# Contents

Chapter One

# Introduction

## 1.1. Air conditioning

Air conditioning has been defined as the simultaneous control of temperature, humidity, air movement, and the quality of air in a given space. Air conditioning is able to provide widely varying atmospheric conditions from those necessary for drying processes to those necessary for high humidity process application. Air conditioning can maintain any atmospheric condition regardless of variations in outdoor weather. The range of temperatures and humidifies used in comfort air conditioning is a small band. The location of this band on the psychometric chart depends on the season of the year.

## 1.2. Classifications of the air conditioning systems

There are several different ways of classifying air conditioning systems.

### 1.2.1. classification based on major function:

***a) Comfort air conditioning systems:***

Their purpose is to create atmospheric conditions conductive to human health, comfort, and efficiency. Air conditioning systems in homes, offices, restaurants, theaters, hospitals, schools and mosques are of the air round year air conditioning system.

***b) Industrial air conditioning systems:***

The purpose of these systems is to control atmospheric conditions primarily for the proper conduct of research and manufacturing operations.

Manufacturing tolerances in the electronics, space and computer industries and in all high-speed automated manufacturing are such as to require absolute control of temperature, moisture and air purity. Air conditioning systems in paper mills, textile mills, candy factories, and printing or photo processing plants are also essential for these industries. Some of these industrial systems incidentally serve human comfort, but some do not. It should be noted that the major emphasis in this project will be on comfort air conditioning systems.

### 1.2.2. Classification based on season of the year:

***a) Winter air conditioning systems:***

These systems, when properly designed and installed to maintain indoor atmospheric conditions for winter comfort, namely, temperature, humidity, air purity, and air movement The major problems of winter air conditioning are to heat the air and bring the moisture contend (humidity) up to an acceptable level, Winter heating is accomplished by distributing heated air to spaces by ductwork or by distributing heat in the space by fin-tube, radiation or by convectors or fan-coils. Heat is supplied by furnaces or boilers fired with gas, oil or coal, or by electrical resistance heaters. Humidification of the heated space is often necessary to attain comfortable condition. Humidifier may be of the simple pan type or spray type. Electrical heating by resistance elements, infrared radiation heat or with heat pumps is finding increasing application in residential, commercials, and industrial fields.

### *b) Summer air condoning systems:*

These systems control all the four atmospheric conditions for summer comfort. The major problems are to cool the air to remove excess moisture from it. Cooling is ordinarily accomplished by mechanical refrigeration. Removed of the moisture “dehumidification” is accomplished as condensation of water vapor in the air occurs on cold coil surfaces.

### *c) Year-round air conditioning systems:*

These systems are composed of heating and coiling equipments with automatic controls and associated components to produce the four atmospheric conditions for human comfort at all times of the year.

### 1.2.3. Classification based on equipment arrangement :

### *a) Central station system:*

This type of system is one in which various apparatus components are selected by the designer, purchased from manufacturer, and erected on the job, usually in a central equipment room or mechanical room. The entire process of air conditioning is done in the central station or mechanical room, and the conditioned air is delivered to various rooms of the building through sheet-metal ducts, some large-capacity systems are of this type, but these systems are not well adapted to hotel and office-building installations where individual room control is essential. In recent years this type of system is declining in favor, being largely replaced by the (combination system). The central air conditioning system is generally used for the load above 25 tons of refrigeration and 2500 (m3/min) of conditioned air.

**The central plants require the following components:**

1. Cooling and dehumidifying coil.
2. Heating coils.
3. Blower with motor.
4. Sprays for cooling dehumidifying or washing.
5. Air cleaning equipment.
6. Control devices.

**Advantages:**

1. The capital cost and running cost are less per unit refrigeration.
2. It can be located away from the air conditioned places.

3. Noise and vibration troubles are less.
4. Better accessibility for maintenance.

### *b) Unitary Air Conditioning Systems:*

The last five years have seen, and most further predictions to, a continually increasing use of unitary systems. These systems make use of air conditioners, which are completely factory assembled or packaged. Single air conditioners may serve various areas. Many of the current unitary or packaged units are designed to be located outside the conditioned space such as on the rooftop or on the ground in order to minimize lost floor space.

***The unitary air conditioned systems are classified as follows:***

i. **Remote air conditioning unit systems :**

All the components of the system are assembled in the factory. The remote air conditioning unit separated from the refrigeration condensing unit and heating plant.

ii. **Self contained air conditioning unit:**

All the components including condensing and heating unit are assembled in one closure.

iii. **Unitary system for multistory building:**

This is a combination of unitary and central air conditioning system.

**Advantages:**

1. Zoning or extensive duct work is eliminated.
2. Unitary system can meet requirements of room separately.
3. Individual room temperature control is a specific feature of this system.

*iv.* **District air conditioning system:**

District ceiling systems are not as popular as district heating systems very recently the use of district cooling system is economically justified. In general the larger the plant, the greater is the advantage.

**Advantages:**

1. Initial cost is less.
2. Less operating cost.
3. Noise of machines, cooling towers and pumps are completely eliminated.

**Disadvantages:**

1. The protection of underground pipes against corrosion and electrolytic action is necessary.
2. The pipe cost is higher.
3. The heat loss increases with an increase in pipe length.

4. Chilled water pumping cost is higher.

***c) combination Systems:***

This type of system combines the features of central-station and unitary systems. The heating and refrigeration equipment is in a central mechanical room. Heat energy is supplied in pipes to several unit air conditioners in the form of steam or hot water .Chilled water from the central refrigerating equipment is also piped to the air conditioners.

An air conditioning unit may be installed in and serve a single room or it may have its own equipment room and serve an enter zone. Heating and cooling units composed of fans, coils, filters, dampers, and controls and known as fan-coil air handlers, may be provide year-round air conditioning in rooms or zones, and fin-tube radiation and convectors may supply additional heating. The performance of the air conditioning unit is governed by a thermostat in each room it serves. The tables 1 and II below show the different methods of applications, related machines and apparatus.

## Table (1-1) central air conditioning systems

| Methods of Air Conditioning | Example of Application | Product |
|---|---|---|
| Single Duct System | Small building and factories | Air conditioners to Assembled on Site |
| Duel Duct System | High-Class large Building | Air Conditioners to be Assembled on Site |
| Multi-Zone System | Medium and Small Building | Air Handling units, and Air Conditioners to be Assembled on |
| Individual floor unit | Extremely forge building | Air Handling Unit. Etc |
| Fan Coil unit System | Individual room of Hospitals, window Side | Fan Coil unites |
| induction Unit System | of general Building | Induction unit |

**Types available in the markets:**

***a) Room coolers:***

These units are in small capacity ranging from (0.25-1.5) tons and do not in cooperated the heating facilities.

***b) Store coolers:***

These are self containing units fixed in decorative cabinets and installed directly on the sale's floor of the store.

***c) A year round air conditioning unit:***

This is used for both heating & cooling with the help of heat pumps.

## 1.3. Comfort Air Conditioning

### 1.3.1. Factors affecting comfort air conditioning :

***a) Air movement:***

Air should circulate freely in the room to which it is delivered. This will allow it to absorb heat and moisture uniformly throughout the entire room during the cooling cycle and to deliver heat and moisture uniformly during the heating cycle.

***b) Air cleaning:***

Air should be cleaned - that is, freed of dust and soot particles and odor. Air cleanliness is important from the stand point of human health. Also, the walls and ceilings of rooms should be supplied with filtered air.

***c) Humidity of air:***

It means the change of moisture contents of air during summer or winter in order to produce comfortable and healthy conditions.

***d) Temperature of air:***

The control of temperature means the maintenance of any desired temperature within an enclosed, space even though die Temperature of the outside air is above or below die desired room temperature.

Chapter Two

# Load Calculations

## 2.1 Introduction

The first step in the designing or selection of the air conditioning system is to estimate the cooling and / or heating loads of the conditioned space. The ultimate objective of this step is the appropriate sizing of the cooling and / or heating system.

This involves the sizing or rating of individual space or room.

Some references give approximate load figures or ranges for different air conditioned spaces in the form of load per unit floor area , per room or per person ,but this figures cant be relied upon under all conditions and are not intended to replace detailed and rigorous load estimations .

## 2.2 Different heat sources for air conditioning systems

It is necessary for air conditioning designers to know about the heat sources and their nature before taking the job of Air conditioning systems. The nature of heat sources which contribute heat to air conditioning systems used for summer is discussed in this chapter.

The Air conditioning systems used have to carry out two types of loads ,which can be classified into many types of loads according to type of heat and the place which it produced .

Cooling load calculations deal with heat gains of two kinds according to their nature:

i. ***Sensible heat :***

Which, as it flows into or produced in a space, will tend to cause a temperature rise in the space.

ii. ***latent heat :***

In the form of moisture, which although it does not cause a temperature rise , does change the condition of the air in the space , resulting in a higher humidity.

### 2.2.1 Sensible heat gains to the space include :

i. Heat transmission through the building structure as a result of Conduction, Convection and Radiation.
ii. Heat entering the space as a result of solar radiation through windows and other transparent components.
iii. Sensible heat produced by occupants.
iv. Sensible heat brought in as a result of ventilation and infiltration of air .
v. Sensible heat produced by lights and other exist equipments.
vi. Sensible heats to be extracted from the products exist in the Conditioned space especially for the “industrial Air Conditioning system “.

### 2.2.2 Latent heat ( moisture gain ) may be classified as :

i. Latent heat from outside air required for ventilation or infiltration.
ii. Latent heat from occupants.
iii. Latent heat from moisture producing equipments such as “cooking, hot bath, hair drier, etc”.
iv. Latent heat from the products.

A further load classification which is frequently used is based on "***the source of heat***" loads classified as:

a. External loads, if the loads are coming from outside the conditioned space they may be either sensible or latent.
b. Internal loads, if the loads are produced within the conditioned space. These, too, may be sensible or latent.

Table (2-1) can easily identify the type of cooling load, sensible or latent, external or internal.

**Table (2-1)**

| | Sensible | Latent | External | Internal |
|---|---|---|---|---|
| Heat Transfer load | ✔ | | ✔ | |
| Solar load | ✔ | | ✔ | |
| Occupants loads | ✔ | ✔ | | ✔ |
| Ventilation , Infiltration Loads | ✔ | ✔ | ✔ | |
| Lighting Loads | ✔ | | | ✔ |
| Equipments Loads | ✔ | ✔ | | ✔ |

From the previous table it is shown that some loads are both sensible and latent Which appear in occupants, ventilation, infiltration and equipments load.

## 2.3 Variability of the cooling loads

The actual cooling load in a building is a function of time and of the so called fly wheel effect of the buildings. Fly wheel effect is observed as the building masses store heat during the hot part of the day and release it later .conversely , a buildings may be sub cooled during the night and early hours of the day and thus ready to absorb a greater amount of heat later ,at sunny hours . This is the "heat inertia" of buildings. The flow of heat through walls, roofs, and ceilings of building is very complicated because of load variation with the time of the day, the nature of wind and weather, the presence of trees or shading devices that block solar radiation, and the relative humidity.

Heat transmission is a function of time, and consequently the minimum rate of heat gain into the conditioned space may lag by several hours, the minimum rate of heat absorption by the outer layers of the building. Further more owing to dissipation and absorption of heat within walls and attics, the maximum rate of gain into the conditioned space is never as great as the maximum rate of heat entry at the outside surfaces. Buildings store heat, absorb and dissipate some of it, and transmit the rest into the conditioned space at some later time, the lag varying from 1 to as much as 8 or 10 hr.

The rate of space gain may conceivably peak as late as 8 or 9 p.m. when the actual outdoor peak occurs at 4 p.m. This lag depends on the building construction, the size and orientation of glass surfaces and percentage of the total load which is due to radiation through glass and which has no transmission – lag characteristics.

## 2.4 Inside design conditions

The inside design conditions may be varying according to the following:

i. Type of building and use of building.
ii. Length of duration of occupancy.
iii. Degree of activity of occupants.
iv. radiant –heat sources such as large glass areas exposed to solar radiation
v. Outside design conditions and daily peak temperatures.

Table (2-2) provides recommended summer and winter inside design conditions for common building types and conditions.

**Table (2-2) Source: Carrier Air conditioning co., Handbook of air conditioning system design, New York, 1966**

| Application | Summer | | Winter | | Pressure | All exhaust air | Return air to AHU |
|---|---|---|---|---|---|---|---|
| | $T_{db}$ °C | RH % | $T_{db}$ °C | RH % | | | |
| Hospitals | 22 - 26 | 40 - 50 | 20 - 27 | 30 - 60 | - | Optional | Optional |
| examination room | 24 | 50 | 24 | 30 | - | Optional | Optional |
| paitiant care | 24 | 50 | 24 | 30 | P | Optional | Refused |
| Offices | 23 - 26 | 40 - 50 | 21 - 23 | 20 - 30 | - | Optional | Optional |
| Kitchines | 26 - 31 | - | 21 - 23 | - | N | Required | Refused |
| Grandstands | 23 - 26 | 50 - 55 | 21 - 23 | 40- 50 | - | Optional | Required |
| café - Restraunt | 23 - 26 | 50 - 60 | 21- 23 | 20- 30 | N | Refused | Refused |
| X- ray | 22.5 - 2.5 | 30 - 60 | 22.5 - 2.5 | 30 - 60 | N | Refused | Required |
| CT scan | 22.5 - 2.5 | 30 - 60 | 22.5 - 2.5 | 30 - 60 | N | Refused | Required |
| Urodynamic | 22 - 24 | 40 - 50 | 21- 23 | 30 - 60 | N | Optional | Optional |
| Endoscopy | 22 - 24 | 40 - 50 | 21- 23 | 30 - 60 | N | Optional | Optional |
| Laboratories | 21 - 24 | 50 - 60 | 21 - 24 | 50 - 60 | - | Refused | Optional |
| Waiting | 23 - 24 | 50 | 22 - 23 | 30 | - | Optional | Optional |
| blood sampling | 21 - 24 | 50 - 60 | 21 - 24 | 50 - 60 | - | Refused | Required |
| blood detonation | 21 - 24 | 50 - 60 | 21 - 24 | 50 - 60 | - | Refused | Required |
| sterlization | 22 - 24 | 40 - 50 | 21- 23 | 30 - 60 | - | Refused | Required |
| changing room | 24 | 50 | 22 | 30 | - | Refused | Required |
| Medecation | 22-24 | 50 | 22 | 30 | - | Refused | Required |
| Pharmacy | 22-24 | 50 | 22 | 30 | | Refused | Required |

## 2.5 Outside design condition

The outside design condition vary markedly with the locality, they are determined by averaging conditions which occur over a number of years. For Mansoura city the outside design conditions will vary with the following variation with the solar time.

Because the lack of the sources of temperature variation during the day, we will establish the following relation which might give a good approximation for temperature variation during the day .the procedures for this derivation assume that the temperature variation will be sinusoidal curve from maximum temperature $T_{max}$ to minimum temperature $T_{min}$ .

$$t = t_{av} + A \sin(\omega \tau + \phi) \qquad {}^{o}C$$

***where:***

$t_{av} = (Tmax + T min)/2$
A: is the amplitude of the wave = ( $T_{max} - T_{av}$ ) [ $^{o}$ C ]
$\omega = 2\pi/24$. [ $hr^{-1}$ ]
$\tau$: is the solar time ( equal zero at 12 pm) [ hr ]

***Table (2-3) :***

The values calculated previous is estimated at the following condition for Mansoura city

| time | Temp (oC) |
|---|---|
| **8:00** | 29.2 |
| **9:00** | 30.75 |
| **10:00** | 32.56 |
| **11:00** | 34.5 |
| **12:00** | 36.44 |
| **1:00** | 38.25 |
| **2:00** | 39.8 |
| **3:00** | 41 |
| **4:00** | 41.7 |
| **5:00** | 42 |

Let us now show how the heating loads for Air conditioning systems to be calculated, and how we use the tables required for this design .and moisture content near to 15.57 g / kg .and approximately assumed to be constant with time.

## 2.6 External load calculations

### 2.6.1 Heat transfer load:

Heat enters the buildings by the means of conduction, convection and radiation. We shall develop now the procedures for calculating the heat transfer load. the heat transfer through walls, ceiling and roofs to the conditioned space can be assumed to be steady ,but the variation of the outside conditions with stability of the inside design conditions , make the heat transfer through buildings to be unsteady heat transfer .In our project we will variety the Outside design conditions with the solar time by hours as it shown above in Table (2-3) in summer for cooling loads respectively, and after that we will estimate the loads for this variation and draw the relation between the load and the solar time for this load and the other loads ,getting the total load for the conditioned space at the several times in the hottest day which occur in July although the longest day occur in June 21 , choosing the maximum total load to be design load after multiplied by safety factor as we will discuss .

Heat transfer through the buildings can be easily estimated by the following heat transfer relations.

$$Q = U \cdot A \cdot (T_o - T_i) \text{ Watt} \qquad \textit{Eqn (2-1)}$$

***Where :***

Q: is the heat transferred to the conditioned space in units of(watt).
To: is the outside Ambient temperature in units of ($^oC$) .
Ti : is the inside design condition in units of ($^oC$ ).
A : is the heat transfer area in ( $m^2$ ).
U : is the overall heat transfer coefficient in ( $W/m^2.k$ ).

The overall heat transfer coefficient is given by the following relation.

$$\frac{1}{U} = \frac{1}{h_i} + \frac{1}{h_o} + \sum \frac{\delta}{k} \qquad \textit{Eqn (2 – 2)}$$

***Where :***

ho: is the convection heat transfer coefficient on the outer surface.
hi : is the convection heat transfer coefficient on the inner surface.
$\sum \delta/k$ : thermal resistances of material used for construction of the wall .

Table (2-4) gives the thermal conductivity of some materials and the recommended thickness of the wall construction.

**Table (2-4)** ***Source*****:** **“*****modern Air Conditioning Practice*** **“ASHRAE *handbook***

| Materials | Thermal conductivity |
|---|---|
| Common brick | 0.72 |
| Cement plaster | 0.72 |
| Glass | 0.75 |
| Sand | 0.3 |
| Concrete Tile | 1.1 |
| Concrete | 0.72 |
| Wood | 0.16 |

Which we can be easily know the thermal resistance for each wall construction. but for the convection heat transfer coefficient values for our needs as shown in the Table (2-5) according to the wind velocity .The convective heat transfer coefficient also can be approximately selected from the flowing table(2-5)

**Table (2-5) Source: ASHRAE *handbook.***

| Direction of heat flow | | Surface position | h ( $w / m^2.k$ ) |
|---|---|---|---|
| Still Air | Upward | Horizontal | 9.26 |
| | Horizontal | Vertical | 8.29 |
| | Down word | Horizontal | 6.13 |
| Moving Air | Wind 6 m/s | Any position | 34 |
| | Wind 3 m/s | Any position | 22.7 |

**2.6.2 Solar load:**

As discussed later the heat transferred from walls due to the temperature difference between outer and inner conditions can be calculated ,but it is known that solar radiation received at the earths surface on a plane perpendicular to the sun rays may amount to about 860 watt per unit area of the surface on a clear day at the see level . Time of day and latitude are the factors which most affect the value of the direct solar radiation.

Glass surfaces are usually not horizontal or perpendicular to the suns rays, although they may be nearly so on east and west exposure in early morning.

Solar radiation which falls on glass has three components:

i. The larger portion is transmitted directly into the interior of the building .
ii. Some is absorbed by the glass.
iii. Some is reflected. As shown in fig (A).

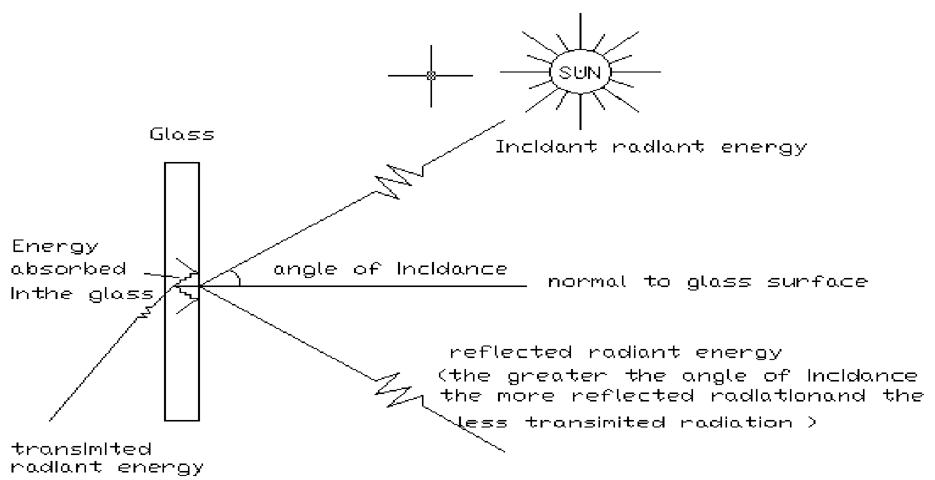



**Fig (A)**

The sum of 1 and 2 is the total rate of heat gain to the space , and although the direct radiation which passes into the space must first be absorbed by walls or furnishings before it can give up its heat to the air , it is common practice to treat this rate of heat gain as instantaneous , without allowing any time lag .

**2.6.2.1 Heat flow due to solar radiation through walls :**

$$Q_{sun,\,wall} = U_{wall} * A * \Delta T_{sun} \qquad \text{Eqn (2 - 3)}$$

Heat gain through the exterior construction (walls and roofs) is normally calculated at the time greatest heat flow. It caused by solar heat being absorbed at the exterior surface and by the temperature difference between the outdoor and indoor.

Both heat sources are highly variable through out any one day and therefore, result in unsteady state flow individual situation. However be handled best by means of an equivalent temperature difference across the structure. The heat flow through the wall structure tray can be calculated using the equation (2 – 3 ).

***Where :***

Q : Heat transfer in (Watt).
U : Overall heat transfer coefficient in ($W/m^2.C$).
$\Delta T_{sun}$: temperature difference for walls due to solar radiation ($^0C$)

### 2.6.2.2 Heat flow due to solar radiation through glass

As the distance traveled or the amount of haze increase, the diffuse radiation component decrease. As either or both these effect is to reduce the total quantity of heat reaching the earth surface. Ordinary glass is specific as crystal glass of single thickness and single or double strength. The solar heat gain through ordinary glass depends on,

i. Location on the earth surface (Latitude).
ii. Time of day.
iii. Time of year.
iv. Facing direction of the window.

Ordinary glass absorbs a small portion of the solar heat(5% – 6% ) and the reflects or transmits the resultant as shown above in fig ( A ). The amount reflected or transmitted depends on the glass of incidence.

***The heat gain by glass can be calculated from the following equation :***

$$Q_{sun\,,\,glass} = A * \left(\frac{W}{m^2}\right)_{glass} * S.C \qquad \textit{Eqn (2-4)}$$

***Where :***

A : area of glass in every direction $m^2$.
$(\frac{W}{m^2})$ : heat gain throw glass from Table ( 2- 7) .
S.C : shading coefficient from Table ( 2 - 8) .

Table ( 2- 6) indicates amount of watts per meter square for glass walls fitted in all directions and the selected values for this amount for building peak time estimations for June month .

**Table (2-6) Source*:* "air conditioning" C.P Arora**

**Solar radiation ($W/m^2$) for 30 North Lattitude at 21-June**

| Direction | Solar time | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **8:00** | **9:00** | **10:00** | **11:00** | **12:00** | **1:00** | **2:00** | **3:00** | **4:00** | **5:00** |
| **NE** | 410 | 305 | 173 | 60 | 44 | 44 | 44 | 44 | 38 | 32 |
| **SE** | 284 | 284 | 230 | 139 | 54 | 44 | 44 | 44 | 38 | 32 |
| **SW** | 38 | 44 | 44 | 44 | 54 | 138 | 230 | 284 | 284 | 237 |
| **NW** | 38 | 44 | 44 | 44 | 44 | 60 | 173 | 310 | 410 | 438 |

**Table (2- 7) indicates the influence of shading coefficient and the selected value for shading coefficient.** ***Source: "air conditioning" Dr. Ramadan Mahmoud***

| No. of glass plates | without shading | with internal blind |
|---|---|---|
| ***Single glass*** | | |
| Regular sheet | 0.83 | 0.64 |
| with stand Plate | 0.69 | 0.57 |
| with reflec. Layer | 0.4 | 0.33 |
| ***Double glass*** | | |
| Regular sheet | 0.88 | 0.57 |
| with reflec. Layer | 0.4 | 0.34 |

### 2.6.2.3 Infiltration and ventilation :

It is obvious that the ventilation and the infiltration are linked together .The ventilation ( supply of outside air ) is provided to the conditioned space in order to minimize odor , concentration of smoke , carbon dioxide and other undesirable gases so that freshness of air could be maintained . The quantity of outside air used for ventilation should provide at least one-half air change per hour in buildings with normal ceiling heights. Also , if the infiltration air quantity is larger than the ventilation quantity , then the latter should be increased to at least equal to the infiltration air .The outside air adds sensible as well as latent heat .The load due to infiltration may be readily calculated by using the design conditions and the following equations :

***Sensible heat gain by ventilated air can be calculated as:***

$$Q_{vent,s} = CMM * \frac{1}{v_o} * Cp_{air} * (t_o - t_r) \qquad \text{Watt}$$

$$Q_{vent,s} = 0.0204 * CMM * ( t_o - t_r ) \qquad \text{KWatt} \qquad \text{Eqn (2-5)}$$

***And latent heat gain by ventilated air can be calculated by :***

$$Q_{vent,l} = CMM * \left(\frac{1}{v_o}\right) * \Delta\omega * h_{fg} \qquad \text{Watt}$$

$$Q_{vent,l} = 50 * CMM * \Delta\omega * 10^{-3} \qquad \text{KWatt} \qquad \text{Eqn ( 2 – 6 )}$$

The only unknown parameter is "CMM" and can be obtained by the following methods:

***a. Air change method :***

$$CMM = \frac{V * N}{60} \qquad \text{cmm} \qquad \text{Eqn ( 2-7 )}$$

***Where:***

**V = W * H * L** (m3) **Eqn ( 2 - 8)**

W : width of the room
H : height of the room
L : length of the room

N : number of air change of the space Cmm : cubic meter per minute.

### *b. Occupancy ventilation rate :*

$$Q = n *(\frac{L}{s.person}) * 60 * 10^{-3} \quad Cmm \qquad \text{Eqn (2-9)}$$

***Where :***

n : number of persons .

($\frac{L}{s.person}$): rate of ventilation of one person estimated by (liter per second) and can be obtained from Table (2 -10).

**Table (2-9) source: *"ASHRAE hospital"***

| Application | L/s/p | L/s/m$^2$ | ζ |
|---|---|---|---|
| examination room | 12 | 1.8 | 2 |
| paitiant care | 14 | 2.8 | 3 |
| Offices | 10 | 1.8 | 2 |
| Kitchines | 10 | 7 | 6 |
| Grandstands | 8 | 6.7 | 6 |
| café - Restraunt | 10 | 1.8 | 2 |
| X- ray | 14 | 2 | 2 |
| CT scan | 14 | 2 | 2 |
| Urodynamic | 14 | 1 | 1 |
| Endoscopy | 14 | 1 | 1 |
| Laboratories | 14 | 2.8 | 3 |
| Waiting | 14 | 6.7 | 7 |
| blood sampling | 14.00 | 6.70 | 7.00 |
| blood detonation | 14.00 | 6.70 | 7.00 |
| sterlization | 14 | 2.8 | 3 |
| changing room | 0 | 2.5 | 1 |
| Medecation | 14 | 2.8 | 3 |
| Pharmacy | 14 | 2.8 | 3 |

## c. Space area ventilation rate :

$$Q_V = A_f * (\frac{L}{sec * m^2}) * 60 \quad cmm \quad \text{Eqn (2 -10)}$$

***Where:***

$A_f$ : the area of the floor ( m$^2$ )

( $\frac{L}{sec * m^2}$ ) : rate of ventilation per square meter in second

## 2.7 Internal loads

### 2.7.1 Occupants load:

The amount of heat which people give off to the surrounding air depends on their size and the degree of muscular activity at the time . the heat dissipated will be partly sensible , partly latent as detailed above in table (2-1). The following Table (2- 11) gives heat – dissipation values for a person 70 kg weight and 172 cm tall for several different degrees of activity . To obtain the heat load due to occupants , the design occupancy is multiplied by the proper factor selected from the following table .The heat transferred from occupants can be easily calculated from the following relation :

$$Q = \left(\frac{Q}{person}\right) * n_{person} \quad \textbf{Watt} \qquad \textbf{Eqn (2-11)}$$

***Where:***

$N_{person}$ : Number of person in the conditioned space

$\left(\frac{Q}{person}\right)$ : is the heat released from one person

**Table 2-10 Sensibe and latent heat for different occupants' activities:**
***Source: "air conditioning" Dr. Ramadan Mahmoud***

| Activity | Sensibe heat (W) | Latent heat (W) |
|---|---|---|
| Confort sitting | 72 | 31 |
| sitting light work | 72 | 45 |
| Sitting and eating | 75 | 95 |
| Moderately actikve office work | 73 | 59 |
| wallking | 81 | 81 |

### 2.7.2 Electric lights , motors appliances loads :

A part of internal loads which must be considered is light, equipments motor and appliance load. Heat dissipated from lights and the equipments motors are both sensible, but for another certain appliance (clothes dryers, hair dryers (helmet)…. Etc) are examples for latent heats can be dissipated from appliances.

### a. Lights:

Lighting loads can be easily estimated from the following equation.

$$Q = \sum I_n + 1.25 * \sum F$$

***Where:***

$I_n$: watts of incandescent lamps.

F : watts of fluorescent lamps .

***Hint***:

"For fluorescent lamps loads are increased by 25 % especially for transformer which exist in the room .Another table can easily give the recommended light intensity (W /$m^2$) for some applications shown in Table (2 – 13).

**Table (2-11) Source: "Air conditioning principles, applications book" Dr .R Mahmoud**

| Building type | W / $m^2$ |
|---|---|
| Offices | 60 |
| Industries | 45 |
| Schools ,Universities | 40 |
| Houses , theater , Hotels | 20 |
| Restaurants | 17 |
| Hospitals , libraries, museums | 15 |

**b. Motors:**

Load gain from motors and from equipments can easily determined from the following relation.

$$Q = (1 - \acute{\eta}) * \text{motor Power } (P_o). \qquad \text{Watt}$$

***Where:***

ή: motor or equipment efficiency .Table (2-14) gives motor power and the recommended efficiency .

**Table (2-12) Source: "ASHRAE handbook ".**

| Motor power | Efficiency |
|---|---|
| Lower than 200 watt | 0.6 |
| From 375 - 750 watt | 0.7 |
| From 1000 - 4000 watt | 0.8 |
| From 5500 - 15000 watt | 0.85 |
| Above 15000 watt | 0.88 |
| From 746 – 3730 watt | 0.75 – 0.82 |
| Down 746 watt | 0.6 – 0.7 |

# Working data

### In door data:

| Ti °C | hi kJ/kg.K | Φi % | Wi gv/kga |
|---|---|---|---|
| 24 | 47.9 | 50 | 9.34 |
| 26 | 53 | 50 | 10.54 |

### Out door data

| Time | To °C | ho kJ/kg.K | Φo % | Wo gv/kga | Vo $m^3$/kg | Po kg/$m^3$ |
|---|---|---|---|---|---|---|
| 8.00 | 29.20 | 69.13 | 60.76 | 15.57 | 0.88 | 1.14 |
| 9.00 | 30.75 | 70.74 | 55.58 | 15.57 | 0.88 | 1.13 |
| 10.00 | 32.56 | 72.61 | 50.16 | 15.57 | 0.89 | 1.13 |
| 11.00 | 34.50 | 74.62 | 45.00 | 15.57 | 0.89 | 1.12 |
| 12.00 | 36.44 | 76.62 | 40.43 | 15.57 | 0.90 | 1.11 |
| 1.00 | 38.25 | 78.50 | 36.64 | 15.57 | 0.90 | 1.11 |
| 2.00 | 39.80 | 80.10 | 33.71 | 15.57 | 0.91 | 1.10 |
| 3.00 | 41.00 | 81.34 | 31.63 | 15.57 | 0.91 | 1.10 |
| 4.00 | 41.70 | 82.07 | 30.48 | 15.57 | 0.91 | 1.09 |
| 5.00 | 42.00 | 82.38 | 30.00 | 15.57 | 0.92 | 1.09 |

**Shading coefecient***: constant for all glass windows*

| S.C. |
|---|
| 0.34 |

### Convection Heat Transfer Coefficient

| Position Of Surface | Direction | hi (w/$m^2$.k) | $h_o$ (w/$m^2$.k) |
|---|---|---|---|
| **Horizontal** | Downword | 7 | 13 |
| Vertical | Horizontal | 8 | 10 |

### Thermal Conductivity

| Item | K |
|---|---|
| Limestone | 0.93 |
| Cement plaster | 0.72 |
| Common Brick | 0.72 |
| Still Air | 0.02624 |
| Concrete | 1.72 |

**Overall Heat Transfer Coeff**

| Item | U ($w/m^2.k$) | α |
|---|---|---|
| Wall "A" | 0.12754 | 0.65 |
| Wall "B" | 1.4389 | 0.65 |
| Wall "C" | 1.78896 | 0.4 |
| Wall "D" | 0.3943 | 0.4 |
| Wall "E" | 2.33 | 0.65 |
| Wall "F" | 2.003 | 0.65 |
| Wall "H" | 1.16 | - |
| Wall "I" | 0 | - |
| Wall "G_1" | 2.1818 | 0.65 |
| Wall "G_2" | 1.565 | 0.65 |
| Glass | 1.1 | Non |

**Outdoor Tempratures**

| time | Temp (oC) |
|---|---|
| 8:00 | 29.2 |
| 9:00 | 30.75 |
| 10:00 | 32.56 |
| 11:00 | 34.5 |
| 12:00 | 36.44 |
| 1:00 | 38.25 |
| 2:00 | 39.8 |
| 3:00 | 41 |
| 4:00 | 41.7 |
| 5:00 | 42 |

**Solar radiation ($W/m^2$) for 30 North Lattitude at 21-June**

| Direction | Solar time | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 1:00 | 2:00 | 3:00 | 4:00 | 5:00 |
| NE | 410 | 305 | 173 | 60 | 44 | 44 | 44 | 44 | 38 | 32 |
| SE | 284 | 284 | 230 | 139 | 54 | 44 | 44 | 44 | 38 | 32 |
| SW | 38 | 44 | 44 | 44 | 54 | 138 | 230 | 284 | 284 | 237 |
| NW | 38 | 44 | 44 | 44 | 44 | 60 | 173 | 310 | 410 | 438 |

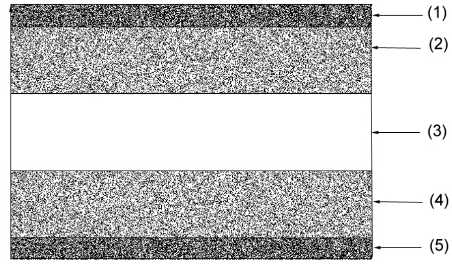
## Types of building walls

**Walls (A)**

*Components:*

1- cement plaster
2- common brick
3- still air
4- common brick
5- cement plaster

U=0.12754 W/m$^2$.k



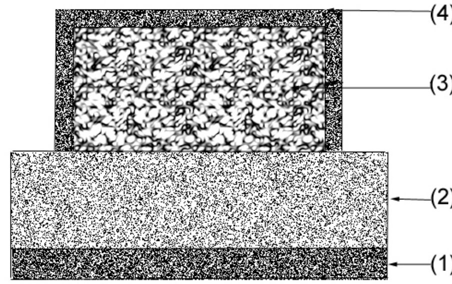

Wall (A)

**Walls (B)**

*Components:*

1- cement plaster
2- common brick
3- concrete column
4- cement plaster

U=1.4389 W/m$^2$.k



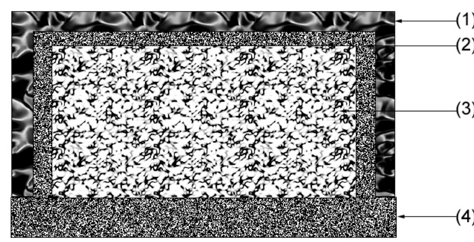

Wall (B)

**Walls (C)**

*Components:*

1- black or dark grey limestone
2- cement plaster
3- concrete column
4- cement plaster

U=1.78896 W/m$^2$.k



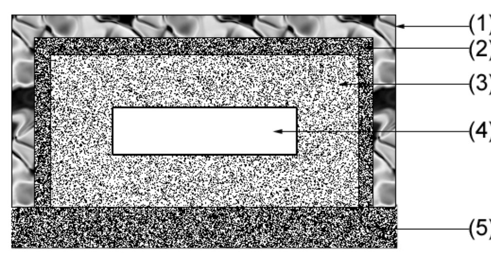

Wall (C)

**Walls (D)**

*Components:*

1. black or dark grey limestone
2. cement plaster
3. common brick
4. still air
5. common brick
6. cement plaster

U=0.3943 W/m$^2$.k



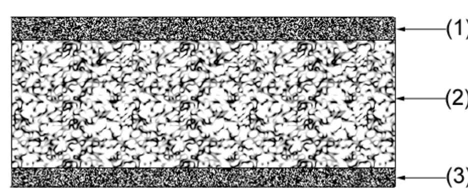

Wall (D)

**Walls (E)**

*Components:*

1. cement plaster
2. concrete wall
3. cement plaster

U=2.33 W/m$^2$.k



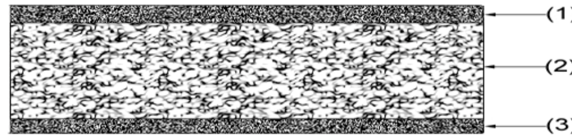

Wall (E)

**Walls (F)**

*Components:*

1. cement plaster
2. concrete wall
3. cement plaster

U=2.003 W/m$^2$.k



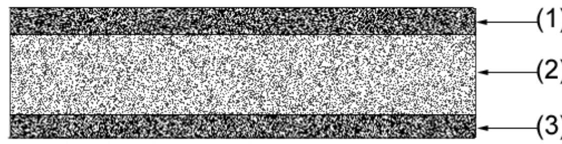
Wall (F)

**Walls (G_1)**

*Components:*

1. cement plaster
2. wall on half brick
3. cement plaster

U=2.1818 W/m$^2$.k



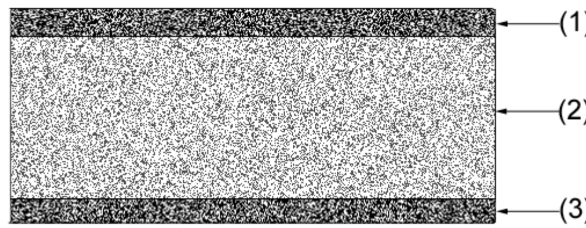
Wall (G_1)

**Walls (G_2)**

*Components:*

1. cement plaster
2. wall on full brick
3. cement plaster

U=1.565 W/m$^2$.k



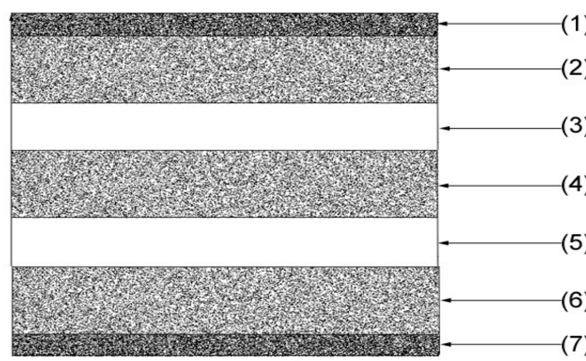
Wall (G_2)

**Walls ( I )** 'raiser wall'

*Components:*

1. cement plaster
2. common brick
3. still air
4. common brick
5. still air
6. common brick
7. cement plaster

U= 0 W/m$^2$.k



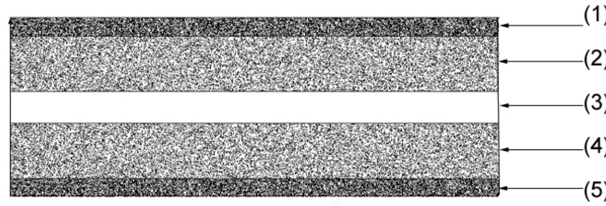
Wall ( I )

**Walls (H)**

*Components:*

1. cement plaster
2. common brick
3. still air
4. common brick
5. cement plaster

U= 1.16 W/m$^2$.k



Wall (H)

# Ground Floor Calculations

## For air Conditioning machine 1

## Room 0-13

### A. External Loads

**1-Wall Load**

| Direction | Time | Type | U (w/m2.k) | A (m2) | ∆T (K) | Q (W) | Qt (W) |
|---|---|---|---|---|---|---|---|
| NE | 08:00 | Wall "A" | 0.13 | 7.17 | 5.20 | 4.76 | 40.99 |
| | | Wall "B" | 1.44 | 1.41 | | 10.51 | |
| | | Wall "C" | 1.79 | 1.20 | | 11.12 | |
| | | Wall "D" | 0.39 | 2.27 | | 4.66 | |
| | | Glass | 1.10 | 1.74 | | 9.95 | |
| | 09:00 | Wall "A" | 0.13 | 7.17 | 6.75 | 6.17 | 53.20 |
| | | Wall "B" | 1.44 | 1.41 | | 13.65 | |
| | | Wall "C" | 1.79 | 1.20 | | 14.43 | |
| | | Wall "D" | 0.39 | 2.27 | | 6.04 | |
| | | Glass | 1.10 | 1.74 | | 12.91 | |
| | 10:00 | Wall "A" | 0.13 | 7.17 | 8.56 | 7.83 | 67.47 |
| | | Wall "B" | 1.44 | 1.41 | | 17.31 | |
| | | Wall "C" | 1.79 | 1.20 | | 18.30 | |
| | | Wall "D" | 0.39 | 2.27 | | 7.66 | |
| | | Glass | 1.10 | 1.74 | | 16.37 | |
| | 11:00 | Wall "A" | 0.13 | 7.17 | 10.50 | 9.60 | 82.76 |
| | | Wall "B" | 1.44 | 1.41 | | 21.23 | |
| | | Wall "C" | 1.79 | 1.20 | | 22.45 | |
| | | Wall "D" | 0.39 | 2.27 | | 9.40 | |
| | | Glass | 1.10 | 1.74 | | 20.08 | |
| | 12:00 | Wall "A" | 0.13 | 7.17 | 12.44 | 11.38 | 98.05 |
| | | Wall "B" | 1.44 | 1.41 | | 25.15 | |
| | | Wall "C" | 1.79 | 1.20 | | 26.59 | |
| | | Wall "D" | 0.39 | 2.27 | | 11.14 | |
| | | Glass | 1.10 | 1.74 | | 23.79 | |
| | 13:00 | Wall "A" | 0.13 | 7.17 | 14.25 | 13.03 | 112.32 |
| | | Wall "B" | 1.44 | 1.41 | | 28.81 | |
| | | Wall "C" | 1.79 | 1.20 | | 30.46 | |
| | | Wall "D" | 0.39 | 2.27 | | 12.76 | |
| | | Glass | 1.10 | 1.74 | | 27.25 | |
| | 14:00 | Wall "A" | 0.13 | 7.17 | 15.80 | 14.45 | 124.53 |
| | | Wall "B" | 1.44 | 1.41 | | 31.94 | |
| | | Wall "C" | 1.79 | 1.20 | | 33.78 | |
| | | Wall "D" | 0.39 | 2.27 | | 14.15 | |
| | | Glass | 1.10 | 1.74 | | 30.22 | |
| | 15:00 | Wall "A" | 0.13 | 7.17 | 17.00 | 15.55 | 133.99 |
| | | Wall "B" | 1.44 | 1.41 | | 34.37 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Wall "C" | 1.79 | 1.20 | | 36.34 | |
| | | Wall "D" | 0.39 | 2.27 | | 15.22 | |
| | | Glass | 1.10 | 1.74 | | 32.51 | |
| | | Wall "A" | 0.13 | 7.17 | | 16.19 | |
| | | Wall "B" | 1.44 | 1.41 | | 35.78 | |
| | 16:00 | Wall "C" | 1.79 | 1.20 | 17.70 | 37.84 | 139.51 |
| | | Wall "D" | 0.39 | 2.27 | | 15.85 | |
| | | Glass | 1.10 | 1.74 | | 33.85 | |
| | | Wall "A" | 0.13 | 7.17 | | 16.46 | |
| | | Wall "B" | 1.44 | 1.41 | | 36.39 | |
| | 17:00 | Wall "C" | 1.79 | 1.20 | 18.00 | 38.48 | 141.87 |
| | | Wall "D" | 0.39 | 2.27 | | 16.11 | |
| | | Glass | 1.10 | 1.74 | | 34.43 | |

**2-Sun Load**

| Direction | Time | Type | U (w/m2.k) | A (m2) | I (W/m2) | ∆Ts (K) | Q (W) | Qt (W) |
|---|---|---|---|---|---|---|---|---|
| NE | | Wall "A" | 0.13 | 7.17 | | 26.65 | 24.37 | |
| | | Wall "B" | 1.44 | 1.41 | | 26.65 | 53.88 | |
| | 08:00 | Wall "C" | 1.79 | 1.20 | 410.00 | 16.40 | 35.06 | 370.37 |
| | | Wall "D" | 0.39 | 2.27 | | 16.40 | 14.68 | |
| | | Glass | 1.10 | 1.74 | | | 242.38 | |
| | | Wall "A" | 0.13 | 7.17 | | 19.83 | 18.13 | |
| | | Wall "B" | 1.44 | 1.41 | | 19.83 | 40.08 | |
| | 09:00 | Wall "C" | 1.79 | 1.20 | 305.00 | 12.20 | 26.08 | 275.52 |
| | | Wall "D" | 0.39 | 2.27 | | 12.20 | 10.92 | |
| | | Glass | 1.10 | 1.74 | | | 180.31 | |
| | | Wall "A" | 0.13 | 7.17 | | 11.25 | 10.28 | |
| | | Wall "B" | 1.44 | 1.41 | | 11.25 | 22.73 | |
| | 10:00 | Wall "C" | 1.79 | 1.20 | 173.00 | 6.92 | 14.79 | 156.28 |
| | | Wall "D" | 0.39 | 2.27 | | 6.92 | 6.20 | |
| | | Glass | 1.10 | 1.74 | | | 102.27 | |
| | | Wall "A" | 0.13 | 7.17 | | 3.90 | 3.57 | |
| | | Wall "B" | 1.44 | 1.41 | | 3.90 | 7.88 | |
| | 11:00 | Wall "C" | 1.79 | 1.20 | 60.00 | 2.40 | 5.13 | 54.20 |
| | | Wall "D" | 0.39 | 2.27 | | 2.40 | 2.15 | |
| | | Glass | 1.10 | 1.74 | | | 35.47 | |
| | | Wall "A" | 0.13 | 7.17 | | 2.86 | 2.62 | |
| | | Wall "B" | 1.44 | 1.41 | | 2.86 | 5.78 | |
| | 12:00 | Wall "C" | 1.79 | 1.20 | 44.00 | 1.76 | 3.76 | 39.75 |
| | | Wall "D" | 0.39 | 2.27 | | 1.76 | 1.58 | |
| | | Glass | 1.10 | 1.74 | | | 26.01 | |
| | | Wall "A" | 0.13 | 7.17 | | 2.86 | 2.62 | |
| | | Wall "B" | 1.44 | 1.41 | | 2.86 | 5.78 | |
| | 13:00 | Wall "C" | 1.79 | 1.20 | 44.00 | 1.76 | 3.76 | 39.75 |
| | | Wall "D" | 0.39 | 2.27 | | 1.76 | 1.58 | |
| | | Glass | 1.10 | 1.74 | | | 26.01 | |
| | 14:00 | Wall "A" | 0.13 | 7.17 | 44.00 | 2.86 | 2.62 | 39.75 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Wall "B" | 1.44 | 1.41 | | 2.86 | 5.78 | |
| | | Wall "C" | 1.79 | 1.20 | | 1.76 | 3.76 | |
| | | Wall "D" | 0.39 | 2.27 | | 1.76 | 1.58 | |
| | | Glass | 1.10 | 1.74 | | | 26.01 | |
| | 15:00 | Wall "A" | 0.13 | 7.17 | 44.00 | 2.86 | 2.62 | 39.75 |
| | | Wall "B" | 1.44 | 1.41 | | 2.86 | 5.78 | |
| | | Wall "C" | 1.79 | 1.20 | | 1.76 | 3.76 | |
| | | Wall "D" | 0.39 | 2.27 | | 1.76 | 1.58 | |
| | | Glass | 1.10 | 1.74 | | | 26.01 | |
| | 16:00 | Wall "A" | 0.13 | 7.17 | 38.00 | 2.47 | 2.26 | 34.33 |
| | | Wall "B" | 1.44 | 1.41 | | 2.47 | 4.99 | |
| | | Wall "C" | 1.79 | 1.20 | | 1.52 | 3.25 | |
| | | Wall "D" | 0.39 | 2.27 | | 1.52 | 1.36 | |
| | | Glass | 1.10 | 1.74 | | | 22.46 | |
| | 17:00 | Wall "A" | 0.13 | 7.17 | 32.00 | 2.08 | 1.90 | 28.91 |
| | | Wall "B" | 1.44 | 1.41 | | 2.08 | 4.21 | |
| | | Wall "C" | 1.79 | 1.20 | | 1.28 | 2.74 | |
| | | Wall "D" | 0.39 | 2.27 | | 1.28 | 1.15 | |
| | | Glass | 1.10 | 1.74 | | | 18.92 | |

**3-Ventilation Load**

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 2.00 | 10.00 | 2.50 | 2.00 |

| | |
|---|---|
| **A (m2)** | 23.04 |
| **H (m)** | 2.60 |
| **V (m3)** | 59.90 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 1.20 |
| **Based on Area** | 3.46 |
| **NO Of Air Changing Times** | 2.00 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 08:00 | 3.46 | 366.61 | 1076.89 | 1443.50 |
| 09:00 | 3.46 | 475.89 | 1076.89 | 1552.78 |
| 10:00 | 3.46 | 603.50 | 1076.89 | 1680.39 |
| 11:00 | 3.46 | 740.28 | 1076.89 | 1817.16 |
| 12:00 | 3.46 | 877.05 | 1076.89 | 1953.94 |
| 13:00 | 3.46 | 1004.66 | 1076.89 | 2081.55 |
| 14:00 | 3.46 | 1113.94 | 1076.89 | 2190.83 |
| 15:00 | 3.46 | 1198.54 | 1076.89 | 2275.43 |
| 16:00 | 3.46 | 1247.89 | 1076.89 | 2324.78 |
| 17:00 | 3.46 | 1269.04 | 1076.89 | 2345.93 |

## B. Internal Loads

### 1-Occupancy Load

| No Of Persons | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 2.00 | sitting | 66.00 | 31.00 | 132.00 | 62.00 | 194.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| fluorescent | 8.00 | 40.00 | 1.25 | 400.00 |

### Variation of load with time

| Q occ_s | Q occ_l | Q lig_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 400.00 | 132.00 | 62.00 | 0.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 0.33 | 40.99 | 370.37 | 366.61 | 1076.89 | 943.36 | 62.00 | 1005.36 |
| 0.38 | 53.20 | 275.52 | 475.89 | 1076.89 | 860.72 | 62.00 | 922.72 |
| 0.42 | 67.47 | 156.28 | 603.50 | 1076.89 | 755.75 | 62.00 | 817.75 |
| 0.46 | 82.76 | 54.20 | 740.28 | 1076.89 | 668.96 | 62.00 | 730.96 |
| 0.50 | 98.05 | 39.75 | 877.05 | 1076.89 | 669.80 | 62.00 | 731.80 |
| 0.54 | 112.32 | 39.75 | 1004.66 | 1076.89 | 684.06 | 62.00 | 746.06 |
| 0.58 | 124.53 | 39.75 | 1113.94 | 1076.89 | 696.28 | 62.00 | 758.28 |
| 0.63 | 133.99 | 39.75 | 1198.54 | 1076.89 | 705.74 | 62.00 | 767.74 |
| 0.67 | 139.51 | 34.33 | 1247.89 | 1076.89 | 705.84 | 62.00 | 767.84 |
| 0.71 | 141.87 | 28.91 | 1269.04 | 1076.89 | 702.78 | 62.00 | 764.78 |

# Room 0-15

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ΔT (K) | Q (W) | Qt (W) |
|---|---|---|---|---|---|---|---|
| NE | 08:00 | Wall "A" | 0.13 | 2.04 | 5.20 | 1.36 | 30.33 |
| | | Wall "B" | 1.44 | 1.24 | | 9.25 | |
| | | Wall "C" | 1.79 | 1.05 | | 9.78 | |
| | | Glass | 1.10 | 1.74 | | 9.95 | |
| | 09:00 | Wall "A" | 0.13 | 2.04 | 6.75 | 1.76 | 39.38 |
| | | Wall "B" | 1.44 | 1.24 | | 12.01 | |
| | | Wall "C" | 1.79 | 1.05 | | 12.70 | |
| | | Glass | 1.10 | 1.74 | | 12.91 | |
| | 10:00 | Wall "A" | 0.13 | 2.04 | 8.56 | 2.23 | 49.94 |
| | | Wall "B" | 1.44 | 1.24 | | 15.23 | |
| | | Wall "C" | 1.79 | 1.05 | | 16.10 | |
| | | Glass | 1.10 | 1.74 | | 16.37 | |
| | 11:00 | Wall "A" | 0.13 | 2.04 | 10.50 | 2.74 | 61.25 |
| | | Wall "B" | 1.44 | 1.24 | | 18.68 | |
| | | Wall "C" | 1.79 | 1.05 | | 19.75 | |
| | | Glass | 1.10 | 1.74 | | 20.08 | |
| | 12:00 | Wall "A" | 0.13 | 2.04 | 12.44 | 3.24 | 72.57 |
| | | Wall "B" | 1.44 | 1.24 | | 22.13 | |
| | | Wall "C" | 1.79 | 1.05 | | 23.40 | |
| | | Glass | 1.10 | 1.74 | | 23.79 | |
| | 13:00 | Wall "A" | 0.13 | 2.04 | 14.25 | 3.72 | 83.13 |
| | | Wall "B" | 1.44 | 1.24 | | 25.35 | |
| | | Wall "C" | 1.79 | 1.05 | | 26.81 | |
| | | Glass | 1.10 | 1.74 | | 27.25 | |
| | 14:00 | Wall "A" | 0.13 | 2.04 | 15.80 | 4.12 | 92.17 |
| | | Wall "B" | 1.44 | 1.24 | | 28.11 | |
| | | Wall "C" | 1.79 | 1.05 | | 29.72 | |
| | | Glass | 1.10 | 1.74 | | 30.22 | |
| | 15:00 | Wall "A" | 0.13 | 2.04 | 17.00 | 4.43 | 99.17 |
| | | Wall "B" | 1.44 | 1.24 | | 30.24 | |
| | | Wall "C" | 1.79 | 1.05 | | 31.98 | |
| | | Glass | 1.10 | 1.74 | | 32.51 | |
| | 16:00 | Wall "A" | 0.13 | 2.04 | 17.70 | 4.61 | 103.26 |
| | | Wall "B" | 1.44 | 1.24 | | 31.49 | |
| | | Wall "C" | 1.79 | 1.05 | | 33.30 | |
| | | Glass | 1.10 | 1.74 | | 33.85 | |
| | 17:00 | Wall "A" | 0.13 | 2.04 | 18.00 | 4.69 | 105.01 |
| | | Wall "B" | 1.44 | 1.24 | | 32.02 | |
| | | Wall "C" | 1.79 | 1.05 | | 33.86 | |
| | | Glass | 1.10 | 1.74 | | 34.43 | |

**2-Sun Load**

| Direction | Time | Type | U | A | I | ∆Ts | Q (W) | Qt (W) |
|---|---|---|---|---|---|---|---|---|
| NE | 08:00 | Wall "A" | 0.13 | 2.04 | 410.00 | 26.65 | 6.95 | 348.89 |
| | | Wall "B" | 1.44 | 1.24 | | 26.65 | 47.41 | |
| | | Wall "C" | 1.79 | 1.05 | | 16.40 | 30.85 | |
| | | Glass | 1.10 | 1.89 | | | 263.68 | |
| | 09:00 | Wall "A" | 0.13 | 2.04 | 305.00 | 19.83 | 5.17 | 266.77 |
| | | Wall "B" | 1.44 | 1.30 | | 19.83 | 37.08 | |
| | | Wall "C" | 1.79 | 1.30 | | 12.20 | 28.37 | |
| | | Glass | 1.10 | 1.89 | | | 196.15 | |
| | 10:00 | Wall "A" | 0.13 | 2.04 | 173.00 | 11.25 | 2.93 | 151.32 |
| | | Wall "B" | 1.44 | 1.30 | | 11.25 | 21.03 | |
| | | Wall "C" | 1.79 | 1.30 | | 6.92 | 16.09 | |
| | | Glass | 1.10 | 1.89 | | | 111.26 | |
| | 11:00 | Wall "A" | 0.13 | 2.04 | 60.00 | 3.90 | 1.02 | 52.48 |
| | | Wall "B" | 1.44 | 1.30 | | 3.90 | 7.30 | |
| | | Wall "C" | 1.79 | 1.30 | | 2.40 | 5.58 | |
| | | Glass | 1.10 | 1.89 | | | 38.59 | |
| | 12:00 | Wall "A" | 0.13 | 2.04 | 44.00 | 2.86 | 0.75 | 38.49 |
| | | Wall "B" | 1.44 | 1.30 | | 2.86 | 5.35 | |
| | | Wall "C" | 1.79 | 1.30 | | 1.76 | 4.09 | |
| | | Glass | 1.10 | 1.89 | | | 28.30 | |
| | 13:00 | Wall "A" | 0.13 | 2.04 | 44.00 | 2.86 | 0.75 | 38.49 |
| | | Wall "B" | 1.44 | 1.30 | | 2.86 | 5.35 | |
| | | Wall "C" | 1.79 | 1.30 | | 1.76 | 4.09 | |
| | | Glass | 1.10 | 1.89 | | | 28.30 | |
| | 14:00 | Wall "A" | 0.13 | 2.04 | 44.00 | 2.86 | 0.75 | 38.49 |
| | | Wall "B" | 1.44 | 1.30 | | 2.86 | 5.35 | |
| | | Wall "C" | 1.79 | 1.30 | | 1.76 | 4.09 | |
| | | Glass | 1.10 | 1.89 | | | 28.30 | |
| | 15:00 | Wall "A" | 0.13 | 2.04 | 44.00 | 2.86 | 0.75 | 38.49 |
| | | Wall "B" | 1.44 | 1.30 | | 2.86 | 5.35 | |
| | | Wall "C" | 1.79 | 1.30 | | 1.76 | 4.09 | |
| | | Glass | 1.10 | 1.89 | | | 28.30 | |
| | 16:00 | Wall "A" | 0.13 | 2.04 | 38.00 | 2.47 | 0.64 | 33.24 |
| | | Wall "B" | 1.44 | 1.30 | | 2.47 | 4.62 | |
| | | Wall "C" | 1.79 | 1.30 | | 1.52 | 3.53 | |
| | | Glass | 1.10 | 1.89 | | | 24.44 | |
| | 17:00 | Wall "A" | 0.13 | 2.04 | 32.00 | 2.08 | 0.54 | 27.99 |
| | | Wall "B" | 1.44 | 1.30 | | 2.08 | 3.89 | |
| | | Wall "C" | 1.79 | 1.30 | | 1.28 | 2.98 | |
| | | Glass | 1.10 | 1.89 | | | 20.58 | |

