AIR-CONDITIONING LOAD ESTIMATION

INTRODUCTION:

The following will serve as a guide for estimating the cooling load requirement for a given space or building.

Before going into a detailed heat load analysis the approximate load may be obtained by using the factors in column 4 of Table 1. The approximate tonnage (1 Ton = 12,000 BTU/HR) is obtained and an idea of the type of equipment to be used can be formed. If room units are to be used then the analysis usually ends by selecting the next highest capacity unit or combination of units. Otherwise, a more detailed analysis, set out as follows is adopted to get a more accurate heat load.

TABLE 1 : Design & Cooling Load Check Figures

Applications	Occupancy ft^2/person		Lighting: w/ft^2		Fresh Air cfm/ft^2.		Refrigeration Btuh/ft^2.		Supply Air cfm/ft^2.	
	Av.	**High**	**Av.**	**High**	**Av.**	**High**	**Av.**	**High**	**Av.**	**High**
Apartments (Flats)	100	50	1	2	0.35	0.5	30	35	1.2	1.75
Auditoriums, Theatres	10	5	1	2	1.5	2.5	48	120	1.5	2.5
Educational Facilities (ex. Schools, Colleges, Universities, etc)	25	20	2	4	0.3	0.4	60	80	1.4	1.8
Factories :										
Assembly Areas	35	25	3+	4.5+	0.25	0.5	50	80	2.25	3.0
Light Manuf.	150	100	9+	10+	0.1	0.15	60	80	2.75	3.0
Hospitals :										
Patient Rooms	50	25	1	1.5	0.75	1.5	55	75	1.2	1.7
Public Areas	80	50	1	1.5	0.75	1.5	86	110	1.2	1.7
Hotels, Motels, Dormitories	150	100	1	2	0.2	0.3	40	55	1.2	1.4
Libraries & Museums	60	40	1	1.5	0.35	0.4	43	60	1.2	1.1
Office Buildings	110	80	4	6+	0.25	0.40	43	65	1.0	1.7
Private Offices	125	100	2	5.8	0.15	0.25	43	65	1.0	1.2
Typing Department	85	70	5+	7.5	0.25	0.35	43	65	1.0	1.3
Restaurants:										
Large	15	13	1.5	1.7	0.75	1.0	120	65	1.5	2.0
Medium	15	13	1.5	1.7	0.6	0.8	100	120	1.5	2.1
Drug Stores	23	17	1	2.	0.3	0.45	48	60	1.5	2.0

\+ Includes other loads expressed in Watts/ft^2.

DEFINITIONS

1. **Air Conditioning**
   A process which heats, cools, cleans and circulates air and controls its moisture content. This process is done simultaneously and all year round.

DESIGN CONSIDERATION

1. **Design Conditions -** Outdoor Air and Indoor Air Temperature (Dry bulb and Wet Bulb), Humidity, Moisture Content.

2. **Orientation of building -** Location of the space to be air conditioned with respect to :
   a) Compass points - sun and wind effects
   b) Nearby permanent structures - shading effects
   c) Reflective surfaces - water, sand, parking lots, etc.

3. **Use of space (s) -** Office, hospitals, department store, specialty shop, machine shop, factory, assembly plant, etc.

4. **Dimensions of space -** Length, width, and height

5. **Ceiling height -** Floor to floor height, floor to ceiling, clearance between suspended ceiling and beams.

6. **Columns and beams -** Size, depth, also knee braces.

7. **Construction materials -** Materials and thickness of walls, roof, ceiling, floors and partitions and their relative position in the structure.

8. **Surrounding conditions -** Exterior colour of walls and roof, shaded by adjacent building or sunlit. Attic spaces - vented or unvented, gravity or forced ventilation. Surrounding spaces conditioned or unconditioned-temperature of non-conditioned adjacent spaces, such as furnace, boiler room, kitchen etc. Floor on ground basement etc.

9. **Windows -** Size and location, wood or metal sash, single or double hung. Type of glass - single or multipane. Type of shading device. Dimensions of reveals and overhangs.

