# Design for Thermal Comfort during Summer & Psychometry Tool for Human Comfort

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**Abstract:** ***Central Air Conditioning is more reliable for easy operation with a lower maintenance cost. The effective design of central air conditioning can provide lower power consumption, capital cost and improve aesthetics of a building. This paper establishes the result of heating load calculation under different climatic conditions by using E-20 for a multi-story building. Heating load items such as people heat gain, lighting heat gain, infiltration and ventilation heat gain and cooling load due to walls and roofs. Using ISHRAE and CARRIER fundamental hand books and here the study of air water vapor mixture (called psychometric) for human comfort in the air conditioning system for the city Hyderabad.***

**Keyword:** Temperature difference, thermal resistance, overall heat transfer coefficient, E-20 performa, ISHRAE Std.

## 1. Introduction

*Heating, ventilation and air conditioning (HVAC*) is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality. HVAC system design is a sub discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer. Refrigeration is sometimes added to the field's abbreviation as *HVAC&R* or *HVACR*, or ventilating is dropped as in *HACR*.

Energy efficiency can be improved more by installing central heating systems which allows more granular application of heat. Zones can be controlled by multiple thermostats. The HVAC industry is a worldwide enterprise, with roles including operation and maintenance, system design and construction, equipment manufacturing and sales, and in education and research. The HVAC industry was historically regulated by the manufacturers of HVAC equipment, but regulating and standards organizations such as *HARDI, ASHRAE, SMACNA, ACCA*, Uniform Mechanical Code, International Mechanical Code, and *AMCA* have been established to support the industry and encourage high standards and achievement.

The starting point in carrying out an estimate both for cooling and heating depends on the exterior climate and interior specified conditions. However, before taking up the heat load calculation, it is necessary to find fresh air requirements for each area in detail, as pressurization is a building environment standards. It establishes the general principles of building environment design. It considers the need to provide a healthy indoor environment for the occupants as well as the need to protect the environment for future generations and promote collaboration among the various parties involved in building environmental design for sustainability. ISO16813 is applicable to new construction and the retrofit of existing buildings.

The building environmental design standard aims to:

- Provide the constraints concerning sustainability issues from the initial stage of the design process, with building and plant life cycle to be considered together with owning and operating costs from the beginning of the design process.
- Assess the proposed design with rational criteria for indoor air quality, thermal comfort, acoustical comfort, visual comfort, energy efficiency and HVAC system controls at every stage of the design process;
- Iterate decisions and evaluations of the design throughout the design process.

## 2. Methodology

- Commercial building plan of 11634.5 square feet
- Calculation of floor, roof, wall and windows areas.
- Calculation of temperature difference ($\Delta T$).
- Thermal resistance of wall, roof and windows.
- E-20 ISHRAE Std.
- Overall heat transfer co – efficient.
- Heating load in BTUH.

## 3. Psychometric condition during summer in Hyderabad

Dry Bulb Temperature- 105$^{o}$F
Relative Humidity-70-80%

As the above conditions for the citizens of Hyderabad is not comfortable. So, the air should be dehumidified and should bring the temperature at 72$^{o}$F-76$^{o}$F, and relative humidity to 50%-60%. For this cooling is required in a space.

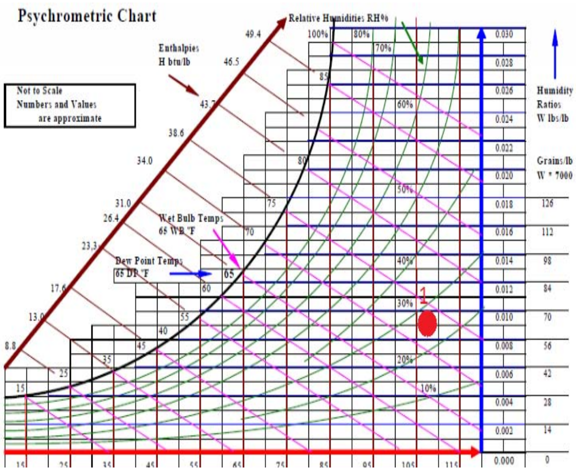



**Figure:** psychometric properties of air during summer

## 4. Design

For estimating cooling loads, one must consider the unsteady state processes, as the peak cooling load occurs during the day time and the outside conditions also vary significantly throughout the day due to solar radiation. In addition, all internal sources add on to the cooling loads and neglecting them would lead to underestimation of the required cooling capacity and the possibility of not being able to maintain the required indoor conditions. Thus, cooling load calculations are inherently more complicated as it involves solving unsteady equations with unsteady boundary conditions and internal heat sources.