### 3-Ventilation Load

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 2.00 | 10.00 | 2.50 | 2.00 |

| | |
|---|---|
| A (m2) | 19.38 |
| H (m) | 2.60 |
| V (m3) | 50.39 |

| Method | CMM |
|---|---|
| Based on No Of Persons | 1.20 |
| Based on Area | 2.91 |
| NO Of Air Changing Times | 1.68 |

| Time | CMMmax | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 08:00 | 2.91 | 308.37 | 905.82 | 1214.20 |
| 09:00 | 2.91 | 400.29 | 905.82 | 1306.12 |
| 10:00 | 2.91 | 507.63 | 905.82 | 1413.45 |
| 11:00 | 2.91 | 622.68 | 905.82 | 1528.50 |
| 12:00 | 2.91 | 737.73 | 905.82 | 1643.55 |
| 13:00 | 2.91 | 845.06 | 905.82 | 1750.89 |
| 14:00 | 2.91 | 936.98 | 905.82 | 1842.81 |
| 15:00 | 2.91 | 1008.15 | 905.82 | 1913.97 |
| 16:00 | 2.91 | 1049.66 | 905.82 | 1955.48 |
| 17:00 | 2.91 | 1067.45 | 905.82 | 1973.27 |

## B-Internal Loads

### 1-Occupancy Load

| No Of Persons | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 2.00 | sitting | 66.00 | 31.00 | 132.00 | 62.00 | 194.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| Florescent | 8.00 | 40.00 | 1.25 | 400.00 |

**Variation of load with time**

| Qs | Qs | Ql | Qs | Ql |
|---|---|---|---|---|
| 400.00 | 132.00 | 62.00 | 0.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 30.33 | 348.89 | 308.37 | 905.82 | 911.22 | 62.00 | 973.22 |
| 09:00 | 39.38 | 266.77 | 400.29 | 905.82 | 838.15 | 62.00 | 900.15 |
| 10:00 | 49.94 | 151.32 | 507.63 | 905.82 | 733.25 | 62.00 | 795.25 |
| 11:00 | 61.25 | 52.48 | 622.68 | 905.82 | 645.73 | 62.00 | 707.73 |
| 12:00 | 72.57 | 38.49 | 737.73 | 905.82 | 643.06 | 62.00 | 705.06 |
| 13:00 | 83.13 | 38.49 | 845.06 | 905.82 | 653.62 | 62.00 | 715.62 |
| 14:00 | 92.17 | 38.49 | 936.98 | 905.82 | 662.66 | 62.00 | 724.66 |
| 15:00 | 99.17 | 38.49 | 1008.15 | 905.82 | 669.66 | 62.00 | 731.66 |
| 16:00 | 103.26 | 33.24 | 1049.66 | 905.82 | 668.49 | 62.00 | 730.49 |
| 17:00 | 105.01 | 27.99 | 1067.45 | 905.82 | 665.00 | 62.00 | 727.00 |

# Room 0-23

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ∆T | Q (W) | Q(Total) ,W |
|---|---|---|---|---|---|---|---|
| SE | 08:00 | Wall "A" | 0.13 | 5.14 | 5.20 | 3.41 | 14.04 |
| | | Glass | 1.10 | 1.86 | | 10.63 | |
| | 09:00 | Wall "A" | 0.13 | 5.14 | 6.75 | 4.42 | 18.22 |
| | | Glass | 1.10 | 1.86 | | 13.80 | |
| | 10:00 | Wall "A" | 0.13 | 5.14 | 8.56 | 5.61 | 23.10 |
| | | Glass | 1.10 | 1.86 | | 17.50 | |
| | 11:00 | Wall "A" | 0.13 | 5.14 | 10.50 | 6.88 | 28.34 |
| | | Glass | 1.10 | 1.86 | | 21.46 | |
| | 12:00 | Wall "A" | 0.13 | 5.14 | 12.44 | 8.15 | 33.58 |
| | | Glass | 1.10 | 1.86 | | 25.43 | |
| | 13:00 | Wall "A" | 0.13 | 5.14 | 14.25 | 9.33 | 38.46 |
| | | Glass | 1.10 | 1.86 | | 29.13 | |
| | 14:00 | Wall "A" | 0.13 | 5.14 | 15.80 | 10.35 | 42.65 |
| | | Glass | 1.10 | 1.86 | | 32.30 | |
| | 15:00 | Wall "A" | 0.13 | 5.14 | 17.00 | 11.14 | 45.88 |
| | | Glass | 1.10 | 1.86 | | 34.75 | |
| | 16:00 | Wall "A" | 0.13 | 5.14 | 17.70 | 11.59 | 47.77 |
| | | Glass | 1.10 | 1.86 | | 36.18 | |
| | 17:00 | Wall "A" | 0.13 | 5.14 | 18.00 | 11.79 | 48.58 |
| | | Glass | 1.10 | 1.86 | | 36.79 | |

| Direction | Time | Type | U | A | ∆T | Q (W) | Q(Total) ,W |
|---|---|---|---|---|---|---|---|
| NE | 08:00 | Wall "A" | 0.13 | 7.06 | 5.20 | 4.68 | 31.86 |
| | | Glass | 1.10 | 3.75 | | 21.46 | |
| | | Wall "D" | 0.39 | 2.78 | | 5.71 | |
| | 09:00 | Wall "A" | 0.13 | 7.06 | 6.75 | 6.08 | 41.35 |
| | | Glass | 1.10 | 3.75 | | 27.86 | |
| | | Wall "D" | 0.39 | 2.78 | | 7.41 | |
| | 10:00 | Wall "A" | 0.13 | 7.06 | 8.56 | 7.71 | 52.44 |
| | | Glass | 1.10 | 3.75 | | 35.33 | |
| | | Wall "D" | 0.39 | 2.78 | | 9.40 | |
| | 11:00 | Wall "A" | 0.13 | 7.06 | 10.50 | 9.46 | 64.32 |
| | | Glass | 1.10 | 3.75 | | 43.34 | |
| | | Wall "D" | 0.39 | 2.78 | | 11.53 | |
| | 12:00 | Wall "A" | 0.13 | 7.06 | 12.44 | 11.20 | 76.21 |
| | | Glass | 1.10 | 3.75 | | 51.35 | |
| | | Wall "D" | 0.39 | 2.78 | | 13.66 | |
| | 13:00 | Wall "A" | 0.13 | 7.06 | 14.25 | 12.83 | 87.30 |
| | | Glass | 1.10 | 3.75 | | 58.82 | |
| | | Wall "D" | 0.39 | 2.78 | | 15.64 | |
| | 14:00 | Wall "A" | 0.13 | 7.06 | 15.80 | 14.23 | 96.79 |
| | | Glass | 1.10 | 3.75 | | 65.21 | |
| | | Wall "D" | 0.39 | 2.78 | | 17.35 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 15:00 | Wall "A" | 0.13 | 7.06 | 17.00 | 15.31 | 104.14 |
| | | Glass | 1.10 | 3.75 | | 70.17 | |
| | | Wall "D" | 0.39 | 2.78 | | 18.66 | |
| | 16:00 | Wall "A" | 0.13 | 7.06 | 17.70 | 15.94 | 108.43 |
| | | Glass | 1.10 | 3.75 | | 73.06 | |
| | | Wall "D" | 0.39 | 2.78 | | 19.43 | |
| | 17:00 | Wall "A" | 0.13 | 7.06 | 18.00 | 16.21 | 110.27 |
| | | Glass | 1.10 | 3.75 | | 74.30 | |
| | | Wall "D" | 0.39 | 2.78 | | 19.76 | |

| Time | Qt(W) |
|---|---|
| 08:00 | 45.89 |
| 09:00 | 59.57 |
| 10:00 | 75.54 |
| 11:00 | 92.66 |
| 12:00 | 109.78 |
| 13:00 | 125.76 |
| 14:00 | 139.44 |
| 15:00 | 150.03 |
| 16:00 | 156.20 |
| 17:00 | 158.85 |

**2-Sun Load**

| Direction | Time | Type | U | A | I | ΔTs | Q | Qtot |
|---|---|---|---|---|---|---|---|---|
| SE | 08:00 | Wall "A" | 0.13 | 5.14 | 284.00 | 18.46 | 12.09 | 191.52 |
| | | Glass | 1.10 | 1.86 | | | 179.43 | |
| | 09:00 | Wall "A" | 0.13 | 5.14 | 284.00 | 18.46 | 12.09 | 191.52 |
| | | Glass | 1.10 | 1.86 | | | 179.43 | |
| | 10:00 | Wall "A" | 0.13 | 5.14 | 230.00 | 18.46 | 12.09 | 157.40 |
| | | Glass | 1.10 | 1.86 | | | 145.31 | |
| | 11:00 | Wall "A" | 0.13 | 5.14 | 139.00 | 18.46 | 12.09 | 99.91 |
| | | Glass | 1.10 | 1.86 | | | 87.82 | |
| | 12:00 | Wall "A" | 0.13 | 5.14 | 54.00 | 18.46 | 12.09 | 46.21 |
| | | Glass | 1.10 | 1.86 | | | 34.12 | |
| | 13:00 | Wall "A" | 0.13 | 5.14 | 44.00 | 18.46 | 12.09 | 39.89 |
| | | Glass | 1.10 | 1.86 | | | 27.80 | |
| | 14:00 | Wall "A" | 0.13 | 5.14 | 44.00 | 18.46 | 12.09 | 39.89 |
| | | Glass | 1.10 | 1.86 | | | 27.80 | |
| | 15:00 | Wall "A" | 0.13 | 5.14 | 44.00 | 18.46 | 12.09 | 39.89 |
| | | Glass | 1.10 | 1.86 | | | 27.80 | |
| | 16:00 | Wall "A" | 0.13 | 5.14 | 38.00 | 18.46 | 12.09 | 36.10 |
| | | Glass | 1.10 | 1.86 | | | 24.01 | |
| | 17:00 | Wall "A" | 0.13 | 5.14 | 32.00 | 18.46 | 12.09 | 32.31 |
| | | Glass | 1.10 | 1.86 | | | 20.22 | |

| Direction | Time | Type | U | A | I | ΔTs | Q | Qtot |
|---|---|---|---|---|---|---|---|---|
| NE | 08:00 | Wall "A" | 0.13 | 7.06 | 410.00 | 26.65 | 24.00 | 576.33 |
| | | Glass | 1.10 | 3.75 | | | 523.07 | |
| | | Wall "D" | 0.39 | 2.78 | | 16.40 | 29.26 | |
| | 09:00 | Wall "A" | 0.13 | 7.06 | 305.00 | 26.65 | 24.00 | 442.37 |
| | | Glass | 1.10 | 3.75 | | | 389.11 | |
| | | Wall "D" | 0.39 | 2.78 | | 16.40 | 29.26 | |
| | 10:00 | Wall "A" | 0.13 | 7.06 | 173.00 | 26.65 | 24.00 | 273.97 |
| | | Glass | 1.10 | 3.75 | | | 220.71 | |
| | | Wall "D" | 0.39 | 2.78 | | 16.40 | 29.26 | |
| | 11:00 | Wall "A" | 0.13 | 7.06 | 60.00 | 26.65 | 24.00 | 129.81 |
| | | Glass | 1.10 | 3.75 | | | 76.55 | |
| | | Wall "D" | 0.39 | 2.78 | | 16.40 | 29.26 | |
| | 12:00 | Wall "A" | 0.13 | 7.06 | 44.00 | 26.65 | 24.00 | 109.39 |
| | | Glass | 1.10 | 3.75 | | | 56.13 | |
| | | Wall "D" | 0.39 | 2.78 | | 16.40 | 29.26 | |
| | 13:00 | Wall "A" | 0.13 | 7.06 | 44.00 | 26.65 | 24.00 | 109.39 |
| | | Glass | 1.10 | 3.75 | | | 56.13 | |
| | | Wall "D" | 0.39 | 2.78 | | 16.40 | 29.26 | |
| | 14:00 | Wall "A" | 0.13 | 7.06 | 44.00 | 26.65 | 24.00 | 109.39 |
| | | Glass | 1.10 | 3.75 | | | 56.13 | |
| | | Wall "D" | 0.39 | 2.78 | | 16.40 | 29.26 | |
| | 15:00 | Wall "A" | 0.13 | 7.06 | 44.00 | 26.65 | 24.00 | 109.39 |
| | | Glass | 1.10 | 3.75 | | | 56.13 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Wall "D" | 0.39 | 2.78 | | 16.40 | 29.26 | |
| | 16:00 | Wall "A" | 0.13 | 7.06 | 38.00 | 26.65 | 24.00 | 101.74 |
| | | Glass | 1.10 | 3.75 | | | 48.48 | |
| | | Wall "D" | 0.39 | 2.78 | | 16.40 | 29.26 | |
| | 17:00 | Wall "A" | 0.13 | 7.06 | 32.00 | 26.65 | 24.00 | 94.08 |
| | | Glass | 1.10 | 3.75 | | | 40.83 | |
| | | Wall "D" | 0.39 | 2.78 | | 16.40 | 29.26 | |

| Time | Qt(W) |
|---|---|
| 08:00 | 767.85 |
| 09:00 | 633.89 |
| 10:00 | 431.37 |
| 11:00 | 229.72 |
| 12:00 | 155.60 |
| 13:00 | 149.28 |
| 14:00 | 149.28 |
| 15:00 | 149.28 |
| 16:00 | 137.84 |
| 17:00 | 126.39 |

### 3-Ventilation Load

| No Of Person | L/s.p | ζ |
|---|---|---|
| 25.00 | 14.00 | 3.00 |

| | |
|---|---|
| **A (m2)** | 112.16 |
| **H (m)** | 2.60 |
| **V (m3)** | 291.62 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 13.30 |
| **Based on Area** | 21.00 |
| **NO Of Air Changing Times** | 7.39 |

| Time | CMMmax | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 08:00 | 21.00 | 2227.68 | 6543.60 | 8771.28 |
| 09:00 | 21.00 | 2891.70 | 6543.60 | 9435.30 |
| 10:00 | 21.00 | 3667.10 | 6543.60 | 10210.70 |
| 11:00 | 21.00 | 4498.20 | 6543.60 | 11041.80 |
| 12:00 | 21.00 | 5329.30 | 6543.60 | 11872.90 |
| 13:00 | 21.00 | 6104.70 | 6543.60 | 12648.30 |
| 14:00 | 21.00 | 6768.72 | 6543.60 | 13312.32 |
| 15:00 | 21.00 | 7282.80 | 6543.60 | 13826.40 |
| 16:00 | 21.00 | 7582.68 | 6543.60 | 14126.28 |
| 17:00 | 21.00 | 7711.20 | 6543.60 | 14254.80 |

# B. Internal Loads

## 1-Occupancy Load

| No.Persons | Work | qs/p | Qs | QL | Qs.tot | QL.tot | Qtot (W) |
|---|---|---|---|---|---|---|---|
| 25.00 | sitting | 66.00 | 1650.00 | 775.00 | 1866.00 | 955.00 | 2821.00 |
| 3.00 | light | 72.00 | 216.00 | 180.00 | | | |

### 2-Light Load

| Type | No . | W/Lamp | Q (W) |
|---|---|---|---|
| Economical | 30.00 | 26.00 | 780.00 |
| spot | 4.00 | 35.00 | 140.00 |
| exit | 2.00 | 60.00 | 120.00 |

### 3-Equipment

| Type | No Of Device | W/device | Q (W) |
|---|---|---|---|
| cooler | 1.00 | 320.00 | 320.00 |

## Variation of load with time

| Q occ_s | Q occ_l | Q ligh_s | Q eq_s |
|---|---|---|---|
| 1040.00 | 1866.00 | 955.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q ven_s | RSH | RLH | RTH |
|---|---|---|---|---|---|---|
| 08:00 | 45.89 | 767.85 | 6543.60 | 4039.74 | 955.00 | 4994.74 |
| 09:00 | 59.57 | 633.89 | 6543.60 | 3919.46 | 955.00 | 4874.46 |
| 10:00 | 75.54 | 431.37 | 6543.60 | 3732.92 | 955.00 | 4687.92 |
| 11:00 | 92.66 | 229.72 | 6543.60 | 3548.38 | 955.00 | 4503.38 |
| 12:00 | 109.78 | 155.60 | 6543.60 | 3491.39 | 955.00 | 4446.39 |
| 13:00 | 125.76 | 149.28 | 6543.60 | 3501.04 | 955.00 | 4456.04 |
| 14:00 | 139.44 | 149.28 | 6543.60 | 3514.72 | 955.00 | 4469.72 |
| 15:00 | 150.03 | 149.28 | 6543.60 | 3525.31 | 955.00 | 4480.31 |
| 16:00 | 156.20 | 137.84 | 6543.60 | 3520.04 | 955.00 | 4475.04 |
| 17:00 | 158.85 | 126.39 | 6543.60 | 3511.24 | 955.00 | 4466.24 |

# Room 0-42

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ΔT | Q | Qtot W |
|---|---|---|---|---|---|---|---|
| NE | 08:00 | Glass | 1.10 | 3.44 | 5.20 | 19.65 | 23.95 |
| | | Wall "A" | 0.13 | 4.71 | | 3.13 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.18 | |
| | 09:00 | Glass | 1.10 | 3.44 | 6.75 | 25.51 | 31.09 |
| | | Wall "A" | 0.13 | 4.71 | | 4.06 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.53 | |
| | 10:00 | Glass | 1.10 | 3.44 | 8.56 | 32.35 | 39.43 |
| | | Wall "A" | 0.13 | 4.71 | | 5.15 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.94 | |
| | 11:00 | Glass | 1.10 | 3.44 | 10.50 | 39.68 | 48.37 |
| | | Wall "A" | 0.13 | 4.71 | | 6.31 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.37 | |
| | 12:00 | Glass | 1.10 | 3.44 | 12.44 | 47.01 | 57.31 |
| | | Wall "A" | 0.13 | 4.71 | | 7.48 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.81 | |
| | 13:00 | Glass | 1.10 | 3.44 | 14.25 | 53.85 | 65.64 |
| | | Wall "A" | 0.13 | 4.71 | | 8.57 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.22 | |
| | 14:00 | Glass | 1.10 | 3.44 | 15.80 | 59.71 | 72.78 |
| | | Wall "A" | 0.13 | 4.71 | | 9.50 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.57 | |
| | 15:00 | Glass | 1.10 | 3.44 | 17.00 | 64.25 | 78.31 |
| | | Wall "A" | 0.13 | 4.71 | | 10.22 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.84 | |
| | 16:00 | Glass | 1.10 | 3.44 | 17.74 | 67.04 | 81.72 |
| | | Wall "A" | 0.13 | 4.71 | | 10.67 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.01 | |
| | 17:00 | Glass | 1.10 | 3.44 | 18.00 | 68.03 | 82.92 |
| | | Wall "A" | 0.13 | 4.71 | | 10.82 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.07 | |

## 2-Sun Load

| Direction | Time | Type | U | A | ΔT s | I | Q | Q tot (W) |
|---|---|---|---|---|---|---|---|---|
| NE | 08:00 | glass | | 3.44 | | 410.00 | 478.93 | 498.66 |
| | | wall"A" | 0.13 | 4.71 | 26.65 | | 16.02 | |
| | | wall"D" | 0.39 | 0.57 | 16.40 | | 3.71 | |
| | 09:00 | glass | | 3.44 | | 305.00 | 356.27 | 370.95 |
| | | wall"A" | 0.13 | 4.71 | 19.83 | | 11.92 | |
| | | wall"D" | 0.39 | 0.57 | 12.20 | | 2.76 | |
| | 10:00 | glass | | 3.44 | | 173.00 | 202.08 | 210.41 |
| | | wall"A" | 0.13 | 4.71 | 11.25 | | 6.76 | |
| | | wall"D" | 0.39 | 0.57 | 6.92 | | 1.57 | |
| | 11:00 | glass | | 3.44 | | 60.00 | 70.09 | 72.97 |
| | | wall"A" | 0.13 | 4.71 | 3.90 | | 2.34 | |
| | | wall"D" | 0.39 | 0.57 | 2.40 | | 0.54 | |
| | 12:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | wall"A" | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | wall"D" | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 13:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | wall"A" | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | wall"D" | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 14:00 | glass | | 3.44 | | 44.00 | 478.93 | 481.04 |
| | | wall"A" | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | wall"D" | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 15:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | wall"A" | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | wall"D" | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 16:00 | glass | | 3.44 | | 38.00 | 44.39 | 46.22 |
| | | wall"A" | 0.13 | 4.71 | 2.47 | | 1.48 | |
| | | wall"D" | 0.39 | 0.57 | 1.52 | | 0.34 | |
| | 17:00 | glass | | 3.44 | | 32.00 | 37.38 | 38.92 |
| | | wall"A" | 0.13 | 4.71 | 2.08 | | 1.25 | |
| | | wall"D" | 0.39 | 0.57 | 1.28 | | 0.29 | |

**3-Ventilation Load**

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 5 | 12 | 1.80 | 2. |

| | |
|---|---|
| **A (m2)** | 16.63 |
| **H (m)** | 2.60 |
| **V (m3)** | 43.24 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 3.60 |
| **Based on Area** | 1.80 |
| **NO Of Changing Times** | 1.44 |

| Time | CMM | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 08:00 | 3.60 | 381.89 | 1121.76 | 1503.65 |
| 09:00 | 3.60 | 495.72 | 1121.76 | 1617.48 |
| 10:00 | 3.60 | 628.65 | 1121.76 | 1750.41 |
| 11:00 | 3.60 | 771.12 | 1121.76 | 1892.88 |
| 12:00 | 3.60 | 913.59 | 1121.76 | 2035.35 |
| 13:00 | 3.60 | 1046.52 | 1121.76 | 2168.28 |
| 14:00 | 3.60 | 1160.35 | 1121.76 | 2282.11 |
| 15:00 | 3.60 | 1248.48 | 1121.76 | 2370.24 |
| 16:00 | 3.60 | 1302.83 | 1121.76 | 2424.59 |
| 17:00 | 3.60 | 1321.92 | 1121.76 | 2443.68 |

## B-Internal Loads

**1-Occupancy Load**

| No Of Pers | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot |
|---|---|---|---|---|---|---|
| 5.00 | Light | 72.00 | 60.00 | 360.00 | 300.00 | 660.00 |

**2-Light Load**

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| Florescent | 8.00 | 20.00 | 1.25 | 200.00 |

**3-Equipment**

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot |
|---|---|---|---|---|
| CPU | 1.00 | 55.00 | 55.00 | 474.00 |
| Monitor | 1.00 | 55.00 | 55.00 | |
| scan light | 1.00 | 100.00 | 100.00 | |
| abjora | 1.00 | 60.00 | 60.00 | |
| scan device | 1.00 | 204.00 | 204.00 | |

**Variation of load with time**

| Q occ_s | Q occ_l | Q lig_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 360.00 | 300.00 | 200.00 | 474.00 | 0.00 |

| Time | Q wall_s | Q sun_s | Q ven_s | Q ven_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 23.95 | 498.66 | 381.89 | 1121.76 | 1556.61 | 300.00 | 1856.61 |
| 09:00 | 31.09 | 370.95 | 495.72 | 1121.76 | 1436.05 | 300.00 | 1736.05 |
| 10:00 | 39.43 | 210.41 | 628.65 | 1121.76 | 1283.84 | 300.00 | 1583.84 |
| 11:00 | 48.37 | 72.97 | 771.12 | 1121.76 | 1155.34 | 300.00 | 1455.34 |
| 12:00 | 57.31 | 53.51 | 913.59 | 1121.76 | 1144.82 | 300.00 | 1444.82 |
| 13:00 | 65.64 | 53.51 | 1046.52 | 1121.76 | 1153.16 | 300.00 | 1453.16 |
| 14:00 | 72.78 | 481.04 | 1160.35 | 1121.76 | 1587.83 | 300.00 | 1887.83 |
| 15:00 | 78.31 | 53.51 | 1248.48 | 1121.76 | 1165.83 | 300.00 | 1465.83 |
| 16:00 | 81.72 | 46.22 | 1302.83 | 1121.76 | 1161.94 | 300.00 | 1461.94 |
| 17:00 | 82.92 | 38.92 | 1321.92 | 1121.76 | 1155.84 | 300.00 | 1455.84 |

# Room 0-43

## A-External Loads

### 1-Wall Load

| Direction | TIMe | Type | U | A | ∆T (K) | Q (W) | Qtot W |
|---|---|---|---|---|---|---|---|
| NE | 8:00 | Glass | 1.10 | 3.44 | 5.20 | 19.65 | 38.12 |
| | | Wall "A" | 0.13 | 4.04 | | 2.68 | |
| | | Wall "B" | 1.44 | 1.03 | | 7.67 | |
| | | Wall "C" | 1.79 | 0.87 | | 8.12 | |
| | 9:00 | Glass | 1.10 | 3.44 | 6.75 | 25.51 | 49.48 |
| | | Wall "A" | 0.13 | 4.04 | | 3.48 | |
| | | Wall "B" | 1.44 | 1.03 | | 9.96 | |
| | | Wall "C" | 1.79 | 0.87 | | 10.53 | |
| | 10:00 | Glass | 1.10 | 3.44 | 8.56 | 32.35 | 62.75 |
| | | Wall "A" | 0.13 | 4.04 | | 4.41 | |
| | | Wall "B" | 1.44 | 1.03 | | 12.63 | |
| | | Wall "C" | 1.79 | 0.87 | | 13.36 | |
| | 11:00 | Glass | 1.10 | 3.44 | 10.50 | 39.68 | 76.97 |
| | | Wall "A" | 0.13 | 4.04 | | 5.41 | |
| | | Wall "B" | 1.44 | 1.03 | | 15.50 | |
| | | Wall "C" | 1.79 | 0.87 | | 16.39 | |
| | 12:00 | Glass | 1.10 | 3.44 | 12.44 | 47.01 | 91.19 |
| | | Wall "A" | 0.13 | 4.04 | | 6.41 | |
| | | Wall "B" | 1.44 | 1.03 | | 18.36 | |
| | | Wall "C" | 1.79 | 0.87 | | 19.41 | |
| | 13:00 | Glass | 1.10 | 3.44 | 14.25 | 53.85 | 104.46 |
| | | Wall "A" | 0.13 | 4.04 | | 7.34 | |
| | | Wall "B" | 1.44 | 1.03 | | 21.03 | |
| | | Wall "C" | 1.79 | 0.87 | | 22.24 | |
| | 14:00 | Glass | 1.10 | 3.44 | 15.80 | 59.71 | 115.83 |
| | | Wall "A" | 0.13 | 4.04 | | 8.14 | |
| | | Wall "B" | 1.44 | 1.03 | | 23.32 | |
| | | Wall "C" | 1.79 | 0.87 | | 24.66 | |
| | 15:00 | Glass | 1.10 | 3.44 | 17.00 | 64.25 | 124.62 |
| | | Wall "A" | 0.13 | 4.04 | | 8.76 | |
| | | Wall "B" | 1.44 | 1.03 | | 25.09 | |
| | | Wall "C" | 1.79 | 0.87 | | 26.53 | |
| | 16:00 | Glass | 1.10 | 3.44 | 17.74 | 67.04 | 130.05 |
| | | Wall "A" | 0.13 | 4.04 | | 9.14 | |
| | | Wall "B" | 1.44 | 1.03 | | 26.18 | |
| | | Wall "C" | 1.79 | 0.87 | | 27.69 | |
| | 17:00 | Glass | 1.10 | 3.44 | 18.00 | 68.03 | 131.95 |
| | | Wall "A" | 0.13 | 4.04 | | 9.27 | |
| | | Wall "B" | 1.44 | 1.03 | | 26.56 | |
| | | Wall "C" | 1.79 | 0.87 | | 28.09 | |

**2-Sun Load**

| Direction | Time | Type | U | A | ∆T s | I | Q | Q tot W |
|---|---|---|---|---|---|---|---|---|
| NE | 8:00 | glass | | 3.44 | | 410.00 | 478.93 | 557.58 |
| | | wall"A" | 0.13 | 4.04 | 26.65 | | 13.73 | |
| | | wall"B" | 1.44 | 1.03 | 26.65 | | 39.33 | |
| | | wall"C" | 1.79 | 0.87 | 16.40 | | 25.59 | |
| | 9:00 | glass | | 3.44 | | 305.00 | 356.27 | 414.78 |
| | | wall"A" | 0.13 | 4.04 | 19.83 | | 10.21 | |
| | | wall"B" | 1.44 | 1.03 | 19.83 | | 29.26 | |
| | | wall"C" | 1.79 | 0.87 | 12.20 | | 19.04 | |
| | 10:00 | glass | | 3.44 | | 173.00 | 202.08 | 235.27 |
| | | wall"A" | 0.13 | 4.04 | 11.25 | | 5.79 | |
| | | wall"B" | 1.44 | 1.03 | 11.25 | | 16.60 | |
| | | wall"C" | 1.79 | 0.87 | 6.92 | | 10.80 | |
| | 11:00 | glass | | 3.44 | | 60.00 | 70.09 | 81.60 |
| | | wall"A" | 0.13 | 4.04 | 3.90 | | 2.01 | |
| | | wall"B" | 1.44 | 1.03 | 3.90 | | 5.76 | |
| | | wall"C" | 1.79 | 0.87 | 2.40 | | 3.75 | |
| | 12:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | wall"A" | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | wall"B" | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | wall"C" | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 13:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | wall"A" | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | wall"B" | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | wall"C" | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 14:00 | glass | | 3.44 | | 44.00 | 478.93 | 487.37 |
| | | wall"A" | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | wall"B" | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | wall"C" | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 15:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | wall"A" | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | wall"B" | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | wall"C" | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 16:00 | glass | | 3.44 | | 38.00 | 44.39 | 51.68 |
| | | wall"A" | 0.13 | 4.04 | 2.47 | | 1.27 | |
| | | wall"B" | 1.44 | 1.03 | 2.47 | | 3.65 | |
| | | wall"C" | 1.79 | 0.87 | 1.52 | | 2.37 | |
| | 17:00 | glass | | 3.44 | | 32.00 | 37.38 | 43.52 |
| | | wall"A" | 0.13 | 4.04 | 2.08 | | 1.07 | |
| | | wall"B" | 1.44 | 1.03 | 2.08 | | 3.07 | |
| | | wall"C" | 1.79 | 0.87 | 1.28 | | 2.00 | |

### 3-Ventilation Load

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 5 | 12 | 1.8 | 2 |

| | |
|---|---|
| **A (m2)** | 17.52 |
| **H (m)** | 2.6 |
| **V (m3)** | 45.552 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 3.6 |
| **Based on Area** | 1.89216 |
| **NO Of Air Changing Times** | 1.5184 |

| Time | CMM | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 8:00 | 3.6 | 381.89 | 1121.76 | 1503.65 |
| 9:00 | 3.6 | 495.72 | 1121.76 | 1617.48 |
| 10:00 | 3.6 | 628.65 | 1121.76 | 1750.41 |
| 11:00 | 3.6 | 771.12 | 1121.76 | 1892.88 |
| 12:00 | 3.6 | 913.59 | 1121.76 | 2035.35 |
| 13:00 | 3.6 | 1046.52 | 1121.76 | 2168.28 |
| 14:00 | 3.6 | 1160.35 | 1121.76 | 2282.11 |
| 15:00 | 3.6 | 1248.48 | 1121.76 | 2370.24 |
| 16:00 | 3.6 | 1302.83 | 1121.76 | 2424.59 |
| 17:00 | 3.6 | 1321.92 | 1121.76 | 2443.68 |

## B-Internal Loads

### 1-Occupancy Load

| NoOf Pers | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot W |
|---|---|---|---|---|---|---|
| 5 | Work | 72 | 60 | 360 | 300 | 660 |

### 2- Light load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| Fluorescent | 8 | 20 | 1.25 | 200 |

### 3-Equipment

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot |
|---|---|---|---|---|
| CPU | 1 | 55 | 55 | 474 |
| Monitor | 1 | 55 | 55 | |
| scan light | 1 | 100 | 100 | |
| abjora | 1 | 60 | 60 | |
| scan device | 1 | 204 | 204 | |

**Variation of load with time**

| Q occ_s | Q oc_l | Q lig_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 360 | 300 | 200 | 474 | 0 |

| Time | Qwal_s | Qsun_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 38.12 | 557.58 | 381.89 | 1121.76 | 1629.70 | 300.00 | 1929.70 |
| 09:00 | 49.48 | 414.78 | 495.72 | 1121.76 | 1498.27 | 300.00 | 1798.27 |
| 10:00 | 62.75 | 235.27 | 628.65 | 1121.76 | 1332.02 | 300.00 | 1632.02 |
| 11:00 | 76.97 | 81.60 | 771.12 | 1121.76 | 1192.57 | 300.00 | 1492.57 |
| 12:00 | 91.19 | 59.84 | 913.59 | 1121.76 | 1185.03 | 300.00 | 1485.03 |
| 13:00 | 104.46 | 59.84 | 1046.52 | 1121.76 | 1198.30 | 300.00 | 1498.30 |
| 14:00 | 115.83 | 487.37 | 1160.35 | 1121.76 | 1637.19 | 300.00 | 1937.19 |
| 15:00 | 124.62 | 59.84 | 1248.48 | 1121.76 | 1218.46 | 300.00 | 1518.46 |
| 16:00 | 130.05 | 51.68 | 1302.83 | 1121.76 | 1215.73 | 300.00 | 1515.73 |
| 17:00 | 131.95 | 43.52 | 1321.92 | 1121.76 | 1209.47 | 300.00 | 1509.47 |

# Room 0-44

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ∆T (K) | Q (W) | Qtot W |
|---|---|---|---|---|---|---|---|
| NE | 08:00 | Glass | 1.10 | 3.44 | 5.20 | 19.65 | 23.95 |
| | | Wall "A" | 0.13 | 4.71 | | 3.13 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.18 | |
| | 09:00 | Glass | 1.10 | 3.44 | 6.75 | 25.51 | 31.09 |
| | | Wall "A" | 0.13 | 4.71 | | 4.06 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.53 | |
| | 10:00 | Glass | 1.10 | 3.44 | 8.56 | 32.35 | 39.43 |
| | | Wall "A" | 0.13 | 4.71 | | 5.15 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.94 | |
| | 11:00 | Glass | 1.10 | 3.44 | 10.50 | 39.68 | 48.37 |
| | | Wall "A" | 0.13 | 4.71 | | 6.31 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.37 | |
| | 12:00 | Glass | 1.10 | 3.44 | 12.44 | 47.01 | 57.31 |
| | | Wall "A" | 0.13 | 4.71 | | 7.48 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.81 | |
| | 13:00 | Glass | 1.10 | 3.44 | 14.25 | 53.85 | 65.64 |
| | | Wall "A" | 0.13 | 4.71 | | 8.57 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.22 | |
| | 14:00 | Glass | 1.10 | 3.44 | 15.80 | 59.71 | 72.78 |
| | | Wall "A" | 0.13 | 4.71 | | 9.50 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.57 | |
| | 15:00 | Glass | 1.10 | 3.44 | 17.00 | 64.25 | 78.31 |
| | | Wall "A" | 0.13 | 4.71 | | 10.22 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.84 | |
| | 16:00 | Glass | 1.10 | 3.44 | 17.74 | 67.04 | 81.72 |
| | | Wall "A" | 0.13 | 4.71 | | 10.67 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.01 | |
| | 17:00 | Glass | 1.10 | 3.44 | 18.00 | 68.03 | 82.92 |
| | | Wall "A" | 0.13 | 4.71 | | 10.82 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.07 | |

## 2-Sun Load

| Direction | Time | Type | U | A | ∆T | I | Q (W) | Q tot (W) |
|---|---|---|---|---|---|---|---|---|
| NE | 8:00 | glass | | 3.44 | | 410.00 | 478.93 | 498.66 |
| | | Wall"A" | 0.13 | 4.71 | 26.65 | | 16.02 | |
| | | Wall"D" | 0.39 | 0.57 | 16.40 | | 3.71 | |
| | 9:00 | glass | | 3.44 | | 305.00 | 356.27 | 370.95 |
| | | Wall"A" | 0.13 | 4.71 | 19.83 | | 11.92 | |
| | | Wall"D" | 0.39 | 0.57 | 12.20 | | 2.76 | |
| | 10:00 | glass | | 3.44 | | 173.00 | 202.08 | 210.41 |
| | | Wall"A" | 0.13 | 4.71 | 11.25 | | 6.76 | |
| | | Wall"D" | 0.39 | 0.57 | 6.92 | | 1.57 | |
| | 11:00 | glass | | 3.44 | | 60.00 | 70.09 | 72.97 |
| | | Wall"A" | 0.13 | 4.71 | 3.90 | | 2.34 | |
| | | Wall"D" | 0.39 | 0.57 | 2.40 | | 0.54 | |
| | 12:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | Wall"A" | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | Wall"D" | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 13:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | Wall"A" | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | Wall"D" | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 14:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | Wall"A" | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | Wall"D" | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 15:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | Wall"A" | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | Wall"D" | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 16:00 | glass | | 3.44 | | 38.00 | 44.39 | 46.22 |
| | | Wall"A" | 0.13 | 4.71 | 2.47 | | 1.48 | |
| | | Wall"D" | 0.39 | 0.57 | 1.52 | | 0.34 | |
| | 17:00 | glass | | 3.44 | | 32.00 | 37.38 | 38.92 |
| | | Wall"A" | 0.13 | 4.71 | 2.08 | | 1.25 | |
| | | Wall"D" | 0.39 | 0.57 | 1.28 | | 0.29 | |

## 3-Ventilation Load

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 5 | 12 | 1.8 | 2 |

| | |
|---|---|
| A (m2) | 16.63 |
| H (m) | 2.6 |
| V (m3) | 43.238 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 3.6 |
| **Based on Area** | 1.80 |
| **NO Of Air Changing Times** | 1.44 |

| Time | CMM | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 8:00 | 3.6 | 381.89 | 1121.76 | 1503.65 |
| 9:00 | 3.6 | 495.72 | 1121.76 | 1617.48 |
| 10:00 | 3.6 | 628.65 | 1121.76 | 1750.41 |
| 11:00 | 3.6 | 771.12 | 1121.76 | 1892.88 |
| 12:00 | 3.6 | 913.59 | 1121.76 | 2035.35 |
| 13:00 | 3.6 | 1046.52 | 1121.76 | 2168.28 |
| 14:00 | 3.6 | 1160.35 | 1121.76 | 2282.11 |
| 15:00 | 3.6 | 1248.48 | 1121.76 | 2370.24 |
| 16:00 | 3.6 | 1302.83 | 1121.76 | 2424.59 |
| 17:00 | 3.6 | 1321.92 | 1121.76 | 2443.68 |

## B-Internal Loads

**1-Occupancy Load**

| NoOf Pers | Work | qs/p | qL/p | Qs | QL | Qtot (W) |
|---|---|---|---|---|---|---|
| 5 | Light Work | 72 | 60 | 360 | 300 | 660 |

**2-Light Load**

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| Florescent | 8 | 20 | 1.25 | 200 |

**3-Equipment**

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot |
|---|---|---|---|---|
| CPU | 1 | 55 | 55 | 474 |
| Monitor | 1 | 55 | 55 | |
| scan light | 1 | 100 | 100 | |
| abjora | 1 | 60 | 60 | |
| scan device | 1 | 204 | 204 | |

**Variation of load with time**

| Q occ_s | Q occ_l | Q lig_s | Q equ_s | Q equip_l |
|---|---|---|---|---|
| 360 | 300 | 200 | 474 | 0 |

| Time | Q wall_s | Q su_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 23.9540 | 498.657 | 381.888 | 1121.76 | 1556.6 | 300 | 1856.611 |
| 09:00 | 31.0942 | 370.952 | 495.72 | 1121.76 | 1436 | 300 | 1736.047 |
| 10:00 | 39.4320 | 210.409 | 628.6464 | 1121.76 | 1283.8 | 300 | 1583.841 |
| 11:00 | 48.3688 | 72.9742 | 771.12 | 1121.76 | 1155.3 | 300 | 1455.343 |
| 12:00 | 57.3055 | 53.5144 | 913.5936 | 1121.76 | 1144.8 | 300 | 1444.82 |
| 13:00 | 65.6433 | 53.5144 | 1046.52 | 1121.76 | 1153.2 | 300 | 1453.158 |
| 14:00 | 72.7835 | 53.5144 | 1160.352 | 1121.76 | 1160.3 | 300 | 1460.298 |
| 15:00 | 78.3114 | 53.5144 | 1248.48 | 1121.76 | 1165.8 | 300 | 1465.826 |
| 16:00 | 81.7202 | 46.2170 | 1302.826 | 1121.76 | 1161.9 | 300 | 1461.937 |
| 17:00 | 82.9179 | 38.9195 | 1321.92 | 1121.76 | 1155.8 | 300 | 1455.838 |

# Room 0-45

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ΔT | Q (W) | Qtot W |
|---|---|---|---|---|---|---|---|
| NE | 8:00 | Glass | 1.10 | 3.44 | 5.20 | 19.65 | 38.12 |
| | | Wall "A" | 0.13 | 4.04 | | 2.68 | |
| | | Wall "B" | 1.44 | 1.03 | | 7.67 | |
| | | Wall "C" | 1.79 | 0.87 | | 8.12 | |
| | 9:00 | Glass | 1.10 | 3.44 | 6.75 | 25.51 | 49.48 |
| | | Wall "A" | 0.13 | 4.04 | | 3.48 | |
| | | Wall "B" | 1.44 | 1.03 | | 9.96 | |
| | | Wall "C" | 1.79 | 0.87 | | 10.53 | |
| | 10:00 | Glass | 1.10 | 3.44 | 8.56 | 32.35 | 62.75 |
| | | Wall "A" | 0.13 | 4.04 | | 4.41 | |
| | | Wall "B" | 1.44 | 1.03 | | 12.63 | |
| | | Wall "C" | 1.79 | 0.87 | | 13.36 | |
| | 11:00 | Glass | 1.10 | 3.44 | 10.50 | 39.68 | 76.97 |
| | | Wall "A" | 0.13 | 4.04 | | 5.41 | |
| | | Wall "B" | 1.44 | 1.03 | | 15.50 | |
| | | Wall "C" | 1.79 | 0.87 | | 16.39 | |
| | 12:00 | Glass | 1.10 | 3.44 | 12.44 | 47.01 | 91.19 |
| | | Wall "A" | 0.13 | 4.04 | | 6.41 | |
| | | Wall "B" | 1.44 | 1.03 | | 18.36 | |
| | | Wall "C" | 1.79 | 0.87 | | 19.41 | |
| | 13:00 | Glass | 1.10 | 3.44 | 14.25 | 53.85 | 104.46 |
| | | Wall "A" | 0.13 | 4.04 | | 7.34 | |
| | | Wall "B" | 1.44 | 1.03 | | 21.03 | |
| | | Wall "C" | 1.79 | 0.87 | | 22.24 | |
| | 14:00 | Glass | 1.10 | 3.44 | 15.80 | 59.71 | 115.83 |
| | | Wall "A" | 0.13 | 4.04 | | 8.14 | |
| | | Wall "B" | 1.44 | 1.03 | | 23.32 | |
| | | Wall "C" | 1.79 | 0.87 | | 24.66 | |
| | 15:00 | Glass | 1.10 | 3.44 | 17.00 | 64.25 | 124.62 |
| | | Wall "A" | 0.13 | 4.04 | | 8.76 | |
| | | Wall "B" | 1.44 | 1.03 | | 25.09 | |
| | | Wall "C" | 1.79 | 0.87 | | 26.53 | |
| | 16:00 | Glass | 1.10 | 3.44 | 17.74 | 67.04 | 130.05 |
| | | Wall "A" | 0.13 | 4.04 | | 9.14 | |
| | | Wall "B" | 1.44 | 1.03 | | 26.18 | |
| | | Wall "C" | 1.79 | 0.87 | | 27.69 | |
| | 17:00 | Glass | 1.10 | 3.44 | 18.00 | 68.03 | 131.95 |
| | | Wall "A" | 0.13 | 4.04 | | 9.27 | |
| | | Wall "B" | 1.44 | 1.03 | | 26.56 | |
| | | Wall "C" | 1.79 | 0.87 | | 28.09 | |

**2-Sun Load**

| Direction | Time | Type | U | A | ∆T s | I | Q (W) | Qtot (W) |
|---|---|---|---|---|---|---|---|---|
| NE | 8:00 | glass | | 3.44 | | 410.00 | 478.93 | 557.58 |
| | | wall"A" | 0.13 | 4.04 | 26.65 | | 13.73 | |
| | | wall"B" | 1.44 | 1.03 | 26.65 | | 39.33 | |
| | | wall"C" | 1.79 | 0.87 | 16.40 | | 25.59 | |
| | 9:00 | glass | | 3.44 | | 305.00 | 356.27 | 414.78 |
| | | wall"A" | 0.13 | 4.04 | 19.83 | | 10.21 | |
| | | wall"B" | 1.44 | 1.03 | 19.83 | | 29.26 | |
| | | wall"C" | 1.79 | 0.87 | 12.20 | | 19.04 | |
| | 10:00 | glass | | 3.44 | | 173.00 | 202.08 | 235.27 |
| | | wall"A" | 0.13 | 4.04 | 11.25 | | 5.79 | |
| | | wall"B" | 1.44 | 1.03 | 11.25 | | 16.60 | |
| | | wall"C" | 1.79 | 0.87 | 6.92 | | 10.80 | |
| | 11:00 | glass | | 3.44 | | 60.00 | 70.09 | 81.60 |
| | | wall"A" | 0.13 | 4.04 | 3.90 | | 2.01 | |
| | | wall"B" | 1.44 | 1.03 | 3.90 | | 5.76 | |
| | | wall"C" | 1.79 | 0.87 | 2.40 | | 3.75 | |
| | 12:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | wall"A" | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | wall"B" | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | wall"C" | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 13:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | wall"A" | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | wall"B" | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | wall"C" | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 14:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | wall"A" | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | wall"B" | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | wall"C" | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 15:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | wall"A" | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | wall"B" | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | wall"C" | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 16:00 | glass | | 3.44 | | 38.00 | 44.39 | 51.68 |
| | | wall"A" | 0.13 | 4.04 | 2.47 | | 1.27 | |
| | | wall"B" | 1.44 | 1.03 | 2.47 | | 3.65 | |
| | | wall"C" | 1.79 | 0.87 | 1.52 | | 2.37 | |
| | 17:00 | glass | | 3.44 | | 32.00 | 37.38 | 43.52 |
| | | wall"A" | 0.13 | 4.04 | 2.08 | | 1.07 | |
| | | wall"B" | 1.44 | 1.03 | 2.08 | | 3.07 | |
| | | wall"C" | 1.79 | 0.87 | 1.28 | | 2.00 | |

**3-Ventilation Load**

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 5 | 12 | 1.8 | 2 |

| | |
|---|---|
| **A (m2)** | 17.52 |
| **H (m)** | 2.6 |
| **V (m3)** | 45.552 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 3.6 |
| **Based on Area** | 1.89216 |
| **NO Of Air Changing Times** | 1.5184 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 8:00 | 3.6 | 381.888 | 1121.76 | 1503.648 |
| 9:00 | 3.6 | 495.72 | 1121.76 | 1617.48 |
| 10:00 | 3.6 | 628.6464 | 1121.76 | 1750.406 |
| 11:00 | 3.6 | 771.12 | 1121.76 | 1892.88 |
| 12:00 | 3.6 | 913.5936 | 1121.76 | 2035.354 |
| 13:00 | 3.6 | 1046.52 | 1121.76 | 2168.28 |
| 14:00 | 3.6 | 1160.352 | 1121.76 | 2282.112 |
| 15:00 | 3.6 | 1248.48 | 1121.76 | 2370.24 |
| 16:00 | 3.6 | 1302.826 | 1121.76 | 2424.586 |
| 17:00 | 3.6 | 1321.92 | 1121.76 | 2443.68 |

## B-Internal Loads

**1-Occupancy Load**

| No Of Pers | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 5 | Light Work | 72 | 60 | 360 | 300 | 660 |

**2-Light Load**

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| Florescent | 8 | 20 | 1.25 | 200 |

**3-Equipment**

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot (W) |
|---|---|---|---|---|
| CPU | 1 | 55 | 55 | 474 |
| Monitor | 1 | 55 | 55 | |
| scan light | 1 | 100 | 100 | |
| Table light | 1 | 60 | 60 | |
| scan device | 1 | 204 | 204 | |

**Variation of load with time**

| Q occ_s | Q occ_l | Q ligh_s | Q equ_s | Q equ_l |
|---|---|---|---|---|
| 360 | 300 | 200 | 474 | 0 |

| Time | Q wal_s | Qsun_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 38.1200 | 557.579 | 381.888 | 1121.76 | 1629.7 | 300 | 1929.7 |
| 9:00 | 49.4827 | 414.785 | 495.72 | 1121.76 | 1498.26 | 300 | 1798.3 |
| 10:00 | 62.7514 | 235.271 | 628.6464 | 1121.76 | 1332.02 | 300 | 1632 |
| 11:00 | 76.9731 | 81.5970 | 771.12 | 1121.76 | 1192.57 | 300 | 1492.6 |
| 12:00 | 91.1948 | 59.8378 | 913.593 | 1121.76 | 1185.03 | 300 | 1485 |
| 13:00 | 104.463 | 59.8378 | 1046.52 | 1121.76 | 1198.30 | 300 | 1498.3 |
| 14:00 | 115.826 | 59.8378 | 1160.35 | 1121.76 | 1209.66 | 300 | 1509.7 |
| 15:00 | 124.623 | 59.8378 | 1248.48 | 1121.76 | 1218.46 | 300 | 1518.5 |
| 16:00 | 130.048 | 51.67813 | 1302.826 | 1121.76 | 1215.72 | 300 | 1515.7 |
| 17:00 | 131.954 | 43.5184 | 1321.92 | 1121.76 | 1209.47 | 300 | 1509.5 |

# Room 0-47

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ∆T | Q (W) | Q t(W) |
|---|---|---|---|---|---|---|---|
| NE | 0.33 | Wall "A" | 0.13 | 4.74 | 5.20 | 3.14 | 17.34 |
| | | Wall "B" | 1.44 | 1.90 | | 14.20 | |
| | 0.38 | Wall "A" | 0.13 | 4.74 | 6.75 | 4.08 | 22.51 |
| | | Wall "B" | 1.44 | 1.90 | | 18.43 | |
| | 0.42 | Wall "A" | 0.13 | 4.74 | 8.56 | 5.17 | 28.55 |
| | | Wall "B" | 1.44 | 1.90 | | 23.38 | |
| | 0.46 | Wall "A" | 0.13 | 4.74 | 10.50 | 6.35 | 35.02 |
| | | Wall "B" | 1.44 | 1.90 | | 28.68 | |
| | 0.50 | Wall "A" | 0.13 | 4.74 | 12.44 | 7.52 | 41.49 |
| | | Wall "B" | 1.44 | 1.90 | | 33.97 | |
| | 0.54 | Wall "A" | 0.13 | 4.74 | 14.25 | 8.61 | 47.53 |
| | | Wall "B" | 1.44 | 1.90 | | 38.92 | |
| | 0.58 | Wall "A" | 0.13 | 4.74 | 15.80 | 9.55 | 52.70 |
| | | Wall "B" | 1.44 | 1.90 | | 43.15 | |
| | 0.63 | Wall "A" | 0.13 | 4.74 | 17.00 | 10.28 | 56.70 |
| | | Wall "B" | 1.44 | 1.90 | | 46.43 | |
| | 0.67 | Wall "A" | 0.13 | 4.74 | 17.70 | 10.70 | 59.04 |
| | | Wall "B" | 1.44 | 1.90 | | 48.34 | |
| | 0.71 | Wall "A" | 0.13 | 4.74 | 18.00 | 10.88 | 60.04 |
| | | Wall "B" | 1.44 | 1.90 | | 49.16 | |

| Direction | Time | Type | U | A | ∆T | Q (W) |
|---|---|---|---|---|---|---|
| NW | 0.33 | Adj Wall | 0.10 | 14.35 | 5.20 | 7.52 |
| | 0.38 | Adj Wall | 0.10 | 14.35 | 6.75 | 9.76 |
| | 0.42 | Adj Wall | 0.10 | 14.35 | 8.56 | 12.37 |
| | 0.46 | Adj Wall | 0.10 | 14.35 | 10.50 | 15.18 |
| | 0.50 | Adj Wall | 0.10 | 14.35 | 12.44 | 17.98 |
| | 0.54 | Adj Wall | 0.10 | 14.35 | 14.25 | 20.59 |
| | 0.58 | Adj Wall | 0.10 | 14.35 | 15.80 | 22.83 |
| | 0.63 | Adj Wall | 0.10 | 14.35 | 17.00 | 24.57 |
| | 0.67 | Adj Wall | 0.10 | 14.35 | 17.70 | 25.58 |
| | 0.71 | Adj Wall | 0.10 | 14.35 | 18.00 | 26.01 |

| Time | Qt(W) |
|---|---|
| 0.33 | 24.86 |
| 0.38 | 32.27 |
| 0.42 | 40.92 |
| 0.46 | 50.20 |
| 0.50 | 59.47 |
| 0.54 | 68.13 |

| | |
|---|---|
| 0.58 | 75.54 |
| 0.63 | 81.27 |
| 0.67 | 84.62 |
| 0.71 | 86.05 |

**2-Sun Load**

| Direction | Time | Type | U | A | I | ∆Ts | Q (W) | Q t(W) |
|---|---|---|---|---|---|---|---|---|
| NE | 0.33 | Wall "A" | 0.13 | 4.74 | 410.00 | 26.65 | 16.11 | 88.89 |
| | | Wall "B" | 1.44 | 1.90 | | 26.65 | 72.78 | |
| | 0.38 | Wall "A" | 0.13 | 4.74 | 305.00 | 19.83 | 11.98 | 66.13 |
| | | Wall "B" | 1.44 | 1.90 | | 19.83 | 54.14 | |
| | 0.42 | Wall "A" | 0.13 | 4.74 | 173.00 | 11.25 | 6.80 | 37.51 |
| | | Wall "B" | 1.44 | 1.90 | | 2.86 | 30.71 | |
| | 0.46 | Wall "A" | 0.13 | 4.74 | 60.00 | 2.86 | 1.73 | 9.54 |
| | | Wall "B" | 1.44 | 1.90 | | 2.86 | 7.81 | |
| | 0.50 | Wall "A" | 0.13 | 4.74 | 44.00 | 2.86 | 1.73 | 9.54 |
| | | Wall "B" | 1.44 | 1.90 | | 3.51 | 7.81 | |
| | 0.54 | Wall "A" | 0.13 | 4.74 | 44.00 | 2.86 | 1.73 | 9.54 |
| | | Wall "B" | 1.44 | 1.90 | | 8.97 | 7.81 | |
| | 0.58 | Wall "A" | 0.13 | 4.74 | 44.00 | 2.86 | 1.73 | 9.54 |
| | | Wall "B" | 1.44 | 1.90 | | 14.95 | 7.81 | |
| | 0.63 | Wall "A" | 0.13 | 4.74 | 44.00 | 2.86 | 1.73 | 9.54 |
| | | Wall "B" | 1.44 | 1.90 | | 18.46 | 7.81 | |
| | 0.67 | Wall "A" | 0.13 | 4.74 | 38.00 | 2.47 | 1.49 | 8.24 |
| | | Wall "B" | 1.44 | 1.90 | | 18.46 | 6.75 | |
| | 0.71 | Wall "A" | 0.13 | 4.74 | 32.00 | 2.08 | 1.26 | 6.94 |
| | | Wall "B" | 1.44 | 1.90 | | 15.41 | 5.68 | |

**3-Ventilation Load**

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 2.00 | 14.00 | 2.50 | 1.00 |

| | |
|---|---|
| A (m2) | 15.46 |
| H (m) | 2.60 |
| V (m3) | 40.20 |

| Method | CMM |
|---|---|
| Based on No Of Persons | 1.68 |
| Based on Area | 2.32 |
| NO Of Air Changing Times | 0.67 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 08:00 | 2.32 | 246.00 | 722.60 | 968.60 |
| 09:00 | 2.32 | 319.33 | 722.60 | 1041.93 |
| 10:00 | 2.32 | 404.95 | 722.60 | 1127.55 |
| 11:00 | 2.32 | 496.73 | 722.60 | 1219.33 |
| 12:00 | 2.32 | 588.51 | 722.60 | 1311.11 |
| 13:00 | 2.32 | 674.13 | 722.60 | 1396.73 |
| 14:00 | 2.32 | 747.46 | 722.60 | 1470.06 |
| 15:00 | 2.32 | 804.23 | 722.60 | 1526.83 |
| 16:00 | 2.32 | 837.34 | 722.60 | 1559.94 |
| 17:00 | 2.32 | 851.54 | 722.60 | 1574.14 |