10. **Doors -** Location, type, size and frequency of use.

11. **Stairways, elevators and escalators -** Location, temperature of space if open to unconditioned area. Horsepower of machinery, ventilated or not.

12. **People -** Number, duration of occupancy, nature of activity, any special concentration. *At times, it is required to estimate the number of people on the basis of square feet per person* or on average traffic.

13. **Lighting -** Wattage at peak. Type - incandescent, fluorescent, recessed, exposed. If the light are recessed, the type of air flow over the lights, exhaust, return or supply, should be anticipated. *At times, it is required to estimate the wattage on a basis of watts per sq. ft.* due to lack of information.

14. **Motors -** location, name plate and brake horsepower and usage. The latter is of great significance and should be carefully evaluated. It is always advisable to measure power input where possible. This is especially important in estimates for industrial installations where the motor machine load is normally a major portion of the cooling load.

15. **Appliances, business machines, electronic equipment -** Locations, rated wattage, steam or gas consumption, hooded or unhooded, exhaust air quantity installed or required, and usage. Avoid pyramiding as not all machines will be used at the same time. Electronics equipment often requires individual air-conditioning - the manufacturers recommendation for temperature and humidity variation must be followed.

16. **Ventilation -** Cfm per person, cfm per sq. ft., scheduled ventilation. Excessive smoking or odours, code requirement. Exhaust fans - type, size, speed, cfm delivery.

17. **Thermal storage -** Operating schedule (12, 16 or 24 hours per day), specifically during peak outdoor conditions, permissible temperature swing in space during design day, rugs on floor, nature of surface materials enclosing the space.

18. **Continuous or intermittent operation -** Whether system be required to operate every business day during cooling season, or only occasionally, such as ballrooms and churches. If intermittent eg. churches, ballrooms, determine duration of time available for pre-cooling or pull-down.

LOAD COMPONENTS

A. Load components can be divided into two (2) types:

i) **SENSIBLE LOAD**
results when **heat** entering the conditioned space that causes **dry bulb temperature** (DB) to increase.

ii) **LATENT LOAD**
results when **moisture** entering the space causes the **humidity** to increase.

A load component may be all sensible, all latent, or a combination of the two.

B. Additionally load components can be classified into three (3) categories:

i) **EXTERNAL LOADS**

a) Solar heat gain through glass (*Formula 1*) - Sun rays entering windows.

b) Solar and transmission gain through walls and roofs (*Formula 2*) - Sun rays striking walls and roofs.

c) Transmission gain through glass, partition, floors (*Formula 3*) - The air temperature outside the conditioned space

d) Infiltration - The wind blowing against a side of the building.

e) Ventilation - Outdoor air usually required for ventilation purposes as in TABLE 11.

C. **INTERNAL LOADS**

a) People - Human body generates heat within itself and releases it by radiation, convection and evaporation from the surface (**sensible**), and by convection and evaporation in the respiratory tract (**latent**). The amount of heat generated and released depends on surrounding temperature and on the activity level of the person as in TABLE 10. Both sensible and latent loads will enter the space.

b) Lights (*Formula 4*) - Illuminants convert electrical power into light and sensible heat. Lighting is either fluorescent or incandescent.

c) Motors

d) Equipment and Appliances

D. **OTHER LOADS (AIR CONDITIONING EQUIPMENT AND DUCT SYSTEM)**

a) Supply duct heat gain

b) Supply duct leakage loss

c) Supply air fan heat

d) Bypass outdoor air

e) Return duct heat gain

f) Return duct leakage gain

g) Return air fan heat

E. **GRAND TOTAL HEAT**

The total load seen by the coil in the central air handling unit is referred to as Grand Total Heat (GTH) or Dehumidified Load. It is the sum of the total room loads, outdoor air loads,

F. **REFERIGERATION LOAD**

Two (2) additional loads are introduced to the refrigeration machine which are not experienced by the coil. They are:

i) Piping sensible heat gain as the cold pipe passes through warm surroundings and;

ii) Pumping heat gain as the pump does work on the water.

