International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 3 Issue 5, August 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Heat Load Calculation

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How to cite this paper: Junaid Hussain | Syed Abdul Gaffar "Heat Load Calculation" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-5, August 2019, pp.1233-1235, **https://doi.org/10.31142/ijtsrd26571**

IJTSRD26571

ABSTRACT
The primary objective of this report is to provide a convenient, consistent and accurate method of calculating heating and cooling loads and to enable the designer to select systems that meet the requirement for efficient utilization and are also responsive to environmental needs. The ability to estimate loads more accurately due to changes in the calculation procedure provides a lessened margin of error. Therefore, it becomes increasingly important to survey and check more carefully the load sources, each item in the load and the effect of the system type on the load.

KEYWORDS: *HVAC system, E20 program, ASHRAE standards, manual heat load calculation*

INTRODUCTION:
HEATING:
Heat is a form of energy transferred from one body, region, or thermodynamic system to another due to thermal contact when the systems are at different temperatures.

PRINCIPLES OF HEAT TRANSFER
Heat energy cannot be destroyed; it can only be transferred to another substance.

To produce cooling, heat must be removed from a substance by transferring the heat to another substance. Heat energy naturally flows from a higher-temperature substance to a lower temperature substance, in other words from hot to cold. Heat cannot be naturally flow from a cold substance to a hot substance.

METHODS OF HEAT TRANSFER
Heat energy is transferred from one substance to another substance by conduction, convection, or radiation. Conduction is the process of transferring heat through a solid and convection is the process of transferring heat as the result of the movement of a fluid. Convection often occurs as the result of the natural movement of air caused by temperature (density) differences. Radiation is the process of transferring heat by means of electromagnetic waves, emitted due to temperature difference between two objects.

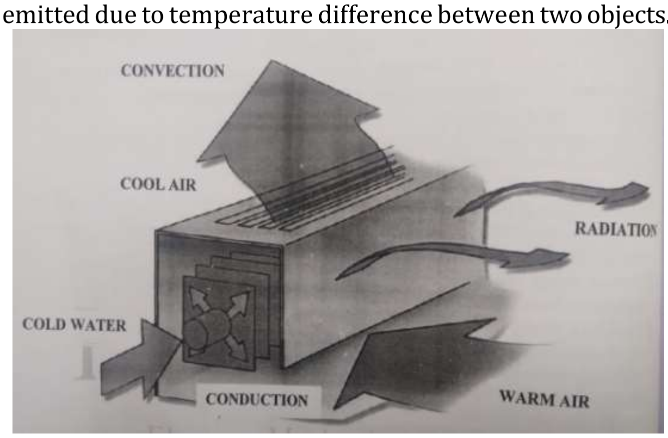

Fig.1.Methods of Heat Transfer

MEASURING HEAT QUANTITY:
The unit for measuring the quantity of heat is the British thermal unit (BTU). The Btu is defined as the quantity of heat energy required to raise the temperature of 1lb of water 1 degree Fahrenheit. In SI system, heat quantity can be expressed using the unit kilo joule (KJ). Rate of heat flow is commonly expressed in terms of Btu/hr. which says that 1 Btu of heat has transferred from one substance to another during a period of 1 hour. In the SI metric system of units, the rate of heat flow is expressed in terms of kilowatts (KW).

SOURCES OF HEAT:
1. External source – Sun and Air
2. Internal sources – people, lighting, and electronics.

The manner in which a load source enters a space is indicated as

- Solar radiation through transparent surface such as windows
- Heat condition through exterior walls and roofs
- Heat conduction through interior partitions ceilings and floors
- Heat generated within the space by occupants, lights, appliances, equipment and processes
- Load as a result of ventilation and infiltration of outdoor air

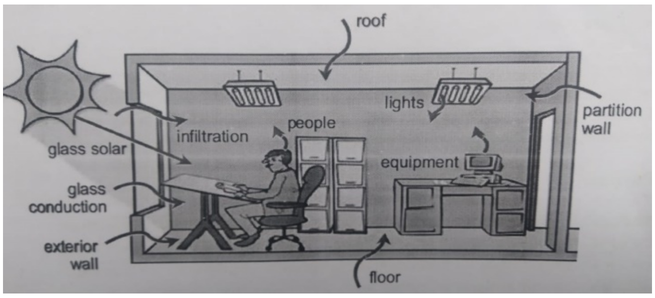

Fig.2. sources of heat

PURPOSE OF HEAT LOAD CALCULATIONS:
- Provide information for equipment selection and HVAC system design.
- Provide data for evaluation of the optimum possibilities for load reduction.
- Permit analysis of partial loads as required for system design, operation and control.