## B-Internal Loads

### 1-Occupancy Load

| No Of Persons | Type Of Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 2.00 | Comfort. sitting | 66.00 | 31.00 | 132.00 | 62.00 | 194.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| florescent | 8.00 | 40.00 | 1.25 | 400.00 |

### Variation of load with time

| Qs | Qs | Ql | Qs | Ql |
|---|---|---|---|---|
| 400.00 | 132.00 | 62.00 | 0.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 24.86 | 88.89 | 246.00 | 722.60 | 645.75 | 62.00 | 707.75 |
| 09:00 | 32.27 | 66.13 | 319.33 | 722.60 | 630.40 | 62.00 | 692.40 |
| 10:00 | 40.92 | 37.51 | 404.95 | 722.60 | 610.43 | 62.00 | 672.43 |
| 11:00 | 50.20 | 9.54 | 496.73 | 722.60 | 591.74 | 62.00 | 653.74 |
| 12:00 | 59.47 | 9.54 | 588.51 | 722.60 | 601.01 | 62.00 | 663.01 |
| 13:00 | 68.13 | 9.54 | 674.13 | 722.60 | 609.67 | 62.00 | 671.67 |
| 14:00 | 75.54 | 9.54 | 747.46 | 722.60 | 617.08 | 62.00 | 679.08 |
| 15:00 | 81.27 | 9.54 | 804.23 | 722.60 | 622.81 | 62.00 | 684.81 |
| 16:00 | 84.62 | 8.24 | 837.34 | 722.60 | 624.86 | 62.00 | 686.86 |
| 17:00 | 86.05 | 6.94 | 851.54 | 722.60 | 624.99 | 62.00 | 686.99 |

## Room 0-48

### A-External Loads

**1-Wall Load**

| Direction | Time | Type | U | A | ΔT | Q (W) | Q t(W) |
|---|---|---|---|---|---|---|---|
| SW | 08:00 | Wall "A" | 0.13 | 5.72 | 5.20 | 3.79 | 17.02 |
| | | Wall "B" | 1.44 | 1.77 | | 13.23 | |
| | 09:00 | Wall "A" | 0.13 | 5.72 | 6.75 | 4.92 | 22.09 |
| | | Wall "B" | 1.44 | 1.77 | | 17.17 | |
| | 10:00 | Wall "A" | 0.13 | 5.72 | 8.56 | 6.24 | 28.02 |
| | | Wall "B" | 1.44 | 1.77 | | 21.78 | |
| | 11:00 | Wall "A" | 0.13 | 5.72 | 10.50 | 7.66 | 34.37 |
| | | Wall "B" | 1.44 | 1.77 | | 26.71 | |
| | 12:00 | Wall "A" | 0.13 | 5.72 | 12.44 | 9.07 | 40.72 |
| | | Wall "B" | 1.44 | 1.77 | | 31.65 | |
| | 13:00 | Wall "A" | 0.13 | 5.72 | 14.25 | 10.39 | 46.64 |
| | | Wall "B" | 1.44 | 1.77 | | 36.25 | |
| | 14:00 | Wall "A" | 0.13 | 5.72 | 15.80 | 11.52 | 51.72 |
| | | Wall "B" | 1.44 | 1.77 | | 40.19 | |
| | 15:00 | Wall "A" | 0.13 | 5.72 | 17.00 | 12.40 | 55.64 |
| | | Wall "B" | 1.44 | 1.77 | | 43.25 | |
| | 16:00 | Wall "A" | 0.13 | 5.72 | 17.70 | 12.91 | 57.94 |
| | | Wall "B" | 1.44 | 1.77 | | 45.03 | |
| | 17:00 | Wall "A" | 0.13 | 5.72 | 18.00 | 13.13 | 58.92 |
| | | Wall "B" | 1.44 | 1.77 | | 45.79 | |

| Direction | Time | Type | U | A (m2) | ΔT (K) | Q (W) |
|---|---|---|---|---|---|---|
| NW | 08:00 | Adj Wall | 0.10 | 15.78 | 5.20 | 8.26 |
| | 09:00 | Adj Wall | 0.10 | 15.78 | 6.75 | 10.73 |
| | 10:00 | Adj Wall | 0.10 | 15.78 | 8.56 | 13.60 |
| | 11:00 | Adj Wall | 0.10 | 15.78 | 10.50 | 16.69 |
| | 12:00 | Adj Wall | 0.10 | 15.78 | 12.44 | 19.77 |
| | 13:00 | Adj Wall | 0.10 | 15.78 | 14.25 | 22.65 |
| | 14:00 | Adj Wall | 0.10 | 15.78 | 15.80 | 25.11 |
| | 15:00 | Adj Wall | 0.10 | 15.78 | 17.00 | 27.02 |
| | 16:00 | Adj Wall | 0.10 | 15.78 | 17.70 | 28.13 |
| | 17:00 | Adj Wall | 0.10 | 15.78 | 18.00 | 28.61 |

| Time | Qt(W) |
|---|---|
| 08:00 | 25.28 |
| 09:00 | 32.82 |
| 10:00 | 41.62 |
| 11:00 | 51.06 |
| 12:00 | 60.49 |
| 13:00 | 69.29 |
| 14:00 | 76.83 |
| 15:00 | 82.66 |
| 16:00 | 86.06 |
| 17:00 | 87.52 |

**2-Sun Load**

| Direction | Time | Type | U | A | I | ΔTs | Q (W) | Q t(W) |
|---|---|---|---|---|---|---|---|---|
| SW | 08:00 | Wall "A" | 0.13 | 5.72 | 38.00 | 2.47 | 1.80 | 8.08 |
| | | Wall "B" | 1.44 | 1.77 | | 2.47 | 6.28 | |
| | 09:00 | Wall "A" | 0.13 | 5.72 | 44.00 | 2.86 | 2.09 | 9.36 |
| | | Wall "B" | 1.44 | 1.77 | | 2.86 | 7.28 | |
| | 10:00 | Wall "A" | 0.13 | 5.72 | 44.00 | 2.86 | 2.09 | 9.36 |
| | | Wall "B" | 1.44 | 1.77 | | 2.86 | 7.28 | |
| | 11:00 | Wall "A" | 0.13 | 5.72 | 44.00 | 2.86 | 2.09 | 9.36 |
| | | Wall "B" | 1.44 | 1.77 | | 2.86 | 7.28 | |
| | 12:00 | Wall "A" | 0.13 | 5.72 | 54.00 | 3.51 | 2.56 | 11.49 |
| | | Wall "B" | 1.44 | 1.77 | | 3.51 | 8.93 | |
| | 13:00 | Wall "A" | 0.13 | 5.72 | 138.00 | 8.97 | 6.54 | 29.36 |
| | | Wall "B" | 1.44 | 1.77 | | 8.97 | 22.82 | |
| | 14:00 | Wall "A" | 0.13 | 5.72 | 230.00 | 14.95 | 10.90 | 48.93 |
| | | Wall "B" | 1.44 | 1.77 | | 14.95 | 38.03 | |
| | 15:00 | Wall "A" | 0.13 | 5.72 | 284.00 | 18.46 | 13.46 | 60.42 |
| | | Wall "B" | 1.44 | 1.77 | | 18.46 | 46.96 | |
| | 16:00 | Wall "A" | 0.13 | 5.72 | 284.00 | 18.46 | 13.46 | 60.42 |
| | | Wall "B" | 1.44 | 1.77 | | 18.46 | 46.96 | |
| | 17:00 | Wall "A" | 0.13 | 5.72 | 237.00 | 15.41 | 11.23 | 50.42 |
| | | Wall "B" | 1.44 | 1.77 | | 15.41 | 39.19 | |

**3-Ventilation Load**

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 2.00 | 10.00 | 2.50 | 2.00 |

| | |
|---|---|
| **A (m2)** | 17.37 |
| **H (m)** | 2.60 |
| **V (m3)** | 45.16 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 1.20 |
| **Based on Area** | 2.61 |
| **NO Of Air Changing Times** | 1.51 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 08:00 | 2.61 | 276.39 | 811.87 | 1088.27 |
| 09:00 | 2.61 | 358.78 | 811.87 | 1170.65 |
| 10:00 | 2.61 | 454.98 | 811.87 | 1266.86 |
| 11:00 | 2.61 | 558.10 | 811.87 | 1369.97 |
| 12:00 | 2.61 | 661.21 | 811.87 | 1473.09 |
| 13:00 | 2.61 | 757.42 | 811.87 | 1569.29 |
| 14:00 | 2.61 | 839.80 | 811.87 | 1651.68 |
| 15:00 | 2.61 | 903.59 | 811.87 | 1715.46 |
| 16:00 | 2.61 | 940.79 | 811.87 | 1752.67 |
| 17:00 | 2.61 | 956.74 | 811.87 | 1768.61 |

## B-Internal Loads

### 1-Occupancy Load

| Persons | Work | qs/p ( | qL/p (W) | Qs (W) | QL (W) | Qt (W) |
|---|---|---|---|---|---|---|
| 2.00 | sitting | 66.00 | 31.00 | 132.00 | 62.00 | 194.00 |

### 2-Light Load

| Type | No. lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| florescent | 8 | 40.00 | 1.25 | 400.00 |

### Variation of load with time

| Qs | Qs | Ql | Qs | Ql |
|---|---|---|---|---|
| 400.00 | 132.00 | 62.00 | 0.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q ven_s | Q vent_l | Qs tot | Ql tot | Q tot (W) |
|---|---|---|---|---|---|---|---|
| 08:00 | 25.28 | 8.08 | 276.39 | 811.87 | 565.37 | 62.00 | 627.37 |
| 09:00 | 32.82 | 9.36 | 358.78 | 811.87 | 574.18 | 62.00 | 636.18 |
| 10:00 | 41.62 | 9.36 | 454.98 | 811.87 | 582.98 | 62.00 | 644.98 |
| 11:00 | 51.06 | 9.36 | 558.10 | 811.87 | 592.42 | 62.00 | 654.42 |
| 12:00 | 60.49 | 11.49 | 661.21 | 811.87 | 603.98 | 62.00 | 665.98 |
| 13:00 | 69.29 | 29.36 | 757.42 | 811.87 | 630.65 | 62.00 | 692.65 |
| 14:00 | 76.83 | 48.93 | 839.80 | 811.87 | 657.76 | 62.00 | 719.76 |
| 15:00 | 82.66 | 60.42 | 903.59 | 811.87 | 675.08 | 62.00 | 737.08 |
| 16:00 | 86.06 | 60.42 | 940.79 | 811.87 | 678.49 | 62.00 | 740.49 |
| 17:00 | 87.52 | 50.42 | 956.74 | 811.87 | 669.95 | 62.00 | 731.95 |

# Room 0-49

## A-External Loads

### 1-Wall Load

| Direction | TIMe | Type | U | A | ∆T | Q (W) | Qtot W |
|---|---|---|---|---|---|---|---|
| SW | 8:00 | Glass | 1.10 | 3.44 | 5.20 | 19.65 | 23.95 |
| | | Wall "A" | 0.13 | 4.71 | | 3.13 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.18 | |
| | 9:00 | Glass | 1.10 | 3.44 | 6.75 | 25.51 | 31.09 |
| | | Wall "A" | 0.13 | 4.71 | | 4.06 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.53 | |
| | 10:00 | Glass | 1.10 | 3.44 | 8.56 | 32.35 | 39.43 |
| | | Wall "A" | 0.13 | 4.71 | | 5.15 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.94 | |
| | 11:00 | Glass | 1.10 | 3.44 | 10.50 | 39.68 | 48.37 |
| | | Wall "A" | 0.13 | 4.71 | | 6.31 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.37 | |
| | 12:00 | Glass | 1.10 | 3.44 | 12.44 | 47.01 | 57.31 |
| | | Wall "A" | 0.13 | 4.71 | | 7.48 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.81 | |
| | 13:00 | Glass | 1.10 | 3.44 | 14.25 | 53.85 | 65.64 |
| | | Wall "A" | 0.13 | 4.71 | | 8.57 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.22 | |
| | 14:00 | Glass | 1.10 | 3.44 | 15.80 | 59.71 | 72.78 |
| | | Wall "A" | 0.13 | 4.71 | | 9.50 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.57 | |
| | 15:00 | Glass | 1.10 | 3.44 | 17.00 | 64.25 | 78.31 |
| | | Wall "A" | 0.13 | 4.71 | | 10.22 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.84 | |
| | 16:00 | Glass | 1.10 | 3.44 | 17.74 | 67.04 | 81.72 |
| | | Wall "A" | 0.13 | 4.71 | | 10.67 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.01 | |
| | 17:00 | Glass | 1.10 | 3.44 | 18.00 | 68.03 | 82.92 |
| | | Wall "A" | 0.13 | 4.71 | | 10.82 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.07 | |

### 2-Sun Load

| Direction | Time | Type | U | A | ∆T s | I | Q (W) | Q Total |
|---|---|---|---|---|---|---|---|---|
| SW | 8:00 | glass | | 3.44 | | 284.00 | 331.74 | 345.41 |
| | | A | 0.13 | 4.71 | 18.46 | | 11.10 | |
| | | D | 0.39 | 0.57 | 11.36 | | 2.57 | |
| | 9:00 | glass | | 3.44 | | 284.00 | 331.74 | 345.41 |
| | | A | 0.13 | 4.71 | 18.46 | | 11.10 | |
| | | D | 0.39 | 0.57 | 11.36 | | 2.57 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 10:00 | glass | | 3.44 | | 230.00 | 268.67 | 279.73 |
| | | A | 0.13 | 4.71 | 14.95 | | 8.99 | |
| | | D | 0.39 | 0.57 | 9.20 | | 2.08 | |
| | 11:00 | glass | | 3.44 | | 139.00 | 162.37 | 169.06 |
| | | A | 0.13 | 4.71 | 9.04 | | 5.43 | |
| | | D | 0.39 | 0.57 | 5.56 | | 1.26 | |
| | 12:00 | glass | | 3.44 | | 54.00 | 63.08 | 65.68 |
| | | A | 0.13 | 4.71 | 3.51 | | 2.11 | |
| | | D | 0.39 | 0.57 | 2.16 | | 0.49 | |
| | 13:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 14:00 | glass | | 3.44 | | 44.00 | 331.74 | 333.86 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 15:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 16:00 | glass | | 3.44 | | 38.00 | 44.39 | 46.22 |
| | | A | 0.13 | 4.71 | 2.47 | | 1.48 | |
| | | D | 0.39 | 0.57 | 1.52 | | 0.34 | |
| | 17:00 | glass | | 3.44 | | 32.00 | 37.38 | 38.92 |
| | | A | 0.13 | 4.71 | 2.08 | | 1.25 | |
| | | D | 0.39 | 0.57 | 1.28 | | 0.29 | |

**3-Ventilation Load**

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 5.00 | 12.00 | 1.80 | 2.00 |

| | |
|---|---|
| **A (m2)** | 16.52 |
| **H (m)** | 2.60 |
| **V (m3)** | 38.91 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 3.60 |
| **Based on Area** | 1.78 |
| **NO Of Air Changing Times** | 1.30 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 8:00 | 3.60 | 381.89 | 1121.76 | 1503.65 |
| 9:00 | 3.60 | 495.72 | 1121.76 | 1617.48 |
| 10:00 | 3.60 | 628.65 | 1121.76 | 1750.41 |
| 11:00 | 3.60 | 771.12 | 1121.76 | 1892.88 |
| 12:00 | 3.60 | 913.59 | 1121.76 | 2035.35 |

| | | | | |
|---|---|---|---|---|
| 13:00 | 3.60 | 1046.52 | 1121.76 | 2168.28 |
| 14:00 | 3.60 | 1160.35 | 1121.76 | 2282.11 |
| 15:00 | 3.60 | 1248.48 | 1121.76 | 2370.24 |
| 16:00 | 3.60 | 1302.83 | 1121.76 | 2424.59 |
| 17:00 | 3.60 | 1321.92 | 1121.76 | 2443.68 |

## B-Internal Loads

### 1-Occupancy Load

| NoOf Pers | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 5.00 | Light | 72.00 | 60.00 | 360.00 | 300.00 | 660.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| Florescent | 8.00 | 20.00 | 1.25 | 200.00 |

### 3-Equipment

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot (W) |
|---|---|---|---|---|
| CPU | 1.00 | 55.00 | 55.00 | 474.00 |
| Monitor | 1.00 | 55.00 | 55.00 | |
| scan light | 1.00 | 100.00 | 100.00 | |
| abjora | 1.00 | 60.00 | 60.00 | |
| scan device | 1.00 | 204.00 | 204.00 | |

## Variation of load with time

| Q occ_s | Q occ_l | Q lig_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 360.00 | 300.00 | 200.00 | 474.00 | 0.00 |

| Time | Q wal_s | Q sun_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 23.95 | 345.41 | 381.89 | 1121.76 | 1403.37 | 300.00 | 1703.37 |
| 9:00 | 31.09 | 345.41 | 495.72 | 1121.76 | 1410.51 | 300.00 | 1710.51 |
| 10:00 | 39.43 | 279.73 | 628.65 | 1121.76 | 1353.17 | 300.00 | 1653.17 |
| 11:00 | 48.37 | 169.06 | 771.12 | 1121.76 | 1251.43 | 300.00 | 1551.43 |
| 12:00 | 57.31 | 65.68 | 913.59 | 1121.76 | 1156.98 | 300.00 | 1456.98 |
| 13:00 | 65.64 | 53.51 | 1046.52 | 1121.76 | 1153.16 | 300.00 | 1453.16 |
| 14:00 | 72.78 | 333.86 | 1160.35 | 1121.76 | 1440.64 | 300.00 | 1740.64 |
| 15:00 | 78.31 | 53.51 | 1248.48 | 1121.76 | 1165.83 | 300.00 | 1465.83 |
| 16:00 | 81.72 | 46.22 | 1302.83 | 1121.76 | 1161.94 | 300.00 | 1461.94 |
| 17:00 | 82.92 | 38.92 | 1321.92 | 1121.76 | 1155.84 | 300.00 | 1455.84 |

# Room 0-50

## A-External Loads

### 1-Wall Load

| Direction | TIMe | Type | U | A | ∆T | Q | Qtot W |
|---|---|---|---|---|---|---|---|
| NE | 8:00 | Glass | 1.10 | 3.44 | 5.20 | 19.65 | 38.12 |
| | | Wall "A" | 0.13 | 4.04 | | 2.68 | |
| | | Wall "B" | 1.44 | 1.03 | | 7.67 | |
| | | Wall "C" | 1.79 | 0.87 | | 8.12 | |
| | 9:00 | Glass | 1.10 | 3.44 | 6.75 | 25.51 | 49.48 |
| | | Wall "A" | 0.13 | 4.04 | | 3.48 | |
| | | Wall "B" | 1.44 | 1.03 | | 9.96 | |
| | | Wall "C" | 1.79 | 0.87 | | 10.53 | |
| | 10:00 | Glass | 1.10 | 3.44 | 8.56 | 32.35 | 62.75 |
| | | Wall "A" | 0.13 | 4.04 | | 4.41 | |
| | | Wall "B" | 1.44 | 1.03 | | 12.63 | |
| | | Wall "C" | 1.79 | 0.87 | | 13.36 | |
| | 11:00 | Glass | 1.10 | 3.44 | 10.50 | 39.68 | 76.97 |
| | | Wall "A" | 0.13 | 4.04 | | 5.41 | |
| | | Wall "B" | 1.44 | 1.03 | | 15.50 | |
| | | Wall "C" | 1.79 | 0.87 | | 16.39 | |
| | 12:00 | Glass | 1.10 | 3.44 | 12.44 | 47.01 | 91.19 |
| | | Wall "A" | 0.13 | 4.04 | | 6.41 | |
| | | Wall "B" | 1.44 | 1.03 | | 18.36 | |
| | | Wall "C" | 1.79 | 0.87 | | 19.41 | |
| | 13:00 | Glass | 1.10 | 3.44 | 14.25 | 53.85 | 104.46 |
| | | Wall "A" | 0.13 | 4.04 | | 7.34 | |
| | | Wall "B" | 1.44 | 1.03 | | 21.03 | |
| | | Wall "C" | 1.79 | 0.87 | | 22.24 | |
| | 14:00 | Glass | 1.10 | 3.44 | 15.80 | 59.71 | 115.83 |
| | | Wall "A" | 0.13 | 4.04 | | 8.14 | |
| | | Wall "B" | 1.44 | 1.03 | | 23.32 | |
| | | Wall "C" | 1.79 | 0.87 | | 24.66 | |
| | 15:00 | Glass | 1.10 | 3.44 | 17.00 | 64.25 | 124.62 |
| | | Wall "A" | 0.13 | 4.04 | | 8.76 | |
| | | Wall "B" | 1.44 | 1.03 | | 25.09 | |
| | | Wall "C" | 1.79 | 0.87 | | 26.53 | |
| | 16:00 | Glass | 1.10 | 3.44 | 17.74 | 67.04 | 130.05 |
| | | Wall "A" | 0.13 | 4.04 | | 9.14 | |
| | | Wall "B" | 1.44 | 1.03 | | 26.18 | |
| | | Wall "C" | 1.79 | 0.87 | | 27.69 | |
| | 17:00 | Glass | 1.10 | 3.44 | 18.00 | 68.03 | 131.95 |
| | | Wall "A" | 0.13 | 4.04 | | 9.27 | |
| | | Wall "B" | 1.44 | 1.03 | | 26.56 | |
| | | Wall "C" | 1.79 | 0.87 | | 28.09 | |

**2-Sun Load**

| Direction | Time | Type | U | A | ΔT s | I | Q | Qtot W |
|---|---|---|---|---|---|---|---|---|
| NE | 8:00 | glass | | 3.44 | | 284.00 | 331.74 | 386.23 |
| | | A | 0.13 | 4.04 | 18.46 | | 9.51 | |
| | | B | 1.44 | 1.03 | 18.46 | | 27.24 | |
| | | C | 1.79 | 0.87 | 11.36 | | 17.73 | |
| | 9:00 | glass | | 3.44 | | 284.00 | 331.74 | 386.23 |
| | | A | 0.13 | 4.04 | 18.46 | | 9.51 | |
| | | B | 1.44 | 1.03 | 18.46 | | 27.24 | |
| | | C | 1.79 | 0.87 | 11.36 | | 17.73 | |
| | 10:00 | glass | | 3.44 | | 230.00 | 268.67 | 312.79 |
| | | A | 0.13 | 4.04 | 14.95 | | 7.70 | |
| | | B | 1.44 | 1.03 | 14.95 | | 22.06 | |
| | | C | 1.79 | 0.87 | 9.20 | | 14.36 | |
| | 11:00 | glass | | 3.44 | | 139.00 | 162.37 | 189.03 |
| | | A | 0.13 | 4.04 | 9.04 | | 4.65 | |
| | | B | 1.44 | 1.03 | 9.04 | | 13.33 | |
| | | C | 1.79 | 0.87 | 5.56 | | 8.68 | |
| | 12:00 | glass | | 3.44 | | 54.00 | 63.08 | 73.44 |
| | | A | 0.13 | 4.04 | 3.51 | | 1.81 | |
| | | B | 1.44 | 1.03 | 3.51 | | 5.18 | |
| | | C | 1.79 | 0.87 | 2.16 | | 3.37 | |
| | 13:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | A | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | B | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | C | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 14:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | A | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | B | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | C | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 15:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | A | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | B | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | C | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 16:00 | glass | | 3.44 | | 38.00 | 44.39 | 51.68 |
| | | A | 0.13 | 4.04 | 2.47 | | 1.27 | |
| | | B | 1.44 | 1.03 | 2.47 | | 3.65 | |
| | | C | 1.79 | 0.87 | 1.52 | | 2.37 | |
| | 17:00 | glass | | 3.44 | | 32.00 | 37.38 | 43.52 |
| | | A | 0.13 | 4.04 | 2.08 | | 1.07 | |
| | | B | 1.44 | 1.03 | 2.08 | | 3.07 | |
| | | C | 1.79 | 0.87 | 1.28 | | 2.00 | |

**3-Ventilation Load**

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 5.00 | 12.00 | 1.80 | 2.00 |

| | |
|---|---|
| **A (m2)** | 17.52 |
| **H (m)** | 2.60 |
| **V (m3)** | 38.91 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 3.60 |
| **Based on Area** | 1.89 |
| **NO Of Air Changing Times** | 1.30 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 8:00 | 3.60 | 381.89 | 1121.76 | 1503.65 |
| 9:00 | 3.60 | 495.72 | 1121.76 | 1617.48 |
| 10:00 | 3.60 | 628.65 | 1121.76 | 1750.41 |
| 11:00 | 3.60 | 771.12 | 1121.76 | 1892.88 |
| 12:00 | 3.60 | 913.59 | 1121.76 | 2035.35 |
| 13:00 | 3.60 | 1046.52 | 1121.76 | 2168.28 |
| 14:00 | 3.60 | 1160.35 | 1121.76 | 2282.11 |
| 15:00 | 3.60 | 1248.48 | 1121.76 | 2370.24 |
| 16:00 | 3.60 | 1302.83 | 1121.76 | 2424.59 |
| 17:00 | 3.60 | 1321.92 | 1121.76 | 2443.68 |

## B-Internal Loads

**1-Occupancy Load**

| No Of Pers | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 5.00 | Light | 72.00 | 60.00 | 360.00 | 300.00 | 660.00 |

**2-Light Load**

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| Florescent | 8.00 | 20.00 | 1.25 | 200.00 |

**3-Equipment**

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot (W) |
|---|---|---|---|---|
| CPU | 1.00 | 55.00 | 55.00 | 474.00 |
| Monitor | 1.00 | 55.00 | 55.00 | |
| scan light | 1.00 | 100.00 | 100.00 | |
| abjora | 1.00 | 60.00 | 60.00 | |
| scan device | 1.00 | 204.00 | 204.00 | |

**Variation of load with time**

| Q occ_s | Q occ_l | Q lig_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 360.00 | 300.00 | 200.00 | 474.00 | 0.00 |

| Time | Q wall_s | Qsun_s | Q vent_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 38.12 | 386.23 | 381.89 | 1121.76 | 1458.35 | 300.00 | 1758.35 |
| 9:00 | 49.48 | 386.23 | 495.72 | 1121.76 | 1469.71 | 300.00 | 1769.71 |
| 10:00 | 62.75 | 312.79 | 628.65 | 1121.76 | 1409.54 | 300.00 | 1709.54 |
| 11:00 | 76.97 | 189.03 | 771.12 | 1121.76 | 1300.01 | 300.00 | 1600.01 |
| 12:00 | 91.19 | 73.44 | 913.59 | 1121.76 | 1198.63 | 300.00 | 1498.63 |
| 13:00 | 104.46 | 59.84 | 1046.52 | 1121.76 | 1198.30 | 300.00 | 1498.30 |
| 14:00 | 115.83 | 59.84 | 1160.35 | 1121.76 | 1209.66 | 300.00 | 1509.66 |
| 15:00 | 124.62 | 59.84 | 1248.48 | 1121.76 | 1218.46 | 300.00 | 1518.46 |
| 16:00 | 130.05 | 51.68 | 1302.83 | 1121.76 | 1215.73 | 300.00 | 1515.73 |
| 17:00 | 131.95 | 43.52 | 1321.92 | 1121.76 | 1209.47 | 300.00 | 1509.47 |

# Room 0-51

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ΔT | Q | Qtot ,W |
|---|---|---|---|---|---|---|---|
| SW | 8:00 | Glass | 1.10 | 3.44 | 5.20 | 19.65 | 23.95 |
| | | Wall "A" | 0.13 | 4.71 | | 3.13 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.18 | |
| | 9:00 | Glass | 1.10 | 3.44 | 6.75 | 25.51 | 31.09 |
| | | Wall "A" | 0.13 | 4.71 | | 4.06 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.53 | |
| | 10:00 | Glass | 1.10 | 3.44 | 8.56 | 32.35 | 39.43 |
| | | Wall "A" | 0.13 | 4.71 | | 5.15 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.94 | |
| | 11:00 | Glass | 1.10 | 3.44 | 10.50 | 39.68 | 48.37 |
| | | Wall "A" | 0.13 | 4.71 | | 6.31 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.37 | |
| | 12:00 | Glass | 1.10 | 3.44 | 12.44 | 47.01 | 57.31 |
| | | Wall "A" | 0.13 | 4.71 | | 7.48 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.81 | |
| | 13:00 | Glass | 1.10 | 3.44 | 14.25 | 53.85 | 65.64 |
| | | Wall "A" | 0.13 | 4.71 | | 8.57 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.22 | |
| | 14:00 | Glass | 1.10 | 3.44 | 15.80 | 59.71 | 72.78 |
| | | Wall "A" | 0.13 | 4.71 | | 9.50 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.57 | |
| | 15:00 | Glass | 1.10 | 3.44 | 17.00 | 64.25 | 78.31 |
| | | Wall "A" | 0.13 | 4.71 | | 10.22 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.84 | |
| | 16:00 | Glass | 1.10 | 3.44 | 17.74 | 67.04 | 81.72 |
| | | Wall "A" | 0.13 | 4.71 | | 10.67 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.01 | |
| | 17:00 | Glass | 1.10 | 3.44 | 18.00 | 68.03 | 82.92 |
| | | Wall "A" | 0.13 | 4.71 | | 10.82 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.07 | |

### 2-Sun Load

| Direction | Time | Type | U | A (m2) | ΔT sun | I | Q | Q Total |
|---|---|---|---|---|---|---|---|---|
| SW | 8:00 | glass | | 3.44 | | 284.00 | 331.74 | 345.41 |
| | | A | 0.13 | 4.71 | 18.46 | | 11.10 | |
| | | D | 0.39 | 0.57 | 11.36 | | 2.57 | |
| | 9:00 | glass | | 3.44 | | 284.00 | 331.74 | 345.41 |
| | | A | 0.13 | 4.71 | 18.46 | | 11.10 | |
| | | D | 0.39 | 0.57 | 11.36 | | 2.57 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 10:00 | glass | | 3.44 | | 230.00 | 268.67 | 279.73 |
| | | A | 0.13 | 4.71 | 14.95 | | 8.99 | |
| | | D | 0.39 | 0.57 | 9.20 | | 2.08 | |
| | 11:00 | glass | | 3.44 | | 139.00 | 162.37 | 169.06 |
| | | A | 0.13 | 4.71 | 9.04 | | 5.43 | |
| | | D | 0.39 | 0.57 | 5.56 | | 1.26 | |
| | 12:00 | glass | | 3.44 | | 54.00 | 63.08 | 65.68 |
| | | A | 0.13 | 4.71 | 3.51 | | 2.11 | |
| | | D | 0.39 | 0.57 | 2.16 | | 0.49 | |
| | 13:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 14:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 15:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 16:00 | glass | | 3.44 | | 38.00 | 44.39 | 46.22 |
| | | A | 0.13 | 4.71 | 2.47 | | 1.48 | |
| | | D | 0.39 | 0.57 | 1.52 | | 0.34 | |
| | 17:00 | glass | | 3.44 | | 32.00 | 37.38 | 38.92 |
| | | A | 0.13 | 4.71 | 2.08 | | 1.25 | |
| | | D | 0.39 | 0.57 | 1.28 | | 0.29 | |

**3-Ventilation Load**

| No Of Persons | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 5.00 | 12.00 | 1.80 | 2.00 |

| | |
|---|---|
| **A (m2)** | 163.63 |
| **H (m)** | 2.60 |
| **V (m3)** | 38.91 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 3.60 |
| **Based on Area** | 17.67 |
| **NO Of Air Changing Times** | 1.30 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 8:00 | 3.60 | 381.89 | 1121.76 | 1503.65 |
| 9:00 | 3.60 | 495.72 | 1121.76 | 1617.48 |
| 10:00 | 3.60 | 628.65 | 1121.76 | 1750.41 |
| 11:00 | 3.60 | 771.12 | 1121.76 | 1892.88 |
| 12:00 | 3.60 | 913.59 | 1121.76 | 2035.35 |
| 13:00 | 3.60 | 1046.52 | 1121.76 | 2168.28 |

| | | | | |
|---|---|---|---|---|
| 14:00 | 3.60 | 1160.35 | 1121.76 | 2282.11 |
| 15:00 | 3.60 | 1248.48 | 1121.76 | 2370.24 |
| 16:00 | 3.60 | 1302.83 | 1121.76 | 2424.59 |
| 17:00 | 3.60 | 1321.92 | 1121.76 | 2443.68 |

## B-Internal Loads

### 1-Occupancy Load

| No Of Pers | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 5.00 | Light Work | 72.00 | 60.00 | 360.00 | 300.00 | 660.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| Florescent | 8.00 | 20.00 | 1.25 | 200.00 |

### 3-Equipment

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot (W) |
|---|---|---|---|---|
| CPU | 1.00 | 55.00 | 55.00 | 474.00 |
| Monitor | 1.00 | 55.00 | 55.00 | |
| scan light | 1.00 | 100.00 | 100.00 | |
| abjora | 1.00 | 60.00 | 60.00 | |
| scan device | 1.00 | 204.00 | 204.00 | |

## Variation of load with time

| Q occ_s | Q occ_l | Q light_s | Q equip_s | Q equip_l |
|---|---|---|---|---|
| 360.00 | 300.00 | 200.00 | 474.00 | 0.00 |

| Time | Q wall_s | Q sun_s | Q vent_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 23.95 | 345.41 | 381.89 | 1121.76 | 1403.3 | 300.00 | 1703.3 |
| 9:00 | 31.09 | 345.41 | 495.72 | 1121.76 | 1410.5 | 300.00 | 1710.5 |
| 10:00 | 39.43 | 279.73 | 628.65 | 1121.76 | 1353.1 | 300.00 | 1653.1 |
| 11:00 | 48.37 | 169.06 | 771.12 | 1121.76 | 1251.4 | 300.00 | 1551.4 |
| 12:00 | 57.31 | 65.68 | 913.59 | 1121.76 | 1156.9 | 300.00 | 1456.9 |
| 13:00 | 65.64 | 53.51 | 1046.52 | 1121.76 | 1153.1 | 300.00 | 1453.1 |
| 14:00 | 72.78 | 53.51 | 1160.35 | 1121.76 | 1160.3 | 300.00 | 1460.3 |
| 15:00 | 78.31 | 53.51 | 1248.48 | 1121.76 | 1165.8 | 300.00 | 1465.8 |
| 16:00 | 81.72 | 46.22 | 1302.83 | 1121.76 | 1161.9 | 300.00 | 1461.9 |
| 17:00 | 82.92 | 38.92 | 1321.92 | 1121.76 | 1155.84 | 300.00 | 1455.84 |

# Room 0-52

## A-External Loads

### 1-Wall Load

| Direction | TIMe | Type | U | A | ∆T | Q | Qtot W |
|---|---|---|---|---|---|---|---|
| NE | 8:00 | Glass | 1.10 | 3.44 | 5.20 | 19.65 | 38.12 |
| | | Wall "A" | 0.13 | 4.04 | | 2.68 | |
| | | Wall "B" | 1.44 | 1.03 | | 7.67 | |
| | | Wall "C" | 1.79 | 0.87 | | 8.12 | |
| | 9:00 | Glass | 1.10 | 3.44 | 6.75 | 25.51 | 49.48 |
| | | Wall "A" | 0.13 | 4.04 | | 3.48 | |
| | | Wall "B" | 1.44 | 1.03 | | 9.96 | |
| | | Wall "C" | 1.79 | 0.87 | | 10.53 | |
| | 10:00 | Glass | 1.10 | 3.44 | 8.56 | 32.35 | 62.75 |
| | | Wall "A" | 0.13 | 4.04 | | 4.41 | |
| | | Wall "B" | 1.44 | 1.03 | | 12.63 | |
| | | Wall "C" | 1.79 | 0.87 | | 13.36 | |
| | 11:00 | Glass | 1.10 | 3.44 | 10.50 | 39.68 | 76.97 |
| | | Wall "A" | 0.13 | 4.04 | | 5.41 | |
| | | Wall "B" | 1.44 | 1.03 | | 15.50 | |
| | | Wall "C" | 1.79 | 0.87 | | 16.39 | |
| | 12:00 | Glass | 1.10 | 3.44 | 12.44 | 47.01 | 91.19 |
| | | Wall "A" | 0.13 | 4.04 | | 6.41 | |
| | | Wall "B" | 1.44 | 1.03 | | 18.36 | |
| | | Wall "C" | 1.79 | 0.87 | | 19.41 | |
| | 13:00 | Glass | 1.10 | 3.44 | 14.25 | 53.85 | 104.46 |
| | | Wall "A" | 0.13 | 4.04 | | 7.34 | |
| | | Wall "B" | 1.44 | 1.03 | | 21.03 | |
| | | Wall "C" | 1.79 | 0.87 | | 22.24 | |
| | 14:00 | Glass | 1.10 | 3.44 | 15.80 | 59.71 | 115.83 |
| | | Wall "A" | 0.13 | 4.04 | | 8.14 | |
| | | Wall "B" | 1.44 | 1.03 | | 23.32 | |
| | | Wall "C" | 1.79 | 0.87 | | 24.66 | |
| | 15:00 | Glass | 1.10 | 3.44 | 17.00 | 64.25 | 124.62 |
| | | Wall "A" | 0.13 | 4.04 | | 8.76 | |
| | | Wall "B" | 1.44 | 1.03 | | 25.09 | |
| | | Wall "C" | 1.79 | 0.87 | | 26.53 | |
| | 16:00 | Glass | 1.10 | 3.44 | 17.74 | 67.04 | 130.05 |
| | | Wall "A" | 0.13 | 4.04 | | 9.14 | |
| | | Wall "B" | 1.44 | 1.03 | | 26.18 | |
| | | Wall "C" | 1.79 | 0.87 | | 27.69 | |
| | 17:00 | Glass | 1.10 | 3.44 | 18.00 | 68.03 | 131.95 |
| | | Wall "A" | 0.13 | 4.04 | | 9.27 | |
| | | Wall "B" | 1.44 | 1.03 | | 26.56 | |
| | | Wall "C" | 1.79 | 0.87 | | 28.09 | |

**2-Sun Load**

| Direction | Time | Type | U | A | ∆T sun | I | Q | Qtot W |
|---|---|---|---|---|---|---|---|---|
| **NE** | 8:00 | glass | | 3.44 | | 284.00 | 331.74 | 386.23 |
| | | A | 0.13 | 4.04 | 18.46 | | 9.51 | |
| | | B | 1.44 | 1.03 | 18.46 | | 27.24 | |
| | | C | 1.79 | 0.87 | 11.36 | | 17.73 | |
| | 9:00 | glass | | 3.44 | | 284.00 | 331.74 | 386.23 |
| | | A | 0.13 | 4.04 | 18.46 | | 9.51 | |
| | | B | 1.44 | 1.03 | 18.46 | | 27.24 | |
| | | C | 1.79 | 0.87 | 11.36 | | 17.73 | |
| | 10:00 | glass | | 3.44 | | 230.00 | 268.67 | 312.79 |
| | | A | 0.13 | 4.04 | 14.95 | | 7.70 | |
| | | B | 1.44 | 1.03 | 14.95 | | 22.06 | |
| | | C | 1.79 | 0.87 | 9.20 | | 14.36 | |
| | 11:00 | glass | | 3.44 | | 139.00 | 162.37 | 189.03 |
| | | A | 0.13 | 4.04 | 9.04 | | 4.65 | |
| | | B | 1.44 | 1.03 | 9.04 | | 13.33 | |
| | | C | 1.79 | 0.87 | 5.56 | | 8.68 | |
| | 12:00 | glass | | 3.44 | | 54.00 | 63.08 | 73.44 |
| | | A | 0.13 | 4.04 | 3.51 | | 1.81 | |
| | | B | 1.44 | 1.03 | 3.51 | | 5.18 | |
| | | C | 1.79 | 0.87 | 2.16 | | 3.37 | |
| | 13:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | A | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | B | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | C | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 14:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | A | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | B | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | C | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 15:00 | glass | | 3.44 | | 44.00 | 51.40 | 59.84 |
| | | A | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | B | 1.44 | 1.03 | 2.86 | | 4.22 | |
| | | C | 1.79 | 0.87 | 1.76 | | 2.75 | |
| | 16:00 | glass | | 3.44 | | 38.00 | 44.39 | 51.68 |
| | | A | 0.13 | 4.04 | 2.47 | | 1.27 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | B | 1.44 | 1.03 | 2.47 | | 3.65 | |
| | | C | 1.79 | 0.87 | 1.52 | | 2.37 | |
| | 17:00 | glass | | 3.44 | | 32.00 | 37.38 | 43.52 |
| | | A | 0.13 | 4.04 | 2.08 | | 1.07 | |
| | | B | 1.44 | 1.03 | 2.08 | | 3.07 | |
| | | C | 1.79 | 0.87 | 1.28 | | 2.00 | |

**3-Ventilation Load**

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 5.00 | 12.00 | 1.80 | 2.00 |

| | |
|---|---|
| **A (m2)** | 17.52 |
| **H (m)** | 2.60 |
| **V (m3)** | 38.91 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 3.60 |
| **Based on Area** | 1.89 |
| **NO Of Air Changing Times** | 1.30 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 8:00 | 3.60 | 381.89 | 1121.76 | 1503.65 |
| 9:00 | 3.60 | 495.72 | 1121.76 | 1617.48 |
| 10:00 | 3.60 | 628.65 | 1121.76 | 1750.41 |
| 11:00 | 3.60 | 771.12 | 1121.76 | 1892.88 |
| 12:00 | 3.60 | 913.59 | 1121.76 | 2035.35 |
| 13:00 | 3.60 | 1046.52 | 1121.76 | 2168.28 |
| 14:00 | 3.60 | 1160.35 | 1121.76 | 2282.11 |
| 15:00 | 3.60 | 1248.48 | 1121.76 | 2370.24 |
| 16:00 | 3.60 | 1302.83 | 1121.76 | 2424.59 |
| 17:00 | 3.60 | 1321.92 | 1121.76 | 2443.68 |

## B-Internal Loads

**1-Occupancy Load**

| No Of Pers | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 5.00 | Light Work | 72.00 | 60.00 | 360.00 | 300.00 | 660.00 |

**2-Light Load**

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| Florescent | 8.00 | 20.00 | 1.25 | 200.00 |

**3-Equipment**

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot (W) |
|---|---|---|---|---|
| CPU | 1.00 | 55.00 | 55.00 | 474.00 |
| Monitor | 1.00 | 55.00 | 55.00 | |
| scan light | 1.00 | 100.00 | 100.00 | |
| abjora | 1.00 | 60.00 | 60.00 | |
| scan device | 1.00 | 204.00 | 204.00 | |

## Variation of load with time

| Q occ_s | Q occ_l | Q lig_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 360.00 | 300.00 | 200.00 | 474.00 | 0.00 |

| Time | Q wall_s | Qsun_s | Q vent_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 38.12 | 386.23 | 381.89 | 1121.76 | 1458.35 | 300.00 | 1758.35 |
| 9:00 | 49.48 | 386.23 | 495.72 | 1121.76 | 1469.71 | 300.00 | 1769.71 |
| 10:00 | 62.75 | 312.79 | 628.65 | 1121.76 | 1409.54 | 300.00 | 1709.54 |
| 11:00 | 76.97 | 189.03 | 771.12 | 1121.76 | 1300.01 | 300.00 | 1600.01 |
| 12:00 | 91.19 | 73.44 | 913.59 | 1121.76 | 1198.63 | 300.00 | 1498.63 |
| 13:00 | 104.46 | 59.84 | 1046.52 | 1121.76 | 1198.30 | 300.00 | 1498.30 |
| 14:00 | 115.83 | 59.84 | 1160.35 | 1121.76 | 1209.66 | 300.00 | 1509.66 |
| 15:00 | 124.62 | 59.84 | 1248.48 | 1121.76 | 1218.46 | 300.00 | 1518.46 |
| 16:00 | 130.05 | 51.68 | 1302.83 | 1121.76 | 1215.73 | 300.00 | 1515.73 |
| 17:00 | 131.95 | 43.52 | 1321.92 | 1121.76 | 1209.47 | 300.00 | 1509.47 |

# Room 0-53

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ΔT | Q | Qtot W |
|---|---|---|---|---|---|---|---|
| SW | 8:00 | Glass | 1.10 | 3.44 | 5.20 | 19.65 | 23.95 |
| | | Wall "A" | 0.13 | 4.71 | | 3.13 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.18 | |
| | 9:00 | Glass | 1.10 | 3.44 | 6.75 | 25.51 | 31.09 |
| | | Wall "A" | 0.13 | 4.71 | | 4.06 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.53 | |
| | 10:00 | Glass | 1.10 | 3.44 | 8.56 | 32.35 | 39.43 |
| | | Wall "A" | 0.13 | 4.71 | | 5.15 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.94 | |
| | 11:00 | Glass | 1.10 | 3.44 | 10.50 | 39.68 | 48.37 |
| | | Wall "A" | 0.13 | 4.71 | | 6.31 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.37 | |
| | 12:00 | Glass | 1.10 | 3.44 | 12.44 | 47.01 | 57.31 |
| | | Wall "A" | 0.13 | 4.71 | | 7.48 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.81 | |
| | 13:00 | Glass | 1.10 | 3.44 | 14.25 | 53.85 | 65.64 |
| | | Wall "A" | 0.13 | 4.71 | | 8.57 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.22 | |
| | 14:00 | Glass | 1.10 | 3.44 | 15.80 | 59.71 | 72.78 |
| | | Wall "A" | 0.13 | 4.71 | | 9.50 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.57 | |
| | 15:00 | Glass | 1.10 | 3.44 | 17.00 | 64.25 | 78.31 |
| | | Wall "A" | 0.13 | 4.71 | | 10.22 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.84 | |
| | 16:00 | Glass | 1.10 | 3.44 | 17.74 | 67.04 | 81.72 |
| | | Wall "A" | 0.13 | 4.71 | | 10.67 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.01 | |
| | 17:00 | Glass | 1.10 | 3.44 | 18.00 | 68.03 | 82.92 |
| | | Wall "A" | 0.13 | 4.71 | | 10.82 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.07 | |

### 2-Sun Load

| Direction | Time | Type | U | A | ΔT sun | I | Q | Qtot W |
|---|---|---|---|---|---|---|---|---|
| SW | 8:00 | glass | | 3.44 | | 284.00 | 331.74 | 345.41 |
| | | A | 0.13 | 4.71 | 18.46 | | 11.10 | |
| | | D | 0.39 | 0.57 | 11.36 | | 2.57 | |
| | 9:00 | glass | | 3.44 | | 284.00 | 331.74 | 345.41 |
| | | A | 0.13 | 4.71 | 18.46 | | 11.10 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | D | 0.39 | 0.57 | 11.36 | | 2.57 | |
| | 10:00 | glass | | 3.44 | | 230.00 | 268.67 | 279.73 |
| | | A | 0.13 | 4.71 | 14.95 | | 8.99 | |
| | | D | 0.39 | 0.57 | 9.20 | | 2.08 | |
| | 11:00 | glass | | 3.44 | | 139.00 | 162.37 | 169.06 |
| | | A | 0.13 | 4.71 | 9.04 | | 5.43 | |
| | | D | 0.39 | 0.57 | 5.56 | | 1.26 | |
| | 12:00 | glass | | 3.44 | | 54.00 | 63.08 | 65.68 |
| | | A | 0.13 | 4.71 | 3.51 | | 2.11 | |
| | | D | 0.39 | 0.57 | 2.16 | | 0.49 | |
| | 13:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 14:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 15:00 | glass | | 3.44 | | 44.00 | 51.40 | 53.51 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 | |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 | |
| | 16:00 | glass | | 3.44 | | 38.00 | 44.39 | 46.22 |
| | | A | 0.13 | 4.71 | 2.47 | | 1.48 | |
| | | D | 0.39 | 0.57 | 1.52 | | 0.34 | |
| | 17:00 | glass | | 3.44 | | 32.00 | 37.38 | 38.92 |
| | | A | 0.13 | 4.71 | 2.08 | | 1.25 | |
| | | D | 0.39 | 0.57 | 1.28 | | 0.29 | |

**3-Ventilation Load**

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 5.00 | 12.00 | 1.80 | 2.00 |

| | |
|---|---|
| **A (m2)** | 16.63 |
| **H (m)** | 2.60 |
| **V (m3)** | 38.91 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 3.60 |
| **Based on Area** | 1.80 |
| **NO Of Air Changing Times** | 1.30 |

| Time | CMMmax | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 8:00 | 3.60 | 381.89 | 1121.76 | 1503.65 |
| 9:00 | 3.60 | 495.72 | 1121.76 | 1617.48 |
| 10:00 | 3.60 | 628.65 | 1121.76 | 1750.41 |
| 11:00 | 3.60 | 771.12 | 1121.76 | 1892.88 |
| 12:00 | 3.60 | 913.59 | 1121.76 | 2035.35 |

| | | | | |
|---|---|---|---|---|
| 13:00 | 3.60 | 1046.52 | 1121.76 | 2168.28 |
| 14:00 | 3.60 | 1160.35 | 1121.76 | 2282.11 |
| 15:00 | 3.60 | 1248.48 | 1121.76 | 2370.24 |
| 16:00 | 3.60 | 1302.83 | 1121.76 | 2424.59 |
| 17:00 | 3.60 | 1321.92 | 1121.76 | 2443.68 |

## B-Internal Loads

### 1-Occupancy Load

| No Of Pers | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 5.00 | Light Work | 72.00 | 60.00 | 360.00 | 300.00 | 660.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| Florescent | 8.00 | 20.00 | 1.25 | 200.00 |

### 3-Equipment

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot (W) |
|---|---|---|---|---|
| CPU | 1.00 | 55.00 | 55.00 | 474.00 |
| Monitor | 1.00 | 55.00 | 55.00 | |
| scan light | 1.00 | 100.00 | 100.00 | |
| abjora | 1.00 | 60.00 | 60.00 | |
| scan device | 1.00 | 204.00 | 204.00 | |

## Variation of load with time

| Q occ_s | Q occ_l | Q lig_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 360.00 | 300.00 | 200.00 | 474.00 | 0.00 |

| Time | Q wall_s | Q sun_s | Q vent_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 23.95 | 345.41 | 381.89 | 1121.76 | 1403.37 | 300.00 | 1703.37 |
| 9:00 | 31.09 | 345.41 | 495.72 | 1121.76 | 1410.51 | 300.00 | 1710.51 |
| 10:00 | 39.43 | 279.73 | 628.65 | 1121.76 | 1353.17 | 300.00 | 1653.17 |
| 11:00 | 48.37 | 169.06 | 771.12 | 1121.76 | 1251.43 | 300.00 | 1551.43 |
| 12:00 | 57.31 | 65.68 | 913.59 | 1121.76 | 1156.98 | 300.00 | 1456.98 |
| 13:00 | 65.64 | 53.51 | 1046.52 | 1121.76 | 1153.16 | 300.00 | 1453.16 |
| 14:00 | 72.78 | 53.51 | 1160.35 | 1121.76 | 1160.30 | 300.00 | 1460.30 |
| 15:00 | 78.31 | 53.51 | 1248.48 | 1121.76 | 1165.83 | 300.00 | 1465.83 |
| 16:00 | 81.72 | 46.22 | 1302.83 | 1121.76 | 1161.94 | 300.00 | 1461.94 |
| 17:00 | 82.92 | 38.92 | 1321.92 | 1121.76 | 1155.84 | 300.00 | 1455.84 |

# Room 0-54

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ΔT | Q | Qtot W |
|---|---|---|---|---|---|---|---|
| NE | 8:00 | Glass | 1.10 | 3.44 | 5.20 | 19.65 | 36.53 |
| | | Wall "A" | 0.13 | 4.04 | | 2.68 | |
| | | Wall "B" | 1.44 | 1.90 | | 14.20 | |
| | 9:00 | Glass | 1.10 | 3.44 | 6.75 | 25.51 | 47.42 |
| | | Wall "A" | 0.13 | 4.04 | | 3.48 | |
| | | Wall "B" | 1.44 | 1.90 | | 18.43 | |
| | 10:00 | Glass | 1.10 | 3.44 | 8.56 | 32.35 | 60.14 |
| | | Wall "A" | 0.13 | 4.04 | | 4.41 | |
| | | Wall "B" | 1.44 | 1.90 | | 23.38 | |
| | 11:00 | Glass | 1.10 | 3.44 | 10.50 | 39.68 | 73.77 |
| | | Wall "A" | 0.13 | 4.04 | | 5.41 | |
| | | Wall "B" | 1.44 | 1.90 | | 28.68 | |
| | 12:00 | Glass | 1.10 | 3.44 | 12.44 | 47.01 | 87.40 |
| | | Wall "A" | 0.13 | 4.04 | | 6.41 | |
| | | Wall "B" | 1.44 | 1.90 | | 33.97 | |
| | 13:00 | Glass | 1.10 | 3.44 | 14.25 | 53.85 | 100.11 |
| | | Wall "A" | 0.13 | 4.04 | | 7.34 | |
| | | Wall "B" | 1.44 | 1.90 | | 38.92 | |
| | 14:00 | Glass | 1.10 | 3.44 | 15.80 | 59.71 | 111.00 |
| | | Wall "A" | 0.13 | 4.04 | | 8.14 | |
| | | Wall "B" | 1.44 | 1.90 | | 43.15 | |
| | 15:00 | Glass | 1.10 | 3.44 | 17.00 | 64.25 | 119.43 |
| | | Wall "A" | 0.13 | 4.04 | | 8.76 | |
| | | Wall "B" | 1.44 | 1.90 | | 46.43 | |
| | 16:00 | Glass | 1.10 | 3.44 | 17.74 | 67.04 | 124.63 |
| | | Wall "A" | 0.13 | 4.04 | | 9.14 | |
| | | Wall "B" | 1.44 | 1.90 | | 48.45 | |
| | 17:00 | Glass | 1.10 | 3.44 | 18.00 | 68.03 | 126.46 |
| | | Wall "A" | 0.13 | 4.04 | | 9.27 | |
| | | Wall "B" | 1.44 | 1.90 | | 49.16 | |

### 2-Sun Load

| Direction | Time | Type | U | A | ΔT sun | I | Q | Qtot W |
|---|---|---|---|---|---|---|---|---|
| NE | 8:00 | glass | | 3.44 | | 284.00 | 331.74 | 391.67 |
| | | A | 0.13 | 4.04 | 18.46 | | 9.51 | |
| | | B | 1.44 | 1.90 | 18.46 | | 50.41 | |
| | 9:00 | glass | | 3.44 | | 284.00 | 331.74 | 391.67 |
| | | A | 0.13 | 4.04 | 18.46 | | 9.51 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | B | 1.44 | 1.90 | 18.46 | | 50.41 | |
| | 10:00 | glass | | 3.44 | | 230.00 | 268.67 | 317.20 |
| | | A | 0.13 | 4.04 | 14.95 | | 7.70 | |
| | | B | 1.44 | 1.90 | 14.95 | | 40.83 | |
| | 11:00 | glass | | 3.44 | | 139.00 | 162.37 | 191.70 |
| | | A | 0.13 | 4.04 | 9.04 | | 4.65 | |
| | | B | 1.44 | 1.90 | 9.04 | | 24.67 | |
| | 12:00 | glass | | 3.44 | | 54.00 | 63.08 | 74.47 |
| | | A | 0.13 | 4.04 | 3.51 | | 1.81 | |
| | | B | 1.44 | 1.90 | 3.51 | | 9.59 | |
| | 13:00 | glass | | 3.44 | | 44.00 | 51.40 | 60.68 |
| | | A | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | B | 1.44 | 1.90 | 2.86 | | 7.81 | |
| | 14:00 | glass | | 3.44 | | 44.00 | 51.40 | 60.68 |
| | | A | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | B | 1.44 | 1.90 | 2.86 | | 7.81 | |
| | 15:00 | glass | | 3.44 | | 44.00 | 51.40 | 60.68 |
| | | A | 0.13 | 4.04 | 2.86 | | 1.47 | |
| | | B | 1.44 | 1.90 | 2.86 | | 7.81 | |
| | 16:00 | glass | | 3.44 | | 38.00 | 44.39 | 52.41 |
| | | A | 0.13 | 4.04 | 2.47 | | 1.27 | |
| | | B | 1.44 | 1.90 | 2.47 | | 6.75 | |
| | 17:00 | glass | | 3.44 | | 32.00 | 37.38 | 44.13 |
| | | A | 0.13 | 4.04 | 2.08 | | 1.07 | |
| | | B | 1.44 | 1.90 | 2.08 | | 5.68 | |

**3-Ventilation Load**

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 5.00 | 12.00 | 1.80 | 2.00 |

| | |
|---|---|
| **A (m2)** | 17.52 |
| **H (m)** | 2.60 |
| **V (m3)** | 38.91 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 3.60 |
| **Based on Area** | 1.89 |
| **NO Of Air Changing Times** | 1.30 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 8:00 | 3.60 | 381.89 | 1121.76 | 1503.65 |
| 9:00 | 3.60 | 495.72 | 1121.76 | 1617.48 |
| 10:00 | 3.60 | 628.65 | 1121.76 | 1750.41 |
| 11:00 | 3.60 | 771.12 | 1121.76 | 1892.88 |

| | | | | |
|---|---|---|---|---|
| 12:00 | 3.60 | 913.59 | 1121.76 | 2035.35 |
| 13:00 | 3.60 | 1046.52 | 1121.76 | 2168.28 |
| 14:00 | 3.60 | 1160.35 | 1121.76 | 2282.11 |
| 15:00 | 3.60 | 1248.48 | 1121.76 | 2370.24 |
| 16:00 | 3.60 | 1302.83 | 1121.76 | 2424.59 |
| 17:00 | 3.60 | 1321.92 | 1121.76 | 2443.68 |