III. Design Conditions:

The following are usually used for comfort design:-

	Dry bulb (^{0}F)	Wet bulb (^{0}F)	% RH	Gr/lb
Outside	**92 (day)/(76 (night)**	**80 (day)/75 (night)**	**60 (day)/95 (night)**	**138**
Room	**75**	**64**	**55**	**72**

These are filled in the heat estimate form as shown.

IV. Solar heat gains:

The exposure with the maximum sunlit glass area is used and the design month is then fixed from Table 4 by selecting the month with the maximum value at that exposure. The peak value for other exposures of sunlit can than be read for that month.

TABLE 4: Peak solar heat gain through Ordinary Glass

Btu/(hr)(sq.ft)

Month	Exposure								
	N	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**	**Horizontal**
June	59	156	147	42	14	42	147	156	226
July & May	48	153	152	52	14	52	152	153	233
August & April	25	141	163	79	14	79	163	141	245
Sept. & March	10	118	167	118	14	118	167	118	250
Oct. & Feb.	10	79	163	141	34	141	163	79	245
Nov. & Jan.	10	52	152	153	67	153	152	52	233
Dec.	10	42	147	156	82	156	147	42	226
Solar gain Correction	Steel sash or no sash x 1.17		Haze - ------- 15% (Max)		Altitude + +0.7% per 1000 ft.		Dew point Above 67^0F --7% per 10F		Dew point Below 67^0F +7% per 10F

TABLE 5 : Storage Load Factors (at 4 pm)

Exposure	Weight (lb/ft^2 of floor area):	24 hr. Operation Constant Space Temperature		12 hr. Operation Constant Space Temperature	
		With internal shade	With external shade	With internal shade	With external shade
NE	150 & over 100 30	0.16 0.15 0.12	0.20 0.19 0.14	0.20 0.17 0.12	0.26 0.23 0.14
E	150 & over 100 30	0.17 0.16 0.11	0.23 0.23 0.15	0.21 0.19 0.11	0.30 0.28 0.15
SE	150 & over 100 30	0.21 0.21 0.17	0.32 0.31 0.23	0.26 0.25 0.17	0.41 0.37 0.23
S	150 & over 100 30	0.42 0.45 0.24	0.48 0.53 0.61	0.49 0.51 0.24	0.61 0.63 0.61
SW	150 & over 100 30	0.61 0.64 0.79	0.47 0.53 0.78	0.69 0.70 0.79	0.60 0.64 0.79
W	150 & over 100 30	0.63 0.66 0.81	0.36 0.40 0.67	0.71 0.72 0.82	0.49 0.51 0.69
NW	150 & over 100 30	0.49 0.52 0.63	0.25 0.29 0.48	0.56 0.58 0.64	0.37 0.39 0.50
N & Shade	150 & over 100 30	0.86 0.88 0.98	0.72 0.79 0.98	0.96 0.98 1.00	0.93 0.95 1.00

The solar heat gains for the glass area sunlit at 4 pm are obtained from :-

Cooling Load (Btu/hr) = (Peak solar heat gain - Table 4)
x (window area, ft^2)
x (storage factor - Table 5)
x (shade factor - Table 6) ***FORMULA 1***

The correction factors at the bottom table 4 are to be used for other application.

The storage load factor in table 5 depends on the type of building. **For normal brick (9") building the weight of the building is normally about 100 lb/ft^2 and a normal brick (4 1/2") building with 5/8" plaster is about 60 lb/ft^2.** For timber or light weight buildings the values for 30 lb/ft^2 are taken. The values for 150 lb/ft^2 and over are used for heavier brick buildings.