HEAT LOAD ESTIMATION

There are two types of heat gain i.e. sensible heat and latent heat. Latent heat is related to change in phase between liquids, gases, and solids. Sensible heat is related to change in temperature of a gas or object with no change in phase.

Table I: Typical Diversity Factor for Large Buildings

Type of Applications	Diversity Factor	
	People	Lights
office	0.75 to 0.90	0.70 to 0.85
Apartment, hotel	0.40 to 0.60	0.30 to 0.50
Department storage	0.80 to 0.90	0.90 to 1.0
industrial	0.85 to 0.95	0.80 to 0.90

The heat load calculation is done with the basic formula i.e. Q=U A ΔT

Table.2.Thermal Resistance for Building and Insulating Material

Material	K. Conductivity Btu/in/hr/sq. ft	Resistance 1/K
Marble Granite	20	0.05
Concrete	12	0.08
Brick	5	0.20
Cement Plaster	8	0.12
Wood	1	1
Glass	0.8	1.25
AC Sheet	2.7	0.37
Water	4.2	0.24
Fiber Glass	0.25	4.00
Inside film coefficient	4.00	0.25
Outside film	1.65	0.65

The U-factor for each of the type of wall is calculated according to the thickness of the wall and its thermal resistance value of each material by U=1/∑R

Where,
∑R is the sum of all resistance of material inbuilt in the wall structure

1. **Heat gained through radiation:**
   - Glass= Area * ΔT glass * U glass {value changes with direction}
   - Wall= Area * ΔT wall * U wall {value changes with direction}
   - Roof= Area * ΔT roof * U roof

2. **Heat gained through conduction:**
   - Glass= Total area of all glasses * ΔT glass * U glass (ΔT=110 - 76°F)
   - Partition/ceiling/floor= Area * ΔT * U (ΔT=110 - 76°F - 5°F)

3. **Heat gained through infiltration:**
   - Infiltration= Infiltration cfm * ΔT * 1.08
   - Outside air= ventilation cfm * ΔT * BF * 1.08

4. **Internal heat gained- sensible heat:**
   - People= no of people * sensible heat
   - Light= Area * 2.5w * 3.41
   - Appliances= W * 3.41
   - **Total effective room sensible heat** = sum of 1+2+3+4.

5. **Internal heat gained- latent heat:**
   - Infiltration= infiltration cfm * sp. Humidity*0.68
   - Outside air = ventilation cfm * sp. Humidity * BF * 0.68
   - People= no of people * latent heat
   - **Total effective room latent heat=** sum of 5

6. **Sensible** heat = ventilation cfm * temperature diference * (1 – BF) * 1.08

7. **Latent** heat = ventilation cfm * sp.humidity * (1 – BF) * 0.68

8. **Total outside air heat** = sum of 6+7

9. **Grand total heat**= sum of total effective room sensible heat + total effective room latent heat + total outside air heat