## B-Internal Loads

### 1-Occupancy Load

| No Of Pers | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 5.00 | Light Work | 72.00 | 60.00 | 360.00 | 300.00 | 660.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| Florescent | 8.00 | 20.00 | 1.25 | 200.00 |

### 3-Equipment

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot |
|---|---|---|---|---|
| CPU | 1.00 | 55.00 | 55.00 | 474.00 |
| Monitor | 1.00 | 55.00 | 55.00 | |
| scan light | 1.00 | 100.00 | 100.00 | |
| abjora | 1.00 | 60.00 | 60.00 | |
| scan device | 1.00 | 204.00 | 204.00 | |

## Variation of load with time

| Q occ_s | Q occ_l | Q lig_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 360.00 | 300.00 | 200.00 | 474.00 | 0.00 |

| Time | Q wall_s | Qsun_s | Q vent_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 36.53 | 391.67 | 381.89 | 1121.76 | 1462.20 | 300.00 | 1762.20 |
| 9:00 | 47.42 | 391.67 | 495.72 | 1121.76 | 1473.09 | 300.00 | 1773.09 |
| 10:00 | 60.14 | 317.20 | 628.65 | 1121.76 | 1411.33 | 300.00 | 1711.33 |
| 11:00 | 73.77 | 191.70 | 771.12 | 1121.76 | 1299.46 | 300.00 | 1599.46 |
| 12:00 | 87.40 | 74.47 | 913.59 | 1121.76 | 1195.87 | 300.00 | 1495.87 |
| 13:00 | 100.11 | 60.68 | 1046.52 | 1121.76 | 1194.79 | 300.00 | 1494.79 |
| 14:00 | 111.00 | 60.68 | 1160.35 | 1121.76 | 1205.68 | 300.00 | 1505.68 |
| 15:00 | 119.43 | 60.68 | 1248.48 | 1121.76 | 1214.11 | 300.00 | 1514.11 |
| 16:00 | 124.63 | 52.41 | 1302.83 | 1121.76 | 1211.04 | 300.00 | 1511.04 |
| 17:00 | 126.46 | 44.13 | 1321.92 | 1121.76 | 1204.59 | 300.00 | 1504.59 |

# Room 0-55

## A-External Loads
### Ventilation Load

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 3.00 | 10.00 | 1.80 | 2.00 |

| | |
|---|---|
| **A (m2)** | 13.39 |
| **H (m)** | 2.60 |
| **V (m3)** | 34.81 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 1.80 |
| **Based on Area** | 1.45 |
| **NO Of Air Changing Times** | 1.16 |

| Time | CMM max | Q s(W) | QL(W) | Q tot (W) |
|---|---|---|---|---|
| 08:00 | 1.80 | 190.94 | 560.88 | 751.82 |
| 09:00 | 1.80 | 247.86 | 560.88 | 808.74 |
| 10:00 | 1.80 | 314.32 | 560.88 | 875.20 |
| 11:00 | 1.80 | 385.56 | 560.88 | 946.44 |
| 12:00 | 1.80 | 456.80 | 560.88 | 1017.68 |
| 13:00 | 1.80 | 523.26 | 560.88 | 1084.14 |
| 14:00 | 1.80 | 580.18 | 560.88 | 1141.06 |
| 15:00 | 1.80 | 624.24 | 560.88 | 1185.12 |
| 16:00 | 1.80 | 649.94 | 560.88 | 1210.82 |
| 17:00 | 1.80 | 660.96 | 560.88 | 1221.84 |

## B-Internal Loads
### 1-Occupancy Load

| No Of Persons | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 3.00 | Light | 72.00 | 60.00 | 216.00 | 180.00 | 396.00 |

### 2-Light Load

| Type | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| florescent | 8.00 | 40.00 | 1.25 | 400.00 |

### 3-Equipment

| Type Of Device | No Of Device | W/device | Q (W) |
|---|---|---|---|
| computer | 1.00 | 110.00 | 110.00 |

**Variation of load with time**

| Q occ_s | Q occ_l | Q lig_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 400.00 | 216.00 | 180.00 | 110.00 | 0 |

| Time | Qs | Qs | Qs | Ql | RSH (W) | RLH (W) | RTH (W) |
|---|---|---|---|---|---|---|---|
| 08:00 | 0.00 | 0.00 | 190.94 | 560.88 | 726.00 | 180.00 | 906.00 |
| 09:00 | 0.00 | 0.00 | 247.86 | 560.88 | 726.00 | 180.00 | 906.00 |
| 10:00 | 0.00 | 0.00 | 314.32 | 560.88 | 726.00 | 180.00 | 906.00 |
| 11:00 | 0.00 | 0.00 | 385.56 | 560.88 | 726.00 | 180.00 | 906.00 |
| 12:00 | 0.00 | 0.00 | 456.80 | 560.88 | 726.00 | 180.00 | 906.00 |
| 13:00 | 0.00 | 0.00 | 523.26 | 560.88 | 726.00 | 180.00 | 906.00 |
| 14:00 | 0.00 | 0.00 | 580.18 | 560.88 | 726.00 | 180.00 | 906.00 |
| 15:00 | 0.00 | 0.00 | 624.24 | 560.88 | 726.00 | 180.00 | 906.00 |
| 16:00 | 0.00 | 0.00 | 649.94 | 560.88 | 726.00 | 180.00 | 906.00 |
| 17:00 | 0.00 | 0.00 | 660.96 | 560.88 | 726.00 | 180.00 | 906.00 |

# Room 0-59

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A (m2) | ∆T (K) | Q (W) | Q t(W) |
|---|---|---|---|---|---|---|---|
| SW | 08:00 | Wall "A" | 0.13 | 4.05 | 5.20 | 2.68 | 38.00 |
| | | Glass | 1.10 | 3.44 | | 19.69 | |
| | | Wall "C" | 1.79 | 0.85 | | 7.95 | |
| | | Wall "B" | 1.44 | 1.03 | | 7.67 | |
| | 09:00 | Wall "A" | 0.13 | 4.05 | 6.75 | 3.48 | 49.33 |
| | | Glass | 1.10 | 3.44 | | 25.56 | |
| | | Wall "C" | 1.79 | 0.85 | | 10.32 | |
| | | Wall "B" | 1.44 | 1.03 | | 9.96 | |
| | 10:00 | Wall "A" | 0.13 | 4.05 | 8.56 | 4.42 | 62.55 |
| | | Glass | 1.10 | 3.44 | | 32.42 | |
| | | Wall "C" | 1.79 | 0.85 | | 13.08 | |
| | | Wall "B" | 1.44 | 1.03 | | 12.63 | |
| | 11:00 | Wall "A" | 0.13 | 4.05 | 10.50 | 5.42 | 76.73 |
| | | Glass | 1.10 | 3.44 | | 39.76 | |
| | | Wall "C" | 1.79 | 0.85 | | 16.05 | |
| | | Wall "B" | 1.44 | 1.03 | | 15.50 | |
| | 12:00 | Wall "A" | 0.13 | 4.05 | 12.44 | 6.42 | 90.91 |
| | | Glass | 1.10 | 3.44 | | 47.11 | |
| | | Wall "C" | 1.79 | 0.85 | | 19.01 | |
| | | Wall "B" | 1.44 | 1.03 | | 18.36 | |
| | 13:00 | Wall "A" | 0.13 | 4.05 | 14.25 | 7.36 | 104.13 |
| | | Glass | 1.10 | 3.44 | | 53.97 | |
| | | Wall "C" | 1.79 | 0.85 | | 21.78 | |
| | | Wall "B" | 1.44 | 1.03 | | 21.03 | |
| | 14:00 | Wall "A" | 0.13 | 4.05 | 15.80 | 8.16 | 115.46 |
| | | Glass | 1.10 | 3.44 | | 59.84 | |
| | | Wall "C" | 1.79 | 0.85 | | 24.15 | |
| | | Wall "B" | 1.44 | 1.03 | | 23.32 | |
| | 15:00 | Wall "A" | 0.13 | 4.05 | 17.00 | 8.78 | 124.23 |
| | | Glass | 1.10 | 3.44 | | 64.38 | |
| | | Wall "C" | 1.79 | 0.85 | | 25.99 | |
| | | Wall "B" | 1.44 | 1.03 | | 25.09 | |
| | 16:00 | Wall "A" | 0.13 | 4.05 | 17.70 | 9.14 | 129.35 |
| | | Glass | 1.10 | 3.44 | | 67.03 | |
| | | Wall "C" | 1.79 | 0.85 | | 27.06 | |
| | | Wall "B" | 1.44 | 1.03 | | 26.12 | |
| | 17:00 | Wall "A" | 0.13 | 4.05 | 18.00 | 9.29 | 131.54 |
| | | Glass | 1.10 | 3.44 | | 68.17 | |
| | | Wall "C" | 1.79 | 0.85 | | 27.51 | |
| | | Wall "B" | 1.44 | 1.03 | | 26.56 | |

### 2-Sun Load

| Direction | Time | Type | U | A | I | ∆T | Q | Q t(W) |
|---|---|---|---|---|---|---|---|---|
| SW | 0.33 | Wall "A" | 0.13 | 4.05 | 38.00 | 2.47 | 1.28 | 53.18 |
| | | Glass | 1.10 | 3.44 | | | 44.48 | |
| | | Wall "C" | 1.79 | 0.85 | | 1.52 | 3.78 | |
| | | Wall "B" | 1.44 | 1.03 | | 2.47 | 3.65 | |
| | 0.38 | Wall "A" | 0.13 | 4.05 | 44.00 | 2.86 | 1.48 | 61.57 |
| | | Glass | 1.10 | 3.44 | | | 51.50 | |
| | | Wall "C" | 1.79 | 0.85 | | 1.76 | 4.37 | |
| | | Wall "B" | 1.44 | 1.03 | | 2.86 | 4.22 | |
| | 0.42 | Wall "A" | 0.13 | 4.05 | 44.00 | 2.86 | 1.48 | 61.57 |
| | | Glass | 1.10 | 3.44 | | | 51.50 | |
| | | Wall "C" | 1.79 | 0.85 | | 1.76 | 4.37 | |
| | | Wall "B" | 1.44 | 1.03 | | 2.86 | 4.22 | |
| | 0.46 | Wall "A" | 0.13 | 4.05 | 44.00 | 2.86 | 1.48 | 61.57 |
| | | Glass | 1.10 | 3.44 | | | 51.50 | |
| | | Wall "C" | 1.79 | 0.85 | | 1.76 | 4.37 | |
| | | Wall "B" | 1.44 | 1.03 | | 2.86 | 4.22 | |
| | 0.50 | Wall "A" | 0.13 | 4.05 | 54.00 | 3.51 | 1.81 | 75.57 |
| | | Glass | 1.10 | 3.44 | | | 63.21 | |
| | | Wall "C" | 1.79 | 0.85 | | 2.16 | 5.37 | |
| | | Wall "B" | 1.44 | 1.03 | | 3.51 | 5.18 | |
| | 0.54 | Wall "A" | 0.13 | 4.05 | 138.00 | 8.97 | 4.63 | 193.12 |
| | | Glass | 1.10 | 3.44 | | | 161.54 | |
| | | Wall "C" | 1.79 | 0.85 | | 5.52 | 13.71 | |
| | | Wall "B" | 1.44 | 1.03 | | 8.97 | 13.24 | |
| | 0.58 | Wall "A" | 0.13 | 4.05 | 230.00 | 14.95 | 7.72 | 321.86 |
| | | Glass | 1.10 | 3.44 | | | 269.23 | |
| | | Wall "C" | 1.79 | 0.85 | | 9.20 | 22.85 | |
| | | Wall "B" | 1.44 | 1.03 | | 14.95 | 22.06 | |
| | 0.63 | Wall "A" | 0.13 | 4.05 | 284.00 | 18.46 | 9.53 | 397.43 |
| | | Glass | 1.10 | 3.44 | | | 332.44 | |
| | | Wall "C" | 1.79 | 0.85 | | 11.36 | 28.22 | |
| | | Wall "B" | 1.44 | 1.03 | | 18.46 | 27.24 | |
| | 0.67 | Wall "A" | 0.13 | 4.05 | 284.00 | 18.46 | 9.53 | 397.43 |
| | | Glass | 1.10 | 3.44 | | | 332.44 | |
| | | Wall "C" | 1.79 | 0.85 | | 11.36 | 28.22 | |
| | | Wall "B" | 1.44 | 1.03 | | 18.46 | 27.24 | |
| | 0.71 | Wall "A" | 0.13 | 4.05 | 237.00 | 15.41 | 7.95 | 331.66 |
| | | Glass | 1.10 | 3.44 | | | 277.42 | |
| | | Wall "C" | 1.79 | 0.85 | | 9.48 | 23.55 | |
| | | Wall "B" | 1.44 | 1.03 | | 15.41 | 22.73 | |

### 3-Ventilation Load

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 6.00 | 14.00 | 6.70 | 7.00 |

| | |
|---|---|
| **A (m2)** | 13.60 |
| **H (m)** | 2.60 |
| **V (m3)** | 35.36 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 5.04 |
| **Based on Area** | 5.47 |
| **NO. Of Air Changing Times** | 4.13 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 08:00 | 5.47 | 579.96 | 1703.58 | 2283.54 |
| 09:00 | 5.47 | 752.83 | 1703.58 | 2456.41 |
| 10:00 | 5.47 | 954.70 | 1703.58 | 2658.28 |
| 11:00 | 5.47 | 1171.07 | 1703.58 | 2874.65 |
| 12:00 | 5.47 | 1387.44 | 1703.58 | 3091.02 |
| 13:00 | 5.47 | 1589.32 | 1703.58 | 3292.89 |
| 14:00 | 5.47 | 1762.19 | 1703.58 | 3465.77 |
| 15:00 | 5.47 | 1896.02 | 1703.58 | 3599.60 |
| 16:00 | 5.47 | 1974.10 | 1703.58 | 3677.68 |
| 17:00 | 5.47 | 2007.56 | 1703.58 | 3711.14 |

## B-Internal Loads
### 1-Occupancy Load

| No Of Persons | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 6.00 | Light Work | 72.00 | 60.00 | 432.00 | 360.00 | 792.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| florescent | 6.00 | 40.00 | 1.25 | 300.00 |

### 3-Equipment

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot (W) |
|---|---|---|---|---|
| Device | 1.00 | 500 | 500 | 750 |
| Refrigerator | 1.00 | 250 | 250 | |

**Variation of load with time**

| Q occ_s | Q occ_l | Q lig_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 300.00 | 432.00 | 360.00 | 750.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 0.33 | 38.00 | 53.18 | 579.96 | 1703.58 | 1573.18 | 360.00 | 1933.18 |
| 0.38 | 49.33 | 61.57 | 752.83 | 1703.58 | 1592.90 | 360.00 | 1952.90 |
| 0.42 | 62.55 | 61.57 | 954.70 | 1703.58 | 1606.13 | 360.00 | 1966.13 |
| 0.46 | 76.73 | 61.57 | 1171.07 | 1703.58 | 1620.30 | 360.00 | 1980.30 |
| 0.50 | 90.91 | 75.57 | 1387.44 | 1703.58 | 1648.47 | 360.00 | 2008.47 |
| 0.54 | 104.13 | 193.12 | 1589.32 | 1703.58 | 1779.25 | 360.00 | 2139.25 |
| 0.58 | 115.46 | 321.86 | 1762.19 | 1703.58 | 1919.32 | 360.00 | 2279.32 |
| 0.63 | 124.23 | 397.43 | 1896.02 | 1703.58 | 2003.66 | 360.00 | 2363.66 |
| 0.67 | 129.35 | 397.43 | 1974.10 | 1703.58 | 2008.77 | 360.00 | 2368.77 |
| 0.71 | 131.54 | 331.66 | 2007.56 | 1703.58 | 1945.19 | 360.00 | 2305.19 |

# Room 0-60

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ΔT | Q | Qt (W) |
|---|---|---|---|---|---|---|---|
| SW | 08:00 | Wall "A" | 0.13 | 4.74 | 6.20 | 3.75 | 28.76 |
| | | Glass | 1.10 | 3.46 | | 23.60 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.40 | |
| | 09:00 | Wall "A" | 0.13 | 4.74 | 7.75 | 4.69 | 35.94 |
| | | Glass | 1.10 | 3.46 | | 29.50 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.75 | |
| | 10:00 | Wall "A" | 0.13 | 4.74 | 9.56 | 5.78 | 44.34 |
| | | Glass | 1.10 | 3.46 | | 36.39 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.16 | |
| | 11:00 | Wall "A" | 0.13 | 4.74 | 11.50 | 6.96 | 53.34 |
| | | Glass | 1.10 | 3.46 | | 43.78 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.60 | |
| | 12:00 | Wall "A" | 0.13 | 4.74 | 13.44 | 8.13 | 62.33 |
| | | Glass | 1.10 | 3.46 | | 51.16 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.04 | |
| | 13:00 | Wall "A" | 0.13 | 4.74 | 15.25 | 9.23 | 70.73 |
| | | Glass | 1.10 | 3.46 | | 58.05 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.45 | |
| | 14:00 | Wall "A" | 0.13 | 4.74 | 16.80 | 10.16 | 77.92 |
| | | Glass | 1.10 | 3.46 | | 63.95 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.80 | |
| | 15:00 | Wall "A" | 0.13 | 4.74 | 18.00 | 10.89 | 83.48 |
| | | Glass | 1.10 | 3.46 | | 68.52 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.07 | |
| | 16:00 | Wall "A" | 0.13 | 4.74 | 18.70 | 11.31 | 86.73 |
| | | Glass | 1.10 | 3.46 | | 71.19 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.23 | |
| | 17:00 | Wall "A" | 0.13 | 4.74 | 19.00 | 11.49 | 88.12 |
| | | Glass | 1.10 | 3.46 | | 72.33 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.30 | |

### 2-Sun Load

| Direction | Time | Type | U | A (m2) | I | ΔTs | Q | Q t(W) |
|---|---|---|---|---|---|---|---|---|
| SW | 08:00 | Wall "A" | 0.13 | 4.74 | 38.00 | 2.47 | 1.49 | 46.77 |
| | | Glass | 1.10 | 3.46 | | | 44.71 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.52 | 0.56 | |
| | 09:00 | Wall "A" | 0.13 | 4.74 | 44.00 | 2.86 | 1.73 | 54.15 |
| | | Glass | 1.10 | 3.46 | | | 51.77 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.76 | 0.65 | |
| | 10:00 | Wall "A" | 0.13 | 4.74 | 44.00 | 2.86 | 1.73 | 54.15 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Glass | 1.10 | 3.46 | | | 51.77 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.76 | 0.65 | |
| | 11:00 | Wall "A" | 0.13 | 4.74 | 44.00 | 2.86 | 1.73 | 54.15 |
| | | Glass | 1.10 | 3.46 | | | 51.77 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.76 | 0.65 | |
| | 12:00 | Wall "A" | 0.13 | 4.74 | 54.00 | 3.51 | 2.12 | 66.46 |
| | | Glass | 1.10 | 3.46 | | | 63.54 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.16 | 0.79 | |
| | 13:00 | Wall "A" | 0.13 | 4.74 | 138.00 | 8.97 | 5.43 | 169.83 |
| | | Glass | 1.10 | 3.46 | | | 162.38 | |
| | | Wall "D" | 0.39 | 0.57 | | 5.52 | 2.03 | |
| | 14:00 | Wall "A" | 0.13 | 4.74 | 230.00 | 14.95 | 9.04 | 283.05 |
| | | Glass | 1.10 | 3.46 | | | 270.63 | |
| | | Wall "D" | 0.39 | 0.57 | | 9.20 | 3.38 | |
| | 15:00 | Wall "A" | 0.13 | 4.74 | 284.00 | 18.46 | 11.17 | 349.51 |
| | | Glass | 1.10 | 3.46 | | | 334.17 | |
| | | Wall "D" | 0.39 | 0.57 | | 11.36 | 4.18 | |
| | 16:00 | Wall "A" | 0.13 | 4.74 | 284.00 | 18.46 | 11.17 | 349.51 |
| | | Glass | 1.10 | 3.46 | | | 334.17 | |
| | | Wall "D" | 0.39 | 0.57 | | 11.36 | 4.18 | |
| | 17:00 | Wall "A" | 0.13 | 4.74 | 237.00 | 15.41 | 9.32 | 291.67 |
| | | Glass | 1.10 | 3.46 | | | 278.86 | |
| | | Wall "D" | 0.39 | 0.57 | | 9.48 | 3.48 | |

### 3-Ventilation Load

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 6.00 | 14.00 | 6.70 | 7.00 |

| | |
|---|---|
| **A (m2)** | 11.43 |
| **H (m)** | 2.60 |
| **V (m3)** | 29.72 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 5.04 |
| **Based on Area** | 4.59 |
| **NO Of Air Changing Times** | 3.47 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 08:00 | 5.04 | 637.46 | 1570.46 | 2207.92 |
| 09:00 | 5.04 | 796.82 | 1570.46 | 2367.29 |
| 10:00 | 5.04 | 982.92 | 1570.46 | 2553.38 |
| 11:00 | 5.04 | 1182.38 | 1570.46 | 2752.85 |
| 12:00 | 5.04 | 1381.85 | 1570.46 | 2952.31 |
| 13:00 | 5.04 | 1567.94 | 1570.46 | 3138.41 |
| 14:00 | 5.04 | 1727.31 | 1570.46 | 3297.77 |
| 15:00 | 5.04 | 1850.69 | 1570.46 | 3421.15 |
| 16:00 | 5.04 | 1922.66 | 1570.46 | 3493.12 |
| 17:00 | 5.04 | 1953.50 | 1570.46 | 3523.97 |

## B-Internal Loads

### 1-Occupancy Load

| No Of Persons | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 6.00 | Light Work | 72.00 | 60.00 | 432.00 | 360.00 | 792.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| florescent | 6.00 | 40.00 | 1.25 | 300.00 |

### Variation of load with time

| Q occ_s | Q occ_l | Q lig_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 300.00 | 432.00 | 360.00 | 0.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 28.76 | 46.77 | 637.46 | 1570.46 | 807.52 | 360.00 | 1167.52 |
| 09:00 | 35.94 | 54.15 | 796.82 | 1570.46 | 822.09 | 360.00 | 1182.09 |
| 10:00 | 44.34 | 54.15 | 982.92 | 1570.46 | 830.49 | 360.00 | 1190.49 |
| 11:00 | 53.34 | 54.15 | 1182.38 | 1570.46 | 839.49 | 360.00 | 1199.49 |
| 12:00 | 62.33 | 66.46 | 1381.85 | 1570.46 | 860.79 | 360.00 | 1220.79 |
| 13:00 | 70.73 | 169.83 | 1567.94 | 1570.46 | 972.56 | 360.00 | 1332.56 |
| 14:00 | 77.92 | 283.05 | 1727.31 | 1570.46 | 1092.97 | 360.00 | 1452.97 |
| 15:00 | 83.48 | 349.51 | 1850.69 | 1570.46 | 1164.99 | 360.00 | 1524.99 |
| 16:00 | 86.73 | 349.51 | 1922.66 | 1570.46 | 1168.24 | 360.00 | 1528.24 |
| 17:00 | 88.12 | 291.67 | 1953.50 | 1570.46 | 1111.79 | 360.00 | 1471.79 |

## Room 0-61

### A-External Loads
### 1-Wall Load

| Direction | Time | Type | U | A | ∆T | Q | Q t(W) |
|---|---|---|---|---|---|---|---|
| SW | 08:00 | Wall "A" | 0.13 | 4.05 | 5.20 | 2.68 | 37.84 |
| | | Glass | 1.10 | 3.44 | | 19.69 | |
| | | Wall "B" | 1.44 | 1.00 | | 7.52 | |
| | | Wall "C" | 1.79 | 0.85 | | 7.95 | |
| | 09:00 | Wall "A" | 0.13 | 4.05 | 6.75 | 3.48 | 49.12 |
| | | Glass | 1.10 | 3.44 | | 25.56 | |
| | | Wall "B" | 1.44 | 1.00 | | 9.76 | |
| | | Wall "C" | 1.79 | 0.85 | | 10.32 | |
| | 10:00 | Wall "A" | 0.13 | 4.05 | 8.56 | 4.42 | 62.29 |
| | | Glass | 1.10 | 3.44 | | 32.42 | |
| | | Wall "B" | 1.44 | 1.00 | | 12.37 | |
| | | Wall "C" | 1.79 | 0.85 | | 13.08 | |
| | 11:00 | Wall "A" | 0.13 | 4.05 | 10.50 | 5.42 | 76.41 |
| | | Glass | 1.10 | 3.44 | | 39.76 | |
| | | Wall "B" | 1.44 | 1.00 | | 15.18 | |
| | | Wall "C" | 1.79 | 0.85 | | 16.05 | |
| | 12:00 | Wall "A" | 0.13 | 4.05 | 12.44 | 6.42 | 90.53 |
| | | Glass | 1.10 | 3.44 | | 47.11 | |
| | | Wall "B" | 1.44 | 1.00 | | 17.98 | |
| | | Wall "C" | 1.79 | 0.85 | | 19.01 | |
| | 13:00 | Wall "A" | 0.13 | 4.05 | 14.25 | 7.36 | 103.70 |
| | | Glass | 1.10 | 3.44 | | 53.97 | |
| | | Wall "B" | 1.44 | 1.00 | | 20.60 | |
| | | Wall "C" | 1.79 | 0.85 | | 21.78 | |
| | 14:00 | Wall "A" | 0.13 | 4.05 | 15.80 | 8.16 | 114.98 |
| | | Glass | 1.10 | 3.44 | | 59.84 | |
| | | Wall "B" | 1.44 | 1.00 | | 22.84 | |
| | | Wall "C" | 1.79 | 0.85 | | 24.15 | |
| | 15:00 | Wall "A" | 0.13 | 4.05 | 17.00 | 8.78 | 123.71 |
| | | Glass | 1.10 | 3.44 | | 64.38 | |
| | | Wall "B" | 1.44 | 1.00 | | 24.57 | |
| | | Wall "C" | 1.79 | 0.85 | | 25.99 | |
| | 16:00 | Wall "A" | 0.13 | 4.05 | 17.70 | 9.14 | 128.81 |
| | | Glass | 1.10 | 3.44 | | 67.03 | |
| | | Wall "B" | 1.44 | 1.00 | | 25.59 | |
| | | Wall "C" | 1.79 | 0.85 | | 27.06 | |
| | 17:00 | Wall "A" | 0.13 | 4.05 | 18.00 | 9.29 | 130.99 |
| | | Glass | 1.10 | 3.44 | | 68.17 | |
| | | Wall "B" | 1.44 | 1.00 | | 26.02 | |
| | | Wall "C" | 1.79 | 0.85 | | 27.51 | |

## 2-Sun Load

| Direction | Time | Type | U | A (m2) | I | ∆T s | Q | Q t(W) |
|---|---|---|---|---|---|---|---|---|
| SW | 08:00 | Wall "A" | 0.13 | 4.05 | 38.00 | 2.47 | 1.28 | 51.65 |
| | | Glass | 1.10 | 3.44 | | | 44.48 | |
| | | Wall "B" | 1.44 | 1.00 | | 2.47 | 3.57 | |
| | | Wall "C" | 1.79 | 0.85 | | 1.52 | 2.32 | |
| | 09:00 | Wall "A" | 0.13 | 4.05 | 44.00 | 2.86 | 1.48 | 59.81 |
| | | Glass | 1.10 | 3.44 | | | 51.50 | |
| | | Wall "B" | 1.44 | 1.00 | | 2.86 | 4.13 | |
| | | Wall "C" | 1.79 | 0.85 | | 1.76 | 2.69 | |
| | 10:00 | Wall "A" | 0.13 | 4.05 | 44.00 | 2.86 | 1.48 | 59.81 |
| | | Glass | 1.10 | 3.44 | | | 51.50 | |
| | | Wall "B" | 1.44 | 1.00 | | 2.86 | 4.13 | |
| | | Wall "C" | 1.79 | 0.85 | | 1.76 | 2.69 | |
| | 11:00 | Wall "A" | 0.13 | 4.05 | 44.00 | 2.86 | 1.48 | 59.81 |
| | | Glass | 1.10 | 3.44 | | | 51.50 | |
| | | Wall "B" | 1.44 | 1.00 | | 2.86 | 4.13 | |
| | | Wall "C" | 1.79 | 0.85 | | 1.76 | 2.69 | |
| | 12:00 | Wall "A" | 0.13 | 4.05 | 54.00 | 3.51 | 1.81 | 73.40 |
| | | Glass | 1.10 | 3.44 | | | 63.21 | |
| | | Wall "B" | 1.44 | 1.00 | | 3.51 | 5.07 | |
| | | Wall "C" | 1.79 | 0.85 | | 2.16 | 3.30 | |
| | 13:00 | Wall "A" | 0.13 | 4.05 | 138.00 | 8.97 | 4.63 | 187.57 |
| | | Glass | 1.10 | 3.44 | | | 161.54 | |
| | | Wall "B" | 1.44 | 1.00 | | 8.97 | 12.97 | |
| | | Wall "C" | 1.79 | 0.85 | | 5.52 | 8.44 | |
| | 14:00 | Wall "A" | 0.13 | 4.05 | 230.00 | 14.95 | 7.72 | 312.62 |
| | | Glass | 1.10 | 3.44 | | | 269.23 | |
| | | Wall "B" | 1.44 | 1.00 | | 14.95 | 21.61 | |
| | | Wall "C" | 1.79 | 0.85 | | 9.20 | 14.06 | |
| | 15:00 | Wall "A" | 0.13 | 4.05 | 284.00 | 18.46 | 9.53 | 386.01 |
| | | Glass | 1.10 | 3.44 | | | 332.44 | |
| | | Wall "B" | 1.44 | 1.00 | | 18.46 | 26.68 | |
| | | Wall "C" | 1.79 | 0.85 | | 11.36 | 17.36 | |
| | 16:00 | Wall "A" | 0.13 | 4.05 | 284.00 | 18.46 | 9.53 | 386.01 |
| | | Glass | 1.10 | 3.44 | | | 332.44 | |
| | | Wall "B" | 1.44 | 1.00 | | 18.46 | 26.68 | |
| | | Wall "C" | 1.79 | 0.85 | | 11.36 | 17.36 | |
| | 17:00 | Wall "A" | 0.13 | 4.05 | 237.00 | 15.41 | 7.95 | 322.14 |
| | | Glass | 1.10 | 3.44 | | | 277.42 | |
| | | Wall "B" | 1.44 | 1.00 | | 15.41 | 22.27 | |
| | | Wall "C" | 1.79 | 0.85 | | 9.48 | 14.49 | |

### 3-Ventilation Load

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 6.00 | 14.00 | 6.70 | 7.00 |

| | |
|---|---|
| **A (m2)** | 12.74 |
| **H (m)** | 2.60 |
| **V (m3)** | 33.12 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 5.04 |
| **Based on Area** | 5.12 |
| **NO Of Air Changing Times** | 3.86 |

| Time | CMMmax | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 08:00 | 5.12 | 543.29 | 1595.85 | 2139.14 |
| 09:00 | 5.12 | 705.23 | 1595.85 | 2301.08 |
| 10:00 | 5.12 | 894.33 | 1595.85 | 2490.19 |
| 11:00 | 5.12 | 1097.02 | 1595.85 | 2692.87 |
| 12:00 | 5.12 | 1299.71 | 1595.85 | 2895.56 |
| 13:00 | 5.12 | 1488.81 | 1595.85 | 3084.67 |
| 14:00 | 5.12 | 1650.76 | 1595.85 | 3246.61 |
| 15:00 | 5.12 | 1776.13 | 1595.85 | 3371.98 |
| 16:00 | 5.12 | 1849.26 | 1595.85 | 3445.12 |
| 17:00 | 5.12 | 1880.61 | 1595.85 | 3476.46 |

## B-Internal Loads

### 1-Occupancy Load

| No Of Persons | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 6 | Light | 72.00 | 60.00 | 432.00 | 360.00 | 792.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| economical | 8.00 | 26.00 | 1.00 | 208.00 |

### 3-Equipment

| Type Of Device | No Of Device | W/device | Q (W) |
|---|---|---|---|
| Refrigerator | 1.00 | 250.00 | 250.00 |

**Variation of load with time**

| Q occ_s | Q occ_l | Q lig_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 208.00 | 432.00 | 360.00 | 250.00 | 0.00 |

| Time | Qs | Qs | Qs | Ql | RSH | RLHH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 37.84 | 51.65 | 543.29 | 1595.85 | 979.49 | 360.00 | 1339.49 |
| 09:00 | 49.12 | 59.81 | 705.23 | 1595.85 | 998.93 | 360.00 | 1358.93 |
| 10:00 | 62.29 | 59.81 | 894.33 | 1595.85 | 1012.10 | 360.00 | 1372.10 |
| 11:00 | 76.41 | 59.81 | 1097.02 | 1595.85 | 1026.22 | 360.00 | 1386.22 |
| 12:00 | 90.53 | 73.40 | 1299.71 | 1595.85 | 1053.93 | 360.00 | 1413.93 |
| 13:00 | 103.70 | 187.57 | 1488.81 | 1595.85 | 1181.27 | 360.00 | 1541.27 |
| 14:00 | 114.98 | 312.62 | 1650.76 | 1595.85 | 1317.60 | 360.00 | 1677.60 |
| 15:00 | 123.71 | 386.01 | 1776.13 | 1595.85 | 1399.73 | 360.00 | 1759.73 |
| 16:00 | 128.81 | 386.01 | 1849.26 | 1595.85 | 1404.82 | 360.00 | 1764.82 |
| 17:00 | 130.99 | 322.14 | 1880.61 | 1595.85 | 1343.13 | 360.00 | 1703.13 |

# Room 0-62

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ΔT | Q | Q t(W) |
|---|---|---|---|---|---|---|---|
| SW | 08:00 | Wall "A" | 0.13 | 4.93 | 5.20 | 3.27 | 25.17 |
| | | Glass | 1.10 | 3.62 | | 20.72 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.18 | |
| | 09:00 | Wall "A" | 0.13 | 4.93 | 6.75 | 4.25 | 32.67 |
| | | Glass | 1.10 | 3.62 | | 26.89 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.53 | |
| | 10:00 | Wall "A" | 0.13 | 4.93 | 8.56 | 5.39 | 41.43 |
| | | Glass | 1.10 | 3.62 | | 34.11 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.94 | |
| | 11:00 | Wall "A" | 0.13 | 4.93 | 10.50 | 6.61 | 50.82 |
| | | Glass | 1.10 | 3.62 | | 41.83 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.37 | |
| | 12:00 | Wall "A" | 0.13 | 4.93 | 12.44 | 7.83 | 60.20 |
| | | Glass | 1.10 | 3.62 | | 49.56 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.81 | |
| | 13:00 | Wall "A" | 0.13 | 4.93 | 14.25 | 8.97 | 68.96 |
| | | Glass | 1.10 | 3.62 | | 56.78 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.22 | |
| | 14:00 | Wall "A" | 0.13 | 4.93 | 15.80 | 9.94 | 76.47 |
| | | Glass | 1.10 | 3.62 | | 62.95 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.57 | |
| | 15:00 | Wall "A" | 0.13 | 4.93 | 17.00 | 10.70 | 82.27 |
| | | Glass | 1.10 | 3.62 | | 67.73 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.84 | |
| | 16:00 | Wall "A" | 0.13 | 4.93 | 17.70 | 11.14 | 85.66 |
| | | Glass | 1.10 | 3.62 | | 70.52 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.00 | |
| | 17:00 | Wall "A" | 0.13 | 4.93 | 18.00 | 11.32 | 87.11 |
| | | Glass | 1.10 | 3.62 | | 71.72 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.07 | |

| Direction | Time | Type | U | A | ΔT | Q | Q t(W) |
|---|---|---|---|---|---|---|---|
| SE | 08:00 | Wall "A" | 0.13 | 10.21 | 5.20 | 6.77 | 27.35 |
| | | Glass | 1.10 | 3.60 | | 20.57 | |
| | 09:00 | Wall "A" | 0.13 | 10.21 | 6.75 | 8.79 | 35.50 |
| | | Glass | 1.10 | 3.60 | | 26.71 | |
| | 10:00 | Wall "A" | 0.13 | 10.21 | 8.56 | 11.15 | 45.01 |
| | | Glass | 1.10 | 3.60 | | 33.87 | |
| | 11:00 | Wall "A" | 0.13 | 10.21 | 10.50 | 13.67 | 55.22 |
| | | Glass | 1.10 | 3.60 | | 41.54 | |
| | 12:00 | Wall "A" | 0.13 | 10.21 | 12.44 | 16.20 | 65.42 |
| | | Glass | 1.10 | 3.60 | | 49.22 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 13:00 | Wall "A" | 0.13 | 10.21 | 14.25 | 18.55 | 74.94 |
| | | Glass | 1.10 | 3.60 | | 56.38 | |
| | 14:00 | Wall "A" | 0.13 | 10.21 | 15.80 | 20.57 | 83.09 |
| | | Glass | 1.10 | 3.60 | | 62.51 | |
| | 15:00 | Wall "A" | 0.13 | 10.21 | 17.00 | 22.14 | 89.40 |
| | | Glass | 1.10 | 3.60 | | 67.26 | |
| | 16:00 | Wall "A" | 0.13 | 10.21 | 17.70 | 23.05 | 93.08 |
| | | Glass | 1.10 | 3.60 | | 70.03 | |
| | 17:00 | Wall "A" | 0.13 | 10.21 | 18.00 | 23.44 | 94.66 |
| | | Glass | 1.10 | 3.60 | | 71.22 | |

| Time | Qt(W) |
|---|---|
| 0.33 | 52.51 |
| 0.38 | 68.16 |
| 0.42 | 86.44 |
| 0.46 | 106.03 |
| 0.50 | 125.62 |
| 0.54 | 143.90 |
| 0.58 | 159.55 |
| 0.63 | 171.67 |
| 0.67 | 178.74 |
| 0.71 | 181.77 |

**2-Sun Load**

| Direction | Time | Type | U | A (m2) | I | ∆Ts | Q | Q t(W) |
|---|---|---|---|---|---|---|---|---|
| **SW** | 08:00 | Wall "A" | 0.13 | 4.93 | 38.00 | 2.47 | 1.55 | 48.91 |
| | | Glass | 1.10 | 3.62 | | | 46.80 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.52 | 0.56 | |
| | 09:00 | Wall "A" | 0.13 | 4.93 | 44.00 | 2.86 | 1.80 | 56.63 |
| | | Glass | 1.10 | 3.62 | | | 54.19 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.76 | 0.65 | |
| | 10:00 | Wall "A" | 0.13 | 4.93 | 44.00 | 2.86 | 1.80 | 56.63 |
| | | Glass | 1.10 | 3.62 | | | 54.19 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.76 | 0.65 | |
| | 11:00 | Wall "A" | 0.13 | 4.93 | 44.00 | 2.86 | 1.80 | 56.63 |
| | | Glass | 1.10 | 3.62 | | | 54.19 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.76 | 0.65 | |
| | 12:00 | Wall "A" | 0.13 | 4.93 | 54.00 | 3.51 | 2.21 | 69.50 |
| | | Glass | 1.10 | 3.62 | | | 66.50 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.16 | 0.79 | |
| | 13:00 | Wall "A" | 0.13 | 4.93 | 138.00 | 8.97 | 5.64 | 177.62 |
| | | Glass | 1.10 | 3.62 | | | 169.95 | |
| | | Wall "D" | 0.39 | 0.57 | | 5.52 | 2.03 | |
| | 14:00 | Wall "A" | 0.13 | 4.93 | 230.00 | 14.95 | 9.41 | 296.03 |
| | | Glass | 1.10 | 3.62 | | | 283.24 | |
| | | Wall "D" | 0.39 | 0.57 | | 9.20 | 3.38 | |
| | 15:00 | Wall "A" | 0.13 | 4.93 | 284.00 | 18.46 | 11.61 | 365.53 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Glass | 1.10 | 3.62 | | | 349.74 | |
| | | Wall "D" | 0.39 | 0.57 | | 11.36 | 4.18 | |
| | 16:00 | Wall "A" | 0.13 | 4.93 | 284.00 | 18.46 | 11.61 | 365.53 |
| | | Glass | 1.10 | 3.62 | | | 349.74 | |
| | | Wall "D" | 0.39 | 0.57 | | 11.36 | 4.18 | |
| | 17:00 | Wall "A" | 0.13 | 4.93 | 237.00 | 15.41 | 9.69 | 305.04 |
| | | Glass | 1.10 | 3.62 | | | 291.86 | |
| | | Wall "D" | 0.39 | 0.57 | | 9.48 | 3.48 | |

| Direction | Time | Type | U (w/m2.k) | A (m2) | I (W/m2) | ∆Ts (K) | Q (W) | Q t(W) |
|---|---|---|---|---|---|---|---|---|
| SE | 08:00 | Wall "A" | 0.13 | 10.21 | 284.00 | 18.46 | 24.04 | 371.36 |
| | | Glass | 1.10 | 3.60 | | | 347.32 | |
| | 09:00 | Wall "A" | 0.13 | 10.21 | 284.00 | 18.46 | 24.04 | 371.36 |
| | | Glass | 1.10 | 3.60 | | | 347.32 | |
| | 10:00 | Wall "A" | 0.13 | 10.21 | 230.00 | 14.95 | 19.47 | 300.75 |
| | | Glass | 1.10 | 3.60 | | | 281.28 | |
| | 11:00 | Wall "A" | 0.13 | 10.21 | 139.00 | 9.04 | 11.76 | 181.76 |
| | | Glass | 1.10 | 3.60 | | | 169.99 | |
| | 12:00 | Wall "A" | 0.13 | 10.21 | 54.00 | 3.51 | 4.57 | 70.61 |
| | | Glass | 1.10 | 3.60 | | | 66.04 | |
| | 13:00 | Wall "A" | 0.13 | 10.21 | 44.00 | 2.86 | 3.72 | 57.53 |
| | | Glass | 1.10 | 3.60 | | | 53.81 | |
| | 14:00 | Wall "A" | 0.13 | 10.21 | 44.00 | 2.86 | 3.72 | 57.53 |
| | | Glass | 1.10 | 3.60 | | | 53.81 | |
| | 15:00 | Wall "A" | 0.13 | 10.21 | 44.00 | 2.86 | 3.72 | 57.53 |
| | | Glass | 1.10 | 3.60 | | | 53.81 | |
| | 16:00 | Wall "A" | 0.13 | 10.21 | 38.00 | 2.47 | 3.22 | 49.69 |
| | | Glass | 1.10 | 3.60 | | | 46.47 | |
| | 17:00 | Wall "A" | 0.13 | 10.21 | 32.00 | 2.08 | 2.71 | 41.84 |
| | | Glass | 1.10 | 3.60 | | | 39.13 | |

| Time | Qt(W) |
|---|---|
| 0.33 | 420.27 |
| 0.38 | 427.99 |
| 0.42 | 357.38 |
| 0.46 | 238.39 |
| 0.50 | 140.11 |
| 0.54 | 235.15 |
| 0.58 | 353.57 |
| 0.63 | 423.07 |
| 0.67 | 415.22 |
| 0.71 | 346.88 |

### 3-Ventilation Load

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 5.00 | 14.00 | 2.80 | 3.00 |

| | |
|---|---|
| A (m2) | 17.96 |
| H (m) | 2.60 |
| V (m3) | 46.70 |

| Method | CMM |
|---|---|
| Based on No Of Persons | 4.20 |
| Based on Area | 3.02 |
| NO. Of Air Changing Times | 2.33 |

| Time | CMMmax | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 08:00 | 4.20 | 445.54 | 1308.72 | 1754.26 |
| 09:00 | 4.20 | 578.34 | 1308.72 | 1887.06 |
| 10:00 | 4.20 | 733.42 | 1308.72 | 2042.14 |
| 11:00 | 4.20 | 899.64 | 1308.72 | 2208.36 |
| 12:00 | 4.20 | 1065.86 | 1308.72 | 2374.58 |
| 13:00 | 4.20 | 1220.94 | 1308.72 | 2529.66 |
| 14:00 | 4.20 | 1353.74 | 1308.72 | 2662.46 |
| 15:00 | 4.20 | 1456.56 | 1308.72 | 2765.28 |
| 16:00 | 4.20 | 1516.54 | 1308.72 | 2825.26 |
| 17:00 | 4.20 | 1542.24 | 1308.72 | 2850.96 |

## B-Internal Loads

### 1-Occupancy Load

| No Of Persons | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 5.00 | Light | 72.00 | 60.00 | 360.00 | 300.00 | 660.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| florescent | 16.00 | 40.00 | 1.25 | 800.00 |

### 3-Equipment

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot (W) |
|---|---|---|---|---|
| computer | 1.00 | 110.00 | 110.00 | 110.00 |

**Variation of load with time**

| Q occ_s | Q occ_l | Q light_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 800.00 | 360.00 | 300.00 | 110.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 52.51 | 420.27 | 445.54 | 1308.72 | 1742.78 | 300.00 | 2042.78 |
| 9:00 | 68.16 | 427.99 | 578.34 | 1308.72 | 1766.15 | 300.00 | 2066.15 |
| 10:00 | 86.44 | 357.38 | 733.42 | 1308.72 | 1713.82 | 300.00 | 2013.82 |
| 11:00 | 106.03 | 238.39 | 899.64 | 1308.72 | 1614.42 | 300.00 | 1914.42 |
| 12:00 | 125.62 | 140.11 | 1065.86 | 1308.72 | 1535.74 | 300.00 | 1835.74 |
| 13:00 | 143.90 | 235.15 | 1220.94 | 1308.72 | 1649.05 | 300.00 | 1949.05 |
| 14:00 | 159.55 | 353.57 | 1353.74 | 1308.72 | 1783.12 | 300.00 | 2083.12 |
| 15:00 | 171.67 | 423.07 | 1456.56 | 1308.72 | 1864.74 | 300.00 | 2164.74 |
| 16:00 | 178.74 | 415.22 | 1516.54 | 1308.72 | 1863.96 | 300.00 | 2163.96 |
| 17:00 | 181.77 | 346.88 | 1542.24 | 1308.72 | 1798.65 | 300.00 | 2098.65 |

## Room 0-63

### A-External Loads

**1-Wall Load**

| Direction | Time | Type | U | A (m2) | ΔT (K) | Q (W) | Qt (W) |
|---|---|---|---|---|---|---|---|
| NE | 08:00 | Wall "A" | 0.13 | 8.93 | 5.20 | 5.92 | 71.08 |
| | | Wall "B" | 1.44 | 0.72 | | 5.41 | |
| | | Wall "C" | 1.79 | 0.84 | | 7.79 | |
| | | Wall "D" | 0.39 | 1.95 | | 4.00 | |
| | | Glass | 1.10 | 8.38 | | 47.96 | |
| | 09:00 | Wall "A" | 0.13 | 8.93 | 6.75 | 7.69 | 92.27 |
| | | Wall "B" | 1.44 | 0.72 | | 7.02 | |
| | | Wall "C" | 1.79 | 0.84 | | 10.11 | |
| | | Wall "D" | 0.39 | 1.95 | | 5.20 | |
| | | Glass | 1.10 | 8.38 | | 62.25 | |
| | 10:00 | Wall "A" | 0.13 | 8.93 | 8.56 | 9.75 | 117.01 |
| | | Wall "B" | 1.44 | 0.72 | | 8.91 | |
| | | Wall "C" | 1.79 | 0.84 | | 12.82 | |
| | | Wall "D" | 0.39 | 1.95 | | 6.59 | |
| | | Glass | 1.10 | 8.38 | | 78.94 | |
| | 11:00 | Wall "A" | 0.13 | 8.93 | 10.50 | 11.96 | 143.52 |
| | | Wall "B" | 1.44 | 0.72 | | 10.92 | |
| | | Wall "C" | 1.79 | 0.84 | | 15.72 | |
| | | Wall "D" | 0.39 | 1.95 | | 8.09 | |
| | | Glass | 1.10 | 8.38 | | 96.83 | |
| | 12:00 | Wall "A" | 0.13 | 8.93 | 12.44 | 14.17 | 170.04 |
| | | Wall "B" | 1.44 | 0.72 | | 12.94 | |
| | | Wall "C" | 1.79 | 0.84 | | 18.63 | |
| | | Wall "D" | 0.39 | 1.95 | | 9.58 | |
| | | Glass | 1.10 | 8.38 | | 114.73 | |
| | 13:00 | Wall "A" | 0.13 | 8.93 | 14.25 | 16.23 | 194.78 |
| | | Wall "B" | 1.44 | 0.72 | | 14.82 | |
| | | Wall "C" | 1.79 | 0.84 | | 21.34 | |
| | | Wall "D" | 0.39 | 1.95 | | 10.97 | |
| | | Glass | 1.10 | 8.38 | | 131.42 | |
| | 14:00 | Wall "A" | 0.13 | 8.93 | 15.80 | 17.99 | 215.97 |
| | | Wall "B" | 1.44 | 0.72 | | 16.44 | |
| | | Wall "C" | 1.79 | 0.84 | | 23.66 | |
| | | Wall "D" | 0.39 | 1.95 | | 12.17 | |
| | | Glass | 1.10 | 8.38 | | 145.71 | |
| | 15:00 | Wall "A" | 0.13 | 8.93 | 17.00 | 19.36 | 232.37 |
| | | Wall "B" | 1.44 | 0.72 | | 17.69 | |
| | | Wall "C" | 1.79 | 0.84 | | 25.46 | |
| | | Wall "D" | 0.39 | 1.95 | | 13.09 | |
| | | Glass | 1.10 | 8.38 | | 156.78 | |
| | 16:00 | Wall "A" | 0.13 | 8.93 | 17.70 | 20.16 | 241.94 |
| | | Wall "B" | 1.44 | 0.72 | | 18.41 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Wall "C" | 1.79 | 0.84 | | 26.50 | |
| | | Wall "D" | 0.39 | 1.95 | | 13.63 | |
| | | Glass | 1.10 | 8.38 | | 163.24 | |
| | 17:00 | Wall "A" | 0.13 | 8.93 | 18.00 | 20.50 | 246.04 |
| | | Wall "B" | 1.44 | 0.72 | | 18.73 | |
| | | Wall "C" | 1.79 | 0.84 | | 26.95 | |
| | | Wall "D" | 0.39 | 1.95 | | 13.86 | |
| | | Glass | 1.10 | 8.38 | | 166.00 | |

| Direction | Time | Type | U | A | ΔT | Q (W) | Q t(W) |
|---|---|---|---|---|---|---|---|
| SE | 08:00 | Wall "A" | 0.13 | 6.40 | 5.20 | 4.24 | 13.58 |
| | | Wall "B" | 1.44 | 1.25 | | 9.34 | |
| | 09:00 | Wall "A" | 0.13 | 6.40 | 6.75 | 5.51 | 17.63 |
| | | Wall "B" | 1.44 | 1.25 | | 12.12 | |
| | 10:00 | Wall "A" | 0.13 | 6.40 | 8.56 | 6.98 | 22.35 |
| | | Wall "B" | 1.44 | 1.25 | | 15.37 | |
| | 11:00 | Wall "A" | 0.13 | 6.40 | 10.50 | 8.57 | 27.42 |
| | | Wall "B" | 1.44 | 1.25 | | 18.86 | |
| | 12:00 | Wall "A" | 0.13 | 6.40 | 12.44 | 10.15 | 32.49 |
| | | Wall "B" | 1.44 | 1.25 | | 22.34 | |
| | 13:00 | Wall "A" | 0.13 | 6.40 | 14.25 | 11.62 | 37.21 |
| | | Wall "B" | 1.44 | 1.25 | | 25.59 | |
| | 14:00 | Wall "A" | 0.13 | 6.40 | 15.80 | 12.89 | 41.26 |
| | | Wall "B" | 1.44 | 1.25 | | 28.37 | |
| | 15:00 | Wall "A" | 0.13 | 6.40 | 17.00 | 13.87 | 44.40 |
| | | Wall "B" | 1.44 | 1.25 | | 30.53 | |
| | 16:00 | Wall "A" | 0.13 | 6.40 | 17.70 | 14.44 | 46.22 |
| | | Wall "B" | 1.44 | 1.25 | | 31.78 | |
| | 17:00 | Wall "A" | 0.13 | 6.40 | 18.00 | 14.68 | 47.01 |
| | | Wall "B" | 1.44 | 1.25 | | 32.32 | |

| Time | Qt(W) |
|---|---|
| 8:00 | 84.66 |
| 9:00 | 109.89 |
| 10:00 | 139.36 |
| 11:00 | 170.94 |
| 12:00 | 202.53 |
| 13:00 | 232.00 |
| 14:00 | 257.23 |
| 15:00 | 276.77 |
| 16:00 | 288.16 |
| 17:00 | 293.05 |

## 2-Sun Load

| Direction | Time | Type | U | A | I | ∆Ts | Q | Qt (W) |
|---|---|---|---|---|---|---|---|---|
| NE | 08:00 | Wall "A" | 0.13 | 8.93 | 410.00 | 26.65 | 30.35 | 1263.98 |
| | | Wall "B" | 1.44 | 0.72 | | 26.65 | 27.72 | |
| | | Wall "C" | 1.79 | 0.84 | | 16.40 | 24.56 | |
| | | Wall "D" | 0.39 | 1.95 | | 16.40 | 12.63 | |
| | | Glass | 1.10 | 8.38 | | | 1168.72 | |
| | 09:00 | Wall "A" | 0.13 | 8.93 | 305.00 | 19.83 | 22.58 | 940.28 |
| | | Wall "B" | 1.44 | 0.72 | | 19.83 | 20.62 | |
| | | Wall "C" | 1.79 | 0.84 | | 12.20 | 18.27 | |
| | | Wall "D" | 0.39 | 1.95 | | 12.20 | 9.39 | |
| | | Glass | 1.10 | 8.38 | | | 869.42 | |
| | 10:00 | Wall "A" | 0.13 | 8.93 | 173.00 | 11.25 | 12.81 | 533.34 |
| | | Wall "B" | 1.44 | 0.72 | | 11.25 | 11.70 | |
| | | Wall "C" | 1.79 | 0.84 | | 6.92 | 10.36 | |
| | | Wall "D" | 0.39 | 1.95 | | 6.92 | 5.33 | |
| | | Glass | 1.10 | 8.38 | | | 493.14 | |
| | 11:00 | Wall "A" | 0.13 | 8.93 | 60.00 | 3.90 | 4.44 | 184.97 |
| | | Wall "B" | 1.44 | 0.72 | | 3.90 | 4.06 | |
| | | Wall "C" | 1.79 | 0.84 | | 2.40 | 3.59 | |
| | | Wall "D" | 0.39 | 1.95 | | 2.40 | 1.85 | |
| | | Glass | 1.10 | 8.38 | | | 171.03 | |
| | 12:00 | Wall "A" | 0.13 | 8.93 | 44.00 | 2.86 | 3.26 | 135.65 |
| | | Wall "B" | 1.44 | 0.72 | | 2.86 | 2.98 | |
| | | Wall "C" | 1.79 | 0.84 | | 1.76 | 2.64 | |
| | | Wall "D" | 0.39 | 1.95 | | 1.76 | 1.36 | |
| | | Glass | 1.10 | 8.38 | | | 125.42 | |
| | 13:00 | Wall "A" | 0.13 | 8.93 | 44.00 | 2.86 | 3.26 | 135.65 |
| | | Wall "B" | 1.44 | 0.72 | | 2.86 | 2.98 | |
| | | Wall "C" | 1.79 | 0.84 | | 1.76 | 2.64 | |
| | | Wall "D" | 0.39 | 1.95 | | 1.76 | 1.36 | |
| | | Glass | 1.10 | 8.38 | | | 125.42 | |
| | 14:00 | Wall "A" | 0.13 | 8.93 | 44.00 | 2.86 | 3.26 | 135.65 |
| | | Wall "B" | 1.44 | 0.72 | | 2.86 | 2.98 | |
| | | Wall "C" | 1.79 | 0.84 | | 1.76 | 2.64 | |
| | | Wall "D" | 0.39 | 1.95 | | 1.76 | 1.36 | |
| | | Glass | 1.10 | 8.38 | | | 125.42 | |
| | 15:00 | Wall "A" | 0.13 | 8.93 | 44.00 | 2.86 | 3.26 | 135.65 |
| | | Wall "B" | 1.44 | 0.72 | | 2.86 | 2.98 | |
| | | Wall "C" | 1.79 | 0.84 | | 1.76 | 2.64 | |
| | | Wall "D" | 0.39 | 1.95 | | 1.76 | 1.36 | |
| | | Glass | 1.10 | 8.38 | | | 125.42 | |
| | 16:00 | Wall "A" | 0.13 | 8.93 | 38.00 | 2.47 | 2.81 | 117.15 |
| | | Wall "B" | 1.44 | 0.72 | | 2.47 | 2.57 | |
| | | Wall "C" | 1.79 | 0.84 | | 1.52 | 2.28 | |
| | | Wall "D" | 0.39 | 1.95 | | 1.52 | 1.17 | |
| | | Glass | 1.10 | 8.38 | | | 108.32 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 17:00 | Wall "A" | 0.13 | 8.93 | 32.00 | 2.08 | 2.37 | 98.65 |
| | | Wall "B" | 1.44 | 0.72 | | 2.08 | 2.16 | |
| | | Wall "C" | 1.79 | 0.84 | | 1.28 | 1.92 | |
| | | Wall "D" | 0.39 | 1.95 | | 1.28 | 0.99 | |
| | | Glass | 1.10 | 8.38 | | | 91.22 | |

| Direction | Time | Type | U | A | I | ∆Ts | Q | Q t(W) |
|---|---|---|---|---|---|---|---|---|
| SE | 08:00 | Wall "A" | 0.13 | 6.40 | 284.00 | 18.46 | 15.06 | 48.21 |
| | | Wall "B" | 1.44 | 1.25 | | | 33.15 | |
| | 09:00 | Wall "A" | 0.13 | 6.40 | 284.00 | 18.46 | 15.06 | 48.21 |
| | | Wall "B" | 1.44 | 1.25 | | | 33.15 | |
| | 10:00 | Wall "A" | 0.13 | 6.40 | 230.00 | 14.95 | 12.20 | 39.04 |
| | | Wall "B" | 1.44 | 1.25 | | | 26.85 | |
| | 11:00 | Wall "A" | 0.13 | 6.40 | 139.00 | 9.04 | 7.37 | 23.59 |
| | | Wall "B" | 1.44 | 1.25 | | | 16.22 | |
| | 12:00 | Wall "A" | 0.13 | 6.40 | 54.00 | 3.51 | 2.86 | 9.17 |
| | | Wall "B" | 1.44 | 1.25 | | | 6.30 | |
| | 13:00 | Wall "A" | 0.13 | 6.40 | 44.00 | 2.86 | 2.33 | 7.47 |
| | | Wall "B" | 1.44 | 1.25 | | | 5.14 | |
| | 14:00 | Wall "A" | 0.13 | 6.40 | 44.00 | 2.86 | 2.33 | 7.47 |
| | | Wall "B" | 1.44 | 1.25 | | | 5.14 | |
| | 15:00 | Wall "A" | 0.13 | 6.40 | 44.00 | 2.86 | 2.33 | 7.47 |
| | | Wall "B" | 1.44 | 1.25 | | | 5.14 | |
| | 16:00 | Wall "A" | 0.13 | 6.40 | 38.00 | 2.47 | 2.01 | 6.45 |
| | | Wall "B" | 1.44 | 1.25 | | | 4.44 | |
| | 17:00 | Wall "A" | 0.13 | 6.40 | 32.00 | 2.08 | 1.70 | 5.43 |
| | | Wall "B" | 1.44 | 1.25 | | | 3.74 | |

| Time | Qt(W) |
|---|---|
| 08:00 | 1312.19 |
| 09:00 | 988.49 |
| 10:00 | 572.38 |
| 11:00 | 208.57 |
| 12:00 | 144.81 |
| 13:00 | 143.12 |
| 14:00 | 143.12 |
| 15:00 | 143.12 |
| 16:00 | 123.60 |
| 17:00 | 104.08 |