TABLE 6 : OVERALL SHADE FACTOR

Type of Glass	No. Shade	Inside Venetian Blind			Outside Awning		
		Light Colour	Medium Colour	Dark Colour	Light Colour	Medium Colour or	Dark Colour
Regular plate 1/4"	0.94	0.56	0.65	0.74	0.19		0.24
Stained Glass		Light Colour = white, cream, etc.					
Amber colour	0.70	Medium Colour = light green, light blue, grey. etc.					
Dark red	0.56						
Dark blue	0.60	Dark Colour = dark blue, dark red, dark brown, etc.					
Dark Green	0.32						
Grayed Green	0.46						
Light Opalescent	0.43						
Dark opalascent	0.37						

The various factors for solar heat gain of the sunlit glass areas at 4 pm are thus found and substituted in the Estimate form and the load/s calculated.

NOTES:

V. Solar heat gain for walls and roof

These are found using Tables 7, 8 & 9 from the formula :-

Heat gain thro' walls/roof = (Area (ft^2))
x (equivalent temp. diff (^0F) - Table 7,Walls & Table 8,Roofs)
x (transmission coefficient (U) - Table 9) ***FORMULA 2***

TABLE 7: Equivalent Temperature Difference (^0F) at 4 pm. for dark coloured, shaded & sunlit walls (insulated and un-insulated)

Exposure	**Weight of Wall ($1b/ft^2$)**				
	20 & less	**60**	**100**	**140**	
NE	18	16	14	18	The weight of a 4½" brick wall with 5/8" plaster is about 60 $1b/ft^2$. 9" brick wall is about 100 $1b/ft^2$
E	18	16	22	22	
SE	20	22	22	20	
S	30	30	20	14	
SW	44	36	18	12	
W	44	30	16	14	
NW	28	16	20	20	
North (Shade)	18	14	8	6	

TABLE 8: Equivalent Temperature Differencen (^0F) at 4 pm. for dark coloured sunlit & shaded Roofs

Condition	**Weight of Roof (1b./ft2)**					
	10	**20**	**40**	**60**	**80**	
Exposed to Sun	47	45	42	39	36	Nomal 4" TK concrete flat roof is about 50 $1b./ft^2$.
Covered with Water	-	22	20	18	-	
Sprayed	-	20	18	16	-	
Shaded	-	18	16	12	-	
Notes: For attic ventilated and ceiling insulated roofs, reduce equivalent temp. difference by 25%. For peak roofs use projected area on horizontal plane.						

The equivalent temp. difference in Tables 7 and 8 should be corrected for light coloured and medium coloured walls and roofs as follows:-

Light coloured wall or roof: (Estimate fig. 0.78)

$\wedge t_e = 0.55 \wedge t_{em} + 0.45 \wedge t_{es}$

and Medium coloured wall or roof: (Estimate fig. 0.87)

$\wedge t_e = 0.78 \wedge t_{em} + 0.22 \wedge t_{es}$

where $\wedge t_e$ = equivalent temp diff. for colour of wall or roof desired.
$\wedge t_{em}$ = equivalent temp. diff. for wall or roof exposed to the sun.
and $\wedge t_{es}$ = equivalent temp. diff. for wall or roof in shade.

NOTES:

TABLE 9 : Transmission Coefficient, for common building structures
Btu/(hr)(sq.ft)(^{0}F temp. diff.)

	DESCRIPTION	U
Roofs	4" - 6" concrete roof with suspended ceiling board.	0.21
	Corrugated asbestos sheets with suspended ceiling boards.	0.28
	Corrugated zinc sheets with suspended ceiling boards.	0.29
	Clay-tiled pitch roof with suspended ceiling boards.	0.28
	Horizontal glass skylight	0.86
External Walls (7□ mph wind)	4 ½" brick wall with cement plaster on both sides.	0.48
	9" brick wall with cement plaster on both sides.	0.34
	3/8" – ½" gypsum or plaster board with plywood and 1" polystyrene sandwiched in between	0.17
	As above but with 1 ½" - 2" polystyrene	0.10
	As above but with airspace instead of polystyrene	0.39
	Metal sliding door with air space in between	0.56
	Plywood door (sandwich)	0.42
	Glass (Vertical)	1.13
Internal walls: (to unconditioned space)	4½" brick wall with plaster on both sides	0.40
	Sandwich gypsum, plaster board or plywood with 1" polystyrene	0.15
	As above but with 1½"- 2" polystyrene	0.10
	As above but with airspace instead of polystyrene	0.33
	Plywood door (sandwich)	0.35
Ceiling and floor:	None or floor tile on 4" x 6" concrete floor with suspended board ceiling (heat flow up)	0.25
	Same as above but heat flow down	0.22