### 1) Cooling load calculation

(heat load calculation i.e. heat gain through all the sources)

- Application for summer
- Process is directly to cooling and dehumidification (required in wet summer)
- Cooling and humidification (required in dry summer like in desert areas where there is no water available for evaporation).

**Definition:** The room cooling load is a rate at which the heat must be removed from the room air in order to maintain it at desired temperature and humidity.

### 2) Sources of heat ($Q_{in}$)

**a) External sources**

- Heat gain through glass due to conduction
- Heat gain through glass due to radiation
- Heat gain through skylight (conduction &radiation)
- Heat gain through wall (sensible)
- Heat gain through roof (sensible)
- Heat gain through partition, floor and ceiling due to conduction (sensible heat)
- Heat gain through ventilation due to convection (sensible & latent heat)
- Heat gain through infiltration due to convection (sensible & latent heat)

**b) Internal sources**

- Heat gain through lighting (sensible heat)
- Heat gain through people (sensible and latent heat)
- Heat gain through appliances

1) Business appliances – printer , computer, scanner etc
2) Kitchen appliances - rice cooker, coffee maker etc

**c) City Temperature:-**

Total number of hours in a year : 8760 hours
For 0.4% : 35 hours ~ 1.5 days/ year
DB: 76 F , MWB : 63 F is comfort level for Hyderabad city

### 3) Finding 'U' Value

U=Overall coefficient of heat transfer in BTU/(hr-sft-F)
R=Thermal resistance of material (R>U)

$$\boxed{U=1/\sum R}$$

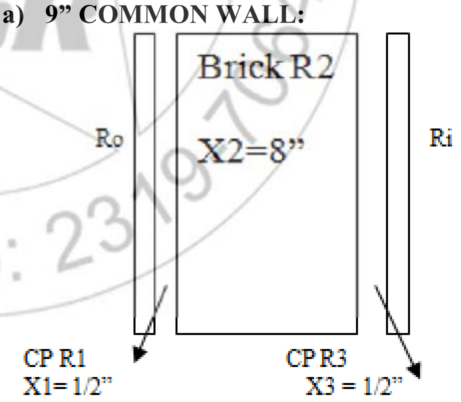
Where, $\sum R=Ri+X1R1+X2R2+X3R3+.......+XnRn+Ro$
Ri = Resistance of inside air film = 0.68 (std value)
Ro = Resistance of outside air film = 0.25 for summer @ 7.5 m/s wind velocity
Ro = 0.17 for winter @ 15 m/s wind velocity
Ra = Resistance of air film gap = 0.91

**Note:**

1) Ro may vary as per location
2) Ra is standard value irrespective of thickness of the air gap.
3) R1,R2,R3...Rn is the resistance of the material
4) X= thickness of material
5) value of R for different material are taken from resistance table of data book.

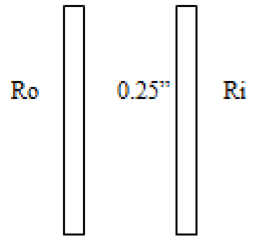
### 4) 'U' Value of Building

**a) 9" COMMON WALL:**



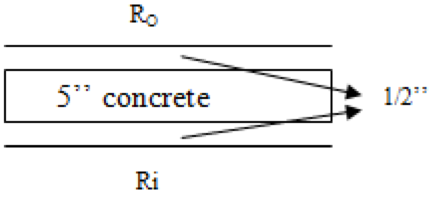

$$\sum R = R_O + X_1R_1+X_2R_2+X_3R_3+R_i$$
$$= 0.25+(0.5x0.12)+(8x0.2)+(0.5x0.12)+0.68$$
$$=2.65$$
$$U = 1/\sum R = 1/2.65 = 0.37 \text{ Btu/(hr-ft}^2\text{-F)}$$

**b) 0.25" GLASS:-**




$\sum R = 0.25+(0.25x1.25)+0.68$
$= 1.24$
$U = 1/\sum R$
$= 1/1.24 = 0.8$ Btu/(hr-ft$^2$-F)

**c) 6" ROOF**




$\sum R = 0.25+(0.5x0.12)+(5x0.08)+(0.5x0.12)+0.68$
$= 1.45$
$U = 1/\sum R$
$= 1/1.45 = 0.69$ Btu/(hr-ft$^2$-F)

- **Cooling Load Calculation of A Spaces**

  - **<u>Input File / Data: (ISHRAE Std.)</u>**

1. Location – Hyderabad
2. Space - C.E.O. Chamber
3. Number of people – 7
4. Bottom of slab (or) section height 9'
5. Outside dry bulb temperature – 105F
6. Inside required dry bulb temperature – 76 F
7. Glass thickness – 0.25"
8. Glass type – ordinary dark color
9. Latitude – 17.45 N
10. Longitude – 78.47 E
11. Elevation – 1788 ft
12. Number of walls – 2 (S,W)
13. Number of partitions – 0
14. Number of windows – 2 (S,W)
15. Number of doors – 0