### 3-Ventilation Load

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 10.00 | 14.00 | 2.80 | 3.00 |

| | |
|---|---|
| A (m2) | 28.33 |
| H (m) | 2.60 |
| V (m3) | 73.66 |

| Method | CMM |
|---|---|
| Based on No Of Persons | 8.40 |
| Based on Area | 4.76 |
| NO Of Air Changing Times | 3.68 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 08:00 | 8.40 | 891.07 | 2617.44 | 3508.51 |
| 09:00 | 8.40 | 1156.68 | 2617.44 | 3774.12 |
| 10:00 | 8.40 | 1466.84 | 2617.44 | 4084.28 |
| 11:00 | 8.40 | 1799.28 | 2617.44 | 4416.72 |
| 12:00 | 8.40 | 2131.72 | 2617.44 | 4749.16 |
| 13:00 | 8.40 | 2441.88 | 2617.44 | 5059.32 |
| 14:00 | 8.40 | 2707.49 | 2617.44 | 5324.93 |
| 15:00 | 8.40 | 2913.12 | 2617.44 | 5530.56 |
| 16:00 | 8.40 | 3033.07 | 2617.44 | 5650.51 |
| 17:00 | 8.40 | 3084.48 | 2617.44 | 5701.92 |

## B-Internal Loads

### 1-Occupancy Load

| No Of Persons | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 10.00 | light working | 72.00 | 60.00 | 720.00 | 600.00 | 1320.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| florescent | 16.00 | 40.00 | 1.25 | 800.00 |

### 3-Equipment

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot (W) |
|---|---|---|---|---|
| computer | 2.00 | 110.00 | 220.00 | 910.00 |
| refrigerator | 1.00 | 690.00 | 690.00 | |

### Variation of load with time

| Q occ_s | Q occ_l | Q light_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 800.00 | 720.00 | 600.00 | 910.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 84.66 | 1312.19 | 891.07 | 2617.44 | 3826.85 | 600.00 | 4426.85 |
| 9:00 | 109.89 | 988.49 | 1156.68 | 2617.44 | 3528.38 | 600.00 | 4128.38 |
| 10:00 | 139.36 | 572.38 | 1466.84 | 2617.44 | 3141.74 | 600.00 | 3741.74 |
| 11:00 | 170.94 | 208.57 | 1799.28 | 2617.44 | 2809.51 | 600.00 | 3409.51 |
| 12:00 | 202.53 | 144.81 | 2131.72 | 2617.44 | 2777.34 | 600.00 | 3377.34 |
| 13:00 | 232.00 | 143.12 | 2441.88 | 2617.44 | 2805.11 | 600.00 | 3405.11 |
| 14:00 | 257.23 | 143.12 | 2707.49 | 2617.44 | 2830.35 | 600.00 | 3430.35 |
| 15:00 | 276.77 | 143.12 | 2913.12 | 2617.44 | 2849.88 | 600.00 | 3449.88 |
| 16:00 | 288.16 | 123.60 | 3033.07 | 2617.44 | 2841.76 | 600.00 | 3441.76 |
| 17:00 | 293.05 | 104.08 | 3084.48 | 2617.44 | 2827.13 | 600.00 | 3427.13 |

# Room 0-66

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ∆T | Q (W) |
|---|---|---|---|---|---|---|
| NE | 08:00 | Wall "A" | 0.13 | 6.50 | 5.20 | 4.31 |
| | 09:00 | Wall "A" | 0.13 | 6.50 | 6.75 | 5.60 |
| | 10:00 | Wall "A" | 0.13 | 6.50 | 8.56 | 7.10 |
| | 11:00 | Wall "A" | 0.13 | 6.50 | 10.50 | 8.70 |
| | 12:00 | Wall "A" | 0.13 | 6.50 | 12.44 | 10.31 |
| | 13:00 | Wall "A" | 0.13 | 6.50 | 14.25 | 11.81 |
| | 14:00 | Wall "A" | 0.13 | 6.50 | 15.80 | 13.10 |
| | 15:00 | Wall "A" | 0.13 | 6.50 | 17.00 | 14.09 |
| | 16:00 | Wall "A" | 0.13 | 6.50 | 17.70 | 14.67 |
| | 17:00 | Wall "A" | 0.13 | 6.50 | 18.00 | 14.92 |

### 2-Sun Load

| Direction | Time | Type | U | A | I | ∆Ts | Q (W) |
|---|---|---|---|---|---|---|---|
| NE | 8:00 | Wall "A" | 0.13 | 6.50 | 410.00 | 26.65 | 22.09 |
| | 9:00 | Wall "A" | 0.13 | 6.50 | 305.00 | 19.83 | 16.44 |
| | 10:00 | Wall "A" | 0.13 | 6.50 | 173.00 | 11.25 | 9.32 |
| | 11:00 | Wall "A" | 0.13 | 6.50 | 60.00 | 2.86 | 2.37 |
| | 12:00 | Wall "A" | 0.13 | 6.50 | 44.00 | 2.86 | 2.37 |
| | 13:00 | Wall "A" | 0.13 | 6.50 | 44.00 | 2.86 | 2.37 |
| | 14:00 | Wall "A" | 0.13 | 6.50 | 44.00 | 2.86 | 2.37 |
| | 15:00 | Wall "A" | 0.13 | 6.50 | 44.00 | 2.86 | 2.37 |
| | 16:00 | Wall "A" | 0.13 | 6.50 | 38.00 | 2.47 | 2.05 |
| | 17:00 | Wall "A" | 0.13 | 6.50 | 32.00 | 2.08 | 1.72 |

### 3-Ventilation Load

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 1.00 | 10.00 | 2.50 | 2.00 |

| | |
|---|---|
| A (m2) | 7.60 |
| H (m) | 2.60 |
| V (m3) | 19.76 |

| Method | CMM |
|---|---|
| Based on No Of Persons | 0.60 |
| Based on Area | 1.14 |
| NO Of Air Changing Times | 0.66 |

| Time | CMMmax | Qs(W) | QL(W) | Qtot |
|---|---|---|---|---|
| 08:00 | 1.14 | 120.93 | 355.22 | 476.16 |
| 09:00 | 1.14 | 156.98 | 355.22 | 512.20 |
| 10:00 | 1.14 | 199.07 | 355.22 | 554.30 |
| 11:00 | 1.14 | 244.19 | 355.22 | 599.41 |
| 12:00 | 1.14 | 289.30 | 355.22 | 644.53 |
| 13:00 | 1.14 | 331.40 | 355.22 | 686.62 |
| 14:00 | 1.14 | 367.44 | 355.22 | 722.67 |
| 15:00 | 1.14 | 395.35 | 355.22 | 750.58 |
| 16:00 | 1.14 | 411.63 | 355.22 | 766.86 |
| 17:00 | 1.14 | 418.61 | 355.22 | 773.83 |

**B-Internal Loads**

**1-Occupancy Load**

| No Of Persons | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 1.00 | sitting | 66.00 | 31.00 | 66.00 | 31.00 | 97.00 |

**2-Light Load**

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| spot | 8.00 | 20.00 | 1.25 | 200.00 |

**Variation of load with time**

| Q occ_s | Q occ_l | Q light_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 200.00 | 66.00 | 31.00 | 0.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q ven_s | Q vent_l | Qs tot (W) | Ql tot (W) | Q tot (W) |
|---|---|---|---|---|---|---|---|
| 0.33 | 4.31 | 22.09 | 120.93 | 355.22 | 292.40 | 31.00 | 323.40 |
| 0.38 | 5.60 | 16.44 | 156.98 | 355.22 | 288.03 | 31.00 | 319.03 |
| 0.42 | 7.10 | 9.32 | 199.07 | 355.22 | 282.42 | 31.00 | 313.42 |
| 0.46 | 8.70 | 2.37 | 244.19 | 355.22 | 277.08 | 31.00 | 308.08 |
| 0.50 | 10.31 | 2.37 | 289.30 | 355.22 | 278.68 | 31.00 | 309.68 |
| 0.54 | 11.81 | 2.37 | 331.40 | 355.22 | 280.18 | 31.00 | 311.18 |
| 0.58 | 13.10 | 2.37 | 367.44 | 355.22 | 281.47 | 31.00 | 312.47 |
| 0.63 | 14.09 | 2.37 | 395.35 | 355.22 | 282.46 | 31.00 | 313.46 |
| 0.67 | 14.67 | 2.05 | 411.63 | 355.22 | 282.72 | 31.00 | 313.72 |
| 0.71 | 14.92 | 1.72 | 418.61 | 355.22 | 282.65 | 31.00 | 313.65 |

# Room 0-67

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ∆T | Q | Q |
|---|---|---|---|---|---|---|---|
| NE | 8:00 | Wall "A" | 0.13 | 4.68 | 5.20 | 3.10 | 16.72 |
| | | Wall "B" | 1.44 | 1.82 | | 13.62 | |
| | 9:00 | Wall "A" | 0.13 | 4.68 | 6.75 | 4.03 | 21.71 |
| | | Wall "B" | 1.44 | 1.82 | | 17.68 | |
| | 10:00 | Wall "A" | 0.13 | 4.68 | 8.56 | 5.11 | 27.53 |
| | | Wall "B" | 1.44 | 1.82 | | 22.42 | |
| | 11:00 | Wall "A" | 0.13 | 4.68 | 10.50 | 6.27 | 33.76 |
| | | Wall "B" | 1.44 | 1.82 | | 27.50 | |
| | 12:00 | Wall "A" | 0.13 | 4.68 | 12.44 | 7.43 | 40.00 |
| | | Wall "B" | 1.44 | 1.82 | | 32.58 | |
| | 13:00 | Wall "A" | 0.13 | 4.68 | 14.25 | 8.51 | 45.82 |
| | | Wall "B" | 1.44 | 1.82 | | 37.32 | |
| | 14:00 | Wall "A" | 0.13 | 4.68 | 15.80 | 9.43 | 50.81 |
| | | Wall "B" | 1.44 | 1.82 | | 41.38 | |
| | 15:00 | Wall "A" | 0.13 | 4.68 | 17.00 | 10.15 | 54.67 |
| | | Wall "B" | 1.44 | 1.82 | | 44.52 | |
| | 16:00 | Wall "A" | 0.13 | 4.68 | 17.70 | 10.56 | 56.92 |
| | | Wall "B" | 1.44 | 1.82 | | 46.35 | |
| | 17:00 | Wall "A" | 0.13 | 4.68 | 18.00 | 10.74 | 57.88 |
| | | Wall "B" | 1.44 | 1.82 | | 47.14 | |

| Direction | Time | Type | U | A | ∆T | Q | Q t(W) |
|---|---|---|---|---|---|---|---|
| NW | 8:00 | Wall "A" | 0.13 | 7.57 | 5.20 | 5.02 | 8.91 |
| | | Wall "B" | 1.44 | 0.52 | | 3.89 | |
| | 9:00 | Wall "A" | 0.13 | 7.57 | 6.75 | 6.51 | 11.56 |
| | | Wall "B" | 1.44 | 0.52 | | 5.05 | |
| | 10:00 | Wall "A" | 0.13 | 7.57 | 8.56 | 8.26 | 14.66 |
| | | Wall "B" | 1.44 | 0.52 | | 6.40 | |
| | 11:00 | Wall "A" | 0.13 | 7.57 | 10.50 | 10.13 | 17.99 |
| | | Wall "B" | 1.44 | 0.52 | | 7.86 | |
| | 12:00 | Wall "A" | 0.13 | 7.57 | 12.44 | 12.00 | 21.31 |
| | | Wall "B" | 1.44 | 0.52 | | 9.31 | |
| | 13:00 | Wall "A" | 0.13 | 7.57 | 14.25 | 13.75 | 24.41 |
| | | Wall "B" | 1.44 | 0.52 | | 10.66 | |
| | 14:00 | Wall "A" | 0.13 | 7.57 | 15.80 | 15.25 | 27.07 |
| | | Wall "B" | 1.44 | 0.52 | | 11.82 | |
| | 15:00 | Wall "A" | 0.13 | 7.57 | 17.00 | 16.40 | 29.12 |
| | | Wall "B" | 1.44 | 0.52 | | 12.72 | |
| | 16:00 | Wall "A" | 0.13 | 7.57 | 17.70 | 17.08 | 30.32 |
| | | Wall "B" | 1.44 | 0.52 | | 13.24 | |
| | 17:00 | Wall "A" | 0.13 | 7.57 | 18.00 | 17.37 | 30.84 |
| | | Wall "B" | 1.44 | 0.52 | | 13.47 | |

| Time | Qt(W) |
|---|---|
| 8:00 | 25.63 |
| 9:00 | 33.27 |
| 10:00 | 42.19 |
| 11:00 | 51.75 |
| 12:00 | 61.32 |
| 13:00 | 70.24 |
| 14:00 | 77.88 |
| 15:00 | 83.79 |
| 16:00 | 87.24 |
| 17:00 | 88.72 |

**2-Sun Load**

| Direction | Time | Type | U | A | I | ΔTs | Q (W) | Q t(W) |
|---|---|---|---|---|---|---|---|---|
| NE | 8:00 | Wall "A" | 0.13 | 5.72 | 410.00 | 26.65 | 19.43 | 87.23 |
| | | Wall "B" | 1.44 | 1.77 | | 26.65 | 67.80 | |
| | 9:00 | Wall "A" | 0.13 | 5.72 | 305.00 | 19.83 | 14.46 | 64.89 |
| | | Wall "B" | 1.44 | 1.77 | | 19.83 | 50.43 | |
| | 10:00 | Wall "A" | 0.13 | 5.72 | 173.00 | 11.25 | 8.20 | 36.81 |
| | | Wall "B" | 1.44 | 1.77 | | 2.86 | 28.61 | |
| | 11:00 | Wall "A" | 0.13 | 5.72 | 60.00 | 2.86 | 2.09 | 9.36 |
| | | Wall "B" | 1.44 | 1.77 | | 2.86 | 7.28 | |
| | 12:00 | Wall "A" | 0.13 | 5.72 | 44.00 | 2.86 | 2.09 | 9.36 |
| | | Wall "B" | 1.44 | 1.77 | | 3.51 | 7.28 | |
| | 13:00 | Wall "A" | 0.13 | 5.72 | 44.00 | 2.86 | 2.09 | 9.36 |
| | | Wall "B" | 1.44 | 1.77 | | 8.97 | 7.28 | |
| | 14:00 | Wall "A" | 0.13 | 5.72 | 44.00 | 2.86 | 2.09 | 9.36 |
| | | Wall "B" | 1.44 | 1.77 | | 14.95 | 7.28 | |
| | 15:00 | Wall "A" | 0.13 | 5.72 | 44.00 | 2.86 | 2.09 | 9.36 |
| | | Wall "B" | 1.44 | 1.77 | | 18.46 | 7.28 | |
| | 16:00 | Wall "A" | 0.13 | 5.72 | 38.00 | 2.47 | 1.80 | 8.08 |
| | | Wall "B" | 1.44 | 1.77 | | 18.46 | 6.28 | |
| | 17:00 | Wall "A" | 0.13 | 5.72 | 32.00 | 2.08 | 1.52 | 6.81 |
| | | Wall "B" | 1.44 | 1.77 | | 15.41 | 5.29 | |

| Direction | Time | Type | U | A (m2) | I | ΔTs | Q | Q t(W) |
|---|---|---|---|---|---|---|---|---|
| NW | 8:00 | Wall "A" | 0.13 | 7.57 | 38.00 | 2.47 | 2.38 | 4.23 |
| | | Wall "B" | 1.44 | 0.52 | | 2.47 | 1.85 | |
| | 9:00 | Wall "A" | 0.13 | 7.57 | 44.00 | 2.86 | 2.76 | 4.90 |
| | | Wall "B" | 1.44 | 0.52 | | 2.86 | 2.14 | |
| | 10:00 | Wall "A" | 0.13 | 7.57 | 44.00 | 2.86 | 2.76 | 4.90 |
| | | Wall "B" | 1.44 | 0.52 | | 2.86 | 2.14 | |
| | 11:00 | Wall "A" | 0.13 | 7.57 | 44.00 | 2.86 | 2.76 | 4.90 |
| | | Wall "B" | 1.44 | 0.52 | | 2.86 | 2.14 | |
| | 12:00 | Wall "A" | 0.13 | 7.57 | 44.00 | 2.86 | 2.76 | 5.39 |
| | | Wall "B" | 1.44 | 0.52 | | 3.51 | 2.63 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 13:00 | Wall "A" | 0.13 | 7.57 | 54.00 | 3.51 | 3.39 | 6.01 |
| | | Wall "B" | 1.44 | 0.52 | | 3.51 | 2.63 | |
| | 14:00 | Wall "A" | 0.13 | 7.57 | 173.00 | 11.25 | 10.85 | 19.27 |
| | | Wall "B" | 1.44 | 0.52 | | 11.25 | 8.42 | |
| | 15:00 | Wall "A" | 0.13 | 7.57 | 310.00 | 20.15 | 19.44 | 34.52 |
| | | Wall "B" | 1.44 | 0.52 | | 20.15 | 15.08 | |
| | 16:00 | Wall "A" | 0.13 | 7.57 | 410.00 | 26.65 | 25.72 | 45.66 |
| | | Wall "B" | 1.44 | 0.52 | | 26.65 | 19.94 | |
| | 17:00 | Wall "A" | 0.13 | 7.57 | 438.00 | 28.47 | 27.47 | 48.77 |
| | | Wall "B" | 1.44 | 0.52 | | 28.47 | 21.30 | |

| Time | Qt(W) |
|---|---|
| 8:00 | 91.46 |
| 9:00 | 69.79 |
| 10:00 | 41.71 |
| 11:00 | 14.26 |
| 12:00 | 14.75 |
| 13:00 | 15.37 |
| 14:00 | 28.63 |
| 15:00 | 43.88 |
| 16:00 | 53.74 |
| 17:00 | 55.58 |

### 3-Ventilation Load

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 0.00 | 10.00 | 2.50 | 2.00 |

| | |
|---|---|
| **A (m2)** | 6.70 |
| **H (m)** | 2.60 |
| **V (m3)** | 17.42 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 0.00 |
| **Based on Area** | 1.01 |
| **NO Of Air Changing Times** | 0.58 |

| Time | CMMmax | Qs(W) | QL(W) | Qtot |
|---|---|---|---|---|
| 8:00 | 1.01 | 106.61 | 313.16 | 419.77 |
| 9:00 | 1.01 | 138.39 | 313.16 | 451.55 |
| 10:00 | 1.01 | 175.50 | 313.16 | 488.66 |
| 11:00 | 1.01 | 215.27 | 313.16 | 528.43 |
| 12:00 | 1.01 | 255.04 | 313.16 | 568.20 |
| 13:00 | 1.01 | 292.15 | 313.16 | 605.31 |
| 14:00 | 1.01 | 323.93 | 313.16 | 637.09 |
| 15:00 | 1.01 | 348.53 | 313.16 | 661.69 |

| | | | | |
|---|---|---|---|---|
| 16:00 | 1.01 | 362.89 | 313.16 | 676.04 |
| 17:00 | 1.01 | 369.04 | 313.16 | 682.19 |

## B-Internal Loads

### 1-Occupancy Load

| No Of Persons | Work | qs/p | qL/p | Qs | QL | Qtot (W) |
|---|---|---|---|---|---|---|
| 2.00 | sitting | 66.00 | 31.00 | 132.00 | 62.00 | 194.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| fluorescent | 4.00 | 40.00 | 1.25 | 200.00 |

## Variation of load with time

| Q occ_s | Q occ_l | Q light_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 200.00 | 132.00 | 62.00 | 0.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q vent_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 25.63 | 91.46 | 106.61 | 313.16 | 449.09 | 62.00 | 511.09 |
| 9:00 | 33.27 | 69.79 | 138.39 | 313.16 | 435.06 | 62.00 | 497.06 |
| 10:00 | 42.19 | 41.71 | 175.50 | 313.16 | 415.90 | 62.00 | 477.90 |
| 11:00 | 51.75 | 14.26 | 215.27 | 313.16 | 398.01 | 62.00 | 460.01 |
| 12:00 | 61.32 | 14.75 | 255.04 | 313.16 | 408.06 | 62.00 | 470.06 |
| 13:00 | 70.24 | 15.37 | 292.15 | 313.16 | 417.61 | 62.00 | 479.61 |
| 14:00 | 77.88 | 28.63 | 323.93 | 313.16 | 438.51 | 62.00 | 500.51 |
| 15:00 | 83.79 | 43.88 | 348.53 | 313.16 | 459.67 | 62.00 | 521.67 |
| 16:00 | 87.24 | 53.74 | 362.89 | 313.16 | 472.98 | 62.00 | 534.98 |
| 17:00 | 88.72 | 55.58 | 369.04 | 313.16 | 476.30 | 62.00 | 538.30 |

# Room 0-46

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ΔT | Q (W) | Qtot |
|---|---|---|---|---|---|---|---|
| NE | 8:00 | Glass | 1.10 | 3.44 | 5.20 | 19.65 | 23.95 |
| | | Wall "A" | 0.13 | 4.71 | | 3.13 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.18 | |
| | 9:00 | Glass | 1.10 | 3.44 | 6.75 | 25.51 | 31.09 |
| | | Wall "A" | 0.13 | 4.71 | | 4.06 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.53 | |
| | 10:00 | Glass | 1.10 | 3.44 | 8.56 | 32.35 | 39.43 |
| | | Wall "A" | 0.13 | 4.71 | | 5.15 | |
| | | Wall "D" | 0.39 | 0.57 | | 1.94 | |
| | 11:00 | Glass | 1.10 | 3.44 | 10.50 | 39.68 | 48.37 |
| | | Wall "A" | 0.13 | 4.71 | | 6.31 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.37 | |
| | 12:00 | Glass | 1.10 | 3.44 | 12.44 | 47.01 | 57.31 |
| | | Wall "A" | 0.13 | 4.71 | | 7.48 | |
| | | Wall "D" | 0.39 | 0.57 | | 2.81 | |
| | 13:00 | Glass | 1.10 | 3.44 | 14.25 | 53.85 | 65.64 |
| | | Wall "A" | 0.13 | 4.71 | | 8.57 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.22 | |
| | 14:00 | Glass | 1.10 | 3.44 | 15.80 | 59.71 | 72.78 |
| | | Wall "A" | 0.13 | 4.71 | | 9.50 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.57 | |
| | 15:00 | Glass | 1.10 | 3.44 | 17.00 | 64.25 | 78.31 |
| | | Wall "A" | 0.13 | 4.71 | | 10.22 | |
| | | Wall "D" | 0.39 | 0.57 | | 3.84 | |
| | 16:00 | Glass | 1.10 | 3.44 | 17.74 | 67.04 | 81.72 |
| | | Wall "A" | 0.13 | 4.71 | | 10.67 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.01 | |
| | 17:00 | Glass | 1.10 | 3.44 | 18.00 | 68.03 | 82.92 |
| | | Wall "A" | 0.13 | 4.71 | | 10.82 | |
| | | Wall "D" | 0.39 | 0.57 | | 4.07 | |

### 2-Sun Load

| Direction | Time | Type | U | A | ΔT | I | Q (W) |
|---|---|---|---|---|---|---|---|
| NE | 8:00 | glass | | 3.44 | | 410.00 | 478.93 |
| | | A | 0.13 | 4.71 | 26.65 | | 16.02 |
| | | D | 0.39 | 0.57 | 16.40 | | 3.71 |
| | 9:00 | glass | | 3.44 | | 305.00 | 356.27 |
| | | A | 0.13 | 4.71 | 19.83 | | 11.92 |
| | | D | 0.39 | 0.57 | 12.20 | | 2.76 |
| | 10:00 | glass | | 3.44 | | 173.00 | 202.08 |
| | | A | 0.13 | 4.71 | 11.25 | | 6.76 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | D | 0.39 | 0.57 | 6.92 | | 1.57 |
| | 11:00 | glass | | 3.44 | | 60.00 | 70.09 |
| | | A | 0.13 | 4.71 | 3.90 | | 2.34 |
| | | D | 0.39 | 0.57 | 2.40 | | 0.54 |
| | 12:00 | glass | | 3.44 | | 44.00 | 51.40 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 |
| | 13:00 | glass | | 3.44 | | 44.00 | 51.40 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 |
| | 14:00 | glass | | 3.44 | | 44.00 | 51.40 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 |
| | 15:00 | glass | | 3.44 | | 44.00 | 51.40 |
| | | A | 0.13 | 4.71 | 2.86 | | 1.72 |
| | | D | 0.39 | 0.57 | 1.76 | | 0.40 |
| | 16:00 | glass | | 3.44 | | 38.00 | 44.39 |
| | | A | 0.13 | 4.71 | 2.47 | | 1.48 |
| | | D | 0.39 | 0.57 | 1.52 | | 0.34 |
| | 17:00 | glass | | 3.44 | | 32.00 | 37.38 |
| | | A | 0.13 | 4.71 | 2.08 | | 1.25 |
| | | D | 0.39 | 0.57 | 1.28 | | 0.29 |

**3-Ventilation Load**

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 5.00 | 12.00 | 1.80 | 2.00 |

| | |
|---|---|
| **A (m2)** | 16.52 |
| **H (m)** | 2.60 |
| **V (m3)** | 42.95 |

| Method | CMM |
|---|---|
| **Based on No Of Persons** | 3.60 |
| **Based on Area** | 1.78 |
| **NO Of Air Changing Times** | 1.43 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 8:00 | 3.60 | 381.89 | 1121.76 | 1503.65 |
| 9:00 | 3.60 | 495.72 | 1121.76 | 1617.48 |
| 10:00 | 3.60 | 628.65 | 1121.76 | 1750.41 |
| 11:00 | 3.60 | 771.12 | 1121.76 | 1892.88 |
| 12:00 | 3.60 | 913.59 | 1121.76 | 2035.35 |
| 13:00 | 3.60 | 1046.52 | 1121.76 | 2168.28 |
| 14:00 | 3.60 | 1160.35 | 1121.76 | 2282.11 |

| | | | | |
|---|---|---|---|---|
| 15:00 | 3.60 | 1248.48 | 1121.76 | 2370.24 |
| 16:00 | 3.60 | 1302.83 | 1121.76 | 2424.59 |
| 17:00 | 3.60 | 1321.92 | 1121.76 | 2443.68 |

## B-Internal Loads

### 1-Occupancy Load

| No Of Pers | Work | qs/p | qL/p | Qs | QL | Qtot (W) |
|---|---|---|---|---|---|---|
| 5.00 | Light | 72.00 | 60.00 | 360.00 | 300.00 | 660.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| Fluorescent | 8.00 | 20.00 | 1.25 | 200.00 |

### 3-Equipment

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot |
|---|---|---|---|---|
| CPU | 1.00 | 55.00 | 55.00 | 474.00 |
| Monitor | 1.00 | 55.00 | 55.00 | |
| scan light | 1.00 | 100.00 | 100.00 | |
| abjora | 1.00 | 60.00 | 60.00 | |
| scan device | 1.00 | 204.00 | 204.00 | |

### Variation of load with time

| Q occ_s | Q occ_l | Q lig_s | Q equ_s | Q equ_l |
|---|---|---|---|---|
| 360.00 | 300.00 | 200.00 | 474.00 | 0.00 |

| Time | Q wall_s | Q sun_s | Q vent_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 23.95 | 498.66 | 381.89 | 1121.76 | 1556.61 | 300.00 | 1856.61 |
| 9:00 | 31.09 | 370.95 | 495.72 | 1121.76 | 1436.05 | 300.00 | 1736.05 |
| 10:00 | 39.43 | 210.41 | 628.65 | 1121.76 | 1283.84 | 300.00 | 1583.84 |
| 11:00 | 48.37 | 72.97 | 771.12 | 1121.76 | 1155.34 | 300.00 | 1455.34 |
| 12:00 | 57.31 | 53.51 | 913.59 | 1121.76 | 1144.82 | 300.00 | 1444.82 |
| 13:00 | 65.64 | 53.51 | 1046.52 | 1121.76 | 1153.16 | 300.00 | 1453.16 |
| 14:00 | 72.78 | 53.51 | 1160.35 | 1121.76 | 1160.30 | 300.00 | 1460.30 |
| 15:00 | 78.31 | 53.51 | 1248.48 | 1121.76 | 1165.83 | 300.00 | 1465.83 |
| 16:00 | 81.72 | 46.22 | 1302.83 | 1121.76 | 1161.94 | 300.00 | 1461.94 |
| 17:00 | 82.92 | 38.92 | 1321.92 | 1121.76 | 1155.84 | 300.00 | 1455.84 |

## For air Conditioning machine 2

# Room 0-17 waiting Area

### A-External Loads

#### 1-Wall Load

| Direction | Time | Type | U | A | ΔT (K) | Q | Qt |
|---|---|---|---|---|---|---|---|
| NE | 08:00 | Wall "A" | 0.13 | 19.76 | 5.20 | 13.10 | 174.96 |
| | | Wall "B" | 1.44 | 3.25 | | 24.32 | |
| | | Wall "C" | 1.79 | 3.25 | | 30.23 | |
| | | Wall "D" | 0.39 | 1.56 | | 3.20 | |
| | | Glass | 1.10 | 18.20 | | 104.10 | |
| | 09:00 | Wall "A" | 0.13 | 19.76 | 6.75 | 17.01 | 227.11 |
| | | Wall "B" | 1.44 | 3.25 | | 31.57 | |
| | | Wall "C" | 1.79 | 3.25 | | 39.25 | |
| | | Wall "D" | 0.39 | 1.56 | | 4.15 | |
| | | Glass | 1.10 | 18.20 | | 135.14 | |
| | 10:00 | Wall "A" | 0.13 | 19.76 | 8.56 | 21.57 | 288.01 |
| | | Wall "B" | 1.44 | 3.25 | | 40.03 | |
| | | Wall "C" | 1.79 | 3.25 | | 49.77 | |
| | | Wall "D" | 0.39 | 1.56 | | 5.27 | |
| | | Glass | 1.10 | 18.20 | | 171.37 | |
| | 11:00 | Wall "A" | 0.13 | 19.76 | 10.50 | 26.46 | 353.28 |
| | | Wall "B" | 1.44 | 3.25 | | 49.10 | |
| | | Wall "C" | 1.79 | 3.25 | | 61.05 | |
| | | Wall "D" | 0.39 | 1.56 | | 6.46 | |
| | | Glass | 1.10 | 18.20 | | 210.21 | |
| | 12:00 | Wall "A" | 0.13 | 19.76 | 12.44 | 31.35 | 418.55 |
| | | Wall "B" | 1.44 | 3.25 | | 58.17 | |
| | | Wall "C" | 1.79 | 3.25 | | 72.33 | |
| | | Wall "D" | 0.39 | 1.56 | | 7.65 | |
| | | Glass | 1.10 | 18.20 | | 249.05 | |
| | 13:00 | Wall "A" | 0.13 | 19.76 | 14.25 | 35.91 | 479.45 |
| | | Wall "B" | 1.44 | 3.25 | | 66.64 | |
| | | Wall "C" | 1.79 | 3.25 | | 82.85 | |
| | | Wall "D" | 0.39 | 1.56 | | 8.77 | |
| | | Glass | 1.10 | 18.20 | | 285.29 | |
| | 14:00 | Wall "A" | 0.13 | 19.76 | 15.80 | 39.82 | 531.60 |
| | | Wall "B" | 1.44 | 3.25 | | 73.89 | |
| | | Wall "C" | 1.79 | 3.25 | | 91.86 | |
| | | Wall "D" | 0.39 | 1.56 | | 9.72 | |
| | | Glass | 1.10 | 18.20 | | 316.32 | |
| | 15:00 | Wall "A" | 0.13 | 19.76 | 17.00 | 42.84 | 571.98 |
| | | Wall "B" | 1.44 | 3.25 | | 79.50 | |
| | | Wall "C" | 1.79 | 3.25 | | 98.84 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Wall "D" | 0.39 | 1.56 | | 10.46 | |
| | | Glass | 1.10 | 18.20 | | 340.34 | |
| | 16:00 | Wall "A" | 0.13 | 19.76 | 17.70 | 44.61 | 595.53 |
| | | Wall "B" | 1.44 | 3.25 | | 82.77 | |
| | | Wall "C" | 1.79 | 3.25 | | 102.91 | |
| | | Wall "D" | 0.39 | 1.56 | | 10.89 | |
| | | Glass | 1.10 | 18.20 | | 354.35 | |
| | 17:00 | Wall "A" | 0.13 | 19.76 | 18.00 | 45.36 | 605.63 |
| | | Wall "B" | 1.44 | 3.25 | | 84.18 | |
| | | Wall "C" | 1.79 | 3.25 | | 104.65 | |
| | | Wall "D" | 0.39 | 1.56 | | 11.07 | |
| | | Glass | 1.10 | 18.20 | | 360.36 | |

| Direction | Time | Type | U | A | ∆T | Q | Q tot |
|---|---|---|---|---|---|---|---|
| SE | 8:00 | Wall "A" | 0.13 | 9.26 | 5.20 | 6.14 | 146.00 |
| | | Wall "G_2" | 1.57 | 17.19 | | 139.86 | |
| | 9:00 | Wall "A" | 0.13 | 9.26 | 6.75 | 7.97 | 189.52 |
| | | Wall "G_2" | 1.57 | 17.19 | | 181.55 | |
| | 10:00 | Wall "A" | 0.13 | 9.26 | 8.56 | 10.11 | 240.34 |
| | | Wall "G_2" | 1.57 | 17.19 | | 230.23 | |
| | 11:00 | Wall "A" | 0.13 | 9.26 | 10.50 | 12.40 | 294.80 |
| | | Wall "G_2" | 1.57 | 17.19 | | 282.41 | |
| | 12:00 | Wall "A" | 0.13 | 9.26 | 12.44 | 14.69 | 349.27 |
| | | Wall "G_2" | 1.57 | 17.19 | | 334.59 | |
| | 13:00 | Wall "A" | 0.13 | 9.26 | 14.25 | 16.82 | 400.09 |
| | | Wall "G_2" | 1.57 | 17.19 | | 383.27 | |
| | 14:00 | Wall "A" | 0.13 | 9.26 | 15.80 | 18.65 | 443.61 |
| | | Wall "G_2" | 1.57 | 17.19 | | 424.96 | |
| | 15:00 | Wall "A" | 0.13 | 9.26 | 17.00 | 20.07 | 477.30 |
| | | Wall "G_2" | 1.57 | 17.19 | | 457.23 | |
| | 16:00 | Wall "A" | 0.13 | 9.26 | 17.70 | 20.90 | 496.96 |
| | | Wall "G_2" | 1.57 | 17.19 | | 476.06 | |
| | 17:00 | Wall "A" | 0.13 | 9.26 | 18.00 | 21.25 | 505.38 |
| | | Wall "G_2" | 1.57 | 17.19 | | 484.13 | |

| Direction | Time | Type | U | A | ∆T | Q | Qtot (W) |
|---|---|---|---|---|---|---|---|
| SW | 8:00 | Wall "A" | 0.13 | 48.05 | 5.20 | 31.87 | 219.06 |
| | | Wall "B" | 1.44 | 2.81 | | 21.03 | |
| | | Wall "C" | 1.79 | 2.39 | | 22.23 | |
| | | Wall "D" | 0.39 | 2.25 | | 4.62 | |
| | | Glass | 1.10 | 24.36 | | 139.32 | |
| | 9:00 | Wall "A" | 0.13 | 48.05 | 6.75 | 41.36 | 284.36 |
| | | Wall "B" | 1.44 | 2.81 | | 27.29 | |
| | | Wall "C" | 1.79 | 2.39 | | 28.86 | |
| | | Wall "D" | 0.39 | 2.25 | | 5.99 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Glass | 1.10 | 24.36 | | 180.85 | |
| | 10:00 | Wall "A" | 0.13 | 48.05 | 8.56 | 52.46 | 360.61 |
| | | Wall "B" | 1.44 | 2.81 | | 34.61 | |
| | | Wall "C" | 1.79 | 2.39 | | 36.60 | |
| | | Wall "D" | 0.39 | 2.25 | | 7.60 | |
| | | Glass | 1.10 | 24.36 | | 229.35 | |
| | 11:00 | Wall "A" | 0.13 | 48.05 | 10.50 | 64.34 | 442.34 |
| | | Wall "B" | 1.44 | 2.81 | | 42.45 | |
| | | Wall "C" | 1.79 | 2.39 | | 44.89 | |
| | | Wall "D" | 0.39 | 2.25 | | 9.32 | |
| | | Glass | 1.10 | 24.36 | | 281.33 | |
| | 12:00 | Wall "A" | 0.13 | 48.05 | 12.44 | 76.23 | 524.07 |
| | | Wall "B" | 1.44 | 2.81 | | 50.30 | |
| | | Wall "C" | 1.79 | 2.39 | | 53.19 | |
| | | Wall "D" | 0.39 | 2.25 | | 11.04 | |
| | | Glass | 1.10 | 24.36 | | 333.30 | |
| | 13:00 | Wall "A" | 0.13 | 48.05 | 14.25 | 87.32 | 600.32 |
| | | Wall "B" | 1.44 | 2.81 | | 57.62 | |
| | | Wall "C" | 1.79 | 2.39 | | 60.93 | |
| | | Wall "D" | 0.39 | 2.25 | | 12.65 | |
| | | Glass | 1.10 | 24.36 | | 381.80 | |
| | 14:00 | Wall "A" | 0.13 | 48.05 | 15.80 | 96.82 | 665.62 |
| | | Wall "B" | 1.44 | 2.81 | | 63.88 | |
| | | Wall "C" | 1.79 | 2.39 | | 67.55 | |
| | | Wall "D" | 0.39 | 2.25 | | 14.02 | |
| | | Glass | 1.10 | 24.36 | | 423.33 | |
| | 15:00 | Wall "A" | 0.13 | 48.05 | 17.00 | 104.18 | 716.17 |
| | | Wall "B" | 1.44 | 2.81 | | 68.74 | |
| | | Wall "C" | 1.79 | 2.39 | | 72.69 | |
| | | Wall "D" | 0.39 | 2.25 | | 15.09 | |
| | | Glass | 1.10 | 24.36 | | 455.48 | |
| | 16:00 | Wall "A" | 0.13 | 48.05 | 17.70 | 108.47 | 745.66 |
| | | Wall "B" | 1.44 | 2.81 | | 71.57 | |
| | | Wall "C" | 1.79 | 2.39 | | 75.68 | |
| | | Wall "D" | 0.39 | 2.25 | | 15.71 | |
| | | Glass | 1.10 | 24.36 | | 474.23 | |
| | 17:00 | Wall "A" | 0.13 | 48.05 | 18.00 | 110.30 | 758.30 |
| | | Wall "B" | 1.44 | 2.81 | | 72.78 | |
| | | Wall "C" | 1.79 | 2.39 | | 76.96 | |
| | | Wall "D" | 0.39 | 2.25 | | 15.98 | |
| | | Glass | 1.10 | 24.36 | | 482.27 | |

| Time | Qt(W) |
|---|---|
| 0.33 | 540.02 |
| 0.38 | 700.99 |
| 0.42 | 888.96 |
| 0.46 | 1008.70 |
| 0.50 | 1291.89 |
| 0.54 | 1479.86 |
| 0.58 | 1640.83 |
| 0.63 | 1765.45 |
| 0.67 | 1838.14 |
| 0.71 | 1869.30 |

**2-Sun Load**

| Direction | Time | Type | U | A | I | ∆Ts | Q | Qtot (W) |
|---|---|---|---|---|---|---|---|---|
| **NE** | 8:00 | Wall "A" | 0.13 | 19.76 | 410.00 | 26.65 | 67.16 | 2834.31 |
| | | Wall "B" | 1.44 | 3.25 | | 26.65 | 124.63 | |
| | | Wall "C" | 1.79 | 3.25 | | 16.40 | 95.35 | |
| | | Wall "D" | 0.39 | 1.56 | | 16.40 | 10.09 | |
| | | Glass | 1.10 | 18.20 | | | 2537.08 | |
| | 9:00 | Wall "A" | 0.13 | 19.76 | 305.00 | 19.83 | 49.96 | 2108.45 |
| | | Wall "B" | 1.44 | 3.25 | | 19.83 | 92.71 | |
| | | Wall "C" | 1.79 | 3.25 | | 12.20 | 70.93 | |
| | | Wall "D" | 0.39 | 1.56 | | 12.20 | 7.50 | |
| | | Glass | 1.10 | 18.20 | | | 1887.34 | |
| | 10:00 | Wall "A" | 0.13 | 19.76 | 173.00 | 11.25 | 28.34 | 1195.94 |
| | | Wall "B" | 1.44 | 3.25 | | 11.25 | 52.59 | |
| | | Wall "C" | 1.79 | 3.25 | | 6.92 | 40.23 | |
| | | Wall "D" | 0.39 | 1.56 | | 6.92 | 4.26 | |
| | | Glass | 1.10 | 18.20 | | | 1070.52 | |
| | 11:00 | Wall "A" | 0.13 | 19.76 | 60.00 | 3.90 | 9.83 | 414.78 |
| | | Wall "B" | 1.44 | 3.25 | | 3.90 | 18.24 | |
| | | Wall "C" | 1.79 | 3.25 | | 2.40 | 13.95 | |
| | | Wall "D" | 0.39 | 1.56 | | 2.40 | 1.48 | |
| | | Glass | 1.10 | 18.20 | | | 371.28 | |
| | 12:00 | Wall "A" | 0.13 | 19.76 | 44.00 | 2.86 | 7.21 | 304.17 |
| | | Wall "B" | 1.44 | 3.25 | | 2.86 | 13.37 | |
| | | Wall "C" | 1.79 | 3.25 | | 1.76 | 10.23 | |
| | | Wall "D" | 0.39 | 1.56 | | 1.76 | 1.08 | |
| | | Glass | 1.10 | 18.20 | | | 272.27 | |
| | 13:00 | Wall "A" | 0.13 | 19.76 | 44.00 | 2.86 | 7.21 | 304.17 |
| | | Wall "B" | 1.44 | 3.25 | | 2.86 | 13.37 | |
| | | Wall "C" | 1.79 | 3.25 | | 1.76 | 10.23 | |
| | | Wall "D" | 0.39 | 1.56 | | 1.76 | 1.08 | |
| | | Glass | 1.10 | 18.20 | | | 272.27 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 14:00 | Wall "A" | 0.13 | 19.76 | 44.00 | 2.86 | 7.21 | 304.17 |
| | | Wall "B" | 1.44 | 3.25 | | 2.86 | 13.37 | |
| | | Wall "C" | 1.79 | 3.25 | | 1.76 | 10.23 | |
| | | Wall "D" | 0.39 | 1.56 | | 1.76 | 1.08 | |
| | | Glass | 1.10 | 18.20 | | | 272.27 | |
| | 15:00 | Wall "A" | 0.13 | 19.76 | 44.00 | 2.86 | 7.21 | 304.17 |
| | | Wall "B" | 1.44 | 3.25 | | 2.86 | 13.37 | |
| | | Wall "C" | 1.79 | 3.25 | | 1.76 | 10.23 | |
| | | Wall "D" | 0.39 | 1.56 | | 1.76 | 1.08 | |
| | | Glass | 1.10 | 18.20 | | | 272.27 | |
| | 16:00 | Wall "A" | 0.13 | 19.76 | 38.00 | 2.47 | 6.22 | 262.69 |
| | | Wall "B" | 1.44 | 3.25 | | 2.47 | 11.55 | |
| | | Wall "C" | 1.79 | 3.25 | | 1.52 | 8.84 | |
| | | Wall "D" | 0.39 | 1.56 | | 1.52 | 0.93 | |
| | | Glass | 1.10 | 18.20 | | | 235.14 | |
| | 17:00 | Wall "A" | 0.13 | 19.76 | 32.00 | 2.08 | 5.24 | 221.21 |
| | | Wall "B" | 1.44 | 3.25 | | 2.08 | 9.73 | |
| | | Wall "C" | 1.79 | 3.25 | | 1.28 | 7.44 | |
| | | Wall "D" | 0.39 | 1.56 | | 1.28 | 0.79 | |
| | | Glass | 1.10 | 18.20 | | | 198.02 | |

| Direction | Time | Type | U | A | I | ∆Ts | Q (W) |
|---|---|---|---|---|---|---|---|
| SE | 8:00 | Wall "A" | 0.13 | 9.26 | 284.00 | 18.46 | 21.79 |
| | 9:00 | Wall "A" | 0.13 | 9.26 | 284.00 | 18.46 | 21.79 |
| | 10:00 | Wall "A" | 0.13 | 9.26 | 230.00 | 14.95 | 17.65 |
| | 11:00 | Wall "A" | 0.13 | 9.26 | 139.00 | 9.04 | 10.67 |
| | 12:00 | Wall "A" | 0.13 | 9.26 | 54.00 | 3.51 | 4.14 |
| | 13:00 | Wall "A" | 0.13 | 9.26 | 44.00 | 2.86 | 3.38 |
| | 14:00 | Wall "A" | 0.13 | 9.26 | 44.00 | 2.86 | 3.38 |
| | 15:00 | Wall "A" | 0.13 | 9.26 | 44.00 | 2.86 | 3.38 |
| | 16:00 | Wall "A" | 0.13 | 9.26 | 38.00 | 2.47 | 2.92 |
| | 17:00 | Wall "A" | 0.13 | 9.26 | 32.00 | 2.08 | 2.46 |

| Direction | Time | Type | U | A | I | ∆Ts | Q | Qtot (W) |
|---|---|---|---|---|---|---|---|---|
| **SW** | 8:00 | Wall "A" | 0.13 | 48.05 | 38.00 | 2.47 | 15.14 | 347.67 |
| | | Wall "B" | 1.44 | 2.81 | | 2.47 | 9.99 | |
| | | Wall "C" | 1.79 | 2.39 | | 1.52 | 6.50 | |
| | | Wall "D" | 0.39 | 2.25 | | 1.52 | 1.35 | |
| | | Glass | 1.10 | 24.36 | | | 314.70 | |
| | 9:00 | Wall "A" | 0.13 | 48.05 | 44.00 | 2.86 | 17.53 | 402.56 |
| | | Wall "B" | 1.44 | 2.81 | | 2.86 | 11.56 | |
| | | Wall "C" | 1.79 | 2.39 | | 1.76 | 7.53 | |
| | | Wall "D" | 0.39 | 2.25 | | 1.76 | 1.56 | |
| | | Glass | 1.10 | 24.36 | | | 364.38 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Wall "A" | 0.13 | 48.05 | | 2.86 | 17.53 | |
| | | Wall "B" | 1.44 | 2.81 | | 2.86 | 11.56 | |
| | 10:00 | Wall "C" | 1.79 | 2.39 | 44.00 | 1.76 | 7.53 | 402.51 |
| | | Wall "D" | 0.39 | 2.25 | | 1.76 | 1.56 | |
| | | Glass | 1.10 | 24.36 | | | 364.38 | |
| | | Wall "A" | 0.13 | 48.05 | | 2.86 | 17.53 | |
| | | Wall "B" | 1.44 | 2.81 | | 2.86 | 11.56 | |
| | 11:00 | Wall "C" | 1.79 | 2.39 | 44.00 | 1.76 | 7.53 | 402.56 |
| | | Wall "D" | 0.39 | 2.25 | | 1.76 | 1.56 | |
| | | Glass | 1.10 | 24.36 | | | 364.38 | |
| | | Wall "A" | 0.13 | 48.05 | | 3.51 | 21.51 | |
| | | Wall "B" | 1.44 | 2.81 | | 3.51 | 14.19 | |
| | 12:00 | Wall "C" | 1.79 | 2.39 | 54.00 | 2.16 | 9.24 | 494.05 |
| | | Wall "D" | 0.39 | 2.25 | | 2.16 | 1.92 | |
| | | Glass | 1.10 | 24.36 | | | 447.20 | |
| | | Wall "A" | 0.13 | 48.05 | | 8.97 | 54.97 | |
| | | Wall "B" | 1.44 | 2.81 | | 8.97 | 36.27 | |
| | 13:00 | Wall "C" | 1.79 | 2.39 | 138.00 | 5.52 | 23.60 | 1262.58 |
| | | Wall "D" | 0.39 | 2.25 | | 5.52 | 4.90 | |
| | | Glass | 1.10 | 24.36 | | | 1142.84 | |
| | | Wall "A" | 0.13 | 48.05 | | 14.95 | 91.61 | |
| | | Wall "B" | 1.44 | 2.81 | | 14.95 | 60.45 | |
| | 14:00 | Wall "C" | 1.79 | 2.39 | 230.00 | 9.20 | 39.34 | 2104.30 |
| | | Wall "D" | 0.39 | 2.25 | | 9.20 | 8.17 | |
| | | Glass | 1.10 | 24.36 | | | 1904.73 | |
| | | Wall "A" | 0.13 | 48.05 | | 18.46 | 113.12 | |
| | | Wall "B" | 1.44 | 2.81 | | 18.46 | 74.64 | |
| | 15:00 | Wall "C" | 1.79 | 2.39 | 284.00 | 11.36 | 48.57 | 2598.35 |
| | | Wall "D" | 0.39 | 2.25 | | 11.36 | 10.08 | |
| | | Glass | 1.10 | 24.36 | | | 2351.93 | |
| | | Wall "A" | 0.13 | 48.05 | | 18.46 | 113.12 | |
| | | Wall "B" | 1.44 | 2.81 | | 18.46 | 74.64 | |
| | 16:00 | Wall "C" | 1.79 | 2.39 | 284.00 | 11.36 | 48.57 | 2598.35 |
| | | Wall "D" | 0.39 | 2.25 | | 11.36 | 10.08 | |
| | | Glass | 1.10 | 24.36 | | | 2351.93 | |
| | | Wall "A" | 0.13 | 48.05 | | 15.41 | 94.40 | |
| | | Wall "B" | 1.44 | 2.81 | | 15.41 | 62.29 | |
| | 17:00 | Wall "C" | 1.79 | 2.39 | 237.00 | 9.48 | 40.53 | 2168.34 |
| | | Wall "D" | 0.39 | 2.25 | | 9.48 | 8.41 | |
| | | Glass | 1.10 | 24.36 | | | 1962.70 | |

| Time | Qt(W) |
|---|---|
| 0.33 | 3203.77 |
| 0.38 | 2532.80 |
| 0.42 | 1616.15 |
| 0.46 | 828.00 |
| 0.50 | 802.37 |
| 0.54 | 1570.12 |
| 0.58 | 2411.84 |
| 0.63 | 2905.90 |
| 0.67 | 2863.96 |
| 0.71 | 2392.01 |

**3-Ventilation Load**

| Ti | hi | φi | Wi |
|---|---|---|---|
| 24.00 | 47.90 | 50.00 | 9.34 |

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 162.00 | 14.00 | 6.70 | 7.00 |

| | |
|---|---|
| A (m2) | 272.31 |
| H (m) | 2.60 |
| V (m3) | 708.01 |

| Method | CMMv |
|---|---|
| Based on No Of Persons | 136.08 |
| Based on Area | 109.47 |
| NO Of Air Changing Times | 82.60 |

| Time | CMM max | Qs(W) | QL(W) | Qtot |
|---|---|---|---|---|
| 8:00 | 136.08 | 14435.37 | 42402.53 | 56837.89 |
| 9:00 | 136.08 | 18738.22 | 42402.53 | 61140.74 |
| 10:00 | 136.08 | 23762.83 | 42402.53 | 66165.36 |
| 11:00 | 136.08 | 29148.34 | 42402.53 | 71550.86 |
| 12:00 | 136.08 | 34533.84 | 42402.53 | 76936.37 |
| 13:00 | 136.08 | 39558.46 | 42402.53 | 81960.98 |
| 14:00 | 136.08 | 43861.31 | 42402.53 | 86263.83 |
| 15:00 | 136.08 | 47192.54 | 42402.53 | 89595.07 |
| 16:00 | 136.08 | 49135.77 | 42402.53 | 91538.29 |
| 17:00 | 136.08 | 49968.58 | 42402.53 | 92371.10 |

## B-Internal Loads

### 1-Occupancy Load

| No Of Persons | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 162.00 | Comfort sitting | 66.00 | 31.00 | 10692.00 | 5022.00 | 15714.00 |

### 2-Light Load

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| ze2reda | 83.00 | 26.00 | 1.00 | 2158.00 |
| ze2reda | 70.00 | 26.00 | 1.00 | 1820.00 |
| spot | 8.00 | 35.00 | 1.00 | 280.00 |

### 3-Equipment

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot |
|---|---|---|---|---|
| computer | 1.00 | 110.00 | 110.00 | 650.00 |
| water cooler | 1.00 | 320.00 | 320.00 | |
| Television | 2.00 | 110.00 | 220.00 | |

## Variation of load with time

| Qs | Qs | Ql | Qs | Ql |
|---|---|---|---|---|
| 2100.00 | 10692.00 | 5022.00 | 650.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 540.02 | 3203.77 | 14435.37 | 42402.53 | 17185.79 | 5022.00 | 22207.79 |
| 9:00 | 700.99 | 2532.80 | 18738.22 | 42402.53 | 16675.79 | 5022.00 | 21697.79 |
| 10:00 | 888.96 | 1616.15 | 23762.83 | 42402.53 | 15947.11 | 5022.00 | 20969.11 |
| 11:00 | 1008.70 | 828.00 | 29148.34 | 42402.53 | 15278.70 | 5022.00 | 20300.70 |
| 12:00 | 1291.89 | 802.37 | 34533.84 | 42402.53 | 15536.26 | 5022.00 | 20558.26 |
| 13:00 | 1479.86 | 1570.12 | 39558.46 | 42402.53 | 16491.99 | 5022.00 | 21513.99 |
| 14:00 | 1640.83 | 2411.84 | 43861.31 | 42402.53 | 17494.67 | 5022.00 | 22516.67 |
| 15:00 | 1765.45 | 2905.90 | 47192.54 | 42402.53 | 18113.34 | 5022.00 | 23135.34 |
| 16:00 | 1838.14 | 2863.96 | 49135.77 | 42402.53 | 18144.10 | 5022.00 | 23166.10 |
| 17:00 | 1869.30 | 2392.01 | 49968.58 | 42402.53 | 17703.31 | 5022.00 | 22725.31 |