VI. Transmission Heat Gains:

The transmission through all glass whether sunlit or in shade is obtained by.

Heat gain thro all glass **=** ***(Area (ft^2)) x (U factor - Table 9) x (outdoor temp - indoor temp)*** ***FORMULA 3***

Infiltration cannot be accurately assessed easily and is usually not computed but allowed for by taking a factor of safety of 10% in the load calculation for both the room sensible and room latent heat totals.

VII. Internal Heat

The internal heat gains from people can be divided into sensible heat gain and latent heat gain. These depend on their activity and the design temperature of the space. They are as shown in Table 10.

TABLE 10 : Heat Gain From People

Degree of Activity	Typical Applications	Room Dry Bulb Temperature					
		78^0F		75^0F		70^0F	
		BTU/HR		BTU/HR		BTU/HR	
		Sensible	Latent	Sensible	Latent	Sensible	Latent
Seated at Rest	Theatre, Grade School	210	140	230	120	260	90
Seated, very light work.	High School	215	185	240	160	275	125
Office Worker	Offices, hotels, colleges.	215	235	245	205	285	165
Standing, Walking Slowly	Dept., Retail Store						
Walking, seated	Drug Store	220	280	255	245	290	210
Standing Walking Slowly	Bank						
Sedentary Work	Restaurant +	240	310	280	270	320	230
Light benchwork	Factory, Lightwork	245	505	295	455	365	385
Moderate dancing	Dance Hall	275	575	325	525	400	450
Walking 3mph	Factory, fairly heavy work	330	670	380	620	460	540
Heavy Work	Bowling alley, factory	485	965	525	925	605	845

The values for this application include 60 Btu/hr for food per individual

The heat gain from lights depends on whether it is fluorescent or incandescent:-

Heat gain = ***Total light watts x 3.4 (for incandescent) or***
= ***Total light watts x 1.25 x 3.4 (for fluorescent)*** ***FORMULA 4***

If no lighting power is given then the values in column 2 of Table 1 can be used.

The heat gain from other equipment also has to be added. This can be obtained from the name plate horsepower or power input and multiplied by 3.4 Btu/hr per watt.

The room sensible heat (RSH) can then be totaled and a factor of safety of 10% added.

RSH = Solar Gain(Glass) + Solar Transmission Gain + Trans. Gain + Internal Heat

NOTES:

VIII. Outside Air :

The outside air required for ventilation purposes can be obtained from table 11 below :-

TABLE 11 : Ventilation Standards

Application	**Smoking**	**CFM Per Person**		**CFM/ft^2. of floor, Minimum**
		Recommended	**Minimum**	
Apartments				
- Average	Some	20	15	-
- De Lux	Some	30	25	0.33
Drug Stores	Considerable	10	7½	-
Factories	None	10	7½	0.10
Garage	-	-	-	1.0
Hospital				
- Operating Rooms	None	-	-	2.0
- Private Rooms	None	30	25	0.33
- Wards	None	20	15	-
Hotel Rooms	Heavy	30	25	0.33
Kitchen				
- Restaurant	-	-	-	4.0
- Residence	-	-	-	2.0
Laboratories	Some	20	15	-
Meeting Rooms	Very Heavy	50	30	1.25
Office				
- General	Some	20	10	0.25
- Private	None	25	15	0.25
- Private	Considerable	30	25	0.25
Restaurant				
- Cafe	Considerable	12	10	-
- Dining Room	Considerable	15	12	-
School Rooms	None	-	-	1.0
Theatres	None	7□	5	-
Theatres	Some	15	10	-
Toilets (exhaust)	-	-	-	2.0