- **Areas**

1) **Orientation : South**
   a. Wall area : 13'x12' = 156 ft$^2$
   b. Glass area : 6'x12' = 74 ft$^2$
2) **Orientition : West**
   a. Wall area : 10'x12' = 120 ft$^2$
   b. Glass area : 9'x12' = 108 ft$^2$
3) **Roof Area :** 18'-6" X 20' = 370 Ft$^2$

- **Heat Gain Through External Sources**

**1. Heat Gain through Glass**

a. Through Conduction :

$\boxed{Q = U \text{ x } A \text{ x } \Delta T}$

Where, Q = Total sensible heat gain
A= Area of glass in sq.ft
$\Delta T$= Temperature difference between outside and inside.

Here , U = 0.8
A= 74+108=180 ft$^2$
$\Delta T$= 105-76=29 F

As a result,

$\boxed{Q = 0.8 \text{ x } 182 \text{ x } 29 = 4222 \text{ Btu/hr}}$

b. Through Radiation :

$\boxed{Q = U_R \text{ x } A \text{ x } \Delta H}$

Where, $U_R$ = solar factor or shade coefficient (depend on the type of glass; light, medium or dark)
$U_R$ = 0.75 [Data book : Table no. 16]

- FOR SOUTH WINDOW

$U_R$ = 0.75
A = 74 ft$^2$

<u>$\Delta H$ requirements :</u>
1) Latitude of the city : 17.49 N
2) Month in which the city faces maximum temperature : May
3) Timings : 8am or 4pm

**Using the above parameters from data book table 15 ; for '20$^o$ North latitude' in the month of 'May' at8am or 4pm,**
$\Delta H$ = 12 Btu/hr-ft$^2$

Thus,

$\boxed{Q = 0.75 \text{ x } 74 \text{ x } 12 = 666 \text{ Btu/hr}}$

- **FOR WEST WINDOW**

$\Delta H$ = 163 Btu/hr-ft$^2$
A = 108 ft$^2$

Therefore,

$\boxed{Q = 0.75 \text{ x } 108 \text{ x } 163 = 13203 \text{ Btu/hr}}$

- **Heat Gain Through Wall**

$\boxed{Q = U \text{ x } A \text{ x } \Delta T \text{ Btu/hr}}$

a) FOR SOUTH WALL
   U = 0.37 Btu/hr-ft$^2$-F
   A = 156 ft$^2$
   $\Delta T$ = Equivalent temperature + correction factor

- **Equivalent temperature requirements :**

1) Weight or thickness of the wall :100 lb/sft or 9"
2) Timing : midday + 2 hours(storage effect)

For Hyderabad, midday is found at 2pm.
Therefore, the timing = 2+2 = 4pm

Using above parameter,

**From [Data book, table – 19]**

We get,
Equivalent temperature = **16 F**

- **Correction factor requirements :**

1) Range = Maximum outside DB – Minimum outside DB
= 10.5°C ( from ASHRAE Climatic Data Software) shown below
= 18.9°F ~ 19°F

2) Temperature Difference = $T_o - T_i$
= 105 – 76
= 29°F

Using above parameters,
From [Data Book, Table – 20A]
We get,

Correction factor = 14F
Therefore, ΔT = 16+14 = 30 F
As a result,

$$\boxed{Q = 0.37 \times 156 \times 30 = 1731.6 \text{ Btu/hr}}$$

**b) FOR WEST WALL**
U = 0.37 Btu/hr-ft$^2$-F
A = 120 ft$^2$
ΔT = Equivalent temperature + Correction factor
= 12+14 = 26 F

Thus,

$$\boxed{Q = 0.37 \times 120 \times 26 = 1154.4 \text{ Btu/hr}}$$

- **Heat Gain Through Roof**

Thickness of the roof = 6"

$$\boxed{Q = U \times A \times \Delta T \text{ Btu/hr}}$$

Where,
U = 0.1 Btu/hr-ft$^2$-F
A = 370 ft$^2$
ΔT = Equivalent temperature + correction factor
(Correction factor = 14)

- **Equivalent temperature requirements :**

1) Weight of the roof : 40 lb/sft
2) Timing: midday + 2 hours
2pm + 2 = 4pm

Using above parameters, we get, from [Data Book, table – 20]
we get,
Equivalent temperature = 38 F
ΔT = Equivalent temperature + correction factor
ΔT = 38 + 14 = 52 F
Thus,

$$\boxed{Q = 0.1 \times 370 \times 52 = 1924 \text{ Btu/hr}}$$

- **Heat Gain Through Ventilation**

**1. Sensible Heat Gain :**

$$\boxed{Q_s = 1.08 \times CFM \times \Delta T \text{ Btu/hr}}$$

Where,
1.08 = specific heat of air
CFM = Ventilation flow rate in cubic feet per minute
ΔT = $T_o - T_i$ = 105 – 76 = 29 F