# Waiting Area 0-20

## A-External Loads

### 1-Wall Load

| Direction | Time | Type | U | A | ΔT | Q (W) |
|---|---|---|---|---|---|---|
| SE | 8:00 | Glass | 1.10 | 47.02 | 5.20 | 268.95 |
| | 9:00 | Glass | 1.10 | 47.02 | 6.75 | 349.12 |
| | 10:00 | Glass | 1.10 | 47.02 | 8.56 | 442.74 |
| | 11:00 | Glass | 1.10 | 47.02 | 10.50 | 543.08 |
| | 12:00 | Glass | 1.10 | 47.02 | 12.44 | 643.42 |
| | 13:00 | Glass | 1.10 | 47.02 | 14.25 | 737.04 |
| | 14:00 | Glass | 1.10 | 47.02 | 15.80 | 817.20 |
| | 15:00 | Glass | 1.10 | 47.02 | 17.00 | 879.27 |
| | 16:00 | Glass | 1.10 | 47.02 | 17.70 | 915.48 |
| | 17:00 | Glass | 1.10 | 47.02 | 18.00 | 930.99 |

| Direction | Time | Type | U | A | ΔT | Q (W) |
|---|---|---|---|---|---|---|
| SW | 8:00 | Wall "B" | 1.44 | 10.40 | 5.20 | 77.82 |
| | 9:00 | Wall "B" | 1.44 | 10.40 | 6.75 | 101.01 |
| | 10:00 | Wall "B" | 1.44 | 10.40 | 8.56 | 128.10 |
| | 11:00 | Wall "B" | 1.44 | 10.40 | 10.50 | 157.13 |
| | 12:00 | Wall "B" | 1.44 | 10.40 | 12.44 | 186.16 |
| | 13:00 | Wall "B" | 1.44 | 10.40 | 14.25 | 213.24 |
| | 14:00 | Wall "B" | 1.44 | 10.40 | 15.80 | 236.44 |
| | 15:00 | Wall "B" | 1.44 | 10.40 | 17.00 | 254.40 |
| | 16:00 | Wall "B" | 1.44 | 10.40 | 17.70 | 264.87 |
| | 17:00 | Wall "B" | 1.44 | 10.40 | 18.00 | 269.36 |

| Direction | Time | Type | U | A | ΔT | Q (W) |
|---|---|---|---|---|---|---|
| NW | 8:00 | Adj Wall | 0.10 | 4.08 | 5.20 | 2.14 |
| | 9:00 | Adj Wall | 0.10 | 4.08 | 6.75 | 2.77 |
| | 10:00 | Adj Wall | 0.10 | 4.08 | 8.56 | 3.52 |
| | 11:00 | Adj Wall | 0.10 | 4.08 | 10.50 | 4.32 |
| | 12:00 | Adj Wall | 0.10 | 4.08 | 12.44 | 5.11 |
| | 13:00 | Adj Wall | 0.10 | 4.08 | 14.25 | 5.86 |
| | 14:00 | Adj Wall | 0.10 | 4.08 | 15.80 | 6.49 |
| | 15:00 | Adj Wall | 0.10 | 4.08 | 17.00 | 6.99 |
| | 16:00 | Adj Wall | 0.10 | 4.08 | 17.70 | 7.28 |
| | 17:00 | Adj Wall | 0.10 | 4.08 | 18.00 | 7.40 |

| Time | Qt(W) |
|---|---|
| 8:00 | 348.91 |
| 9:00 | 452.91 |
| 10:00 | 574.35 |
| 11:00 | 704.52 |
| 12:00 | 834.69 |
| 13:00 | 956.14 |
| 14:00 | 1060.14 |
| 15:00 | 1140.66 |
| 16:00 | 1187.62 |
| 17:00 | 1207.75 |

**2-Sun Load**

| Direction | Time | Type | A | I | Q (W) |
|---|---|---|---|---|---|
| SE | 8:00 | glass | 47.02 | 284.00 | 7611.57 |
| | 9:00 | glass | 47.02 | 284.00 | 7611.57 |
| | 10:00 | glass | 47.02 | 230.00 | 6164.30 |
| | 11:00 | glass | 47.02 | 139.00 | 3725.38 |
| | 12:00 | glass | 47.02 | 54.00 | 1447.27 |
| | 13:00 | glass | 47.02 | 44.00 | 1179.26 |
| | 14:00 | glass | 47.02 | 44.00 | 1179.26 |
| | 15:00 | glass | 47.02 | 44.00 | 1179.26 |
| | 16:00 | glass | 47.02 | 38.00 | 1018.45 |
| | 17:00 | glass | 47.02 | 32.00 | 857.64 |

| Direction | Time | Type | A | U | I | ∆T sun | Q (W) |
|---|---|---|---|---|---|---|---|
| SW | 8:00 | Wall "B" | 10.40 | 1.44 | 38.00 | 2.47 | 36.96 |
| | 9:00 | Wall "B" | 10.40 | 1.44 | 44.00 | 2.86 | 42.80 |
| | 10:00 | Wall "B" | 10.40 | 1.44 | 44.00 | 2.86 | 42.80 |
| | 11:00 | Wall "B" | 10.40 | 1.44 | 44.00 | 2.86 | 42.80 |
| | 12:00 | Wall "B" | 10.40 | 1.44 | 54.00 | 3.51 | 52.53 |
| | 13:00 | Wall "B" | 10.40 | 1.44 | 138.00 | 8.97 | 134.23 |
| | 14:00 | Wall "B" | 10.40 | 1.44 | 230.00 | 14.95 | 223.72 |
| | 15:00 | Wall "B" | 10.40 | 1.44 | 284.00 | 18.46 | 276.25 |
| | 16:00 | Wall "B" | 10.40 | 1.44 | 284.00 | 18.46 | 276.25 |
| | 17:00 | Wall "B" | 10.40 | 1.44 | 237.00 | 15.41 | 230.53 |

| Time | Qt(W) |
|---|---|
| 8:00 | 7648.53 |
| 9:00 | 7654.37 |
| 10:00 | 6207.10 |
| 11:00 | 3768.18 |
| 12:00 | 1499.80 |
| 13:00 | 1313.49 |
| 14:00 | 1402.98 |
| 15:00 | 1455.50 |
| 16:00 | 1294.70 |
| 17:00 | 1088.17 |

**3-Ventilation Load**

| No Of Person | L/s.p | L/s.m2 | ζ |
|---|---|---|---|
| 125.00 | 14.00 | 2.80 | 3.00 |

| | |
|---|---|
| **A (m2)** | 435.02 |
| **H (m)** | 2.60 |
| **V (m3)** | 1131.05 |

| Method | CMMv |
|---|---|
| **Based on No Of Persons** | 105.00 |
| **Based on Area** | 73.08 |
| **NO Of Air Changing Times** | 56.55 |

| Time | CMM max | Qs(W) | QL(W) | Qtot (W) |
|---|---|---|---|---|
| 8:00 | 105.00 | 11138.40 | 32718.00 | 43856.40 |
| 9:00 | 105.00 | 14458.50 | 32718.00 | 47176.50 |
| 10:00 | 105.00 | 18335.52 | 32718.00 | 51053.52 |
| 11:00 | 105.00 | 22491.00 | 32718.00 | 55209.00 |
| 12:00 | 105.00 | 26646.48 | 32718.00 | 59364.48 |
| 13:00 | 105.00 | 30523.50 | 32718.00 | 63241.50 |
| 14:00 | 105.00 | 33843.60 | 32718.00 | 66561.60 |
| 15:00 | 105.00 | 36414.00 | 32718.00 | 69132.00 |
| 16:00 | 105.00 | 37913.40 | 32718.00 | 70631.40 |
| 17:00 | 105.00 | 38556.00 | 32718.00 | 71274.00 |

## B-Internal Loads

**1-Occupancy Load**

| No Of Persons | Work | qs/p (W) | qL/p (W) | Qs (W) | QL (W) | Qtot (W) |
|---|---|---|---|---|---|---|
| 117.00 | sitting | 66.00 | 31.00 | 7722.00 | 3627.00 | 11349.00 |
| 8.00 | Light Work | 72.00 | 60.00 | 576.00 | 480.00 | 1056.00 |

**2-Light Load**

| Type Of Lamps | No OF Lamps | W/Lamp | F | Q (W) |
|---|---|---|---|---|
| ze2reda | 106.00 | 26.00 | 1.00 | 2756.00 |
| spot | 25.00 | 35.00 | 1.00 | 875.00 |
| exit | 5.00 | 60.00 | 1.00 | 300.00 |

**3-Equipment**

| Type Of Device | No Of Device | W/device | Q (W) | Q Tot (W) |
|---|---|---|---|---|
| television | 1.00 | 110.00 | 110.00 | 110.00 |

**Variation of load with time**

| Q occ_s | Q occ_l | Q light_s | Q eq_s | Q eq_l |
|---|---|---|---|---|
| 3931.00 | 8298.00 | 4107.00 | 110.00 | 0.00 |

| Time | Qwal_s | Qsun_s | Q ven_s | Q vent_l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 348.91 | 7648.53 | 11138.40 | 32718.00 | 20336.44 | 4107.00 | 24443.44 |
| 9:00 | 452.91 | 7654.37 | 14458.50 | 32718.00 | 20446.28 | 4107.00 | 24553.28 |
| 10:00 | 574.35 | 6207.10 | 18335.52 | 32718.00 | 19120.45 | 4107.00 | 23227.45 |
| 11:00 | 704.52 | 3768.18 | 22491.00 | 32718.00 | 16812.70 | 4107.00 | 20919.70 |
| 12:00 | 834.69 | 1499.80 | 26646.48 | 32718.00 | 14673.49 | 4107.00 | 18780.49 |
| 13:00 | 956.14 | 1313.49 | 30523.50 | 32718.00 | 14608.63 | 4107.00 | 18715.63 |
| 14:00 | 1060.14 | 1402.98 | 33843.60 | 32718.00 | 14802.12 | 4107.00 | 18909.12 |
| 15:00 | 1140.66 | 1455.50 | 36414.00 | 32718.00 | 14935.16 | 4107.00 | 19042.16 |
| 16:00 | 1187.62 | 1294.70 | 37913.40 | 32718.00 | 14821.32 | 4107.00 | 18928.32 |
| 17:00 | 1207.75 | 1088.17 | 38556.00 | 32718.00 | 14634.92 | 4107.00 | 18741.92 |

# Ground floor total Load calculations

## For 1st machine

| Time | TRSH | TRLH | TRTH | RSHF |
|---|---|---|---|---|
| 8:00 | 35570.0 | 7056.0 | 42626.0 | 0.83 |
| 9:00 | 34358.6 | 7056.0 | 41414.6 | 0.83 |
| 10:00 | 32228.0 | 7056.0 | 39284.0 | 0.82 |
| 11:00 | 30014.4 | 7056.0 | 37070.4 | 0.81 |
| 12:00 | 29307.1 | 7056.0 | 36363.1 | 0.81 |
| 1:00 | 29945.1 | 7056.0 | 37001.1 | 0.81 |
| 2:00 | 31834.1 | 7056.0 | 38890.1 | 0.82 |
| 3:00 | 31192.5 | 7056.0 | 38248.5 | 0.82 |
| 4:00 | 31168.4 | 7056.0 | 38224.4 | 0.82 |
| 5:00 | 30812.1 | 7056.0 | 37868.1 | 0.81 |

| TIME | Qvent_s | Qvent_l | Qvent_T |
|---|---|---|---|
| 8:00 | 11523.5 | 33547.2 | 45070.7 |
| 9:00 | 14927.8 | 33547.2 | 48475.0 |
| 10:00 | 18903.0 | 33547.2 | 52450.3 |
| 11:00 | 23163.8 | 33547.2 | 56711.1 |
| 12:00 | 27424.6 | 33547.2 | 60971.9 |
| 1:00 | 31399.9 | 33547.2 | 64947.1 |
| 2:00 | 34804.2 | 33547.2 | 68351.4 |
| 3:00 | 37439.7 | 33547.2 | 70986.9 |
| 4:00 | 39012.4 | 33547.2 | 72559.6 |
| 5:00 | 39636.0 | 33547.2 | 73183.2 |

| TIME | GRSH | GRLH | GRTH | GRSHF |
|---|---|---|---|---|
| 8:00 | 47093.5 | 40603.2 | 87696.7 | 0.54 |
| 9:00 | 49286.4 | 40603.2 | 89889.6 | 0.55 |
| 10:00 | 51131.1 | 40603.2 | 91734.3 | 0.56 |
| 11:00 | 53178.2 | 40603.2 | 93781.4 | 0.57 |
| 12:00 | 56731.8 | 40603.2 | 97335.0 | 0.58 |
| 1:00 | 61345.0 | 40603.2 | 101948.2 | 0.60 |
| 2:00 | 66638.2 | 40603.2 | 107241.5 | 0.62 |
| 3:00 | 68632.2 | 40603.2 | 109235.5 | 0.63 |
| 4:00 | 70180.8 | 40603.2 | 110784.0 | 0.63 |
| 5:00 | 70448.1 | 40603.2 | 111051.3 | 0.63 |

**The max load occurs at 2:00 PM and its value equals:**

| TIME | TRSH (W) | TRLH (W) | TRTH (W) | RSHF |
|---|---|---|---|---|
| 2:00 | 31834.1 | 7056.0 | 38890.1 | 0.82 |

| TIME | Qven s (W) | Qvent_l (W) | Qvent_T (W) |
|---|---|---|---|
| 2:00 | 34804.2 | 33547.2 | 68351.4 |

| TIME | ERSH (W) | ERLH (W) | ERTH(W) | ERSHF |
|---|---|---|---|---|
| 2:00 | 42299.7 | 17143.7 | 59443.3 | 0.71 |

| TIME | GRSH(W) | GRLH(W) | GRTH(W) | GRSHF |
|---|---|---|---|---|
| 2:00 | 66638.2 | 40603.2 | 107241.5 | 0.54 |

| Time | GTH (KW) | GTH (HP) | GTH (TR) |
|---|---|---|---|
| 2:00 | 107.24 | 143.70 | 30.64 |

## For $2^{nd}$ machine

| TIME | TRSH | TRLH | TRTH | RSHF |
|---|---|---|---|---|
| 8:00 | 37522.2 | 9129.0 | 46651.2 | 0.80 |
| 9:00 | 37122.1 | 9129.0 | 46251.1 | 0.80 |
| 10:00 | 35067.6 | 9129.0 | 44196.6 | 0.79 |
| 11:00 | 32091.4 | 9129.0 | 41220.4 | 0.78 |
| 12:00 | 30209.7 | 9129.0 | 39338.7 | 0.77 |
| 1:00 | 31100.6 | 9129.0 | 40229.6 | 0.77 |
| 2:00 | 32296.8 | 9129.0 | 41425.8 | 0.78 |
| 3:00 | 33048.5 | 9129.0 | 42177.5 | 0.78 |
| 4:00 | 32965.4 | 9129.0 | 42094.4 | 0.78 |
| 5:00 | 32338.2 | 9129.0 | 41467.2 | 0.78 |

| TIME | Qvent_s | Qvent_l | Qvent_T |
|---|---|---|---|
| 8:00 | 37097.2804 | 108667.752 | 145765 |
| 9:00 | 48124.4765 | 108667.752 | 156792.2 |
| 10:00 | 61001.3958 | 108667.752 | 169669.1 |
| 11:00 | 74803.1768 | 108667.752 | 183470.9 |
| 12:00 | 88604.9577 | 108667.752 | 197272.7 |
| 1:00 | 101481.877 | 108667.752 | 210149.6 |
| 2:00 | 112509.073 | 108667.752 | 221176.8 |
| 3:00 | 121046.257 | 108667.752 | 229714 |
| 4:00 | 126061.532 | 108667.752 | 234729.3 |
| 5:00 | 128160.577 | 108667.752 | 236828.3 |

| TIME | GRSH | GRLH | GRTH | GRSHF |
|---|---|---|---|---|
| 8:00 | 74619.5 | 117796.8 | 192416.3 | 0.39 |
| 9:00 | 85246.5 | 117796.8 | 203043.3 | 0.42 |
| 10:00 | 96069.0 | 117796.8 | 213865.7 | 0.45 |
| 11:00 | 106894.6 | 117796.8 | 224691.3 | 0.48 |
| 12:00 | 118814.7 | 117796.8 | 236611.5 | 0.50 |
| 1:00 | 132582.5 | 117796.8 | 250379.2 | 0.53 |
| 2:00 | 144805.9 | 117796.8 | 262602.6 | 0.55 |
| 3:00 | 154094.8 | 117796.8 | 271891.5 | 0.57 |
| 4:00 | 159027.0 | 117796.8 | 276823.7 | 0.57 |
| 5:00 | 160498.8 | 117796.8 | 278295.6 | 0.58 |

**The max load occurs at 5:00 PM and its value equals:**

| TIME | TRSH (W) | TRLH (W) | TRTH (W) | RSHF |
|---|---|---|---|---|
| 5:00 | 32338.2 | 9129.0 | 41467.2 | 0.78 |

| TIME | Qvent_s (W) | Qvent_l (W) | Qvent_T (W) |
|---|---|---|---|
| 5:00 | 128160.577 | 108667.752 | 236828.3 |

| TIME | ERSH (W) | ERLH (W) | ERTH(W) | ERSHF |
|---|---|---|---|---|
| 5:00 | 54125.5 | 27602.5 | 81728.1 | 0.66 |

| TIME | GRSH(W) | GRLH(W) | GRTH(W) | GRSHF |
|---|---|---|---|---|
| 5:00 | 160498.8 | 117796.8 | 278295.6 | 0.58 |

| Time | GTH (KW) | GTH (HP) | GTH (TR) |
|---|---|---|---|
| 5:00 | 278.30 | 372.92 | 79.51 |

# 1st Floor calculations

## Corridor 1-11

**Variation of load with time**

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 146.00 | 146.00 | 1050.00 | 0.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 87.14 | 0.00 | 466.09 | 1369.11 | 1283.14 | 146.00 | 1429.14 |
| 9:00 | 87.14 | 0.00 | 605.03 | 1369.11 | 1283.14 | 146.00 | 1429.14 |
| 10:00 | 87.14 | 0.00 | 767.26 | 1369.11 | 1283.14 | 146.00 | 1429.14 |
| 11:00 | 87.14 | 0.00 | 941.15 | 1369.11 | 1283.14 | 146.00 | 1429.14 |
| 12:00 | 87.14 | 0.00 | 1115.04 | 1369.11 | 1283.14 | 146.00 | 1429.14 |
| 13:00 | 87.14 | 0.00 | 1277.28 | 1369.11 | 1283.14 | 146.00 | 1429.14 |
| 14:00 | 87.14 | 0.00 | 1416.21 | 1369.11 | 1283.14 | 146.00 | 1429.14 |
| 15:00 | 87.14 | 0.00 | 1523.77 | 1369.11 | 1283.14 | 146.00 | 1429.14 |
| 16:00 | 87.14 | 0.00 | 1586.51 | 1369.11 | 1283.14 | 146.00 | 1429.14 |
| 17:00 | 87.14 | 0.00 | 1613.40 | 1369.11 | 1283.14 | 146.00 | 1429.14 |

## Room 1-13

**Variation of load with time**

| Qocc_s | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|
| 0 | 400 | 0 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 206.07 | 379.32 | 148.68 | 436.74 | 985.40 | 0.00 | 985.40 |
| 9:00 | 216.86 | 282.18 | 193.00 | 436.74 | 899.03 | 0.00 | 899.03 |
| 10:00 | 229.45 | 160.06 | 244.75 | 436.74 | 789.50 | 0.00 | 789.50 |
| 11:00 | 242.94 | 55.51 | 300.22 | 436.74 | 698.45 | 0.00 | 698.45 |
| 12:00 | 256.44 | 40.71 | 355.69 | 436.74 | 697.15 | 0.00 | 697.15 |
| 13:00 | 269.03 | 40.71 | 407.45 | 436.74 | 709.74 | 0.00 | 709.74 |
| 14:00 | 279.82 | 40.71 | 451.76 | 436.74 | 720.52 | 0.00 | 720.52 |
| 15:00 | 288.16 | 40.71 | 486.07 | 436.74 | 728.87 | 0.00 | 728.87 |
| 16:00 | 293.03 | 35.16 | 506.09 | 436.74 | 728.19 | 0.00 | 728.19 |
| 17:00 | 295.12 | 29.61 | 514.67 | 436.74 | 724.73 | 0.00 | 724.73 |

# Room 1-15

### Variation Of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 0.00 | 0.00 | 200.00 | 0.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 186.62 | 288.69 | 96.81 | 284.37 | 675.31 | 0.00 | 675.31 |
| 9:00 | 191.58 | 214.76 | 125.67 | 284.37 | 606.34 | 0.00 | 606.34 |
| 10:00 | 197.38 | 121.81 | 159.36 | 284.37 | 519.19 | 0.00 | 519.19 |
| 11:00 | 203.59 | 42.25 | 195.48 | 284.37 | 445.83 | 0.00 | 445.83 |
| 12:00 | 209.80 | 30.98 | 231.60 | 284.37 | 440.78 | 0.00 | 440.78 |
| 13:00 | 215.59 | 30.98 | 265.29 | 284.37 | 446.57 | 0.00 | 446.57 |
| 14:00 | 220.55 | 30.98 | 294.15 | 284.37 | 451.53 | 0.00 | 451.53 |
| 15:00 | 224.39 | 30.98 | 316.49 | 284.37 | 455.37 | 0.00 | 455.37 |
| 16:00 | 226.63 | 26.76 | 329.52 | 284.37 | 453.39 | 0.00 | 453.39 |
| 17:00 | 227.59 | 22.53 | 335.11 | 284.37 | 450.12 | 0.00 | 450.12 |

# Room 1-41

### Variation of load with time

| Qocc_s | Qocc_i | Qligh_s | Qequ_s | Qequ_l |
|---|---|---|---|---|
| 176 | 408 | 200 | 0 | 0 |

| TIME | Qwal S | Qsun S | Qven S | Qvent | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 3.62 | 18.56 | 178.21 | 523.49 | 398.18 | 408.00 | 806.18 |
| 9:00 | 4.70 | 13.81 | 231.34 | 523.49 | 394.51 | 408.00 | 802.51 |
| 10:00 | 5.96 | 7.83 | 293.37 | 523.49 | 389.79 | 408.00 | 797.79 |
| 11:00 | 7.31 | 2.72 | 359.86 | 523.49 | 386.03 | 408.00 | 794.03 |
| 12:00 | 8.66 | 1.99 | 426.34 | 523.49 | 386.65 | 408.00 | 794.65 |
| 13:00 | 9.92 | 1.99 | 488.38 | 523.49 | 387.91 | 408.00 | 795.91 |
| 14:00 | 11.00 | 1.99 | 541.50 | 523.49 | 388.99 | 408.00 | 796.99 |
| 15:00 | 11.84 | 1.99 | 582.62 | 523.49 | 389.83 | 408.00 | 797.83 |
| 16:00 | 12.33 | 1.72 | 606.61 | 523.49 | 390.05 | 408.00 | 798.05 |
| 17:00 | 12.53 | 1.45 | 616.90 | 523.49 | 389.98 | 408.00 | 797.98 |

# Room 1-42

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequ_s | Qequ_l |
|---|---|---|---|---|
| 176 | 408 | 200 | 0 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 16.59 | 61.74 | 178.21 | 523.49 | 454.33 | 408.00 | 862.33 |
| 9:00 | 21.54 | 46.92 | 231.34 | 523.49 | 444.45 | 408.00 | 852.45 |
| 10:00 | 27.31 | 27.80 | 293.37 | 523.49 | 431.12 | 408.00 | 839.12 |
| 11:00 | 33.50 | 11.44 | 359.86 | 523.49 | 420.95 | 408.00 | 828.95 |
| 12:00 | 39.69 | 9.13 | 426.34 | 523.49 | 424.82 | 408.00 | 832.82 |
| 13:00 | 45.47 | 10.13 | 488.38 | 523.49 | 431.60 | 408.00 | 839.60 |
| 14:00 | 50.41 | 17.20 | 541.50 | 523.49 | 443.62 | 408.00 | 851.62 |
| 15:00 | 54.24 | 25.78 | 582.62 | 523.49 | 456.03 | 408.00 | 864.03 |
| 16:00 | 56.48 | 31.17 | 606.61 | 523.49 | 463.65 | 408.00 | 871.65 |
| 17:00 | 57.43 | 32.06 | 616.90 | 523.49 | 465.49 | 408.00 | 873.49 |

# Room 1-49

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 432 | 384 | 200 | 0 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 52.05 | 0.00 | 534.64 | 1570.46 | 684.05 | 384.00 | 1068.05 |
| 9:00 | 67.57 | 0.00 | 694.01 | 1570.46 | 699.57 | 384.00 | 1083.57 |
| 10:00 | 85.68 | 0.00 | 880.10 | 1570.46 | 717.68 | 384.00 | 1101.68 |
| 11:00 | 105.10 | 0.00 | 1079.57 | 1570.46 | 737.10 | 384.00 | 1121.10 |
| 12:00 | 124.52 | 0.00 | 1279.03 | 1570.46 | 756.52 | 384.00 | 1140.52 |
| 13:00 | 142.64 | 0.00 | 1465.13 | 1570.46 | 774.64 | 384.00 | 1158.64 |
| 14:00 | 158.15 | 0.00 | 1624.49 | 1570.46 | 790.15 | 384.00 | 1174.15 |
| 15:00 | 170.17 | 0.00 | 1747.87 | 1570.46 | 802.17 | 384.00 | 1186.17 |
| 16:00 | 177.17 | 0.00 | 1819.84 | 1570.46 | 809.17 | 384.00 | 1193.17 |
| 17:00 | 180.18 | 0.00 | 1850.69 | 1570.46 | 812.18 | 384.00 | 1196.18 |

# Room 1-50

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 220 | 155 | 600 | 320 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 51.4995 | 61.8115 | 267.322 | 785.232 | 1253.3 | 155 | 1408.31 |
| 9:00 | 66.8503 | 71.5713 | 347.004 | 785.232 | 1278.4 | 155 | 1433.42 |
| 10:00 | 84.7761 | 71.5713 | 440.052 | 785.232 | 1296.3 | 155 | 1451.35 |
| 11:00 | 103.989 | 71.5713 | 539.784 | 785.232 | 1315.5 | 155 | 1470.56 |
| 12:00 | 123.203 | 73.1979 | 639.516 | 785.232 | 1336.4 | 155 | 1491.4 |
| 13:00 | 141.128 | 224.474 | 732.564 | 785.232 | 1505.6 | 155 | 1660.6 |
| 14:00 | 156.479 | 374.123 | 812.246 | 785.232 | 1670.6 | 155 | 1825.6 |
| 15:00 | 168.364 | 461.96 | 873.936 | 785.232 | 1770.3 | 155 | 1925.32 |
| 16:00 | 175.296 | 461.96 | 909.922 | 785.232 | 1777.2 | 155 | 1932.26 |
| 17:00 | 178.267 | 385.509 | 925.344 | 785.232 | 1703.7 | 155 | 1858.78 |

# Room 1-55

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 225 | 165 | 100 | 110 | 0 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 39.81 | 56.70 | 267.32 | 785.23 | 531.52 | 165.00 | 696.52 |
| 9:00 | 51.68 | 65.66 | 347.00 | 785.23 | 552.34 | 165.00 | 717.34 |
| 10:00 | 65.54 | 65.66 | 440.05 | 785.23 | 566.19 | 165.00 | 731.19 |
| 11:00 | 80.39 | 65.66 | 539.78 | 785.23 | 581.05 | 165.00 | 746.05 |
| 12:00 | 95.24 | 67.15 | 639.52 | 785.23 | 597.39 | 165.00 | 762.39 |
| 13:00 | 109.10 | 205.92 | 732.56 | 785.23 | 750.02 | 165.00 | 915.02 |
| 14:00 | 120.97 | 343.20 | 812.25 | 785.23 | 899.17 | 165.00 | 1064.17 |
| 15:00 | 130.16 | 423.78 | 873.94 | 785.23 | 988.94 | 165.00 | 1153.94 |
| 16:00 | 135.52 | 423.78 | 909.92 | 785.23 | 994.30 | 165.00 | 1159.30 |
| 17:00 | 137.81 | 353.65 | 925.34 | 785.23 | 926.46 | 165.00 | 1091.46 |

# Room 1-56

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequ_s | Qequ_l |
|---|---|---|---|---|
| 220.00 | 155 | 300 | 596 | 0 |

| TIME | Qwall S | Qsun S | Qvent S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 102.9479 | 52.81 | 267.32 | 921.06 | 1271.76 | 155.00 | 1426.76 |
| 9:00 | 111.9508 | 61.15 | 347.00 | 921.06 | 1289.10 | 155.00 | 1444.10 |
| 10:00 | 122.4639 | 61.15 | 440.05 | 921.06 | 1299.61 | 155.00 | 1454.61 |
| 11:00 | 133.7321 | 61.15 | 539.78 | 921.06 | 1310.88 | 155.00 | 1465.88 |
| 12:00 | 145.0003 | 75.05 | 639.52 | 921.06 | 1336.05 | 155.00 | 1491.05 |
| 13:00 | 155.5134 | 191.79 | 732.56 | 921.06 | 1463.30 | 155.00 | 1618.30 |
| 14:00 | 164.5163 | 319.65 | 812.25 | 921.06 | 1600.17 | 155.00 | 1755.17 |
| 15:00 | 171.4863 | 394.70 | 873.94 | 921.06 | 1682.19 | 155.00 | 1837.19 |
| 16:00 | 175.5521 | 394.70 | 909.92 | 921.06 | 1686.25 | 155.00 | 1841.25 |
| 17:00 | 177.2946 | 329.38 | 925.34 | 921.06 | 1622.67 | 155.00 | 1777.67 |

# Room1-61

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 75 | 55 | 600 | 1319.8 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 105.29 | 108.22 | 179.87 | 528.35 | 2208.3 | 55.00 | 2263.31 |
| 9:00 | 125.88 | 125.30 | 233.48 | 528.35 | 2245.9 | 55.00 | 2300.98 |
| 10:00 | 149.92 | 125.30 | 296.09 | 528.35 | 2270.0 | 55.00 | 2325.03 |
| 11:00 | 175.69 | 125.30 | 363.20 | 528.35 | 2295.8 | 55.00 | 2350.80 |
| 12:00 | 201.46 | 128.15 | 430.30 | 528.35 | 2324.4 | 55.00 | 2379.41 |
| 13:00 | 225.51 | 392.99 | 492.91 | 528.35 | 2613.3 | 55.00 | 2668.30 |
| 14:00 | 246.10 | 654.99 | 546.53 | 528.35 | 2895.8 | 55.00 | 2950.89 |
| 15:00 | 262.04 | 808.77 | 588.03 | 528.35 | 3065.6 | 55.00 | 3120.61 |
| 16:00 | 271.34 | 808.77 | 612.25 | 528.35 | 3074.9 | 55.00 | 3129.90 |
| 17:00 | 275.32 | 674.92 | 622.62 | 528.35 | 2945.0 | 55.00 | 3000.04 |

# Room 1-62

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 750.00 | 550.00 | 1,200.00 | 2,416.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 243.41 | 558.43 | 891.07 | 2,617.44 | 5,167.8 | 550.00 | 5,717.8 |
| 9:00 | 279.85 | 583.70 | 1,156.68 | 2,617.44 | 5,229.5 | 550.00 | 5,779.5 |
| 10:00 | 322.40 | 507.94 | 1,466.84 | 2,617.44 | 5,196.3 | 550.00 | 5,746.3 |
| 11:00 | 368.01 | 380.27 | 1,799.28 | 2,617.44 | 5,114.2 | 550.00 | 5,664.2 |
| 12:00 | 413.62 | 265.23 | 2,131.72 | 2,617.44 | 5,044.8 | 550.00 | 5,594.8 |
| 13:00 | 456.17 | 642.77 | 2,441.88 | 2,617.44 | 5,464.9 | 550.00 | 6,014.9 |
| 14:00 | 492.61 | 1,030.1 | 2,707.49 | 2,617.44 | 5,888.7 | 550.00 | 6,438.7 |
| 15:00 | 520.82 | 1,25749 | 2,913.12 | 2,617.44 | 6,144.3 | 550.00 | 6,694.3 |
| 16:00 | 537.28 | 1,249.0 | 3,033.07 | 2,617.44 | 6,152.3 | 550.00 | 6,702.3 |
| 17:00 | 544.33 | 1,042.7 | 3,084.48 | 2,617.44 | 5,953.1 | 550.00 | 6,503.1 |

# Room 1-63

### Variation of load with Time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 225.00 | 165.00 | 400.00 | 1234.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 216.51 | 1214.11 | 436.80 | 1283.07 | 3289.62 | 165.00 | 3454.62 |
| 9:00 | 239.18 | 915.52 | 567.00 | 1283.07 | 3013.70 | 165.00 | 3178.70 |
| 10:00 | 265.65 | 530.99 | 719.05 | 1283.07 | 2655.65 | 165.00 | 2820.65 |
| 11:00 | 294.03 | 194.21 | 882.01 | 1283.07 | 2347.24 | 165.00 | 2512.24 |
| 12:00 | 322.40 | 134.29 | 1044.97 | 1283.07 | 2315.69 | 165.00 | 2480.69 |
| 13:00 | 348.87 | 132.59 | 1197.01 | 1283.07 | 2340.46 | 165.00 | 2505.46 |
| 14:00 | 371.54 | 132.59 | 1327.21 | 1283.07 | 2363.13 | 165.00 | 2528.13 |
| 15:00 | 389.09 | 132.59 | 1428.01 | 1283.07 | 2380.68 | 165.00 | 2545.68 |
| 16:00 | 399.33 | 114.51 | 1486.81 | 1283.07 | 2372.84 | 165.00 | 2537.84 |
| 17:00 | 403.72 | 96.43 | 1512.01 | 1283.07 | 2359.15 | 165.00 | 2524.15 |

# Room 1-64

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 300.00 | 220.00 | 500.00 | 730.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 53.07 | 1147.52 | 489.38 | 1437.50 | 2730.58 | 220.00 | 2950.58 |
| 9:00 | 68.89 | 853.64 | 635.25 | 1437.50 | 2452.53 | 220.00 | 2672.53 |
| 10:00 | 87.36 | 484.20 | 805.59 | 1437.50 | 2101.55 | 220.00 | 2321.55 |
| 11:00 | 107.16 | 167.93 | 988.16 | 1437.50 | 1805.08 | 220.00 | 2025.08 |
| 12:00 | 126.95 | 123.15 | 1170.74 | 1437.50 | 1780.10 | 220.00 | 2000.10 |
| 13:00 | 145.42 | 123.15 | 1341.08 | 1437.50 | 1798.57 | 220.00 | 2018.57 |
| 14:00 | 161.24 | 123.15 | 1486.95 | 1437.50 | 1814.39 | 220.00 | 2034.39 |
| 15:00 | 173.49 | 123.15 | 1599.89 | 1437.50 | 1826.64 | 220.00 | 2046.64 |
| 16:00 | 180.63 | 106.36 | 1665.76 | 1437.50 | 1816.99 | 220.00 | 2036.99 |
| 17:00 | 183.69 | 89.56 | 1694.00 | 1437.50 | 1803.26 | 220.00 | 2023.26 |

# Room 1-65

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 0.00 | 0.00 | 300.00 | 110.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 19.07 | 228.50 | 121.95 | 358.22 | 657.57 | 0.00 | 657.57 |
| 9:00 | 24.75 | 222.97 | 158.30 | 358.22 | 657.73 | 0.00 | 657.73 |
| 10:00 | 31.39 | 176.68 | 200.75 | 358.22 | 618.08 | 0.00 | 618.08 |
| 11:00 | 38.51 | 104.44 | 246.24 | 358.22 | 552.94 | 0.00 | 552.94 |
| 12:00 | 45.62 | 41.66 | 291.74 | 358.22 | 497.28 | 0.00 | 497.28 |
| 13:00 | 52.26 | 34.37 | 334.19 | 358.22 | 496.63 | 0.00 | 496.63 |
| 14:00 | 57.94 | 34.37 | 370.54 | 358.22 | 502.32 | 0.00 | 502.32 |
| 15:00 | 62.34 | 34.37 | 398.68 | 358.22 | 506.72 | 0.00 | 506.72 |
| 16:00 | 64.91 | 29.69 | 415.10 | 358.22 | 504.60 | 0.00 | 504.60 |
| 17:00 | 66.01 | 25.00 | 422.13 | 358.22 | 501.01 | 0.00 | 501.01 |

# Room 1-67 , 1-68 , 1-69

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 290.00 | 200.00 | 400.00 | 510.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 33.68 | 52.05 | 356.43 | 1046.98 | 1285.73 | 200.00 | 1485.73 |
| 9:00 | 43.72 | 60.27 | 462.67 | 1046.98 | 1303.99 | 200.00 | 1503.99 |
| 10:00 | 55.45 | 60.27 | 586.74 | 1046.98 | 1315.71 | 200.00 | 1515.71 |
| 11:00 | 68.01 | 60.27 | 719.71 | 1046.98 | 1328.28 | 200.00 | 1528.28 |
| 12:00 | 80.58 | 61.64 | 852.69 | 1046.98 | 1342.22 | 200.00 | 1542.22 |
| 13:00 | 92.30 | 189.02 | 976.75 | 1046.98 | 1481.32 | 200.00 | 1681.32 |
| 14:00 | 102.34 | 315.03 | 1083.00 | 1046.98 | 1617.38 | 200.00 | 1817.38 |
| 15:00 | 110.12 | 389.00 | 1165.25 | 1046.98 | 1699.11 | 200.00 | 1899.11 |
| 16:00 | 114.65 | 389.00 | 1213.23 | 1046.98 | 1703.65 | 200.00 | 1903.65 |
| 17:00 | 116.59 | 324.62 | 1233.79 | 1046.98 | 1641.22 | 200.00 | 1841.22 |

# Room 1-70

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 936.00 | 780.00 | 800.00 | 0.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 71.69 | 106.00 | 1158.39 | 3402.67 | 1913.69 | 780.00 | 2693.69 |
| 9:00 | 93.06 | 122.74 | 1503.68 | 3402.67 | 1951.80 | 780.00 | 2731.80 |
| 10:00 | 118.01 | 122.74 | 1906.89 | 3402.67 | 1976.75 | 780.00 | 2756.75 |
| 11:00 | 144.76 | 122.74 | 2339.06 | 3402.67 | 2003.50 | 780.00 | 2783.50 |
| 12:00 | 171.50 | 125.53 | 2771.23 | 3402.67 | 2033.03 | 780.00 | 2813.03 |
| 13:00 | 196.45 | 384.96 | 3174.44 | 3402.67 | 2317.42 | 780.00 | 3097.42 |
| 14:00 | 217.82 | 641.60 | 3519.73 | 3402.67 | 2595.43 | 780.00 | 3375.43 |
| 15:00 | 234.37 | 792.24 | 3787.06 | 3402.67 | 2762.61 | 780.00 | 3542.61 |
| 16:00 | 244.02 | 792.24 | 3942.99 | 3402.67 | 2772.26 | 780.00 | 3552.26 |
| 17:00 | 248.15 | 661.13 | 4009.82 | 3402.67 | 2645.28 | 780.00 | 3425.28 |

# Room 1- 71

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 290.00 | 200.00 | 400.00 | 510.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 66.35 | 969.99 | 2001.48 | 1046.98 | 2236.35 | 200.00 | 2436.35 |
| 9:00 | 86.13 | 824.82 | 2107.73 | 1046.98 | 2110.95 | 200.00 | 2310.95 |
| 10:00 | 109.23 | 565.67 | 2231.79 | 1046.98 | 1874.90 | 200.00 | 2074.90 |
| 11:00 | 133.98 | 280.26 | 2364.77 | 1046.98 | 1614.25 | 200.00 | 1814.25 |
| 12:00 | 158.74 | 137.49 | 2497.74 | 1046.98 | 1496.23 | 200.00 | 1696.23 |
| 13:00 | 181.84 | 123.29 | 2621.81 | 1046.98 | 1505.13 | 200.00 | 1705.13 |
| 14:00 | 201.61 | 123.29 | 2728.05 | 1046.98 | 1524.91 | 200.00 | 1724.91 |
| 15:00 | 216.93 | 123.29 | 2810.30 | 1046.98 | 1540.22 | 200.00 | 1740.22 |
| 16:00 | 225.86 | 106.48 | 2858.28 | 1046.98 | 1532.34 | 200.00 | 1732.34 |
| 17:00 | 229.69 | 89.67 | 2878.85 | 1046.98 | 1519.35 | 200.00 | 1719.35 |

# Room 1-72 , 1-73

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 290.00 | 200.00 | 400.00 | 510.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 34.35 | 566.86 | 356.43 | 1046.98 | 1801.21 | 200.00 | 2001.21 |
| 9:00 | 44.59 | 421.69 | 462.67 | 1046.98 | 1666.28 | 200.00 | 1866.28 |
| 10:00 | 56.55 | 239.19 | 586.74 | 1046.98 | 1495.74 | 200.00 | 1695.74 |
| 11:00 | 69.36 | 82.96 | 719.71 | 1046.98 | 1352.32 | 200.00 | 1552.32 |
| 12:00 | 82.18 | 60.83 | 852.69 | 1046.98 | 1343.01 | 200.00 | 1543.01 |
| 13:00 | 94.14 | 60.83 | 976.75 | 1046.98 | 1354.97 | 200.00 | 1554.97 |
| 14:00 | 104.38 | 60.83 | 1083.00 | 1046.98 | 1365.21 | 200.00 | 1565.21 |
| 15:00 | 112.30 | 60.83 | 1165.25 | 1046.98 | 1373.14 | 200.00 | 1573.14 |
| 16:00 | 116.93 | 52.54 | 1213.23 | 1046.98 | 1369.47 | 200.00 | 1569.47 |
| 17:00 | 118.91 | 44.24 | 1233.79 | 1046.98 | 1363.15 | 200.00 | 1563.15 |

# Room 1-74

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 290.00 | 200.00 | 400.00 | 510.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 74.70 | 566.86 | 356.43 | 1046.98 | 1841.56 | 200.00 | 2041.56 |
| 9:00 | 85.13 | 421.69 | 462.67 | 1046.98 | 1706.82 | 200.00 | 1906.82 |
| 10:00 | 97.31 | 239.19 | 586.74 | 1046.98 | 1536.50 | 200.00 | 1736.50 |
| 11:00 | 110.37 | 82.96 | 719.71 | 1046.98 | 1393.32 | 200.00 | 1593.32 |
| 12:00 | 123.42 | 60.83 | 852.69 | 1046.98 | 1384.25 | 200.00 | 1584.25 |
| 13:00 | 135.60 | 60.83 | 976.75 | 1046.98 | 1396.43 | 200.00 | 1596.43 |
| 14:00 | 146.03 | 60.83 | 1083.00 | 1046.98 | 1406.86 | 200.00 | 1606.86 |
| 15:00 | 154.10 | 60.83 | 1165.25 | 1046.98 | 1414.94 | 200.00 | 1614.94 |
| 16:00 | 158.82 | 52.54 | 1213.23 | 1046.98 | 1411.35 | 200.00 | 1611.35 |
| 17:00 | 160.83 | 44.24 | 1233.79 | 1046.98 | 1405.08 | 200.00 | 1605.08 |

# Room 1-75

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 500.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 101.79 | 0.00 | 68.49 | 162.37 | 601.79 | 0.00 | 601.79 |
| 9:00 | 124.05 | 0.00 | 88.90 | 162.37 | 624.05 | 0.00 | 624.05 |
| 10:00 | 148.58 | 0.00 | 112.74 | 162.37 | 648.58 | 0.00 | 648.58 |
| 11:00 | 174.23 | 0.00 | 138.29 | 162.37 | 674.23 | 0.00 | 674.23 |
| 12:00 | 199.89 | 0.00 | 163.84 | 162.37 | 699.89 | 0.00 | 699.89 |
| 13:00 | 224.42 | 0.00 | 187.68 | 162.37 | 724.42 | 0.00 | 724.42 |
| 14:00 | 246.67 | 0.00 | 208.09 | 162.37 | 746.67 | 0.00 | 746.67 |
| 15:00 | 265.88 | 0.00 | 223.89 | 162.37 | 765.88 | 0.00 | 765.88 |
| 16:00 | 280.71 | 0.00 | 233.11 | 162.37 | 780.71 | 0.00 | 780.71 |
| 17:00 | 292.06 | 0.00 | 237.06 | 162.37 | 792.06 | 0.00 | 792.06 |

# Waiting Area 1-12 , 1-17 , 1-18 , 1-19

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 3922 | 1941 | 2100 | 760 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 254.40 | 482.76 | 5257.32 | 15442.90 | 7519.16 | 1941.00 | 9460.16 |
| 9:00 | 286.82 | 483.55 | 6824.41 | 15442.90 | 7552.38 | 1941.00 | 9493.38 |
| 10:00 | 324.68 | 392.72 | 8654.37 | 15442.90 | 7499.40 | 1941.00 | 9440.40 |
| 11:00 | 365.26 | 239.65 | 10615.75 | 15442.90 | 7386.91 | 1941.00 | 9327.91 |
| 12:00 | 405.84 | 98.00 | 12577.14 | 15442.90 | 7285.83 | 1941.00 | 9226.83 |
| 13:00 | 443.70 | 92.31 | 14407.09 | 15442.90 | 7318.01 | 1941.00 | 9259.01 |
| 14:00 | 476.12 | 104.51 | 15974.18 | 15442.90 | 7362.63 | 1941.00 | 9303.63 |
| 15:00 | 501.22 | 111.68 | 17187.41 | 15442.90 | 7394.89 | 1941.00 | 9335.89 |
| 16:00 | 515.86 | 101.58 | 17895.12 | 15442.90 | 7399.44 | 1941.00 | 9340.44 |
| 17:00 | 522.13 | 85.26 | 18198.43 | 15442.90 | 7389.39 | 1941.00 | 9330.39 |

# Waiting Area 1-22 , 1- 54

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 6965 | 3395 | 4650 | 1110 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 189.206 | 0 | 9356.26 | 27483.12 | 12914.21 | 3395.00 | 16309.21 |
| 9:00 | 189.206 | 0 | 12145.14 | 27483.12 | 12914.21 | 3395.00 | 16309.21 |
| 10:00 | 189.206 | 0 | 15401.84 | 27483.12 | 12914.21 | 3395.00 | 16309.21 |
| 11:00 | 189.206 | 0 | 18892.44 | 27483.12 | 12914.21 | 3395.00 | 16309.21 |
| 12:00 | 189.206 | 0 | 22383.04 | 27483.12 | 12914.21 | 3395.00 | 16309.21 |
| 13:00 | 189.206 | 0 | 25639.74 | 27483.12 | 12914.21 | 3395.00 | 16309.21 |
| 14:00 | 189.206 | 0 | 28428.62 | 27483.12 | 12914.21 | 3395.00 | 16309.21 |
| 15:00 | 189.206 | 0 | 30587.76 | 27483.12 | 12914.21 | 3395.00 | 16309.21 |
| 16:00 | 189.206 | 0 | 31847.26 | 27483.12 | 12914.21 | 3395.00 | 16309.21 |
| 17:00 | 189.206 | 0 | 32387.04 | 27483.12 | 12914.21 | 3395.00 | 16309.21 |

# Waiting Area 1-66 , 1-10 , 1-40

### Variation Of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 219 | 177 | 1540 | 130 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 577.96 | 49.73 | 1364.03 | 4006.70 | 2516.69 | 177.00 | 2693.69 |
| 9:00 | 609.17 | 57.58 | 1770.61 | 4006.70 | 2555.74 | 177.00 | 2732.74 |
| 10:00 | 645.61 | 57.58 | 2245.40 | 4006.70 | 2592.18 | 177.00 | 2769.18 |
| 11:00 | 684.66 | 57.58 | 2754.29 | 4006.70 | 2631.24 | 177.00 | 2808.24 |
| 12:00 | 723.72 | 69.74 | 3263.17 | 4006.70 | 2682.45 | 177.00 | 2859.45 |
| 13:00 | 760.16 | 173.35 | 3737.96 | 4006.70 | 2822.51 | 177.00 | 2999.51 |
| 14:00 | 791.36 | 295.68 | 4144.55 | 4006.70 | 2976.04 | 177.00 | 3153.04 |
| 15:00 | 815.52 | 374.04 | 4459.32 | 4006.70 | 3078.56 | 177.00 | 3255.56 |
| 16:00 | 829.61 | 383.31 | 4642.94 | 4006.70 | 3101.92 | 177.00 | 3278.92 |
| 17:00 | 835.65 | 328.76 | 4721.63 | 4006.70 | 3053.41 | 177.00 | 3230.41 |

# Room 1-44 ,1-43

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 441 | 390 | 900 | 1220 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 24.13 | 372.08 | 552.72 | 1904.40 | 2957.21 | 390.00 | 3347.2 |
| 9:00 | 31.32 | 276.79 | 717.47 | 1904.40 | 2869.11 | 390.00 | 3259.1 |
| 10:00 | 39.72 | 157.00 | 909.86 | 1904.40 | 2757.72 | 390.00 | 3147.7 |
| 11:00 | 48.72 | 54.45 | 1116.07 | 1904.40 | 2664.17 | 390.00 | 3054.1 |
| 12:00 | 57.72 | 39.93 | 1322.27 | 1904.40 | 2658.65 | 390.00 | 3048.6 |
| 13:00 | 66.12 | 39.93 | 1514.66 | 1904.40 | 2667.05 | 390.00 | 3057.0 |
| 14:00 | 73.31 | 39.93 | 1679.42 | 1904.40 | 2674.24 | 390.00 | 3064.2 |
| 15:00 | 78.88 | 39.93 | 1806.97 | 1904.40 | 2679.81 | 390.00 | 3069.8 |
| 16:00 | 82.13 | 157.00 | 1881.37 | 1904.40 | 2800.13 | 390.00 | 3190.1 |
| 17:00 | 83.52 | 29.04 | 1913.26 | 1904.40 | 2673.56 | 390.00 | 3063.5 |

# Room 1-47 , 1-48

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequ s | Qequ l |
|---|---|---|---|---|
| 441 | 390 | 900 | 1330 | 0 |

| TIME | Qwall S | Qsun S | Qven S | Qvent l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 164.29 | 468.19 | 534.64 | 1842.12 | 3303.4 | 390.00 | 3693.48 |
| 9:00 | 197.00 | 348.29 | 694.01 | 1842.12 | 3216.2 | 390.00 | 3606.29 |
| 10:00 | 235.20 | 197.55 | 880.10 | 1842.12 | 3103.7 | 390.00 | 3493.75 |
| 11:00 | 276.14 | 68.52 | 1079.5 | 1842.12 | 3015.6 | 390.00 | 3405.66 |
| 12:00 | 317.08 | 50.25 | 1279.0 | 1842.12 | 3038.3 | 390.00 | 3428.33 |
| 13:00 | 355.28 | 50.25 | 1465.1 | 1842.12 | 3076.5 | 390.00 | 3466.53 |
| 14:00 | 387.99 | 50.25 | 1624.4 | 1842.12 | 3109.2 | 390.00 | 3499.24 |
| 15:00 | 413.32 | 50.25 | 1747.8 | 1842.12 | 3134.5 | 390.00 | 3524.57 |
| 16:00 | 428.09 | 43.39 | 1819.8 | 1842.12 | 3142.4 | 390.00 | 3532.49 |
| 17:00 | 434.42 | 36.54 | 1850.6 | 1842.12 | 3141.9 | 390.00 | 3531.97 |

# Room 1-53 ,1-52

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 220 | 155 | 300 | 596 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 8:00 | 50.0676 | 59.3640 | 267.3216 | 921.06 | 1225.43 | 155 | 1380.4 |
| 9:00 | 64.9916 | 68.7373 | 347.004 | 921.06 | 1249.72 | 155 | 1404. |
| 10:00 | 82.41897 | 68.7373 | 440.0525 | 921.06 | 1267.15 | 155 | 1422.1 |
| 11:00 | 101.098 | 68.73731 | 539.784 | 921.06 | 1285.83 | 155 | 1440.83 |
| 12:00 | 119.7771 | 70.29952 | 639.5155 | 921.06 | 1306.07 | 155 | 1461.07 |
| 13:00 | 137.204 | 215.585 | 732.564 | 921.06 | 1468.79 | 155 | 1623.79 |
| 14:00 | 152.128 | 359.308 | 812.2464 | 921.06 | 1627.43 | 155 | 1782.43 |
| 15:00 | 163.682 | 443.668 | 873.936 | 921.06 | 1723.35 | 155 | 1878.35 |
| 16:00 | 170.422 | 443.668 | 909.921 | 921.06 | 1730.09 | 155 | 1885.09 |
| 17:00 | 173.310 | 370.244 | 925.34 | 921.06 | 1659.55 | 155 | 1814.55 |

# 1st floorTotal Load calculations

| TIME | TRSH | TRLH | TRTH | RSHF |
|---|---|---|---|---|
| 8:00 | 67733.71 | 11539 | 79272.71 | 0.85 |
| 9:00 | 66750.09 | 11539 | 78289.09 | 0.85 |
| 10:00 | 65018.93 | 11539 | 76557.93 | 0.85 |
| 11:00 | 63400.21 | 11539 | 74939.21 | 0.85 |
| 12:00 | 63290.67 | 11539 | 74829.67 | 0.85 |
| 1:00 | 65696.75 | 11539 | 77235.75 | 0.85 |
| 2:00 | 68118.34 | 11539 | 79657.34 | 0.86 |
| 3:00 | 69631.51 | 11539 | 81170.51 | 0.86 |
| 4:00 | 69844.4 | 11539 | 81383.4 | 0.86 |
| 5:00 | 68681.64 | 11539 | 80220.64 | 0.86 |

| TIME | Qvent_s | Qvent_l | Qvent_T |
|---|---|---|---|
| 8:00 | 27247.43 | 76306.5 | 103553.9 |
| 9:00 | 34878.9 | 76306.5 | 111185.4 |
| 10:00 | 43790.5 | 76306.5 | 120097 |
| 11:00 | 53342.15 | 76306.5 | 129648.7 |
| 12:00 | 62893.8 | 76306.5 | 139200.3 |
| 1:00 | 71805.4 | 76306.5 | 148111.9 |
| 2:00 | 79436.87 | 76306.5 | 155743.4 |
| 3:00 | 85345.11 | 76306.5 | 161651.6 |
| 4:00 | 88791.58 | 76306.5 | 165098.1 |
| 5:00 | 90268.64 | 76306.5 | 166575.2 |

| TIME | GRSH | GRLH | GRTH | GRSHF |
|---|---|---|---|---|
| 8:00 | 94981.14 | 87845.5 | 182826.6 | 0.52 |
| 9:00 | 101629 | 87845.5 | 189474.5 | 0.54 |
| 10:00 | 108809.4 | 87845.5 | 196654.9 | 0.55 |
| 11:00 | 116742.4 | 87845.5 | 204587.9 | 0.57 |
| 12:00 | 126184.5 | 87845.5 | 214030 | 0.59 |
| 1:00 | 137502.1 | 87845.5 | 225347.7 | 0.61 |
| 2:00 | 147555.2 | 87845.5 | 235400.7 | 0.63 |
| 3:00 | 154976.6 | 87845.5 | 242822.1 | 0.64 |
| 4:00 | 158636 | 87845.5 | 246481.5 | 0.64 |
| 5:00 | 158950.3 | 87845.5 | 246795.8 | 0.64 |

**The max load occures at 5:00 PM and its value equals:**

| TIME | TRSH (W) | TRLH (W) | TRTH (W) | RSHF |
|---|---|---|---|---|
| 5:00 | 68681.64 | 11539 | 80220.64 | 0.86 |

| TIME | Qvent_s (W) | Qvent_l (W) | Qvent_T (W) |
|---|---|---|---|
| 2:00 | 90268.64 | 76306.5 | 166575.2 |

| TIME | ERSH (W) | ERLH (W) | ERTH(W) | ERSHF |
|---|---|---|---|---|
| 2:00 | 94859.5 | 33667.9 | 128527.4 | 0.74 |

| TIME | GRSH(W) | GRLH(W) | GRTH(W) | GRSHF |
|---|---|---|---|---|
| 2:00 | 158950.3 | 87845.5 | 246795.8 | 0.64 |

| Time | GTH (KW) | GTH (HP) | GTH (TR) |
|---|---|---|---|
| 2:00 | 246.80 | 330.71 | 70.51 |

# 2nd floor calculation

## Corridor 2-10

### Variation of load with Time

| Qocc-s | Qocc-l | Ql-s | Qeq-s | Qeq-l |
|---|---|---|---|---|
| 942.00 | 521.00 | 2096.00 | 0.00 | 0.00 |

| Time | Qw-s | Qsun-s | Qvent-s | Qvent-l | Qs tot | Ql tot |
|---|---|---|---|---|---|---|
| 08:00 | 119.63 | 1923.39 | 2305.92 | 6773.41 | 5081.02 | 521 |
| 09:00 | 155.29 | 1923.39 | 2993.26 | 6773.41 | 5116.68 | 521 |
| 10:00 | 196.93 | 1557.67 | 3795.89 | 6773.41 | 4792.61 | 521 |
| 11:00 | 241.57 | 941.38 | 4656.18 | 6773.41 | 4220.94 | 521 |
| 12:00 | 285.28 | 365.71 | 5516.46 | 6773.41 | 3688.99 | 521 |
| 13:00 | 327.84 | 297.99 | 6319.10 | 6773.41 | 3663.83 | 521 |
| 14:00 | 363.50 | 297.99 | 7006.44 | 6773.41 | 3699.49 | 521 |
| 15:00 | 391.11 | 297.99 | 7538.57 | 6773.41 | 3727.10 | 521 |
| 16:00 | 408.13 | 257.35 | 7848.98 | 6773.41 | 3703.49 | 521 |
| 17:00 | 414.11 | 216.72 | 7982.02 | 6773.41 | 3668.83 | 521 |

## Corridor 2-12

### Variation of load with Time

| Qocc-s | Qocc-l | Ql-s | Qeq-s | Qeq-l |
|---|---|---|---|---|
| 144 | 120 | 1316 | 0 | 0 |

| Time | Qw-s | Qsun-s | Qvent-s | Qvent-l | Qs tot | Ql tot (W) |
|---|---|---|---|---|---|---|
| 08:00 | 171.10 | 2804.33 | 453.62 | 1332.46 | 4435.43 | 120 |
| 09:00 | 222.09 | 2086.15 | 588.83 | 1332.46 | 3768.24 | 120 |
| 10:00 | 281.65 | 1183.29 | 746.73 | 1332.46 | 2924.94 | 120 |
| 11:00 | 345.48 | 410.39 | 915.96 | 1332.46 | 2215.87 | 120 |
| 12:00 | 409.31 | 300.95 | 1085.20 | 1332.46 | 2170.26 | 120 |
| 13:00 | 468.87 | 300.95 | 1243.09 | 1332.46 | 2229.82 | 120 |
| 14:00 | 519.87 | 300.95 | 1378.30 | 1332.46 | 2280.82 | 120 |
| 15:00 | 559.35 | 300.95 | 1482.99 | 1332.46 | 2320.30 | 120 |
| 16:00 | 583.70 | 259.91 | 1544.05 | 1332.46 | 2303.61 | 120 |
| 17:00 | 592.25 | 218.87 | 1570.22 | 1332.46 | 2271.13 | 120 |