NOTES: * When the minimum is used, use the larger
+ All outdoor air is recommended

The heat gain from outside air is then obtained from :-

O.A Sensible Heat = (ventilation, cfm -Table 11) x (design temp. difference, ^{0}F (DB)) x (by-pass factor (BF) x 1.09) ***FORMULA 5***

The **BYPASS FACTOR (BF)** is a characteristic of the cooling coils used and unit design. It represents the portion of air which is considered to pass through the cooling coils without being cooled.

The BF = Velocity of air through coils (time for air to contact surface of coils) / available coil surface (rows of coils, spacing of coil tubes)

Coil bypass factor	Type of Application	Example
0.30 to 0.50	A small total load or a load that is larger with a low sensible heat factor (ie. high latent load)	Residence
0.20 to 0.30	Typical comfort application with a relatively small total load or a low sensible heat factor with a somewhat larger load.	Residence Small retail shop, Factory
0.10 to 0.20	Typical comfort application	Dept. Store, Bank, Factory
0.05 to 0.10	Applications with high internal sensible loads or requiring a large amount of outdoor air for ventilation.	Dept. Store, Restaurant, Factory
0 to 0.10	All outdoor air applications	Hospital, Operating Room, Factory

Table 12 is a guide for design purposes. Usually a value of 0.3 is chosen for package units and 0.1 for chilled water or central DX systems. These should be compared with the final equipment bypass factor. If there should be a difference of 8% or more than the heat estimate for outside air should be recalculated.

The Effective Room Sensible heat (ERSH) is then totaled up.

ERSH = RSH + OA Heat(bypass) + Supply Duct Heat Gain + S.D Leak Loss + Fan H.P ***FORMULA 6***

IX. Room Latent heat:

The latent heat gain from people can be obtained from Table 10. Any equipment latent heat is also added. The room latent heat (RLH) can then be totaled and a factor of safety of 10% added.

The latent heat from the ventilation outside air is obtained from:-

O.A. Latent heat = ventilation, cfm
x design specific humidity, gr/lb.
x BF x 0.68 **FORMULA 7**

The Effective Room Latent Heat (ERLH) is then totalled up.

ERLH = RLH + OAHeat (bypass) + Supply Duct Leakage Loss ***FORMULA 8***

The Effective Room TOTAL Heat (ERTH) is then obtained:

ERTH = ERSH + ERLH ***FORMULA 9***

X. Outdoor air heat:

The remaining heat (less bypass air) from the outside air is computed as set out below, and the Grand Total heat is obtained. This is the actual amount of heat that is physically seen by the coil.

O.A Sensible Heat = ventilation, cfm -Table 11
x design temp. difference, ^{0}F (DB)
x (1-BF) x 1.09. ***FORMULA 10***

O.A. Latent heat = ventilation, cfm
x design specific humidity, gr/lb.
x (1-BF) x 0.68 ***FORMULA 11***

The Grand Total Heat (GTH) is thus obtained by adding this load to the ERTH.

GTH = ERTH + O.A Heat + RA Heat Gain + Ra Leakage + Blow Thru Fan
FORMULA 12

XI Refrigeration Load

The Refrigeration Load is the actual load that is seen by the refrigeration machine.

Refrigeration Load = GTH + Piping Heat Gain + Pump H.P ***FORMULA 13***

XII Dehumidified and Supply air quantity:

The effective sensible heat factor (ESHF) is obtained from :

$$ESHF = ERSH / ERTH \qquad \textbf{FORMULA 14}$$

Knowing the ESHF, the apparatus dew point, ADP, of the coil can be found from table 13.