10. **Room tonnage** = grand total heat/12000

Item	Area or Quantity			Sun Gain or Temp. Diff			Factor	Btu/Hour	W
		ROOM HEAT							
ROOM SENSIBLE HEAT									
Solar Gain - Glass									
Glass - N		SqFt	x	23	F	x	0.59	0	
Glass - NE		SqFt	x	138	F	x	0.59	0	
Glass - E		SqFt	x	163	F	x	0.59	0	
Glass - SE		SqFt	x	85	F	x	0.59	0	
Glass - S		SqFt	x	14	F	x	0.59	0	
Glass - SW		SqFt	x	85	F	x	0.59	0	
Glass - W	24	SqFt	x	163	F	x	0.59	2308	
Glass - NW		SqFt	x	138	F	x	0.59	0	
Skylight		SqFt	x		F	x	0.59	0	
Solar & Transmission Gain - Walls & Roof									
Wall - N		SqFt	x	15	F	x	0.38	0	
Wall - NE		SqFt	x	21	F	x	0.38	0	
Wall - E		SqFt	x	29	F	x	0.38	0	
Wall - SE		SqFt	x	29	F	x	0.38	0	
Wall - S		SqFt	x	27	F	x	0.38	0	
Wall - SW		SqFt	x	25	F	x	0.38	0	
Wall - W	144	SqFt	x	23	F	x	0.38	1259	
Wall - NW		SqFt	x	17	F	x	0.38	0	
Roof		SqFt	x	43	F	x	0.38	0	
Transmission Gain - Except Walls & Roof									
All Glass	24	SqFt	x	30	F	x	0.59	425	
Partition		SqFt	x	25	F	x	0.54	0	
Ceiling		SqFt	x		F	x		0	
Floor		SqFt	x		F	x		0	
INFILTRATION AND BY PASSED AIR									
Infiltration	11	CFM	x	30	T.Diff	x	1.08	343	
Ventilation	53	CFM	x	30	T.Diff	x	BF x 1.08	346	
Internal Heat									
People	2	Nos.	x	245	Btu/Hour Per Person			490	
Lighting	162	SqFt	x	2.5	W/SqFt	x	3.41	1381	
Lighting & S. P.		SqFt	x		W/SqFt	x	3.41		
Equipment	0.50	kW	x	3410				1705	
			Sub Total					8257	
			Factor				5-10%	826	
			Effective Room Sensible Heat					9083	
ROOM LATENT HEAT									
Infiltration	11	CFM	x	32	Gr/Lb	x	0.68	231	
Outside Air	53	CFM	x	32	Gr/Lb	x	BFx0.68	233	
People	2	Nos.	x	205	Btu/Hour Per Person			410	
			Sub Total					873	
			Factor				2.5 - 5%	44	
			Effective Room Latent Heat					917	
EFFECTIVE ROOM TOTAL HEAT								10000	
		OUTSIDE AIR HEAT							
Sensible	53	CFM	x	30	F(TD)	x	CF x 1.08	1386	
Latent	53	CFM	x	32	Gr/Lb	x	CF x 0.68	931	
OUTSIDE AIR TOTAL HEAT								2316	
		GRAND TOTAL HEAT						12316	
			Sub Total						
TONS=GRAND TOTAL HEAT/12000								1.03	

Estimate for	Summer				
Design Conditions	DB (F)	WB (F)	RH (%)		SH Gr/Lb
Ambient	106	78	28		100
Room	76	63.5	50		68
Difference	30	14.5	-22		32
By Pass Factor (BF)				=	0.20
Contact Factor (CF = 1 - BF)				=	0.80
CFM Ventilation					
CFM Per Person	2	No =	20	=	40
CFM Per SqFt	162	Sqft x	0.33	=	53
Air Change Per Hour (CFM)		=			
CFM Cu.ft	1,944	x 1.5	x 1/60	=	49
CFM Infiltration					
Swinging		x 10	cfm/door	=	-
Revolving Doors (People)		x 6.4	cfm/door	=	-
Open Doors		x 1.2	cfm/door	=	-
Crack (feet)	20	x 0.53	cfm/ft	=	10.60
					10.60
Supply CFM from Machine					
Effective Room Sensible Heat Factor =					
Effective Room Sensible Heat/Eff Room Total Heat				=	0.9083
Apparatus Dew Point (ADP)					
Indicated ADP (°F)				=	
Selected ADP (°F)				=	55.0
Dehumidified Rise					
(Room DB - ADP) x CF				=	16.80
DEHUMIDIFIED AIR QUANTITY					
Effective Room Sensible Heat		=	501		CFM
Dehumidified Rise x 1.08					
		=	235		L/s
TOTAL HEAT CAPACITY					
Grand Total Heat		=	1.03		TR
SENSIBLE HEAT CAPACITY					
Grand Sensible Heat		=	1.03		TR
12000					
		=			MBH
		=			kW
Check Figures:					
SqFt Per TR		=	158		
Btu/Hour Per SqFt		=	12000		
Dehumidified CFM Per SqFt		=	3.09		
Dehumidified CFM Per TR		=	488		
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Fig.3. Heat Load Calculation using E20 sheet

CONCLUSION

1. Heat gained through radiation changes with direction.
2. Radiated heat doesn't heat the air between the sources and the object it contacts; it only heats the object itself.
3. Considering the roof till its false ceiling while calculating the heat load decreases the load on machines.
4. E20 program reduces human errors and provides accurate heat loads.
5. Ducted return air duct reducdes the load on machines

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