To find CFM we use two methods
1) Person method
2) Area method

- **Person method :**

CFM = number of people x CFM per person
[Data Book, Table – 45]
we get,
CFM per person = 25
Therefore according to the people method

$$\boxed{CFM = 7 \times 25 = 175}$$

- **Area method:**

CFM = Floor area x CFM per sq.ft
[Data Book, Table – 45] from above table, we get,
CFM per sq.ft = 0.25
There according to the area method

$$\boxed{CFM = 370 \times 0.25 = 92.5}$$

We should select the maximum value among two.

Thus,

$$\boxed{Q_s = 1.08 \times 175 \times 29 = 5481}$$

**2. Latent heat gain:**

$$\boxed{Q_L = 0.68 \times CFM \times \Delta W \text{ Btu/hr}}$$

Where,
0.68 = specific heat of moister
CFM = 175
ΔW = $W_o - W_i$ = Humidity Ratio
Now considering the psychometric chart, we have the following details,
DB = 105 F & WB = 72 F
Therefore, $W_o$ =65 gain/lb
And also, DB = 76 F and RH = 50% which provides the details for $W_i$ = 67 gain/lb

Therefore,
$Q_L = 0.68 \times CFM \times (W_o - W_i)$

$$\boxed{Q_L = 0.68 \times 175 \times (-2) = -238 \text{ Btu/hr}}$$

Note : the –ve sign indicates loss in latent heat because of decrease in humidity.

- **Heat Gain Through Infiltration**

The infiltration occurs when the outside air enters through the opening due to the wind pressure. Infiltration of air through crack around windows and through area from doors results in both sensible and latent heat gained to rooms.

**1. Sensible heat gain :**

$Q_s = 1.08 \text{ x CFM x } \Delta T$ Btu/hr

- **Crack Method to find CFM for infiltration**

The crack method assumes that a reasonably accurate estimate of the rate of infiltration perfect of crack opening.

- **For windows**

CFM = crack in ft(Perimeter) x CFM/ft
Where perimeter of glass = (6x2)+(12x2)+(9x2)+(12x2) = 78 ft
CFM = 78 x 0.37 = 28.86

- **For doors**

CFM = crack in $ft^2$(Area) x CFM/$ft^2$
Since there is no exposed door in this space so door CFM would not be considered, if there is door CFM then total CFM will be sum of the windows and doors CFM.
now the total CFM is

CFM = 78 x 0.37 = 28.86

$Q_s = 1.08 \text{ x } 28.86 \text{ x } 29 = 903.86$ Btu/hr

**2. Latent Heat Gain :**

$Q_L = 0.68 \text{ x CFM x } \Delta W$ Btu/hr

$Q_L = 0.68 \text{ x } 28.86 \text{ x } (-2) = -39.24$ Btu/hr

- **Heat Gain Through Internal Sources**

**1) Heat Gain Through Lighting :**

Q = W X B.F X 3.4 Btu/hr

Where,
W = Wattage
B.F = ballast factor
1 W= 3.4 Bt/hr

Ballast factor depends on the type of light, since we are using fluorescent light so the ballast factor is 1.25.
Using the thumb rule, for office application, we have
W = 2 x floor area = 2 x 370 = 740 watts

As a result,

Q = 740 x 1.25 x 3.4 = 3145 Btu/hr

**2) Heat Gain Through People :**

- **Sensible Heat Gain:**

$Q_s = q_s \text{ x n}$ Btu/hr

Where,
$Q_s$ = Total sensible heat gain
$q_s$ = sensible heat gain per person
n = number of people = 7
[Data Book, Table – 48]

From the above, for office worker at room temperature 75 F,
$q_s$ = 245 Btu/hr
therefore,

$Q_s = 245 \text{ x } 7 = 1715$ Btu/hr

- **Latent Heat Gain :**

$Q_L = q_l \text{x n}$ Btu/hr
=205 x 7 Btu/hr

$Q_L = 205 \text{ x } 7 = 1435$ Btu/hr

Note:

- The rate of heat gained from people depends upon the physical activity.
- As the physical activity increases, the latent heat increases when compare with sensible heat.