# Room 2-13

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 66 | 31 | 300 | 0 | 0 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|
| 08:00 | 0 | 0 | 260.31 | 764.63 | 366 | 31 | 397 |
| 09:00 | 0 | 0 | 337.90 | 764.63 | 366 | 31 | 397 |
| 10:00 | 0 | 0 | 428.51 | 764.63 | 366 | 31 | 397 |
| 11:00 | 0 | 0 | 525.62 | 764.63 | 366 | 31 | 397 |
| 12:00 | 0 | 0 | 622.74 | 764.63 | 366 | 31 | 397 |
| 13:00 | 0 | 0 | 713.34 | 764.63 | 366 | 31 | 397 |
| 14:00 | 0 | 0 | 790.93 | 764.63 | 366 | 31 | 397 |
| 15:00 | 0 | 0 | 851.01 | 764.63 | 366 | 31 | 397 |
| 16:00 | 0 | 0 | 886.05 | 764.63 | 366 | 31 | 397 |
| 17:00 | 0 | 0 | 901.06 | 764.63 | 366 | 31 | 397 |

# Room 2-15

### Variation of loads with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 66 | 31 | 300 | 0 | 0 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|
| 08:00 | 0 | 0 | 260.31 | 764.63 | 366 | 31 | 397 |
| 09:00 | 0 | 0 | 337.90 | 764.63 | 366 | 31 | 397 |
| 10:00 | 0 | 0 | 428.51 | 764.63 | 366 | 31 | 397 |
| 11:00 | 0 | 0 | 525.62 | 764.63 | 366 | 31 | 397 |
| 12:00 | 0 | 0 | 622.74 | 764.63 | 366 | 31 | 397 |
| 13:00 | 0 | 0 | 713.34 | 764.63 | 366 | 31 | 397 |
| 14:00 | 0 | 0 | 790.93 | 764.63 | 366 | 31 | 397 |
| 15:00 | 0 | 0 | 851.01 | 764.63 | 366 | 31 | 397 |
| 16:00 | 0 | 0 | 886.05 | 764.63 | 366 | 31 | 397 |
| 17:00 | 0 | 0 | 901.06 | 764.63 | 366 | 31 | 397 |

# Room 2-18

## Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 144 | 120 | 200 | 0 | 0 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|
| 08:00 | 0 | 0 | 178.2144 | 523.488 | 344 | 120 | 464 |
| 09:00 | 0 | 0 | 231.336 | 523.488 | 344 | 120 | 464 |
| 10:00 | 0 | 0 | 293.36832 | 523.488 | 344 | 120 | 464 |
| 11:00 | 0 | 0 | 359.856 | 523.488 | 344 | 120 | 464 |
| 12:00 | 0 | 0 | 426.34368 | 523.488 | 344 | 120 | 464 |
| 13:00 | 0 | 0 | 488.376 | 523.488 | 344 | 120 | 464 |
| 14:00 | 0 | 0 | 541.4976 | 523.488 | 344 | 120 | 464 |
| 15:00 | 0 | 0 | 582.624 | 523.488 | 344 | 120 | 464 |
| 16:00 | 0 | 0 | 606.6144 | 523.488 | 344 | 120 | 464 |
| 17:00 | 0 | 0 | 616.896 | 523.488 | 344 | 120 | 464 |

# Room 2-20

## Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 144 | 120 | 300 | 0 | 0 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|
| 08:00 | 0 | 0 | 223.74 | 657.21 | 444 | 120 | 564 |
| 09:00 | 0 | 0 | 290.43 | 657.21 | 444 | 120 | 564 |
| 10:00 | 0 | 0 | 368.31 | 657.21 | 444 | 120 | 564 |
| 11:00 | 0 | 0 | 451.78 | 657.21 | 444 | 120 | 564 |
| 12:00 | 0 | 0 | 535.25 | 657.21 | 444 | 120 | 564 |
| 13:00 | 0 | 0 | 613.13 | 657.21 | 444 | 120 | 564 |
| 14:00 | 0 | 0 | 679.82 | 657.21 | 444 | 120 | 564 |
| 15:00 | 0 | 0 | 731.45 | 657.21 | 444 | 120 | 564 |
| 16:00 | 0 | 0 | 761.57 | 657.21 | 444 | 120 | 564 |
| 17:00 | 0 | 0 | 774.48 | 657.21 | 444 | 120 | 564 |

# Room 2-41

### Variation of load with time

| Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|
| 60 | 200 | 0 | 0 |

| Time | Qwall_S | Qsun_S | Qvent_S | Qvent _l | Qocc_s | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|---|
| 08:00 | 62.86 | 299.39 | 38.59 | 113.35 | 72.00 | 634.25 | 60.00 | 694.25 |
| 09:00 | 81.60 | 223.68 | 50.09 | 113.35 | 72.00 | 577.27 | 60.00 | 637.27 |
| 10:00 | 103.48 | 128.04 | 63.52 | 113.35 | 72.00 | 503.52 | 60.00 | 563.52 |
| 11:00 | 126.93 | 46.17 | 77.92 | 113.35 | 72.00 | 445.09 | 60.00 | 505.09 |
| 12:00 | 150.38 | 34.57 | 92.32 | 113.35 | 72.00 | 456.95 | 60.00 | 516.95 |
| 13:00 | 172.26 | 35.55 | 105.75 | 113.35 | 72.00 | 479.81 | 60.00 | 539.81 |
| 14:00 | 191.00 | 42.47 | 117.25 | 113.35 | 72.00 | 505.47 | 60.00 | 565.47 |
| 15:00 | 205.50 | 50.86 | 126.15 | 113.35 | 72.00 | 528.36 | 60.00 | 588.36 |
| 16:00 | 214.45 | 52.63 | 131.35 | 113.35 | 72.00 | 539.08 | 60.00 | 599.08 |
| 17:00 | 217.59 | 50.00 | 133.58 | 113.35 | 72.00 | 539.59 | 60.00 | 599.59 |

# Room 2-42

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 72 | 60 | 200 | 0 | 0 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|
| 08:00 | 0 | 0 | 76.377 | 224.352 | 272 | 60 | 332 |
| 09:00 | 0 | 0 | 99.144 | 224.352 | 272 | 60 | 332 |
| 10:00 | 0 | 0 | 125.729 | 224.352 | 272 | 60 | 332 |
| 11:00 | 0 | 0 | 154.224 | 224.352 | 272 | 60 | 332 |
| 12:00 | 0 | 0 | 182.718 | 224.352 | 272 | 60 | 332 |
| 13:00 | 0 | 0 | 209.304 | 224.352 | 272 | 60 | 332 |
| 14:00 | 0 | 0 | 232.070 | 224.352 | 272 | 60 | 332 |
| 15:00 | 0 | 0 | 249.696 | 224.352 | 272 | 60 | 332 |
| 16:00 | 0 | 0 | 259.977 | 224.352 | 272 | 60 | 332 |
| 17:00 | 0 | 0 | 264.384 | 224.352 | 272 | 60 | 332 |

# Room 2-43

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 216.00 | 180.00 | 800.00 | 0.00 | 0.00 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|
| 8:00 | 0.00 | 0.00 | 304.80 | 895.31 | 1016.00 | 180.00 | 1196.00 |
| 9:00 | 0.00 | 0.00 | 395.65 | 895.31 | 1016.00 | 180.00 | 1196.00 |
| 10:00 | 0.00 | 0.00 | 501.74 | 895.31 | 1016.00 | 180.00 | 1196.00 |
| 11:00 | 0.00 | 0.00 | 615.45 | 895.31 | 1016.00 | 180.00 | 1196.00 |
| 12:00 | 0.00 | 0.00 | 729.17 | 895.31 | 1016.00 | 180.00 | 1196.00 |
| 13:00 | 0.00 | 0.00 | 835.26 | 895.31 | 1016.00 | 180.00 | 1196.00 |
| 14:00 | 0.00 | 0.00 | 926.11 | 895.31 | 1016.00 | 180.00 | 1196.00 |
| 15:00 | 0.00 | 0.00 | 996.45 | 895.31 | 1016.00 | 180.00 | 1196.00 |
| 16:00 | 0.00 | 0.00 | 1037.48 | 895.31 | 1016.00 | 180.00 | 1196.00 |
| 17:00 | 0.00 | 0.00 | 1055.06 | 895.31 | 1016.00 | 180.00 | 1196.00 |

# Room 2-45

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 72.00 | 60.00 | 200.00 | 0.00 | 0.00 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|
| 8:00 | 0.00 | 0.00 | 76.38 | 224.35 | 272.00 | 60.00 | 332.00 |
| 9:00 | 0.00 | 0.00 | 99.14 | 224.35 | 272.00 | 60.00 | 332.00 |
| 10:00 | 0.00 | 0.00 | 125.73 | 224.35 | 272.00 | 60.00 | 332.00 |
| 11:00 | 0.00 | 0.00 | 154.22 | 224.35 | 272.00 | 60.00 | 332.00 |
| 12:00 | 0.00 | 0.00 | 182.72 | 224.35 | 272.00 | 60.00 | 332.00 |
| 13:00 | 0.00 | 0.00 | 209.30 | 224.35 | 272.00 | 60.00 | 332.00 |
| 14:00 | 0.00 | 0.00 | 232.07 | 224.35 | 272.00 | 60.00 | 332.00 |
| 15:00 | 0.00 | 0.00 | 249.70 | 224.35 | 272.00 | 60.00 | 332.00 |
| 16:00 | 0.00 | 0.00 | 259.98 | 224.35 | 272.00 | 60.00 | 332.00 |
| 17:00 | 0.00 | 0.00 | 264.38 | 224.35 | 272.00 | 60.00 | 332.00 |

## Room 2-46

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 288.00 | 240.00 | 200.00 | 0.00 | 0.00 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|
| 8:00 | 0.00 | 0.00 | 356.43 | 1046.98 | 488.00 | 240.00 | 728.00 |
| 9:00 | 0.00 | 0.00 | 462.67 | 1046.98 | 488.00 | 240.00 | 728.00 |
| 10:00 | 0.00 | 0.00 | 586.74 | 1046.98 | 488.00 | 240.00 | 728.00 |
| 11:00 | 0.00 | 0.00 | 719.71 | 1046.98 | 488.00 | 240.00 | 728.00 |
| 12:00 | 0.00 | 0.00 | 852.69 | 1046.98 | 488.00 | 240.00 | 728.00 |
| 13:00 | 0.00 | 0.00 | 976.75 | 1046.98 | 488.00 | 240.00 | 728.00 |
| 14:00 | 0.00 | 0.00 | 1083.00 | 1046.98 | 488.00 | 240.00 | 728.00 |
| 15:00 | 0.00 | 0.00 | 1165.25 | 1046.98 | 488.00 | 240.00 | 728.00 |
| 16:00 | 0.00 | 0.00 | 1213.23 | 1046.98 | 488.00 | 240.00 | 728.00 |
| 17:00 | 0.00 | 0.00 | 1233.79 | 1046.98 | 488.00 | 240.00 | 728.00 |

## Room 2-47

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 360.00 | 300.00 | 300.00 | 0.00 | 0.00 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|
| 0.33 | 0.00 | 0.00 | 445.54 | 1308.72 | 660.00 | 300.00 | 960.00 |
| 0.38 | 0.00 | 0.00 | 578.34 | 1308.72 | 660.00 | 300.00 | 960.00 |
| 0.42 | 0.00 | 0.00 | 733.42 | 1308.72 | 660.00 | 300.00 | 960.00 |
| 0.46 | 0.00 | 0.00 | 899.64 | 1308.72 | 660.00 | 300.00 | 960.00 |
| 0.50 | 0.00 | 0.00 | 1065.86 | 1308.72 | 660.00 | 300.00 | 960.00 |
| 0.54 | 0.00 | 0.00 | 1220.94 | 1308.72 | 660.00 | 300.00 | 960.00 |
| 0.58 | 0.00 | 0.00 | 1353.74 | 1308.72 | 660.00 | 300.00 | 960.00 |
| 0.63 | 0.00 | 0.00 | 1456.56 | 1308.72 | 660.00 | 300.00 | 960.00 |
| 0.67 | 0.00 | 0.00 | 1516.54 | 1308.72 | 660.00 | 300.00 | 960.00 |
| 0.71 | 0.00 | 0.00 | 1542.24 | 1308.72 | 660.00 | 300.00 | 960.00 |

## Room 2-48

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 198 | 93 | 300 | 0 | 0 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|
| 08:00 | 23.08 | 74.18 | 253.52 | 744.70 | 595.25 | 93.00 | 688.25 |
| 09:00 | 29.96 | 55.18 | 329.09 | 744.70 | 583.14 | 93.00 | 676.14 |
| 10:00 | 37.99 | 31.30 | 417.34 | 744.70 | 567.29 | 93.00 | 660.29 |
| 11:00 | 52.00 | 10.85 | 511.92 | 744.70 | 560.85 | 93.00 | 653.85 |
| 12:00 | 60.25 | 7.96 | 606.50 | 744.70 | 566.21 | 93.00 | 659.21 |
| 13:00 | 55.59 | 7.96 | 694.75 | 744.70 | 561.55 | 93.00 | 654.55 |
| 14:00 | 70.12 | 7.96 | 770.32 | 744.70 | 576.08 | 93.00 | 669.08 |
| 15:00 | 75.45 | 7.96 | 828.82 | 744.70 | 581.41 | 93.00 | 674.41 |
| 16:00 | 78.73 | 6.87 | 862.95 | 744.70 | 583.61 | 93.00 | 676.61 |
| 17:00 | 79.88 | 5.79 | 877.57 | 744.70 | 583.67 | 93.00 | 676.67 |

## Room 2-49

### Variation of load with Time

| Qocc-s | Qocc-l | Ql-s | Qeq-s | Qeq-l |
|---|---|---|---|---|
| 6168.00 | 4468.00 | 3000.00 | 56000.00 | 0.00 |

| Time | Qw-s | Qsun-s | Qvent-s | Qvent-l | Qs tot | Ql tot | Q tot |
|---|---|---|---|---|---|---|---|
| 08:00 | 257 | 343 | 7841 | 23033 | 65768 | 4468 | 70236 |
| 09:00 | 333 | 397 | 10179 | 23033 | 65899 | 4468 | 70367 |
| 10:00 | 422 | 397 | 12908 | 23033 | 65988 | 4468 | 70456 |
| 11:00 | 518 | 397 | 23033 | 23033 | 66084 | 4468 | 70552 |
| 12:00 | 612 | 488 | 18759 | 23033 | 66268 | 4468 | 70736 |
| 13:00 | 703 | 1246 | 21489 | 23033 | 67118 | 4468 | 71586 |
| 14:00 | 780 | 2077 | 23826 | 23033 | 68025 | 4468 | 72493 |
| 15:00 | 839 | 2565 | 25635 | 23033 | 68572 | 4468 | 73040 |
| 16:00 | 876 | 2565 | 26691 | 23033 | 68608 | 4468 | 73076 |
| 17:00 | 888 | 2140 | 27143 | 23033 | 68197 | 4468 | 72665 |

# Room 2-50

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 210 | 151 | 300 | 55 | 0 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|
| 08:00 | 0 | 0 | 296.41 | 870.67 | 565 | 151 | 716 |
| 09:00 | 0 | 0 | 384.76 | 870.67 | 565 | 151 | 716 |
| 10:00 | 0 | 0 | 487.93 | 870.67 | 565 | 151 | 716 |
| 11:00 | 0 | 0 | 598.51 | 870.67 | 565 | 151 | 716 |
| 12:00 | 0 | 0 | 709.09 | 870.67 | 565 | 151 | 716 |
| 13:00 | 0 | 0 | 812.27 | 870.67 | 565 | 151 | 716 |
| 14:00 | 0 | 0 | 900.62 | 870.67 | 565 | 151 | 716 |
| 15:00 | 0 | 0 | 969.02 | 870.67 | 565 | 151 | 716 |
| 16:00 | 0 | 0 | 1008.92 | 870.67 | 565 | 151 | 716 |
| 17:00 | 0 | 0 | 1026.02 | 870.67 | 565 | 151 | 716 |

# Room 2-51

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 210 | 151 | 300 | 55 | 0 |

| Time | Qwall_S | Qsun_S | Qvent _S | Qvent _l | QTOT_S | QTOT_l | QTOT |
|---|---|---|---|---|---|---|---|
| 08:00 | 0 | 0 | 315.87 | 927.83 | 565 | 151 | 716 |
| 09:00 | 0 | 0 | 410.02 | 927.83 | 565 | 151 | 716 |
| 10:00 | 0 | 0 | 519.97 | 927.83 | 565 | 151 | 716 |
| 11:00 | 0 | 0 | 637.81 | 927.83 | 565 | 151 | 716 |
| 12:00 | 0 | 0 | 755.65 | 927.83 | 565 | 151 | 716 |
| 13:00 | 0 | 0 | 865.60 | 927.83 | 565 | 151 | 716 |
| 14:00 | 0 | 0 | 959.75 | 927.83 | 565 | 151 | 716 |
| 15:00 | 0 | 0 | 1032.64 | 927.83 | 565 | 151 | 716 |
| 16:00 | 0 | 0 | 1075.16 | 927.83 | 565 | 151 | 716 |
| 17:00 | 0 | 0 | 1093.39 | 927.83 | 565 | 151 | 716 |

# Room 2-52

### Variation of load with Time

| Qocc-s | Qocc-l | Ql-s | Qeq-s | Qeq-l |
|---|---|---|---|---|
| 420 | 302 | 300 | 55 | 0 |

| Time | Qw-s | Qsun-s | Qvent-s | Qvent-l | Qs tot | Ql tot (W) | Q tot |
|---|---|---|---|---|---|---|---|
| 08:00 | 31.42 | 49.00 | 534.64 | 1570.46 | 855.43 | 302.00 | 1157.43 |
| 09:00 | 40.79 | 56.74 | 694.01 | 1570.46 | 872.53 | 302.00 | 1174.53 |
| 10:00 | 51.72 | 56.74 | 880.10 | 1570.46 | 883.47 | 302.00 | 1185.47 |
| 11:00 | 63.45 | 56.74 | 1079.57 | 1570.46 | 895.19 | 302.00 | 1197.19 |
| 12:00 | 74.93 | 69.64 | 1279.03 | 1570.46 | 919.56 | 302.00 | 1221.56 |
| 13:00 | 86.10 | 177.96 | 1465.13 | 1570.46 | 1039.07 | 302.00 | 1341.07 |
| 14:00 | 95.47 | 296.61 | 1624.49 | 1570.46 | 1167.08 | 302.00 | 1469.08 |
| 15:00 | 102.72 | 366.24 | 1747.87 | 1570.46 | 1243.97 | 302.00 | 1545.97 |
| 16:00 | 107.19 | 366.24 | 1819.84 | 1570.46 | 1248.44 | 302.00 | 1550.44 |
| 17:00 | 108.76 | 305.63 | 1850.69 | 1570.46 | 1189.40 | 302.00 | 1491.40 |

# Room 2-53

### Variation of load with Time

| Qocc-s | Qocc-l | Ql-s | Qeq-s | Qeq-l |
|---|---|---|---|---|
| 354.00 | 271.00 | 400.00 | 55.00 | 0.00 |

| Time | Qw-s | Qsun-s | Qvent-s | Qvent-l | Qs tot | Ql tot |
|---|---|---|---|---|---|---|
| 08:00 | 39.07 | 50.87 | 445.54 | 1308.72 | 898.93 | 271 |
| 09:00 | 51.09 | 59.06 | 578.34 | 1308.72 | 919.15 | 271 |
| 10:00 | 64.79 | 59.06 | 733.42 | 1308.72 | 932.85 | 271 |
| 11:00 | 79.47 | 59.06 | 899.64 | 1308.72 | 947.53 | 271 |
| 12:00 | 93.85 | 72.48 | 1065.86 | 1308.72 | 975.33 | 271 |
| 13:00 | 185.23 | 185.23 | 1220.94 | 1308.72 | 1179.46 | 271 |
| 14:00 | 118.70 | 307.88 | 1353.74 | 1308.72 | 1235.58 | 271 |
| 15:00 | 127.72 | 380.16 | 1456.56 | 1308.72 | 1316.88 | 271 |
| 16:00 | 133.28 | 380.16 | 1516.54 | 1308.72 | 1322.44 | 271 |
| 17:00 | 135.23 | 317.25 | 1542.24 | 1308.72 | 1261.48 | 271 |

# Room 2-54

### Variation of load with Time

| Qocc-s | Qocc-l | Ql-s | Qeq-s | Qeq-l |
|---|---|---|---|---|
| 288 | 240 | 300 | 0 | 0 |

| Time | Qw-s | Qsun-s | Qvent-s | Qvent-l | Qs tot (W) | Ql tot (W) |
|---|---|---|---|---|---|---|
| 08:00 | 92.84 | 480.27 | 305.51 | 897.41 | 1161.11 | 240 |
| 09:00 | 120.51 | 497.07 | 396.58 | 897.41 | 1205.58 | 240 |
| 10:00 | 152.83 | 425.97 | 502.92 | 897.41 | 1166.80 | 240 |
| 11:00 | 244.84 | 306.17 | 616.90 | 897.41 | 1139.01 | 240 |
| 12:00 | 221.39 | 222.25 | 730.87 | 897.41 | 1031.64 | 240 |
| 13:00 | 254.42 | 444.22 | 837.22 | 897.41 | 1286.64 | 240 |
| 14:00 | 282.09 | 701.75 | 502.92 | 897.41 | 1571.84 | 240 |
| 15:00 | 303.52 | 852.91 | 998.78 | 897.41 | 1744.42 | 240 |
| 16:00 | 316.73 | 845.01 | 1039.91 | 897.41 | 1749.73 | 240 |
| 17:00 | 321.37 | 705.54 | 1057.54 | 897.41 | 1614.91 | 240 |

# Room 2-45a

### Variation of load with Time

| Qocc-s | Qocc-l | Ql-s | Qeq-s | Qeq-l |
|---|---|---|---|---|
| 216 | 180 | 200 | 2000.00 | 0 |

| Time | Qw-s | Qsun-s | Qven-s | Qvent-l | Qs tot | Ql tot |
|---|---|---|---|---|---|---|
| 08:00 | 36.50 | 54.82 | 336.47 | 988.35 | 2507.31 | 180 |
| 09:00 | 47.37 | 63.47 | 436.76 | 988.35 | 2526.85 | 180 |
| 10:00 | 60.08 | 63.47 | 553.88 | 988.35 | 2539.55 | 180 |
| 11:00 | 73.69 | 63.47 | 679.41 | 988.35 | 2553.17 | 180 |
| 12:00 | 87.03 | 77.90 | 804.94 | 988.35 | 2580.93 | 180 |
| 13:00 | 100.01 | 199.08 | 922.05 | 988.35 | 2715.09 | 180 |
| 14:00 | 110.89 | 331.80 | 1022.35 | 988.35 | 2858.69 | 180 |
| 15:00 | 119.31 | 409.70 | 1099.99 | 988.35 | 2945.01 | 180 |
| 16:00 | 124.51 | 409.70 | 1145.29 | 988.35 | 2950.20 | 180 |
| 17:00 | 126.33 | 341.89 | 1164.70 | 988.35 | 2884.23 | 180 |

# 2nd floor Total load calculation

| TIME | TRSH | TRLH | TRTH | RSHF |
|---|---|---|---|---|
| 8:00 | 87898.0 | 8640.0 | 96538.0 | 0.91 |
| 9:00 | 86980.5 | 8640.0 | 95620.5 | 0.91 |
| 10:00 | 85581.5 | 8640.0 | 94221.5 | 0.91 |
| 11:00 | 84444.0 | 8640.0 | 93084.0 | 0.91 |
| 12:00 | 84534.9 | 8640.0 | 93174.9 | 0.91 |
| 1:00 | 86220.6 | 8640.0 | 94860.6 | 0.91 |
| 2:00 | 87871.4 | 8640.0 | 96511.4 | 0.91 |
| 3:00 | 88933.5 | 8640.0 | 97573.5 | 0.91 |
| 4:00 | 88977.7 | 8640.0 | 97617.7 | 0.91 |
| 5:00 | 88392.1 | 8640.0 | 101221.9 | 0.87 |

| TIME | Qvent_s | Qvent_l | Qvent_T |
|---|---|---|---|
| 8:00 | 19474.5 | 57204.5 | 76679.0 |
| 9:00 | 25279.4 | 57204.5 | 82483.9 |
| 10:00 | 32058.0 | 57204.5 | 89262.6 |
| 11:00 | 46523.3 | 57204.5 | 103727.8 |
| 12:00 | 46589.0 | 57204.5 | 103793.5 |
| 1:00 | 53367.6 | 57204.5 | 110572.2 |
| 2:00 | 53178.4 | 57204.5 | 110382.9 |
| 3:00 | 63666.6 | 57204.5 | 120871.2 |
| 4:00 | 66288.2 | 57204.5 | 123492.7 |
| 5:00 | 65939.5 | 55955.2 | 121894.6 |

| TIME | GRSH | GRLH | GRTH | GRSHF |
|---|---|---|---|---|
| 8:00 | 107372.5 | 65844.5 | 173217.0 | 0.54 |
| 9:00 | 113177.4 | 65844.5 | 179021.9 | 0.55 |
| 10:00 | 119956.0 | 65844.5 | 185800.5 | 0.56 |
| 11:00 | 134421.3 | 65844.5 | 200265.8 | 0.57 |
| 12:00 | 134487.0 | 65844.5 | 200331.5 | 0.58 |
| 1:00 | 141265.6 | 65844.5 | 207110.1 | 0.60 |
| 2:00 | 141076.4 | 65844.5 | 206920.9 | 0.62 |
| 3:00 | 151564.6 | 65844.5 | 217409.1 | 0.63 |
| 4:00 | 154186.2 | 65844.5 | 220030.7 | 0.63 |
| 5:00 | 153837.4 | 64595.2 | 218432.6 | 0.63 |

**The max load occures at 5:00 PM and its value equals:**

| TIME | TRSH (W) | TRLH (W) | TRTH (W) | RSHF |
|---|---|---|---|---|
| 5:00 | 88392.1 | 8640.0 | 101221.9 | 0.87 |

| TIME | Qvent_s (W) | Qvent l (W) | Qvent_T (W) |
|---|---|---|---|
| 5:00 | 65939.5 | 55955.2 | 121894.6 |

| TIME | ERSH (W) | ERLH (W) | ERTH(W) | ERSHF |
|---|---|---|---|---|
| 5:00 | 107514.6 | 24867.0 | 132381.6 | 0.71 |

| TIME | GRSH(W) | GRLH(W) | GRTH(W) | GRSHF |
|---|---|---|---|---|
| 5:00 | 153837.4 | 64595.2 | 218432.6 | 0.63 |

| Time | GTH (KW) | GTH (HP) | GTH (TR) |
|---|---|---|---|
| 5:00 | 218.43 | 292.70 | 62.41 |

# 3rd floor calculation

## Room 3-40

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 288 | 360 | 600 | 110 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 73.68 | 1243.73 | 302.89 | 889.72 | 2315.41 | 360.00 | 2675.41 |
| 09:00 | 95.64 | 1243.73 | 393.18 | 889.72 | 2337.37 | 360.00 | 2697.37 |
| 10:00 | 121.28 | 1007.25 | 498.61 | 889.72 | 2126.53 | 360.00 | 2486.53 |
| 11:00 | 148.77 | 608.73 | 611.61 | 889.72 | 1755.50 | 360.00 | 2115.50 |
| 12:00 | 175.69 | 236.48 | 722.28 | 889.72 | 1410.17 | 360.00 | 1770.17 |
| 13:00 | 201.90 | 192.69 | 830.04 | 889.72 | 1392.59 | 360.00 | 1752.59 |
| 14:00 | 223.86 | 192.69 | 920.33 | 889.72 | 1414.55 | 360.00 | 1774.55 |
| 15:00 | 240.86 | 192.69 | 990.22 | 889.72 | 1431.55 | 360.00 | 1791.55 |
| 16:00 | 251.35 | 166.41 | 1033.33 | 889.72 | 1415.76 | 360.00 | 1775.76 |
| 17:00 | 140.14 | 140.14 | 1048.47 | 889.72 | 1278.28 | 360.00 | 1638.28 |

## Room 3-41

### Variation of loads with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 216.00 | 270.00 | 150.00 | 110.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 0.00 | 0.00 | 190.94 | 560.88 | 476.00 | 270.00 | 746.00 |
| 09:00 | 0.00 | 0.00 | 247.86 | 560.88 | 476.00 | 270.00 | 746.00 |
| 10:00 | 0.00 | 0.00 | 314.32 | 560.88 | 476.00 | 270.00 | 746.00 |
| 11:00 | 0.00 | 0.00 | 385.56 | 560.88 | 476.00 | 270.00 | 746.00 |
| 12:00 | 0.00 | 0.00 | 455.33 | 560.88 | 476.00 | 270.00 | 746.00 |
| 13:00 | 0.00 | 0.00 | 523.26 | 560.88 | 476.00 | 270.00 | 746.00 |
| 14:00 | 0.00 | 0.00 | 580.18 | 560.88 | 476.00 | 270.00 | 746.00 |
| 15:00 | 0.00 | 0.00 | 624.24 | 560.88 | 476.00 | 270.00 | 746.00 |
| 16:00 | 0.00 | 0.00 | 651.41 | 560.88 | 476.00 | 270.00 | 746.00 |
| 17:00 | 0.00 | 0.00 | 660.96 | 560.88 | 476.00 | 270.00 | 746.00 |

# Room 3-43

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 360 | 300 | 400 | 330 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 24.10 | 502.75 | 318.24 | 934.80 | 1616.85 | 300.00 | 1916.85 |
| 09:00 | 31.28 | 374.00 | 413.10 | 934.80 | 1495.28 | 300.00 | 1795.28 |
| 10:00 | 39.67 | 212.14 | 523.87 | 934.80 | 1341.81 | 300.00 | 1641.81 |
| 11:00 | 48.66 | 73.57 | 642.60 | 934.80 | 1212.23 | 300.00 | 1512.23 |
| 12:00 | 57.46 | 53.95 | 758.88 | 934.80 | 1201.42 | 300.00 | 1501.42 |
| 13:00 | 66.04 | 53.95 | 872.10 | 934.80 | 1209.99 | 300.00 | 1509.99 |
| 14:00 | 73.22 | 53.95 | 966.96 | 934.80 | 1217.17 | 300.00 | 1517.17 |
| 15:00 | 78.78 | 53.95 | 1040.40 | 934.80 | 1222.73 | 300.00 | 1522.73 |
| 16:00 | 82.21 | 46.60 | 1085.69 | 934.80 | 1218.81 | 300.00 | 1518.81 |
| 17:00 | 83.41 | 39.24 | 1101.60 | 934.80 | 1212.65 | 300.00 | 1512.65 |

# Room 3-44

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 360.00 | 300.00 | 400.00 | 330.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 37.23 | 557.42 | 318.24 | 934.80 | 1684.65 | 300.00 | 1984.65 |
| 09:00 | 48.33 | 414.66 | 413.10 | 934.80 | 1552.99 | 300.00 | 1852.99 |
| 10:00 | 61.29 | 235.20 | 523.87 | 934.80 | 1386.49 | 300.00 | 1686.49 |
| 11:00 | 75.18 | 81.57 | 642.60 | 934.80 | 1246.75 | 300.00 | 1546.75 |
| 12:00 | 88.79 | 59.82 | 758.88 | 934.80 | 1238.61 | 300.00 | 1538.61 |
| 13:00 | 102.03 | 59.82 | 872.10 | 934.80 | 1251.85 | 300.00 | 1551.85 |
| 14:00 | 113.13 | 59.82 | 966.96 | 934.80 | 1262.95 | 300.00 | 1562.95 |
| 15:00 | 121.72 | 59.82 | 1040.40 | 934.80 | 1271.54 | 300.00 | 1571.54 |
| 16:00 | 127.02 | 51.66 | 1085.69 | 934.80 | 1268.68 | 300.00 | 1568.68 |
| 17:00 | 43.51 | 43.51 | 1101.60 | 934.80 | 1177.01 | 300.00 | 1477.01 |

# Room 3-45

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 144 | 120 | 200 | 1630 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 15.71 | 80.52 | 127.3 | 373.92 | 2070.23 | 120 | 2190.23 |
| 09:00 | 20.39 | 59.90 | 165.2 | 373.92 | 2054.3 | 120 | 2174.29 |
| 10:00 | 25.86 | 33.97 | 209.5 | 373.92 | 2033.84 | 120 | 2153.84 |
| 11:00 | 31.72 | 11.78 | 257 | 373.92 | 2017.51 | 120 | 2137.50 |
| 12:00 | 37.46 | 8.64 | 303.6 | 373.92 | 2020.11 | 120 | 2140.10 |
| 13:00 | 43.05 | 8.64 | 348.8 | 373.92 | 2025.7 | 120 | 2145.69 |
| 14:00 | 47.73 | 8.64 | 386.8 | 373.92 | 2030.38 | 120 | 2150.38 |
| 15:00 | 51.36 | 8.64 | 416.2 | 373.92 | 2034.01 | 120 | 2154.00 |
| 16:00 | 53.60 | 7.46 | 434.3 | 373.92 | 2035.06 | 120 | 2155.06 |
| 17:00 | 54.38 | 6.28 | 440.6 | 373.92 | 2034.67 | 120 | 2154.67 |

# Room 3-46

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 360.00 | 300.00 | 400.00 | 330.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 24.10 | 502.75 | 318.24 | 934.80 | 1616.85 | 300.00 | 1916.85 |
| 09:00 | 31.28 | 374.00 | 413.10 | 934.80 | 1495.28 | 300.00 | 1795.28 |
| 10:00 | 39.67 | 212.14 | 523.87 | 934.80 | 1341.81 | 300.00 | 1641.81 |
| 11:00 | 48.66 | 73.57 | 642.60 | 934.80 | 1212.23 | 300.00 | 1512.23 |
| 12:00 | 57.46 | 53.95 | 758.88 | 934.80 | 1201.42 | 300.00 | 1501.42 |
| 13:00 | 66.04 | 53.95 | 872.10 | 934.80 | 1209.99 | 300.00 | 1509.99 |
| 14:00 | 73.22 | 53.95 | 966.96 | 934.80 | 1217.17 | 300.00 | 1517.17 |
| 15:00 | 78.78 | 53.95 | 1040.40 | 934.80 | 1222.73 | 300.00 | 1522.73 |
| 16:00 | 82.21 | 46.60 | 1085.69 | 934.80 | 1218.81 | 300.00 | 1518.81 |
| 17:00 | 83.41 | 39.24 | 1101.60 | 934.80 | 1212.65 | 300.00 | 1512.65 |

# Room 3-47

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 360.00 | 300.00 | 400.00 | 330.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 41.27 | 593.03 | 318.24 | 934.80 | 1724.31 | 300.00 | 2024.31 |
| 09:00 | 53.58 | 441.16 | 413.10 | 934.80 | 1584.74 | 300.00 | 1884.74 |
| 10:00 | 67.94 | 250.23 | 523.87 | 934.80 | 1408.17 | 300.00 | 1708.17 |
| 11:00 | 83.34 | 86.79 | 642.60 | 934.80 | 1260.13 | 300.00 | 1560.13 |
| 12:00 | 98.42 | 63.64 | 758.88 | 934.80 | 1252.07 | 300.00 | 1552.07 |
| 13:00 | 113.11 | 63.64 | 872.10 | 934.80 | 1266.75 | 300.00 | 1566.75 |
| 14:00 | 125.41 | 63.64 | 966.96 | 934.80 | 1279.05 | 300.00 | 1579.05 |
| 15:00 | 134.94 | 63.64 | 1040.40 | 934.80 | 1288.58 | 300.00 | 1588.58 |
| 16:00 | 140.81 | 54.96 | 1085.69 | 934.80 | 1285.77 | 300.00 | 1585.77 |
| 17:00 | 142.87 | 46.29 | 1101.60 | 934.80 | 1279.16 | 300.00 | 1579.16 |

# Room 3-51

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 7556.00 | 7300.00 | 1136.00 | 3731.00 | 207.00 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 375.33 | 2727.40 | 5473.73 | 16078.56 | 15525.73 | 7507.00 | 23032.73 |
| 09:00 | 487.21 | 2772.39 | 7105.32 | 16078.56 | 15682.60 | 7507.00 | 23189.60 |
| 10:00 | 617.85 | 2772.39 | 9010.60 | 16078.56 | 15813.24 | 7507.00 | 23320.24 |
| 11:00 | 757.87 | 1525.36 | 11052.72 | 16078.56 | 14706.24 | 7507.00 | 22213.24 |
| 12:00 | 895.01 | 869.32 | 13052.74 | 16078.56 | 14187.34 | 7507.00 | 21694.34 |
| 13:00 | 1028.54 | 1413.19 | 15000.12 | 16078.56 | 14864.73 | 7507.00 | 22371.73 |
| 14:00 | 1140.42 | 2103.04 | 16631.71 | 16078.56 | 15666.46 | 7507.00 | 23173.46 |
| 15:00 | 1227.03 | 2507.95 | 17894.88 | 16078.56 | 16157.98 | 7507.00 | 23664.98 |
| 16:00 | 1280.45 | 2456.35 | 18673.83 | 16078.56 | 16159.79 | 7507.00 | 23666.79 |
| 17:00 | 1299.21 | 2052.32 | 18947.52 | 16078.56 | 15774.54 | 7507.00 | 23281.54 |

# Room 3-54

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequ_s | Qequ_l |
|---|---|---|---|---|
| 5780.00 | 2975.00 | 2175.00 | 440.00 | 0.00 |

| TIME | Qwall_S | Qsun_S | Qven _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 270.67 | 4569.19 | 4723.51 | 13874.87 | 13234.86 | 2975.00 | 16209.86 |
| 09:00 | 351.35 | 4569.19 | 6131.48 | 13874.87 | 13315.54 | 2975.00 | 16290.54 |
| 10:00 | 445.56 | 3700.40 | 7775.63 | 13874.87 | 12540.96 | 2975.00 | 15515.96 |
| 11:00 | 546.54 | 2236.33 | 9537.86 | 13874.87 | 11177.87 | 2975.00 | 14152.87 |
| 12:00 | 645.44 | 868.79 | 11263.76 | 13874.87 | 9909.23 | 2975.00 | 12884.23 |
| 13:00 | 741.74 | 707.90 | 12944.24 | 13874.87 | 9844.64 | 2975.00 | 12819.64 |
| 14:00 | 822.42 | 707.90 | 14352.21 | 13874.87 | 9925.32 | 2975.00 | 12900.32 |
| 15:00 | 884.88 | 707.90 | 15442.25 | 13874.87 | 9987.78 | 2975.00 | 12962.78 |
| 16:00 | 923.40 | 611.37 | 16114.44 | 13874.87 | 9929.77 | 2975.00 | 12904.77 |
| 17:00 | 936.93 | 514.84 | 16350.62 | 13874.87 | 9846.77 | 2975.00 | 12821.77 |

# Corridor 3-10

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 0.00 | 0.00 | 2105. | 0 | 0 |

| TIME | Qwall_S | Qsun_S | Qvent _S | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 0.00 | 0.00 | 468.14 | 1375.13 | 2105 | 0 | 2105 |
| 09:00 | 0.00 | 0.00 | 607.69 | 1375.13 | 2105 | 0 | 2105 |
| 10:00 | 0.00 | 0.00 | 770.64 | 1375.13 | 2105 | 0 | 2105 |
| 11:00 | 0.00 | 0.00 | 945.29 | 2320.42 | 2105 | 0 | 2105 |
| 12:00 | 0.00 | 0.00 | 1116.34 | 2491.47 | 2105 | 0 | 2105 |
| 13:00 | 0.00 | 0.00 | 1282.89 | 2658.02 | 2105 | 0 | 2105 |
| 14:00 | 0.00 | 0.00 | 1422.44 | 2797.57 | 2105 | 0 | 2105 |
| 15:00 | 0.00 | 0.00 | 1530.47 | 2905.60 | 2105 | 0 | 2105 |
| 16:00 | 0.00 | 0.00 | 1597.09 | 2972.22 | 2105 | 0 | 2105 |
| 17:00 | 0.00 | 0.00 | 1620.50 | 2995.63 | 2105 | 0 | 2105 |

# Room 3-53

### Variation of load with time

| Qocc_s | Qocc_l | Qlight_s | Qequip_s | Qequip_l |
|---|---|---|---|---|
| 522 | 798 | 400 | 17240 | 8605 |

| TIME | Qw_s | Qsun_s | Qvent _s | Qvent _l | RSH | RLH | RTH |
|---|---|---|---|---|---|---|---|
| 08:00 | 0 | 0 | 235.008 | 664.101 | 18162 | 9403 | 27565 |
| 09:00 | 0 | 0 | 348.84 | 664.101 | 18162 | 9403 | 27565 |
| 10:00 | 0 | 0 | 481.7664 | 664.101 | 18162 | 9403 | 27565 |
| 11:00 | 0 | 0 | 624.24 | 664.101 | 18162 | 9403 | 27565 |
| 12:00 | 0 | 0 | 763.776 | 664.101 | 18162 | 9403 | 27565 |
| 01:00 | 0 | 0 | 899.64 | 664.101 | 18162 | 9403 | 27565 |
| 02:00 | 0 | 0 | 1013.472 | 664.101 | 18162 | 9403 | 27565 |
| 03:00 | 0 | 0 | 1101.6 | 664.101 | 18162 | 9403 | 27565 |
| 04:00 | 0 | 0 | 1155.946 | 664.101 | 18162 | 9403 | 27565 |
| 05:00 | 0 | 0 | 1175.04 | 664.101 | 18162 | 9403 | 27565 |

## Total 3-53 (kitchen) load

| TIME | RSH | RLH | RTH | R S H F |
|---|---|---|---|---|
| 08:00 | 18162 | 9403 | 27565 | 0.66 |
| 09:00 | 18162 | 9403 | 27565 | 0.66 |
| 10:00 | 18162 | 9403 | 27565 | 0.66 |
| 11:00 | 18162 | 9403 | 27565 | 0.66 |
| 12:00 | 18162 | 9403 | 27565 | 0.66 |
| 13:00 | 18162 | 9403 | 27565 | 0.66 |
| 14:00 | 18162 | 9403 | 27565 | 0.66 |
| 15:00 | 18162 | 9403 | 27565 | 0.66 |
| 16:00 | 18162 | 9403 | 27565 | 0.66 |
| 17:00 | 18162 | 9403 | 27565 | 0.66 |

| TIME | QASH | OALH | OATH |
|---|---|---|---|
| 08:00 | 88.128 | 664.1016 | 752.2296 |
| 09:00 | 201.96 | 664.1016 | 866.0616 |
| 10:00 | 334.886 | 664.1016 | 998.988 |
| 11:00 | 477.36 | 664.1016 | 1141.462 |
| 12:00 | 616.896 | 664.1016 | 1280.998 |
| 13:00 | 752.76 | 664.1016 | 1416.862 |
| 14:00 | 866.592 | 664.1016 | 1530.694 |
| 15:00 | 954.72 | 664.1016 | 1618.822 |
| 16:00 | 1009.07 | 664.1016 | 1673.167 |
| 17:00 | 1028.16 | 664.1016 | 1692.262 |

| TIME | G S H | G L H | G T H | ( K W) | T R | H P | GSHF |
|---|---|---|---|---|---|---|---|
| 08:00 | 18250.13 | 10067.10 | 28317.23 | 28.32 | 8.09 | 37.76 | 0.64 |
| 09:00 | 18363.96 | 10067.10 | 28431.06 | 28.43 | 8.12 | 37.91 | 0.65 |
| 10:00 | 18496.89 | 10067.10 | 28563.99 | 28.56 | 8.16 | 38.09 | 0.65 |
| 11:00 | 18639.36 | 10067.10 | 28706.46 | 28.71 | 8.20 | 38.28 | 0.65 |
| 12:00 | 18778.90 | 10067.10 | 28846.00 | 28.85 | 8.24 | 38.46 | 0.65 |
| 13:00 | 18914.76 | 10067.10 | 28981.86 | 28.98 | 8.28 | 38.64 | 0.65 |
| 14:00 | 19028.59 | 10067.10 | 29095.69 | 29.10 | 8.31 | 38.79 | 0.65 |
| 15:00 | 19116.72 | 10067.10 | 29183.82 | 29.18 | 8.34 | 38.91 | 0.66 |
| 16:00 | 19171.07 | 10067.10 | 29238.17 | 29.24 | 8.35 | 38.98 | 0.66 |
| 17:00 | 19190.16 | 10067.10 | 29257.26 | 29.26 | 8.36 | 39.01 | 0.66 |

## 3$^{rd}$ floor Total load calculation

| TIME | TRSH | TRLH | TRTH | RSHF |
|---|---|---|---|---|
| 8:00 | 60531.89 | 21835.00 | 82366.89 | 0.73 |
| 9:00 | 60261.09 | 21835.00 | 82096.09 | 0.73 |
| 10:00 | 58735.85 | 21835.00 | 80570.85 | 0.73 |
| 11:00 | 55331.46 | 21835.00 | 77166.46 | 0.72 |
| 12:00 | 53163.36 | 21835.00 | 74998.36 | 0.71 |
| 1:00 | 53809.24 | 21835.00 | 75644.24 | 0.71 |
| 2:00 | 54756.06 | 21835.00 | 76591.06 | 0.71 |
| 3:00 | 55359.92 | 21835.00 | 77194.92 | 0.72 |
| 4:00 | 55275.46 | 21835.00 | 77110.46 | 0.72 |
| 5:00 | 54558.73 | 21835.00 | 76393.73 | 0.71 |

| TIME | Qvent_s | Qvent_l | Qvent_T |
|---|---|---|---|
| 8:00 | 12794.4828 | 37556.3749 | 50350.8577 |
| 9:00 | 16652.0044 | 37556.3749 | 54208.3793 |
| 10:00 | 21156.5942 | 37556.3749 | 58712.9691 |
| 11:00 | 25984.718 | 38501.6652 | 64486.3832 |
| 12:00 | 30713.2929 | 38672.7177 | 69386.0106 |
| 1:00 | 35317.4316 | 38839.2689 | 74156.7004 |
| 2:00 | 39174.9532 | 38978.8117 | 78153.7649 |
| 3:00 | 42161.4215 | 39086.8449 | 81248.2664 |
| 4:00 | 44003.077 | 39153.4654 | 83156.5424 |
| 5:00 | 44650.1451 | 39176.8726 | 83827.0177 |

| TIME | GRSH | GRLH | GRTH | GRSHF |
|---|---|---|---|---|
| 8:00 | 73326.37 | 59391.37 | 132717.74 | 0.55 |
| 9:00 | 76913.09 | 59391.37 | 136304.47 | 0.56 |
| 10:00 | 79892.44 | 59391.37 | 139283.82 | 0.57 |
| 11:00 | 81316.17 | 60336.66 | 141652.84 | 0.57 |
| 12:00 | 83876.64 | 60507.71 | 144384.36 | 0.58 |
| 1:00 | 89126.67 | 60674.26 | 149800.94 | 0.59 |
| 2:00 | 93931.01 | 60813.81 | 154744.82 | 0.60 |
| 3:00 | 97521.33 | 60921.84 | 158443.18 | 0.61 |
| 4:00 | 99278.53 | 60988.46 | 160267 | 0.61 |
| 5:00 | 99208.87 | 61011.87 | 160220.748 | 0.61 |

**The max load occures at 4:00 PM and its value equals:**

| TIME | TRSH (W) | TRLH (W) | TRTH (W) | RSHF |
|---|---|---|---|---|
| 4:00 | 55275.46 | 21835 | 77110.46 | 0.72 |

| TIME | Qvent_s (W) | Qvent_l (W) | Qvent_T (W) |
|---|---|---|---|
| 4:00 | 44003.07 | 39153.46 | 83156.54 |

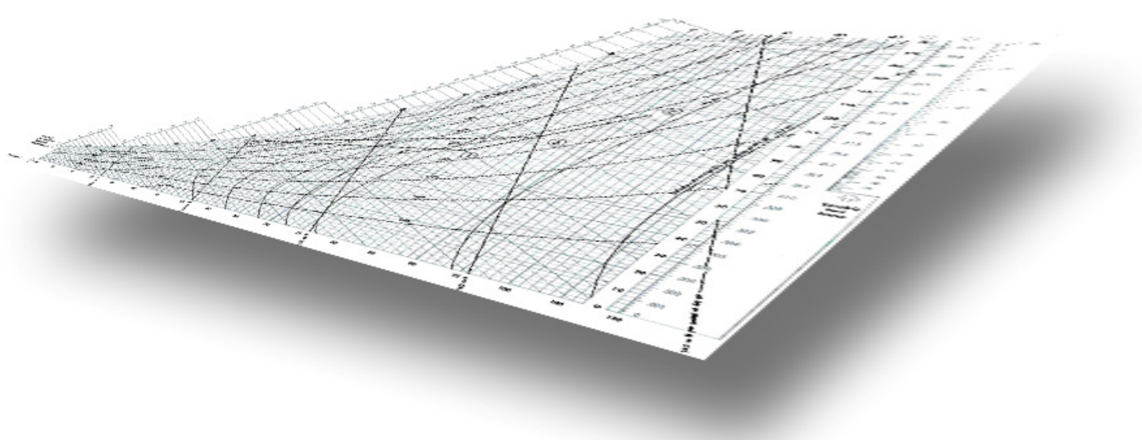
| TIME | ERSH (W) | ERLH (W) | ERTH(W) | ERSHF |
|---|---|---|---|---|
| 4:00 | 40074.37 | 47623.7369 | 87698.1069 | 0.690703 |

| TIME | GRSH(W) | GRLH(W) | GRTH(W) | GRSHF |
|---|---|---|---|---|
| 4:00 | 99278.53 | 60988.46 | 160267 | 0.61 |

| Time | GTH (KW) | GTH (HP) | GTH (TR) |
|---|---|---|---|
| 4:00 | 160.267 | 45.790 | 229.342 |

Chapter Three

# Psychrometry



## Introduction

This chapter describes practical psychrometries as applied to apparatus selection. It is divided into three parts:

**1.** Description of terms, processes and factors – as encountered in normal air conditioning applications.
**2.** Air conditioning apparatus - factors affecting common processes and the effect of these factors on selection of air conditioning equipment.
**3.** Psychrometries of partial load control – the effect of partial load on equipment selection and on the common processes. To help recognize terms, factors and processes described in this chapter, a brief definition of psychrometries is offered at this point, along with an illustration and definition of terms appearing on a standard psychrometric chart (Fig. 3.1).

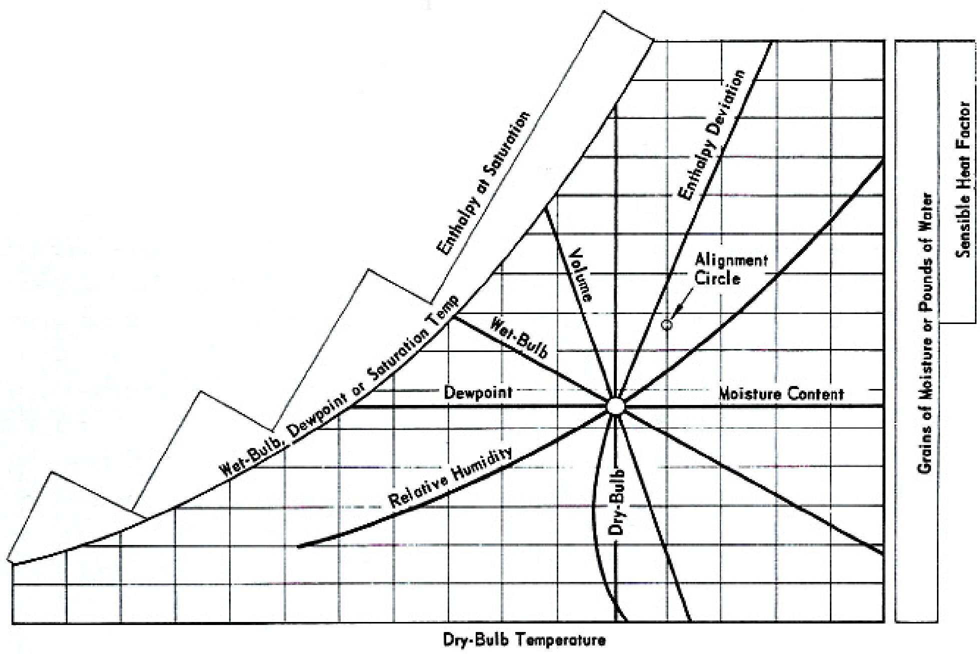



Fig 3.1 Skeleton psychrometric chart

# Psychometric terms:

**Dry-bulb Temperature**:
The temperature of air as registered by an ordinary thermometer.

**Wet-bulb Temperature:**
The temperature registered by a thermometer whose bulb is covered by a wetted wick and exposed to a current of rapidly moving air.

**DewpointTemperature:**
The temperature at which condensation of moisture begins when the air is cooled.

**Relative Humidity:**
Ratio of the actual water vapor pressure of the air to the saturated water vapor pressure of the air at the same temperature.

**Specific Humidity or Moisture Content:**
The weight of water vapor in grains or pounds of moisture per pound of dry air.

**Enthalpy:**
A thermal property indicating the quantity of heat in the air above an arbitrary datum, in Btu per pound of dry air. The datum for dry air is O°F and, for the moisture content, 32 F water.

**Specific Volume:**
The cubic feet of the mixture per pound of dry air.

**Sensible Heat Factor:**
The ratio of sensible to total heat. Alignment Circle-Located at 24 C db and 50% RH and used in conjunction with the sensible heat factor to plot the various air conditioning process lines.

*Hint:*
The dry-bulb, Wet-bulb, and dew point temperatures and the relative humidity are so related that if two properties are known. All other properties shown may then be determined. When air is saturated, dry-bulb, wet-bulb and dew point temperatures are all equal.

# Definition

Psychrometrics is the science involving thermodynamic properties of moist air and the effect of atmospheric moisture on materials and human comfort. The chart is normally constructed for standard atmospheric pressure of 760mm.Hg or 1.01325 bar .corresponding to the pressure at the mean sea level.

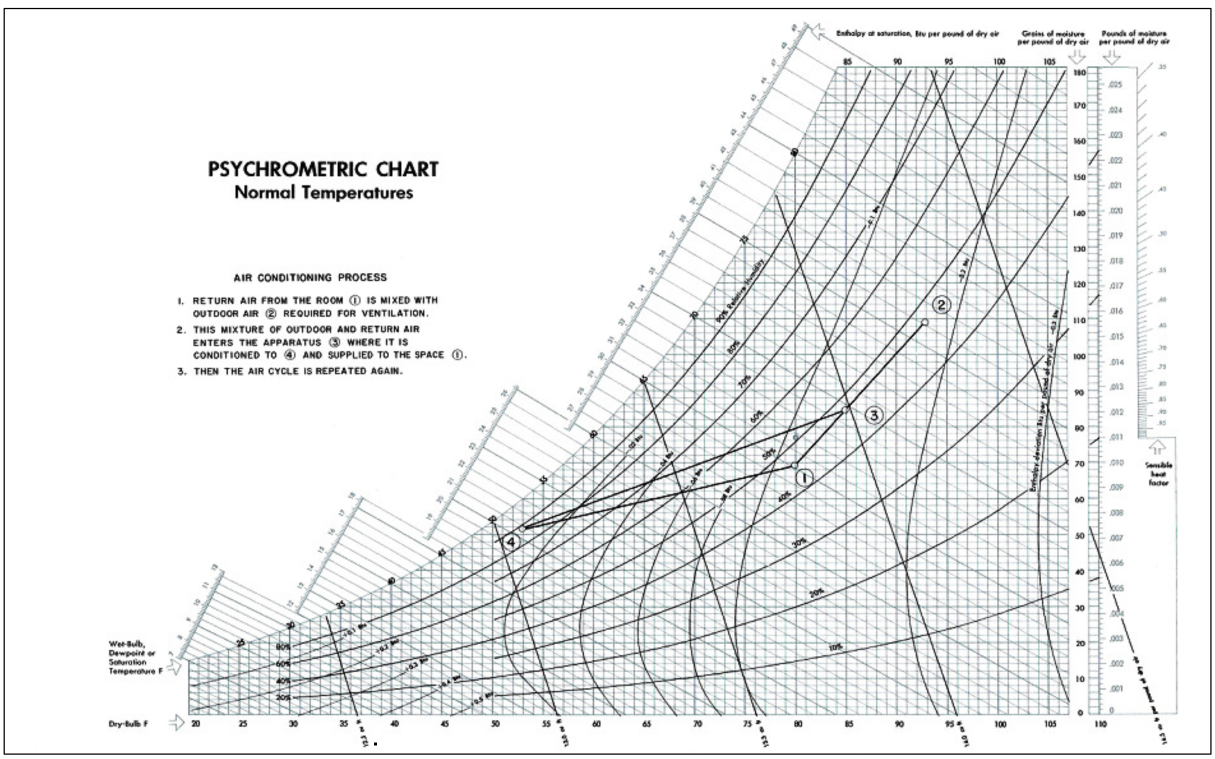



Fig. 3.2 Typical air conditioning process tracked on a standard psychrometric chart

### Air conditioning processes

Fig. 3.2 shows a typical air conditioning process traced on a psychrometric chart. Outdoor air (2) is mixed with return air from the room (1) and enters the apparatus (3). Air flows through the conditioning apparatus (3 - 4) and is supplied to the space (4).The air supplied to the space moves along line (4 -1) as it picks up the room loads, and the cycle is repeated. Normally most of the air supplied to the space by the air conditioning system is returned to the conditioning apparatus. There, it is mixed with outdoor air required for ventilation. The mixture then passes through the apparatus where heat and moisture are added or removed, as required, to maintain the desired conditions. The selection of proper equipment to accomplish this conditioning and to control the thermodynamic properties of the air depends upon a variety of elements. However, only those which affect the psychrometric properties of air will be discussed in this chapter. These elements are: room sensible heat factor (RSHF), grand sensible heat factor (GSHF), effective surface temperature ($t_{es}$) bypass factor (BF), and effective sensible heat factor (ESHF).