TABLE 13 : Apparatus Dew Points

Room Conditions				Effective Sensible Heat Factor (ESHF) and Apparatus Dewpoint (ADP)									
DB	RH	WB	W										
^{0}F	%	^{0}F	gr/1b										
75	50	62.6	65	ESHF ADP	1.00 55.2	0.92 54	0.84 52	0.78 50	0.74 48	0.71 46	0.69 44	0.66 40	0.64+ 34 +
75	55	64	71.5	ESHF ADP	1.00 57.8	0.94 57	0.87 56	0.78 54	0.73 52	0.69 50	0.65 47	0.65 44	0.61 + 39 +

The values shown in the last column indicate the lowest effective sensible heat factor possible without the use of reheat.

The dehumidified air quantity required is than obtained from :-

$$CFM_{DA} = \frac{ERSH}{1.09 \times (1\text{-}BF) \times (T_{RM} - T_{ADP})} \qquad \textbf{FORMULA 15}$$

Where T_{RM} is the design room dry bulb temperature and T_{ADP} is the apparatus dew point found from the above table.

The outlet temperature difference is obtained from :

$$(T_{RM} - T_{OUTLET\ AIR}) = \frac{RSH}{1.09 \times CFM_{DA}} \qquad \textbf{FORMULA 16}$$

This difference should be less than 20^{0}F for normal ceiling heights and up to 35^{0}F for high ceiling when using ceiling diffusers and up to 25^{0}F when using supply air grilles.

If the temperature difference is too high, cold drafts will be experienced. The supply cfm should then be calculated from

$$Supply\ cfm = \frac{RSH}{1.09 \times temp.\ diff.\ desired} \qquad \textbf{FORMULA 17}$$

The amount of air to be bypassed physically round the coil would then be

$$cfm_{BA} = cfm_{SA} - cfm_{DA} \qquad \textbf{FORMULA 18}$$

XIII. Resulting Entering and Leaving Conditions at Apparatus :

The conditions of the air entering and leaving the coils can be obtained from :-

$$T_{EDB} = T_{RM} + ((cfm_{OA}/cfm_{DA}) \times (T_{OA} - T_{RM})) \qquad \textbf{FORMULA 19}$$

and

$$T_{LDB} = T_{ADP} + (BF \times (T_{EDB} - T_{ADP})) \qquad \textbf{FORMULA 20}$$

The wet bulb temperatures can then be obtained from the psychometric chart showing the process.

Check figures

The values of the items listed at the bottom of the Estimate form should be calculated and checked with table 1. The figures should not vary much, otherwise a check on the calculations may be necessary.

The total air change should not be greater than 20 air change or drafts would occur. Exceptional to this is the design of special rooms such as Operation Theatre, Clean Room and Pathology Laboratory.

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C. **INTERNAL LOADS**

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These are filled in the heat estimate form as shown.

IV. Solar heat gains:

The solar heat gains for the glass area sunlit at 4 pm are obtained from :-

Cooling Load (Btu/hr) = (Peak solar heat gain - Table 4)
x (window area, ft^2)
x (storage factor - Table 5)
x (shade factor - Table 6) ***FORMULA 1***

V. Solar heat gain for walls and roof

These are found using Tables 7, 8 & 9 from the formula :-

Heat gain thro' walls/roof = (Area (ft^2))
x (equivalent temp. diff (^0F) - Table 7,Walls & Table 8,Roofs)
x (transmission coefficient (U) - Table 9) ***FORMULA 2***

VI. Transmission Heat Gains:

The transmission through all glass whether sunlit or in shade is obtained by.

Heat gain thro all glass = (Area (ft^2)) x (U factor - Table 9)
x (outdoor temp - indoor temp) ***FORMULA 3***

Infiltration cannot be accurately assessed easily and is usually not computed but allowed for by taking a factor of safety of 10% in the load calculation for both the room sensible and room latent heat totals.

VII. Internal Heat

The heat gain from lights depends on whether it is fluorescent or incandescent:-

Heat gain = Total light watts x 3.4 (for incandescent) or
= Total light watts x 1.25 x 3.4 (for fluorescent) ***FORMULA 4***

VIII. Outside Air :

The heat gain from outside air is then obtained from :-

O.A Sensible Heat = (ventilation, cfm -Table 11) x (design temp. difference, ^0F (DB))
x (by-pass factor (BF) x 1.09) ***FORMULA 5***

The Effective Room Sensible heat (ERSH) is then totaled up.