**3) Heat Gain Through Appliances**

Q = W x 3.4 Btu/hr

Where, W = Wattage
WATTAGE PER APPLIANCE:

**1. Wattage for computer**

Number of computer : 5
CPU : 49 Watts
Monitor : 28 Watts
Total : 49 + 28 = 77 watts
Therefore, as per requirement,
5 x 77 = 385 watts

**2. Wattage for printer**

Number of printer : 01
Wattage : 130 watts
Therefore, as per requirement,
1 x 130 = 130 watts.

Total Wattage Acquired = 385 + 130 = 515 Watts.

Heat gain through appliances:
Q = W x 3.4 Btu/hr

Q = 515 x 3.4 = 1751 Btu/hr

| *S.No* | *Sources* | *Sensible heat gain (Btu/hr)* | *Latent heat gain (Btu/hr)* |
|---|---|---|---|
| 01 | Glass | 18091 | |
| 02 | Walls | 2886 | |
| 03 | Roof | 1924 | |
| 04 | Ventilation | 5481 | -238 |
| 05 | Infiltration | 904 | -39 |
| 06 | Lighting | 3145 | |
| 07 | People | 1715 | 1407 |
| 08 | Appliances | 1751 | |
| 09 | Sub Total | 35897 | 1130 |
| 10 | Safety factor | 10% = 3589.7 | 5% = 56.5 |
| 11 | Total | 39487 | 1187 |

**Grand Total =** total sensible heat gained + total latent heat gained

= 39487 + 1187

= 40674 Btu/hr

- Converting Btu/hr into ton of refrigeration (T.R)

12000 Btu/hr = 1 T.R

Therefore,

Ton of refrigeration = 40674/12000 = 3.3 ~ 3.5 T.R

**PERFORMA OF E-20 OF A SPACE**

**COOLING LOAD CALCULATIONS**

**20 N LATITUTE** 0 0

| PROJECT DETAILS | | | DESIGN CONDITIONS - HYDERABAD | | | | | |
|---|---|---|---|---|---|---|---|---|
| Project Name: | MINI PROJECT | Date: | | DBT ( F) | WBT ( F) | | RH (%) | HR (Gr/lb) |
| Space: | ROOM : 101 | | Outdoor Design Conditions: | 105 | 72 | | XX | 65 |
| Space Area: | 370 | (Sqft) | Indoor Design Conditions: | 76 | XX | | 50 | 67 |
| Total Height | 12 | (Ft) | Differrence: | 29 | xx | | xx | -2 |
| Volume | 4440 | Cu.ft. | | | | | | |

| ITEM | | AREA (Sqft) | | Sun Gain / ΔT / CLTD | U-FACTOR (Btu/ F.hr.Ft²) | Total (Btu/hr) |
|---|---|---|---|---|---|---|
| **ROOM SENSIBLE HEAT** | | | | | | |
| **Solar Gain - Glass** | | | | | | |
| GLASS | N | | Sqft | 23 F | 0.75 | 0 |
| GLASS | NE | | Sqft | 12 F | 0.75 | 0 |
| GLASS | E | | Sqft | 163 F | 0.75 | 0 |
| GLASS | SE | | Sqft | 12 F | 0.75 | 0 |
| GLASS | S | 74 | Sqft | 12 F | 0.75 | 666 |
| GLASS | SW | | Sqft | 85 F | 0.75 | 0 |
| GLASS | W | 108 | Sqft | 163 F | 0.75 | 13203 |
| GLASS | NW | | Sqft | 138 F | 0.75 | 0 |
| SKYLIGHT | | | Sqft | 251 F | 1 | 0 |
| **Solar & Trans Gain Through - Walls & Roof** | | | | | | |
| WALL | N | | Sqft | 18 | 0.37 | 0 |
| WALL | NE | | Sqft | 37 | 0.37 | 0 |
| WALL | E | | Sqft | 37 | 0.37 | 0 |
| WALL | SE | | Sqft | 43 | 0.37 | 0 |
| WALL | S | 156 | Sqft | 30 | 0.37 | 1732 |
| WALL | SW | | Sqft | 57 | 0.37 | 0 |
| WALL | W | 120 | Sqft | 26 | 0.37 | 1154 |
| WALL | NW/door | 0 | Sqft | 54 | 0.34 | 0 |
| ROOF | | 370 | Sqft | 52 | 0.1 | 1924 |
| **Trans. Gain - Except walls & Roof** | | | | | | |
| All Glass | | 182 | Sqft | 29 | 0.8 | 4222.4 |
| Partition-01 | | | Sqft | 24 | 0.48 | 0 |
| SKYLIGHT | | | Sqft | 29 | 0.45 | 0 |
| Partition-02 | | | Sqft | 24 | 0.48 | 0 |
| Ceiling | | | Sqft | 24 | 0.52 | 0 |
| Floor | | | Sqft | 24 | 0.52 | 0 |
| **Outside Air** | | | | | | |
| Infilteration | | 29 | | 29 | 1.08 | 908 |
| Ventilation | | 175 | cfm | 29 | 1.08 | 5481 |
| **Internal Heat** | | | | | | |
| Peoples | | 7 | No.s | 245 | | 1715 |
| Lights | | 370 | Sqft | 3.4 | 2 | 2516 |
| Equipments | | 515 | w | 3.4 | 1 | 1751 |
| **Effective Room Sensible Subtotal** | | | | | Subtotal | 35272.4 |
| **Safety Factor** | | | | | 10% | 3527.24 |
| **Effective Room Sensible Heat ( SBH)** | | | | | Total | 38799.64 |
| **ROOM LATENT HEAT** | | | | | | |
| Ventilation | | 175 | cfm | -2 | 0.68 | -238 |
| Infilteration | | 29 | | -2 | 0.68 | -39.44 |
| People | | 7 | No.s | 205 | 1 | 1435 |
| APPLIANCES | | | | 0 | | 0 |
| **Effective Room Latent Subtotal** | | | | | Subtotal | 1157.56 |
| **Safety Factor** | | | | | 5% | 57.878 |
| **Effective Room Latent Heat** | | | | | Total | 1215.438 |
| **EFFECTIVE ROOM TOTAL HEAT** | | | | | Total | 40015.078 |
| **OUTSIDE AIR HEAT (VENTILATION)** | | | | | | |
| SENSIBLE | 175 | cfm | 29 | | 0.99 | 5024 |
| LATENT | 175 | cfm | -2 | | 0.612 | -214 |
| Grand Total Heat Subtotal | | | | | Subtotal | 44825.078 |
| Safety Factor | | | | | 0% | 0 |
| **GRAND TOTAL HEAT** | | | | | Total | 44825.078 |

