6	9	12	13	14	13	12	10	8	5	2	1	0	-1	-3	-4	-5	-5
	40	-5	-5	-4	-3	-2	0	2	5	8	10	12	13	12	11	10	8	6	4	2	0	-1	-3	-4	-5
	60	-3	-3	-2	-2	-2	-1	0	2	4	6	8	9	10	10	10	9	8	6	4	2	1	0	-1	-2
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
		AM							PM												AM			
		SUN TIME																						

Equation: Heat Gain Thru Roofs, Btu/hr = (Area, sq ft) × (equivalent temp diff) × (transmission coefficient U, *Tables 27 or 28*)

*With attic ventilated and ceiling insulated roofs, reduce equivalent temp diff 25%

For peaked roofs, use the roof area projected on a horizontal plane.

†For other conditions, refer to corrections on *page 64*.

‡"Weight per sq ft" values for common types of construction are listed in *Tables 27 or 28*.

External load (window)

TABLE 15—SOLAR HEAT GAIN THRU ORDINARY GLASS (Contd)

30° Btu/(hr) (sq ft sash area) 30°

30° NORTH LATITUDE		AM						SUN TIME				PM			30° SOUTH LATITUDE	
Time of Year	Exposure	6	7	8	9	10	11	Noon	1	2	3	4	5	6	Exposure	Time of Year
JUNE 21	North	33	29	18	14	14	14	14	14	14	14	18	29	33	South	DEC 22
	Northeast	105	139	130	97	55	19	14	14	14	14	12	10	5	Southeast	
	East	108	156	161	143	98	44	14	14	14	14	12	10	5	East	
	Southeast	42	75	90	90	73	44	17	14	14	14	12	10	5	Northeast	
	South	5	10	12	14	15	19	21	19	15	14	12	10	5	North	
	Southwest	5	10	12	14	14	14	17	44	73	90	90	75	42	Northwest	
	West	5	10	12	14	14	14	14	44	98	143	161	156	108	West	
	Northwest	5	10	12	14	14	14	14	19	55	97	130	139	105	Southwest	
	Horizontal	19	61	131	180	217	240	250	240	217	180	131	61	19	Horizontal	
JULY 23 & MAY 21	North	22	20	14	13	14	14	14	14	14	13	14	20	22	South	JAN 21 & NOV 21
	Northeast	93	131	123	89	46	16	14	14	14	13	12	9	4	Southeast	
	East	100	155	164	145	99	44	14	14	14	13	12	9	4	East	
	Southeast	42	82	100	100	83	53	22	14	14	13	12	9	4	Northeast	
	South	4	9	12	14	20	27	30	27	20	14	12	9	4	North	
	Southwest	4	9	12	13	14	14	14	53	83	100	100	82	42	Northwest	
	West	4	9	12	13	14	14	14	44	99	145	164	155	100	West	
	Northwest	4	9	12	13	14	14	14	16	46	89	123	131	93	Southwest	
	Horizontal	15	66	123	176	214	236	246	236	214	176	123	66	15	Horizontal	
AUG 24 & APR 20	North	6	8	11	13	13	14	14	14	13	13	11	8	6	South	FEB 20 & OCT 23
	Northeast	55	108	100	66	27	14	14	14	13	13	11	8	2	Southeast	
	East	66	147	165	148	102	46	14	14	13	13	11	8	2	East	
	Southeast	37	98	127	129	112	82	39	15	13	13	11	8	2	Northeast	
	South	2	8	13	27	47	58	63	58	47	27	13	8	2	North	
	Southwest	2	8	11	13	13	15	39	82	112	129	127	98	37	Northwest	
	West	2	8	11	13	13	14	14	46	102	148	165	147	66	West	
	Northwest	2	8	11	13	13	14	14	14	27	66	100	108	55	Southwest	
	Horizontal	6	47	107	161	200	225	235	225	200	161	107	47	6	Horizontal	