ERSH = RSH + OA Heat(bypass) + Supply Duct Heat Gain + S.D Leak Loss + Fan H.P
FORMULA 6

IX. Room Latent heat:

The latent heat gain from people can be obtained from Table 10. Any equipment latent heat is also added. The room latent heat (RLH) can then be totaled and a factor of safety of 10% added.

The latent heat from the ventilation outside air is obtained from:-

O.A. Latent heat = ventilation, cfm
x design specific humidity, gr/lb.
x BF x 0.68 ***FORMULA 7***

The Effective Room Latent Heat (ERLH) is then totalled up.

ERLH = RLH + OAHeat (bypass) + Supply Duct Leakage Loss ***FORMULA 8***

The Effective Room TOTAL Heat (ERTH) is then obtained:

ERTH = ERSH + ERLH ***FORMULA 9***

X. Outdoor air heat:

The remaining heat (less bypass air) from the outside air is computed as set out below, and the Grand Total heat is obtained. This is the actual amount of heat that is physically seen by the coil.

O.A Sensible Heat = ventilation, cfm -Table 11
x design temp. difference, ^{0}F (DB)
x (1-BF) x 1.09. ***FORMULA 10***

O.A. Latent heat = ventilation, cfm
x design specific humidity, gr/lb.
x (1-BF) x 0.68 ***FORMULA 11***

The Grand Total Heat (GTH) is thus obtained by adding this load to the ERTH.

GTH = ERTH + O.A Heat + RA Heat Gain + Ra Leakage + Blow Thru Fan
FORMULA 12

XI Refrigeration Load

The Refrigeration Load is the actual load that is seen by the refrigeration machine.

Refrigeration Load = GTH + Piping Heat Gain + Pump H.P ***FORMULA 13***

<u>XII</u> <u>Dehumidified and Supply air quantity:</u>

The effective sensible heat factor (ESHF) is obtained from :

ESHF = ERSH / ERTH **FORMULA 14**

Knowing the ESHF, the apparatus dew point, ADP, of the coil can be found from table 13.

The dehumidified air quantity required is than obtained from :-

$$CFM_{DA} = \frac{ERSH}{1.09 \times (1-BF) \times (T_{RM} - T_{ADP})} \qquad \textbf{FORMULA 15}$$

Where T_{RM} is the design room dry bulb temperature and T_{ADP} is the apparatus dew point found from the above table.

The outlet temperature difference is obtained from :

$$(T_{RM} - T_{OUTLET\ AIR}) = \frac{RSH}{1.09 \times CFM_{DA}} \qquad \textbf{FORMULA 16}$$

This difference should be less than 20^0F for normal ceiling heights and up to 35^0F for high ceiling when using ceiling diffusers and up to 25^0F when using supply air grilles.

If the temperature difference is too high, cold drafts will be experienced. The supply cfm should then be calculated from

$$Supply\ cfm = \frac{RSH}{1.09 \times temp.\ diff.\ desired} \qquad \textbf{FORMULA 17}$$

The amount of air to be bypassed physically round the coil would then be

$$cfm_{BA} = cfm_{SA} - cfm_{DA} \qquad \textbf{FORMULA 18}$$

XIII. Resulting Entering and Leaving Conditions at Apparatus :

The conditions of the air entering and leaving the coils can be obtained from :-

$$T_{EDB} = T_{RM} + ((cfm_{OA}/cfm_{DA}) \times (T_{OA} - T_{RM}))$$ ***FORMULA 19***

and $$T_{LDB} = T_{ADP} + (BF \times (T_{EDB} - T_{ADP}))$$ ***FORMULA 20***

The wet bulb temperatures can then be obtained from the psychometric chart showing the process.