| | | | | |
|---|---|---|---|---|
| Daily Range ( F) : | | | | 19 |
| Correction for Temperature Difference ( F) : | | | | 14 |
| By Pass Factor ( BF ) : | | | | 0.1 |
| Contact Factor ( CF ) : | | | | 0.9 |
| Occupancy ( No.s ) : | | | | 4 |
| Light Load ( W/Sqft ) : | | | | 2 |
| Equipment Load ( w ) : | | | | 1838 |
| **OUTSIDE AIR** | | | | |
| CFM Per Person | 25 | | 7 | 175 |
| AREA IN SFT | | 370 | 0.25 | 92.5 |
| Selected Ventilation (Cfm) | | | | 175 |
| **EFF. ROOM SEN. HEAT FACTOR** | | | | |
| ERSH | 38799.64 | | | 0.9696255 |
| ERTH | 40015.078 | | | |
| **Apparatus Dew Point ( ADP )** | | | | |
| Indicated ADP ( F ) | | | | 55 |
| Selected ADP ( F ) | | | | 55 |
| **Dehumidified Air Rise** | | | | |
| CFX( Trm - ADP ) = | | | | 18.9 |
| **DEHUMIDIFIED CFM** | | | | |
| Room Sensble | 38799.64 | | | 1866.26455 |
| Demudified RiseXSP. HEAT | 20.79 | | | |
| TOTAL CFM | | | | 2204.525 |
| **TONNES OF REFRIGERATION** | | | | 3.735423167 |
| **DEHUMIDIFIED CFM PER SQFT** | | | | 5.043958244 |
| **SQFT PER TONNAGE OF REF.** | | | | 99.05169602 |
| U- Values from Architectural/ Structural Drawings | | | **FINAL RESULT** | |
| Glass Solar Gain Coef. | 0.75 | | **TMBH** | 44.825078 |
| Glass Trans Gain Coef. | 0.8 | | **SMBH** | 43.82364 |
| External Wall | 0.37 | | **CFM** | 2204.525 |
| | | | **FA (cfm)** | 175 |
| Roof | 0.69 | | | |
| Ceiling / Floor | 0.52 | | | |
| Partition | 0.48 | | | |
| DOOR | 0.34 | | | |

**Notes :**

The U-Values must not exceed Municipality Values.

Roof area should be added if roof is exposed to sun.

1MBH=1000 BTU/HR

I THERM=100 MBH

**PERFORMA OF E-20 OF OVERALL PROJECT**

**COOLING LOAD CALCULATIONS**

**20 N LATITUTE**

| PROJECT DETAILS | | | |
|---|---|---|---|
| **Project Name:** | MINI PROJECT | **Date:** | |
| **Space:** | OVERALL BUILDING | | |
| **Space Area:** | 11634.5 | | (Sqft) |
| **Total Height** | 12 | | (Ft) |
| **Volume** | 139614 | | Cu.ft. |

| DESIGN CONDITIONS - HYDERABAD | DBT ( F) | WBT ( F) | | RH (%) | HR (Gr/lb) |
|---|---|---|---|---|---|
| **Outdoor Design Conditions:** | 105 | 72 | | XX | 65 |
| **Indoor Design Conditions:** | 76 | XX | | 50 | 67 |
| **Differrence:** | 29 | xx | | xx | -2 |

| ITEM | | AREA (Sqft) | | Sun Gain / ΔT / CLTD | U-FACTOR (Btu/ F.hr.Ft²) | Total (Btu/hr) |
|---|---|---|---|---|---|---|
| **ROOM SENSIBLE HEAT** | | | | | | |
| **Solar Gain - Glass** | | | | | | |
| GLASS | N | 633 | Sqft | 23 F | 0.75 | 10919 |
| GLASS | NE | | Sqft | 12 F | 0.75 | 0 |
| GLASS | E | 1056 | Sqft | 163 F | 0.75 | 129096 |
| GLASS | SE | | Sqft | 12 F | 0.75 | 0 |
| GLASS | S | 674 | Sqft | 12 F | 0.75 | 6066 |
| GLASS | SW | | Sqft | 85 F | 0.75 | 0 |
| GLASS | W | 375 | Sqft | 163 F | 0.75 | 45844 |
| GLASS | NW | | Sqft | 138 F | 0.75 | 0 |
| SKYLIGHT | | | Sqft | 251 F | 1 | 0 |
| **Solar & Trans Gain Through - Walls & Roof** | | | | | | |
| WALL | N | 465 | Sqft | 18 | 0.37 | 3097 |
| WALL | NE | | Sqft | 37 | 0.37 | 0 |
| WALL | E | 462 | Sqft | 32 | 0.37 | 5470 |
| WALL | SE | | Sqft | 43 | 0.37 | 0 |
| WALL | S | 444 | Sqft | 30 | 0.37 | 4928 |
| WALL | SW | | Sqft | 57 | 0.37 | 0 |
| WALL | W | 880 | Sqft | 26 | 0.37 | 8466 |
| WALL | NW/door | 0 | Sqft | 54 | 0.34 | 0 |
| ROOF | | 11634.5 | Sqft | 49 | 0.1 | 57009 |
| **Trans. Gain - Except walls & Roof** | | | | | | |
| All Glass | | 2739 | Sqft | 29 | 0.8 | 63544.8 |
| Partition-01 | | | Sqft | 24 | 0.48 | 0 |
| SKYLIGHT | | | Sqft | 29 | 0.45 | 0 |
| Partition-02 | | | Sqft | 24 | 0.48 | 0 |
| Ceiling | | | Sqft | 24 | 0.52 | 0 |
| Floor | | | Sqft | 24 | 0.52 | 0 |
| **Outside Air** | | | | | | |
| Infilteration | | 310 | | 29 | 1.08 | 9709 |
| Ventilation | | 2908.625 | cfm | 29 | 1.08 | 91098 |
| **Internal Heat** | | | | | | |
| Peoples | | 246 | No.s | 245 | | 60270 |
| Lights | | 11634.5 | Sqft | 3.4 | 2 | 79115 |
| Equipments | | 21710 | w | 3.4 | 1 | 73814 |
| **Effective Room Sensible Subtotal** | | | | | Subtotal | 648445.8 |
| **Safety Factor** | | | | | 10% | 64844.58 |
| **Effective Room Sensible Heat ( SBH)** | | | | | Total | 713290.38 |
| **ROOM LATENT HEAT** | | | | | | |
| Ventilation | | 2908.625 | cfm | -2 | 0.068 | -396 |
| Infilteration | | 310 | | -2 | 0.68 | -421.6 |
| People | | 246 | No.s | 205 | 1 | 50430 |
| APPLIANCES | | | | 1540 | | 1540 |
| **Effective Room Latent Subtotal** | | | | | Subtotal | 51152.4 |
| **Safety Factor** | | | | | 5% | 2557.62 |
| **Effective Room Latent Heat** | | | | | Total | 53710.02 |
| **EFFECTIVE ROOM TOTAL HEAT** | | | | | Total | 767000.4 |
| **OUTSIDE AIR HEAT (VENTILATION)** | | | | | | |
| SENSIBLE | 2908.625 | cfm | 29 | | 0.99 | 83507 |
| LATENT | 2908.625 | cfm | -2 | | 0.612 | -3560 |
| Grand Total Heat Subtotal | | | | | Subtotal | 846947.4 |
| Safety Factor | | | | | 0% | 0 |
| **GRAND TOTAL HEAT** | | | | | Total | 846947.4 |

| | | | | |
|---|---|---|---|---|
| Daily Range ( F) : | | | | 19 |
| Correction for Temperature Difference ( F) : | | | | 14 |
| By Pass Factor ( BF ) : | | | | 0.1 |
| Contact Factor ( CF ) : | | | | 0.9 |
| Occupancy ( No.s ) : | | | | 4 |
| Light Load ( W/Sqft ) : | | | | 2 |
| Equipment Load ( w ) : | | | | 1838 |
| **OUTSIDE AIR** | | | | |
| CFM Per Person | 25 | | 246 | 6150 |
| AREA IN SFT | | 11634.5 | 0.25 | 2908.625 |
| Selected Ventilation (Cfm) | | | | 2908.625 |
| **EFF. ROOM SEN. HEAT FACTOR** | | | | |
| ERSH | 713290.38 | | | 0.929973935 |
| ERTH | 767000.4 | | | |
| **Apparatus Dew Point ( ADP )** | | | | |
| Indicated ADP ( F ) | | | | 55 |
| Selected ADP ( F ) | | | | 55 |
| **Dehumidified Air Rise** | | | | |
| CFX( Trm - ADP ) = | | | | 18.9 |
| **DEHUMIDIFIED CFM** | | | | |
| Room Sensble | 713290.38 | | | 34309.30159 |
| Demudified RiseXSP. HEAT | 20.79 | | | |
| TOTAL CFM | | | | 40527.8625 |
| **TONNES OF REFRIGERATION** | | | | 70.57895 |
| **DEHUMIDIFIED CFM PER SQ FT** | | | | 2.948927894 |
| **SQ FT PER TONNAGE OF REF.** | | | | 164.8437672 |

| U- Values from Architectural/ Structural Drawings | |
|---|---|
| Glass Solar Gain Coef. | 0.75 |
| Glass Trans Gain Coef. | 0.8 |
| External Wall | 0.37 |
| Roof | 0.69 |
| Ceiling / Floor | 0.52 |
| Partition | 0.48 |
| DOOR | 0.34 |

| **FINAL RESULT** | |
|---|---|
| **TMBH** | 846.9474 |
| **SMBH** | 796.79738 |
| **CFM** | 40527.8625 |
| **FA (cfm)** | 2908.625 |

**Notes :**

The U-Values must not exceed Municipality Values.
Roof area should be added if roof is exposed to sun.

1MBH=1000 BTU/HR
I THERM=100 MBH

The heating load calculation of the project is calculated
The BTU per hour for space 101 is 44825.
12000 BTU per hour is equal to 1ton of refrigeration.
Therefore, the calculated tonnage for the room no. 101 is (44825)/12000 = 3.51Tr

The BTU per hour for overall space is 846947.
12000 BTU per hour is equal to 1ton of refrigeration
Therefore, the calculated tonnage for the overall space is (846947)/12000 = 70.57tr

Room sensible heat – 713290 BTUH
Room latent heat – 53710 BTUH
Room total heat – 767000 BTUH
Grand total Heat – 846947 BTUH

The Psychometric condition of a space after cooling load calculation is done.

## 5. Conclusion

Using E-20 as per ISHRAE standards we provide effective comfort solution for the commercial building during summer, for that building heat absorption to be 846000BTUH.
Building Infiltration – 9288 BTUH

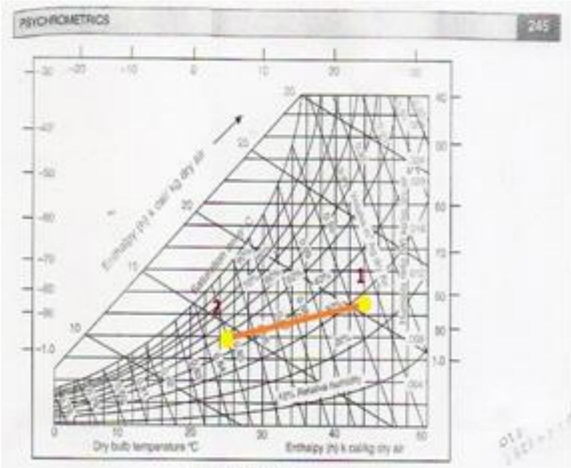



Fig. 9.5. Carrier chart.

At point 1
Dry bulb temperature is 105 F
Wet bulb temperature is 72 F

At point 2
Dry bulb temperature is 76 F
Relative humidity is 50%

## References

[1] Milne, M, et al., Climate Consultant 40 Develops Design Guidelines for Each Unique Climate,” proceedings of the American Solar Society. Buffalo New York, 2009.
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[3] Givoni, B., Climate Considerations in building and Urban Design. John Wiley and Sons, New York, 1998.
[4] Driscoll, M. P., Psychology of learning for Instruction. Pearson Education, Florida State University, 2005.