## Description of terms, processes and factors

### Sensible heat factor

The thermal properties of air can be separated into latent and sensible heat. The term sensible heat factor is the ratio of sensible to total heat, where total heat is the sum of sensible .and latent heat. This ratio may be expressed as:

$$SHF = \frac{SH}{SH + LH} = \frac{SH}{TH} \qquad \textbf{Eqn (3.1)}$$

*Where:*

SHF = sensible heat factor
SH = sensible heat
LH = latent heat
TH = total heat

**Room sensible heat factor (RSHF):**

The room sensible heat factor is the ratio of room sensible heat to the summation of room sensible and room latent heat. This ratio is expressed in the following formula:

$$RSHF = \frac{RSH}{RSH + RLH} = \frac{RSH}{RTH} \qquad \textbf{Eqn (3.2)}$$

The supply air to a conditioned space must have the capacity to offset simultaneously both the room sensible and room latent heat loads.

**Grand Sensible heat Factor (GSHF):**

The grand sensible heat factor is the ratio of the total sensible heat .to the grand total heat load that the conditioning apparatus must handle, including the outdoor air heat loads. This ratio is determined from the following equation:

$$GSHF = \frac{TSH}{TSH + TLH} = \frac{TSH}{GTH} \qquad \textbf{Eqn (3.3)}$$

$$TSH = RSH + OASH \qquad \& \qquad TLH = RLH + OALH$$

**Required Air Quantity:**

The air quantity required to offset simultaneously the room sensible and latent loads and the air quantity required thru the apparatus to handle the total sensible and latent loads may be calculated, using the conditions on their respective RSHF and GSHF lines. For a particular application, when both the RSHF and GSHF ratio lines are plotted on the psychrometric chart, the intersection of the two lines (1) Fig(3-3), represents the condition of the supply air to the space. It is also the condition of the air leaving the apparatus.

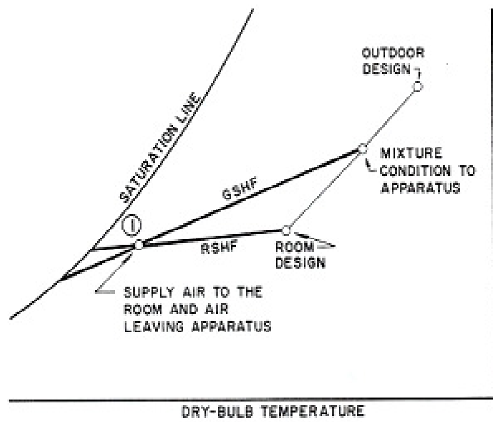



Fig (3.3): RSHF and GSHF Lines Plotted On Skeleton Psychrometric Chart

This neglects fan and duct heat gain, duct leakage losses, etc. In actual practice, these heat gains and losses are taken into account in estimating the cooling load. The temperature of the air leaving the apparatus is not necessarily equal to the temperature of the air supplied to the space as indicated in Fig (3-3).

Fig (3-4) illustrates what actually happens when these supplementary loads are considered plotting the RSHF and GSHF lines. Point (1) is the condition of air leaving the apparatus and point (2) is the condition of supply air to the space. Line (1 -2) represents the temperature rise of the air stream resulting from fan horsepower and heat gain to the duct.

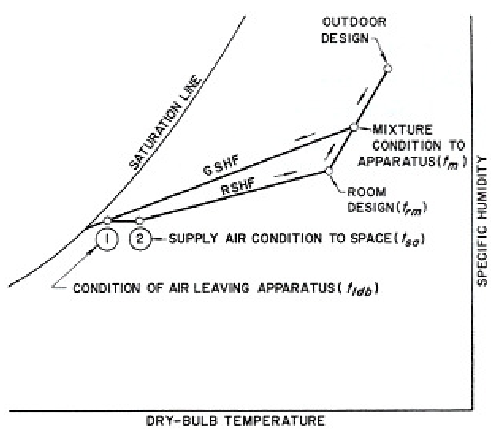



Fig (3.4): RSHF and GSHF Lines Plotted With Supplementary Load Line

The air quantity required to satisfy the room load may be calculated from the following equation:

$$CMMsa = \frac{RSH}{0.0204\ (t_R - t_{sa})} \qquad \textbf{Eqn (3.4)}$$

The air quantity required thru the conditioning apparatus to satisfy the total air conditioning load (including the supplementary loads) is calculated from the following equation:

$$CMMda = \frac{TSH}{0.0204\ (t_m - t_{1db})} \qquad \textbf{Eqn (3.5)}$$

The required air quantity supplied to the spaces equal to the air quantity required thru the apparatus, neglecting leakage losses. The above equation contains the term $t_m$ which is the mixture condition of air entering the apparatus. With the exception of an all outdoor air application, the term $t_m$ can only be determined by trial and error.

In a normal, well designed, tight system the difference in supply air temperature and the condition of the air leaving the apparatus ($t_{sa}$ - $t_{,db}$) is usually not more than a few degrees. To simplify the discussion on the interrelationship of RSHF and GSHF, the supplementary loads have been neglected in the various discussions, formulas and problems in the remainder of this chapter.

The RSHF ratio will be constant (at full load) under a specified set of conditions; however, the GSHF ratio may increase or decrease as the outdoor air quantity and mixture conditions are varied for design purposes. As the GSHF ratio changes, the supply air condition to the space varies along the RSHF line (Fig. (3-3)).

The difference in temperature between the room and the air supply to the room determines the air quantity required to satisfy the room sensible and room latent loads. As this temperature difference increases (supplying colder air, since the room conditions are fixed), the required air quantity to the space decreases.

**Effective Surface Temperature** ($t_{es}$) or (ADP):

The surface temperature of the conditioning equipment varies throughout the surface of the apparatus as the air comes in contact with it. However, the effective surface temperature can be considered to be the uniform surface temperature which would produce the same leaving air conditions as the no uniform surface temperature that actually occurs when the apparatus is in operation. This is more clearly understood by illustrating the heat transfer effect between the air and the cooling (or heating) medium. Fig. (3.5) illustrates this process and is applicable to a chilled water cooling medium with the supply air counter flow in relation to the chilled water.

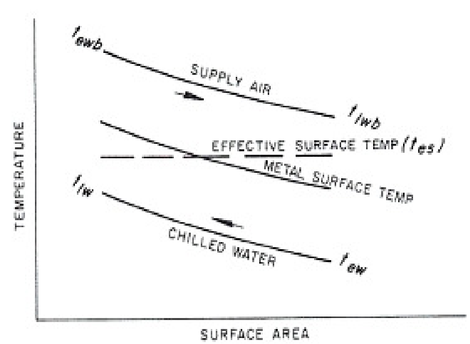



Fig (3.5): Relationship of Effective Surface Temp to Supply Air and Chilled Water

For applications involving cooling and dehumidification, the effective surface temperature is at the point where the GSHF line crosses the saturation line on the psychrometric chart (Fig.(3.3)). As such, this effective surface temperature is considered to be the dew point of the apparatus, and hence the term apparatus dew point (ADP) has come into common usage for cooling and dehumidifying processes. The psychrometric of air can be applied equally well to other types of heat transfer applications such as sensible heating, evaporative cooling, sensible cooling, etc., but for these applications the effective surface temperature will not necessarily fall on the saturation line.

**By Pass Factor (BF)**

Bypass factor is a function of the physical and operating characteristics of the conditioning apparatus and, as such, represents that portion of the air which is considered to pass through the conditioning apparatus completely unaltered.

There is a psychrometric relationship of bypass factor to GSHF and RSHF. Under specified room outdoor design conditions and quantity of outdoor air, RSHF and GSHF are fixed. The position of RSHF is also fixed, but the relative position of GSHF may vary as the supply air quantity and supply air condition change. To properly maintain room design conditions, the air must be supplied to the space at some point along the RSHF line. Therefore, as the bypass factor varies the relative position of GSHF to RSHF changes, as shown by the dotted lines in Fig. (3.6). As the position of GSHF changes, the entering and leaving air conditions at the apparatus, the required air quantity, bypass factor and the apparatus dew point also change. The effect of varying the bypass factor on the conditioning equipment is as follows:

I. Smaller bypass factor

a. higher ADP - DX equipment selected for higher refrigerant temperature and chilled water equipment would be selected for less or higher temperature chilled water. Possibly smaller refrigeration machine.

b. Less air - smaller fan and fan motor.

c. More heat transfer surface - more rows of coil or more coil surface available.

d. Smaller piping if less chilled water is used.

2. Larger bypass factor

-a. Lower ADP - Lower refrigerant temperature to select DX equipment, and more water or lower temperature for chilled water equipment. Possibly Larger Refrigeration Machine.

b. More air -larger fan and fan motor.

c. Less heat transfer surface - less rows of coiler less coil surface available.

d. Larger piping if more chilled water is used.

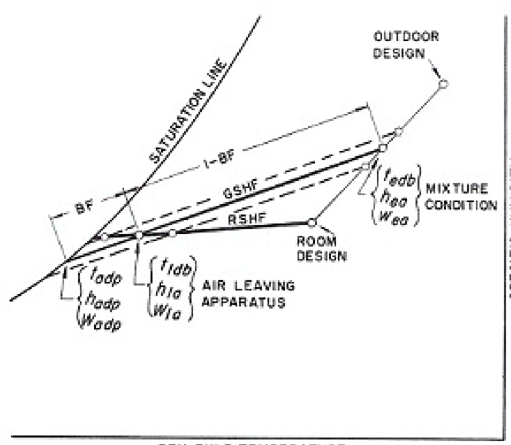


Fig (3.6): RSHF and GSHF Lines Plotted On Skeleton Psychrometric Chart

It is, therefore, an economic balance of first cost and operating cost in selecting the proper bypass factor for a particular application. Table (3.2), its suggested bypass factors for various applications and is a guide for the engineer to proper bypass factor selection for use in load calculations.

Tables have also been prepared to illustrate the various configurations of heat transfer surfaces and the resulting bypass factor for different air velocities.

Table (3.1), lists bypass factors for various coil surfaces. Spray washer equipment is normally rated in terms of saturation efficiency which is the complement of bypass factor (I - BF).Table (3.3), is a guide to representative saturation efficiencies for various spray arrangements.

As previously indicated the entering and leaving air conditions at the conditioning apparatus and the apparatus dew point are related psychrometrically to the bypass factor. Although it is recognized that bypass factor is not a true straight line function, it can be accurately evaluated mathematically from the following equations:

$$BF = \frac{t_{ldb} - t_{adp}}{t_{edb} - t_{adp}} = \frac{h_{la} - h_{adp}}{h_{ea} - h_{adp}} = \frac{W_{la} - W_{adp}}{W_{ea} - W_{adp}}$$

**Eqn (3.6)**

**And**

$$1-BF = \frac{t_{edb} - t_{ldb}}{t_{edb} - t_{adp}} = \frac{h_{ea} - h_{la}}{h_{ea} - h_{adp}} = \frac{W_{ea} - W_{la}}{W_{ea} - W_{adp}}$$

**Eqn (3.7)**

**NOTE**: The quantity (I-BF) is frequently called contact factor and is considered to be that portion of the air leaving the apparatus at the ADP.

## TABLE (3.1) - TYPICAL BYPASS FACTORS

(For Finned Coils)

| DEPTH OF COILS | WITHOUT SPRAYS | | WITH SPRAYS | |
|---|---|---|---|---|
| | 8 fins/in. | 14 fins/in. | 8 fins/in. | 14 fins/in. |
| | Velocity (fpm) | | | |
| (rows) | 300 - 700 | 300 - 700 | 300 - 600 | 300 - 600 |
| 2 | .42 - .55 | .22 - .38 | | |
| 3 | .27 - .40 | .10 - .23 | | |
| 4 | .15 - .28 | .05 - .14 | .12 - .22 | .04 - .10 |
| 5 | .10 - .22 | .03 - .09 | .08 - .16 | .02 - .06 |
| 6 | .06 - .15 | .01 - .05 | .05 - .11 | .01 - .03 |
| 8 | .02 - .08 | .00 - .02 | .02 - .06 | .00 - .02 |

**TABLE (3.2) —TYPICAL BYPASS FACTORS**

(For Various Applications)

| COIL BYPASS FACTOR | TYPE OF APPLICATION | EXAMPLE |
|---|---|---|
| 0.30 to 0.50 | A *small* total load or a load that is somewhat larger with a low sensible heat factor (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 (3.3) —TYPICAL SATURATION EFFICIENCY***

**For Spray Chambers**

| NO. OF BANKS | DIRECTION OF WATER SPRAY | ¼″ NOZZLE (25 psig Nozzle Pressure 3 gpm/sq ft†) | | ⅛″ NOZZLE (30 psig Nozzle Pressure 2.5 gpm/sq ft†) | |
|---|---|---|---|---|---|
| | | Velocity‡ (fpm) | | | |
| | | 300 | 700 | 300 | 700 |
| 1 | Parallel | 70% | 50% | 80% | 60% |
| | Counter | 75% | 65% | 82% | 70% |
| 2 | Parallel | 90% | 85% | 92% | 87% |
| | Opposing | 98% | 92% | 98% | 93% |
| | Counter | 99% | 93% | 99% | 94% |

**Effective Sensible Heat Factor (ESHF)**

To relate bypass factor and apparatus dew point to the load calculation, the effective sensible heat factor term was developed. ESHF is interwoven with BF and ADP, and thus greatly simplifies the calculation of air quantity and apparatus selection. The effective sensible heat factor is the ratio of effective room sensible heat to the effective room sensible and latent heats. Effective room sensible heat is composed of room sensible heat (plus that portion of the outdoor air sensible load which is considered as being bypassed, unaltered, thru the conditioning apparatus. The effective room latent heat is composed of the room latent heat plus that portion of the outdoor air latent heat load which is considered as being by-passed, unaltered, thru the conditioning apparatus. This ratio is expressed in the following formula:

$$ESHF = \frac{ERSH}{ERSH + ERLH} = \frac{ERSH}{ERTH} \qquad \textbf{Eqn (3.8)}$$

Drawing a straight line between the ADP and room design conditions (1 -2), Fig. (3.7) represents the ESHF ratio. The interrelationship of RSHF and GSHF to BF, ADP and ESHF is graphically illustrated in Fig. (3.7).

**Air Quantity Using ESHF, ADP and BPF**

A simplified approach for determining the required air quantity is to use the psychrometric correlation of effective sensible heat factor, apparatus dew point and bypass factor. Previously in this chapter, the interrelationship of ESHF, BPF and ADP was shown with GSHF and RSHF. These two factors need not be calculated to determine the required air quantity, since the use of ESHF, BPF and ADP results in the same air quantity. The formula for calculating air quantity, using BPF and $t_{adP}$' is:

$$CMMda = \frac{ERSH}{0.0204\ (t_{rm} - t_{adp})\ (1 - BF)} \qquad \textbf{Eqn (3.5)}$$

(ESHF is used to determine $t_{adp}$')

This air quantity simultaneously offsets the room sensible and room latent loads, and also handles the total sensible and latent loads for which the conditioning apparatus is designed, including the outdoor air loads and the supplementary loads.

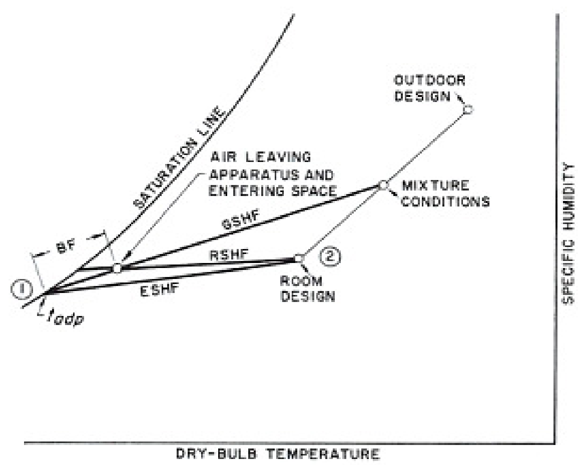



Fig (3.7): RSHF and GSHF Lines Plotted On Skeleton Psychrometric Chart

## Air Conditioning Apparatus

The following section describes the characteristic psychrometric performance of air conditioning equipment.

Coils, sprays and sorbent dehumidifiers are the three basic types of heat transfer equipment required for air conditioning applications. These components may be used singly or in combination to control the psychrometric properties of the air passing thru them.

The selection of this equipment is normally determined by the requirements of the specific application. The components must be selected and integrated to result in a practical system; that does, one having the most economical own and operating cost.

An economical system requires the optimum combination of air conditioning components. It also requires an air distribution system that provides good air distribution within the conditioned space, using a practical rise between supply air and room air temperatures.

Since the only known items are the load in the space and the conditions to be maintained within the space, the selection of the various components is based on these items. Normally, performance requirements are established and then equipment is selected to meet the requirements.

## Psychrometrics of partial load control

The apparatus required to maintain proper space conditions is normally selected for peak load operation. Actually, peak load occurs but a few times each year and operation is predominantly at partial load conditions. Partial load may be caused by a reduction in sensible or latent loads in the space, or in the outdoor air load. It may also be caused by a reduction in these loads in any combination.

## Partial load analysis

Since the system operates at partial load most of the time and must maintain conditions commensurate with job requirements, partial load analysis is at least as important as the selection of equipment. Partial load analysis should include a study of resultant room conditions at minimum total load. Usually this will be sufficient. Certain applications, however, should be evaluated at minimum latent load with design sensible load, or minimum sensible load and full latent load. Realistic minimum and maximum loads should be assumed for the particular application so that, psychrometrically; the resulting room conditions are properly analyzed. The six most common methods, used singly or in combination, of controlling space conditions for cooling applications at partial load are the following:

I. Reheat the supply air.
2. Bypass the heat transfer equipment.
3. Control the volume of the supply air.
4. Use on-off control of the air handling equipment.
5. Use on-off control of the refrigeration machine.
6. Control the refrigeration capacity.

The type of control selected for a specific application depends on the nature of the loads, the conditions to be maintained within the space, and available plant facilities.

### 1. Reheat control

Reheat control maintains the dry-bulb temperature within the space by replacing any decrease in the sensible loads by an artificial load. As the internal latent load and/or the outdoor latent load decreases, the space relative humidity decreases. If humidity is to be maintained, dehumidifying is required in addition to reheat.

Figure (3.8) illustrates the psychrometrics of reheat control. The solid lines represent the process at design load, and the broken lines indicate the resulting process at partial load. The RSHF value, plotted from room design conditions to point (2), must be calculated for the minimum practical room sensible load. The room thermostat then controls the temperature of the air leaving the reheat coil along line (1 -2). This type of control is applicable for any RSHF ratio that intersects line (1 -2). If the internal latent loads decrease, the resulting room conditions are at point (3), and the new RSHF process line is along line (2 -3). However, if humidity is to be maintained within the space, the reduced latent load is compensated by humidifying, thus returning to the design room conditions.

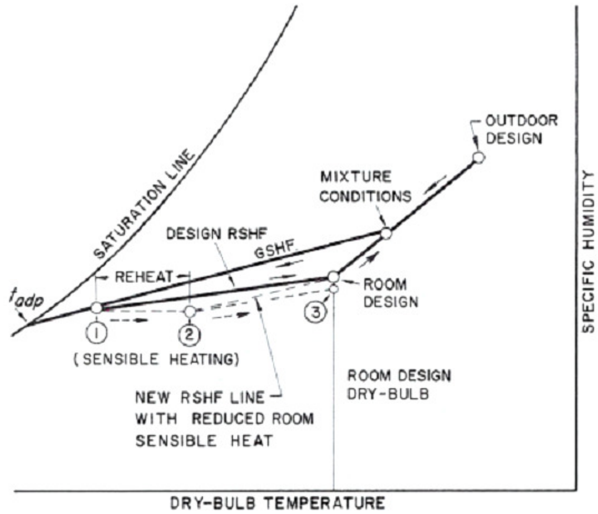
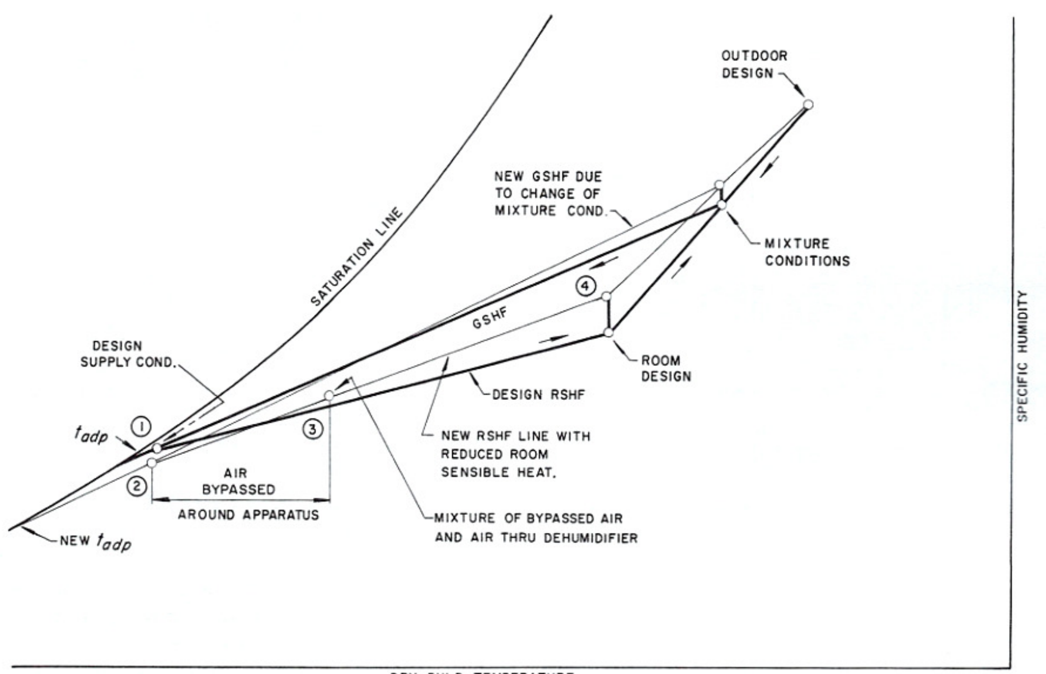



Fig. (3.8) Psychrometric of reheat control

**2. Bypass control**

Bypass control maintains the dry-bulb temperature within the space by modulating the amount of air to be cooled, thus varying the supply air temperature to the space. Fig.(3.9) illustrates one method of bypass control when bypassing return air only. Bypass control may also be accomplished by bypassing a mixture of outdoor and return air around the heat transfer equipment. This method of control is inferior to bypassing return air only since it introduces raw unconditioned air into the space, thus allowing an increase in room relative humidity . A reduction in room sensible load causes the bypass control to reduce the amount of air thru the dehumidifier. This reduced air quantity results in equipment operation at a lower apparatus dew point. Also, the air leaves the dehumidifier at a lower temperature so that there is a tendency to adjust for a decrease in sensible load that is proportionately greater than the decrease in latent load. Bypass control maintains the room dry-bulb temperature but does not prevent the relative humidity from rising above design. With bypass control, therefore, increased relative humidity occurs under conditions of decreasing room sensible load and relatively constant room latent load and outdoor air load.




Fig(3.9) Psychrometrics of bypass control with return air only

**3. Volume control**

Volume control of the supply air quantity provides essentially the same type of control that result from bypassing return air around the heat transfer equipment, Fig. 60. However, this type of control may produce problems in air distribution within the space and, therefore, the required air quantity at partial load should be evaluated for proper air distribution.

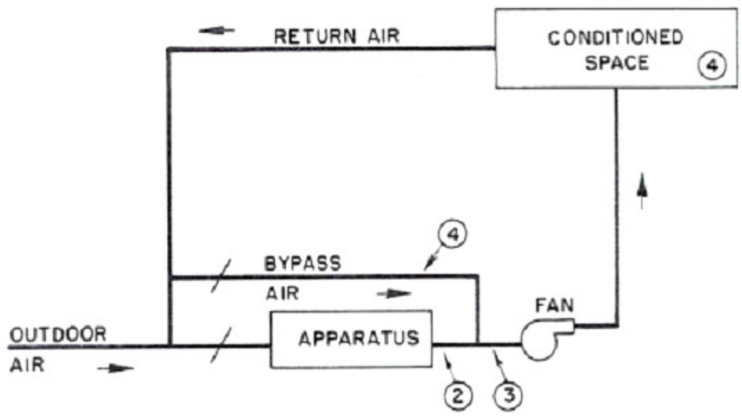



Fig. (3.10) schematic sketch of by pass control with bypass of return air only

**4. On-off control of air handling equipment**

On-off control of air handling equipment (fan- coil units) results in a fluctuating room temperature and space relative humidity. During the "off" operation the ventilation air supply is shut 'off, but chilled water continues to flow thru the coils. This method of control is not recommended for high latent load applications, as control of humidity may be lost at reduced room sensible loads

**5. On-Off control of refrigeration equipment**

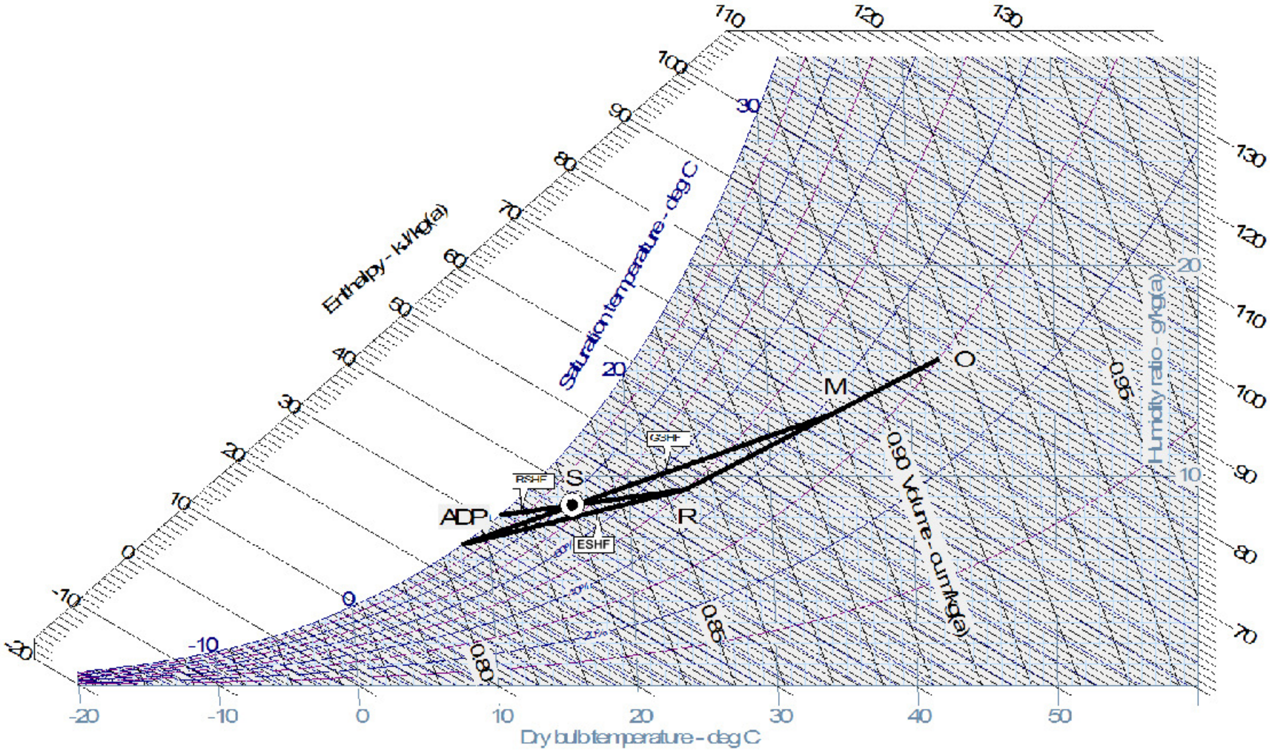
On-off control of refrigeration equipment (large packaged equipment) results in a fluctuating room temperature and space relative humidity. During the "off" operation air is available for ventilation purposes but the coil does not provide cooling. Thus, any outdoor air in the system is introduced into the space unconditioned. Also the condensed moisture that remains on the cooling coil, when the refrigeration equipment is turned off, is re-evaporated in the warm air stream. This is known as re-evaporation. Both of these conditions increase the space latent load, and excessive humidity results. This method of control is not recommended for high latent load applications since control of humidity may be lost at decreased room sensible loads

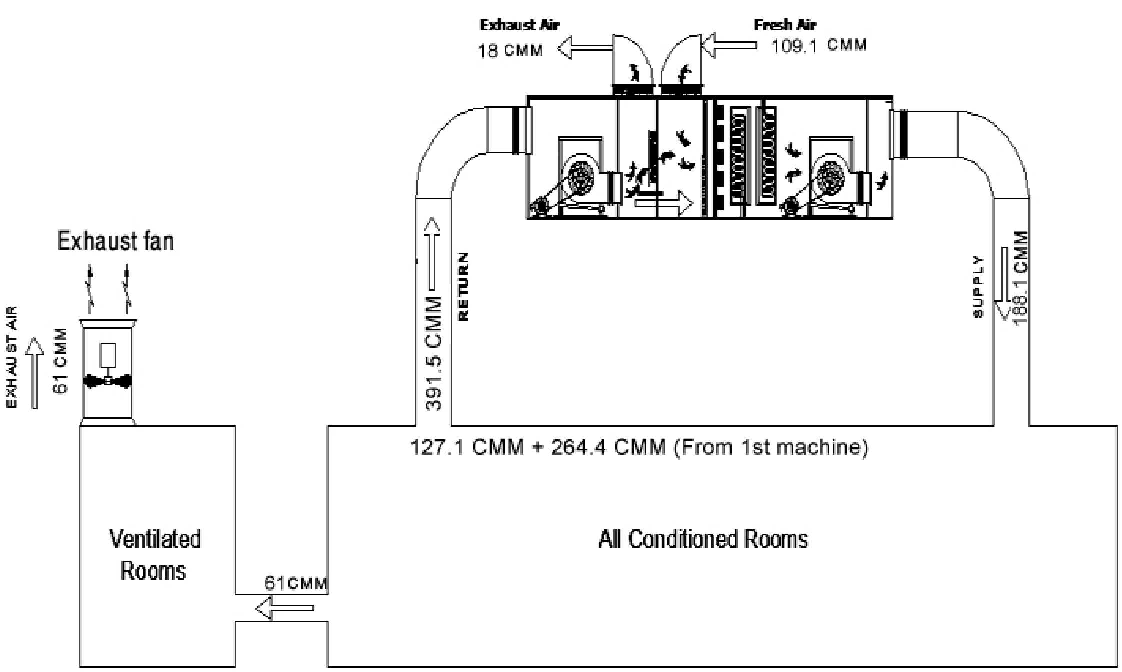
**6. Refrigeration capacity control**

Refrigeration capacity control may be used on either chilled water or direct expansion refrigeration equipment. Partial load control is accomplished on chilled water equipment by bypassing the chilled water around the air side equipment (fan-coil units). Direct expansion refrigeration equipment is controlled either by unloading the compressor cylinders or by back pressure regulation in the refrigerant suction line. Refrigeration capacity controls is normally used in combination with bypass or reheat control. When used in combination, results are excellent. When used alone, results are not as effective. For example, temperature can be maintained reasonably well, but relative humidity will rise above design at partial load conditions, because the latent load may not reduce in proportion to the sensible load.

# Ground psychrometric calculations:

## *For 1st machine*



RSH = 30.82 kw
RLH = 7.06 kw
RTH = 37.87 kw
RSHF = 0.814

OASH = 39.64 kw
OALH = 33.55 kw
OATH = 37.18 kw

GSH = 70.448 kw
GLH = 40.61 kw
GTH = 111.051 kw
GTH = 31.7 TR
GSHF = 0.63

$CMM_{v\text{-}max}$ = 108.1 $m^3/min$

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $T_R$ | = | 24 | $^oC$ | $h_R$ | = | 47.9 | kj/kg |
| $T_S$ | = | 16 | $^oC$ ***"Assumed"*** | $h_S$ | = | 37.83 | kj/hg |
| $T_M$ | = | 34.47 | $^oC$ | $\rho_S$ | = | 1.2 | $kg/m^3$ |

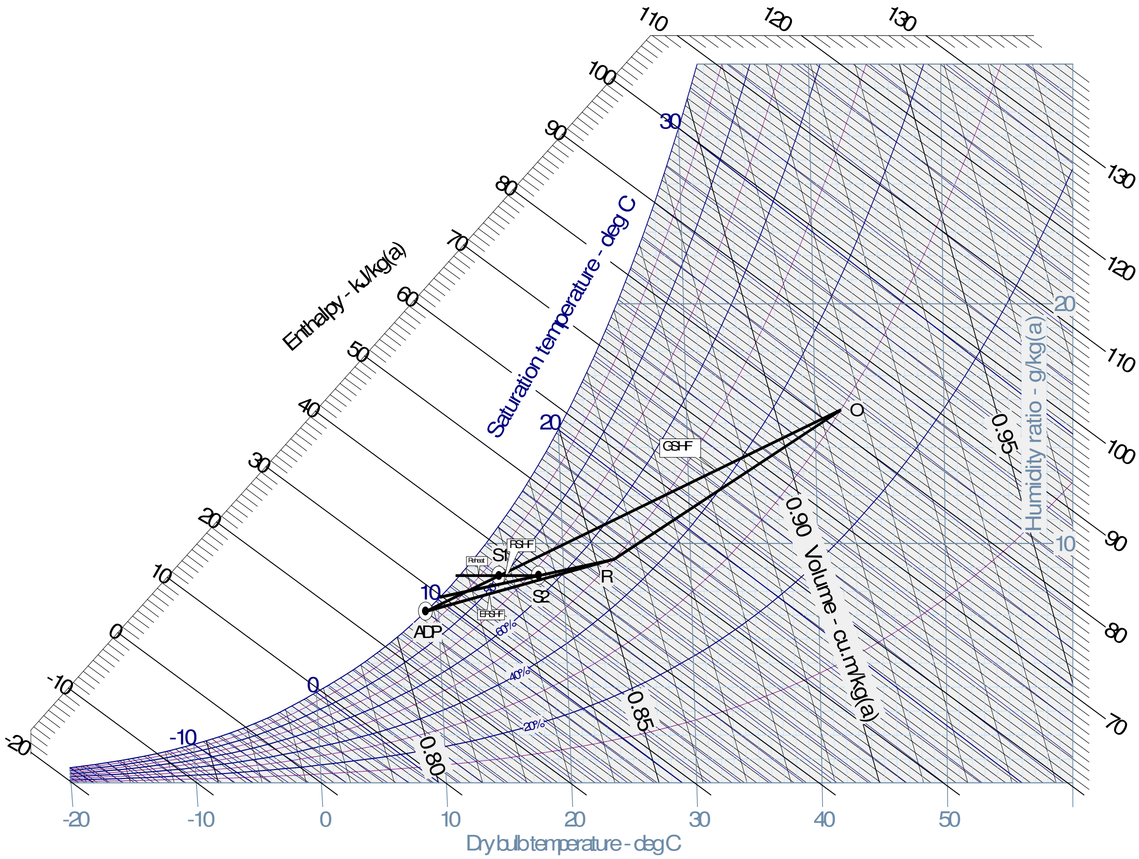
Mixing Ratio = 0.58
$T_{ADP}$ = 8.06 $^oC$
BPF = 0.3

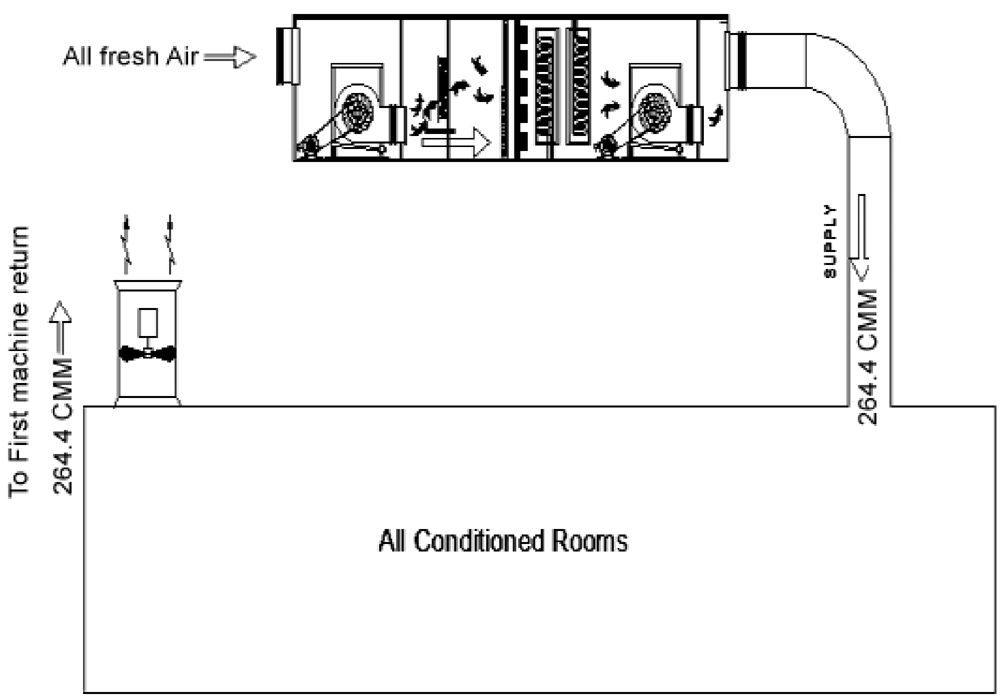
<u>The air supplied to rooms</u>
RTH = $\dot{m}_d * (h_R - h_S)$
37.87 = $\dot{m}_d *(48 - 37.84)$
$\dot{m}_d$ = 3.73 kg/s
$\dot{q}_d$ = $\dot{m}_d / \rho_S$ = 3.1 $m^3/s$

***$CMM_d$ = 3.1 * 60 = 188.1 $m^3/min$***

$Q_{coolingcoil} = \dot{m}_d*(h_m-h_s)$
$= 3.73*(67.9-37.84)$
**$Q_{coolingcoil}$ =112.12 KW**

## ***For 2nd machine "All fresh air"***



RSH = 32.34 kw
RLH = 9.13 kw
RTH = 41.47 kw
RSHF = 0.78

OASH = 128.16 kw
OALH = 108.67 kw
OATH = 236.83 kw

GSH = 160.5 kw
GLH = 117.8 kw
GTH = 278.3 kw
GTH = 79.5 TR
GSHF = 0.58

$CMM_{v\text{-}max}$ = 241.08 $m^3$/min

| | | | | | |
|---|---|---|---|---|---|
| $T_R$ | = 24 | $^oC$ | $h_R$ | = 48 | kj/kg |
| $T_{S1}$ | = 14.9 | $^oC$ | $h_{S1}$ | = 36.84 | kj/hg |
| $T_{S2}$ | = 18.03 | $^oC$ | $h_{S2}$ | = 40.06 | kj/hg |
| $T_M$ | = 42 | $^oC$ | $\rho_{S2}$ | = 1.2 | kg/$m^3$ |

Mixing Ratio = 0.00 ***<u>"All fresh air"</u>***
$T_{ADP}$ = 9 $^oc$
BPF = 0.18

<u>The air supplied to rooms</u>

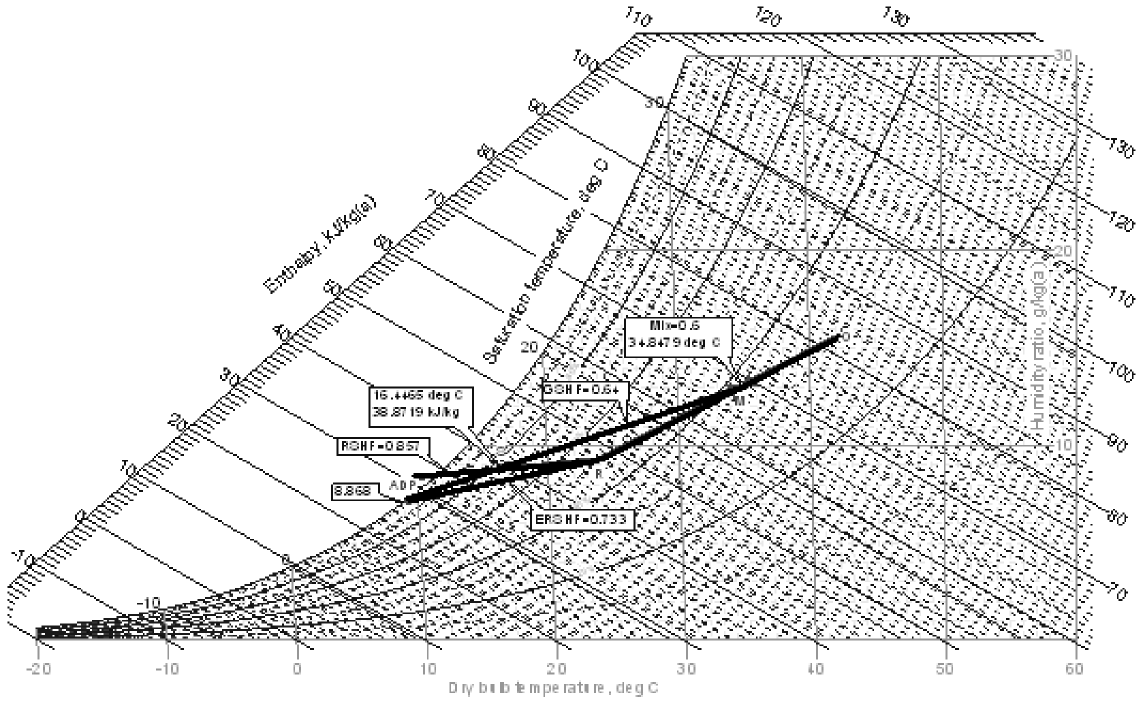
RTH = $\dot{m}_d * (h_r - h_{S2})$
41.47 = $\dot{m}_d *(48 - 40.06)$
$\dot{m}_d$ = 5.22 kg/s
$\dot{q}_d$ = $\dot{m}_d / \rho_{S2}$ = 4.35 $m^3$/s

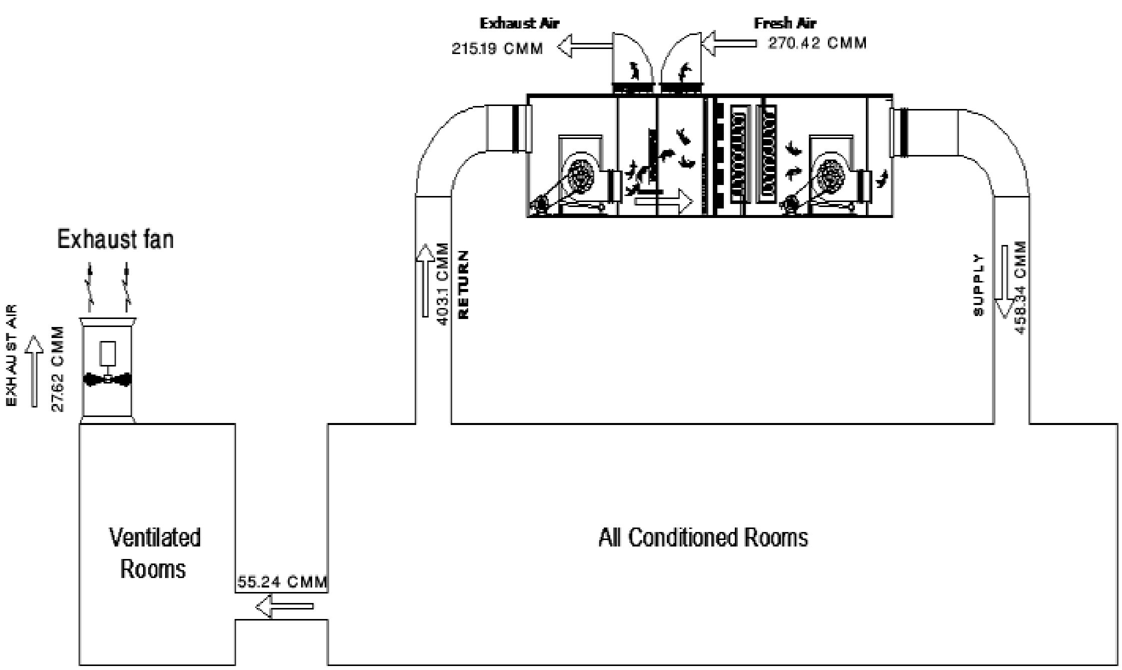
***$CMM_d$ = 4.53 * 60 = 264.43 $m^3$/min***

**$Q_{coolingcoil}$ =** $\dot{m}_d*(h_m-h_s)$
**=** 5.22*(82.38-40.06)

**$Q_{coolingcoil}$ =220.91 KW**

# 1st floor psychometric calculations:



RSH = 71.705 kw
RLH = 11.98 kw
RTH = 83.689 kw
RSHF = 0.857

OASH = 99.144 kw
OALH = 84.24 kw
OATH = 183.38 kw

GSH = 170.85 kw
GLH = 96.116 kw
GTH = 266.95 kw
GTH = 76.27 TR
GSHF = 0.64

$CMM_{v\text{-}max}$ = 253.6 $m^3/min$

| | | | | | |
|---|---|---|---|---|---|
| $T_R$ | = 24 °C | | $h_R$ | = 48 | kj/kg |
| $T_S$ | = 16.45 °C | ***"Assumed"*** | $h_S$ | = 38.87 | kj/hg |
| $T_M$ | = 34.85 °C | | $\rho_S$ | = 1.2 | $kg/m^3$ |

Mixing Ratio = 0.59
$T_{ADP}$ = 8.87°c
BPF = 0.29

<u>The air supplied to rooms</u>

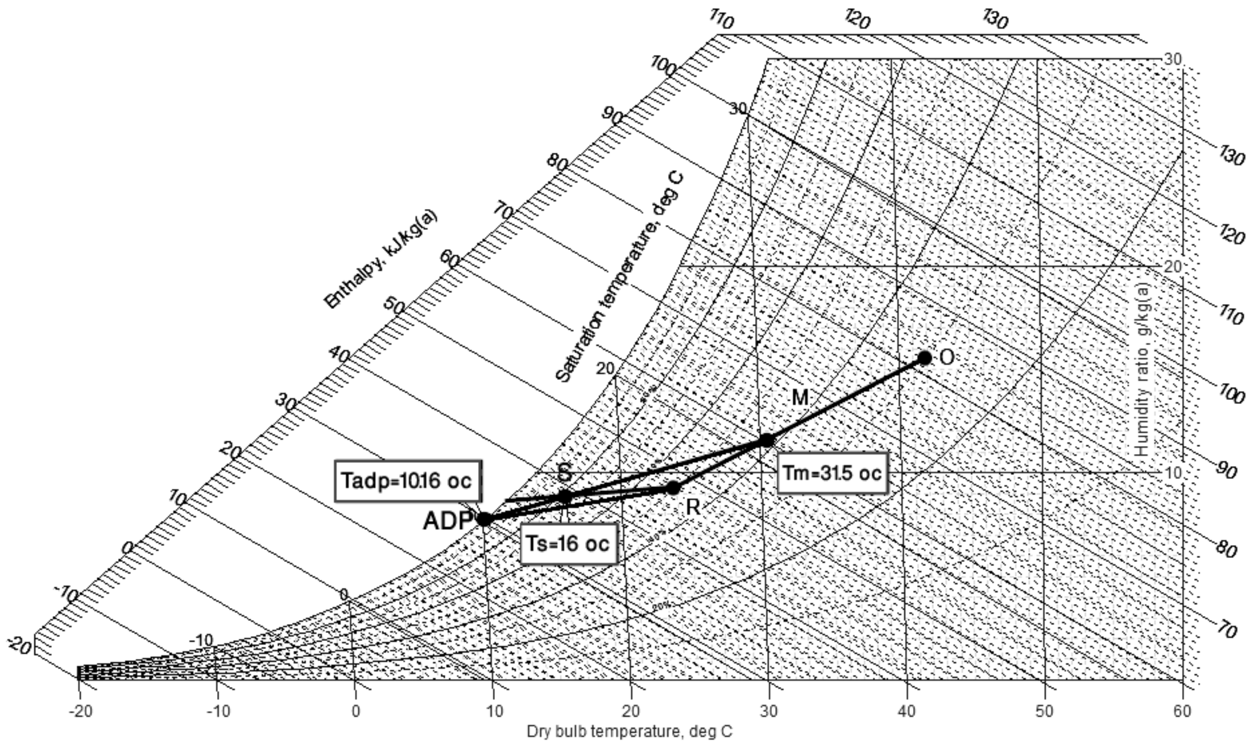
RTH = $\dot{m}_d * (h_r - h_s)$
83.689 = $\dot{m}_d * (48 - 38.87)$
$\dot{m}_d$ = 9.168 kg/s
$\dot{q}_d$ = $\dot{m}_d / \rho_{S2}$ = 7.64 $m^3/s$

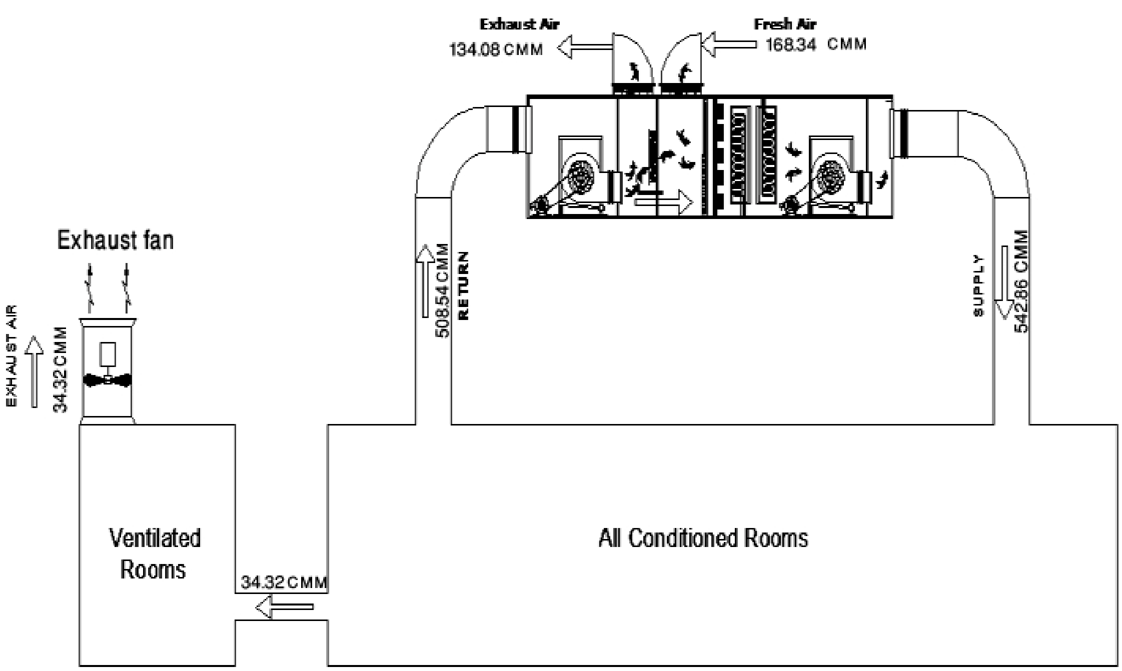
***$CMM_d$ = 7.64 * 60 = 458.345 $m^3/min$***

**$Q_{coolingcoil}$** **=** $\dot{m}_d*(h_m-h_s)$
**=** 9.168*(68.59-38.87)

**$Q_{coolingcoil}$ = 272.47 KW**

# 2nd Floor Psychrometric Calculations:



| | | | |
|---|---|---|---|
| RSH | = | 87.692 | kw |
| RLH | = | 13.53 | kw |
| RTH | = | 101.222 | kw |
| RSHF | = | 0.87 | |
| OASH | = | 65.94 | kw |
| OALH | = | 55.955 | kw |
| OATH | = | 121.89 | kw |
| GSH | = | 153.656 | kw |
| GLH | = | 69.46 | kw |
| GTH | = | 223.117 | kw |
| GTH | = | 63.75 | TR |
| GSHF | = | 0.69 | |

$CMM_{v\text{-}max}$ = 168.34 $m^3$/min

| | | | | | |
|---|---|---|---|---|---|
| $T_R$ = 24 | °C | | $h_R$ | = 48 | kj/kg |
| $T_{S1}$ = 16 | °C | ***"Assumed"*** | $h_S$ | = 38.58 | kj/hg |
| $T_M$ = 29.5 | °C | | $\rho_S$ | = 1.2 | kg/$m^3$ |

Mixing Ratio = 0.31
$T_{ADP}$ = 10.165 °C
BPF = 0.29

<u>The air supplied to rooms</u>

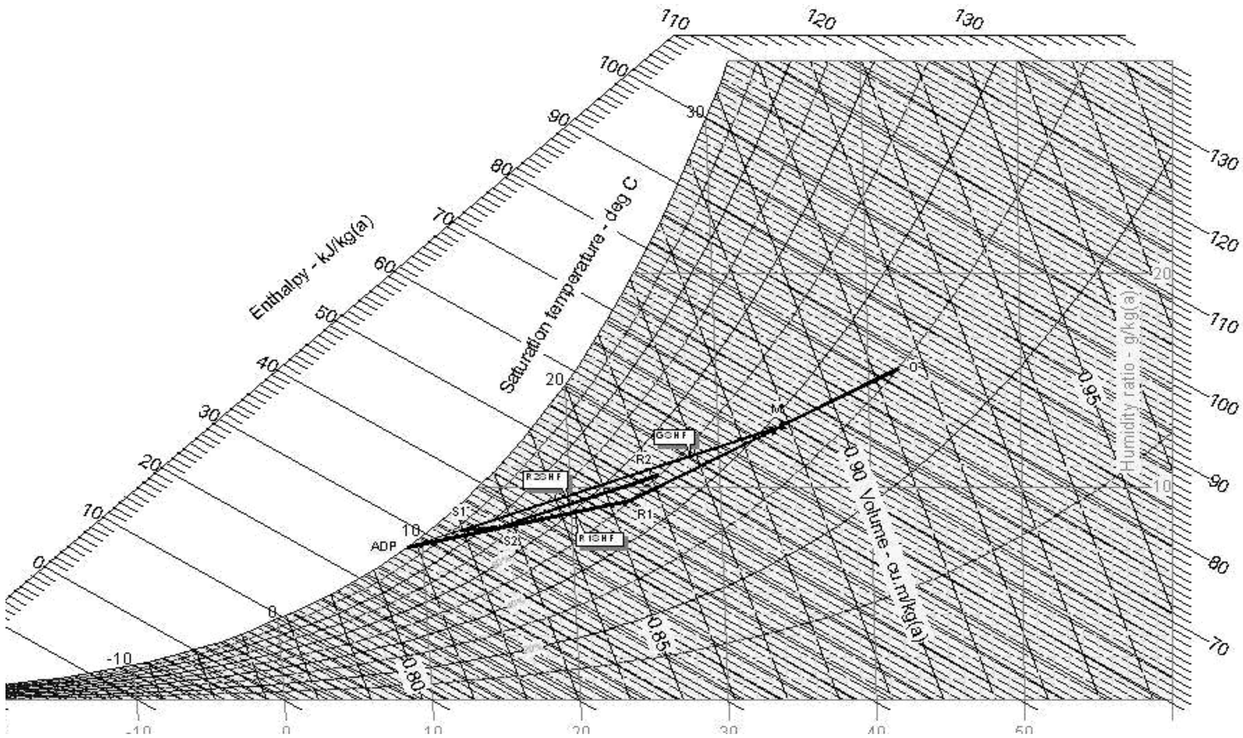
RTH = $\dot{m}_d * (h_r - h_s)$
101.222 = $\dot{m}_d$ *(48 – 38.58)
$\dot{m}_d$ = 10.86 kg/s
$\dot{q}_d$ = $\dot{m}_d / \rho_{S2}$ = 9.05 $m^3$/s

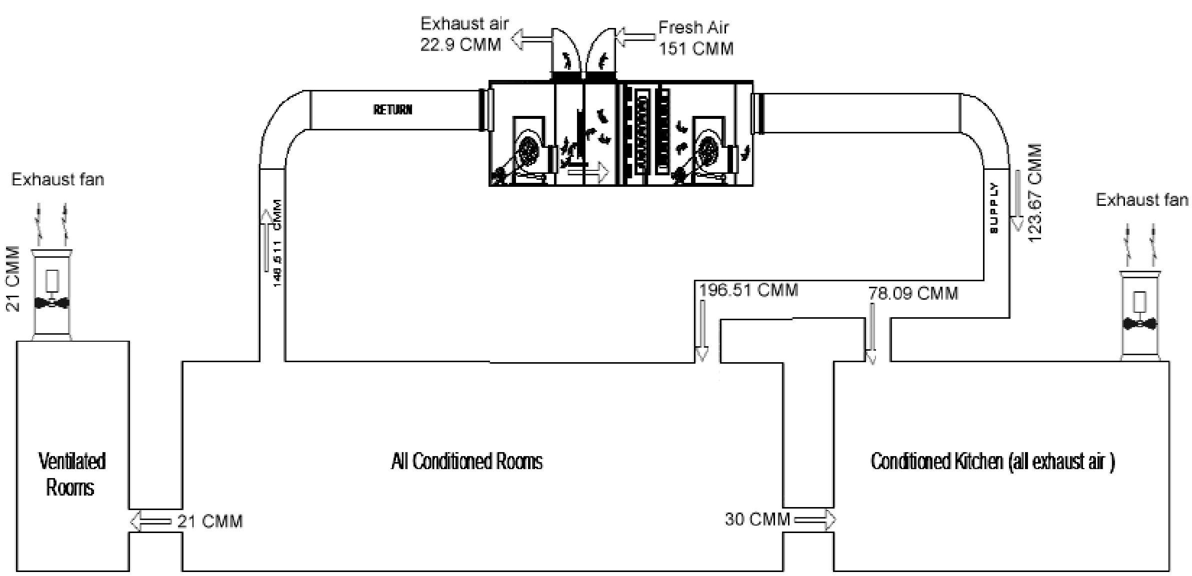
***$CMM_d$ = 9.05 * 60 = 542.86 $m^3$/min***

**$Q_{coolingcoil}$ =** $\dot{m}_d$*($h_m$-$h_s$)
**=** 10.86*(58.5 -38.58)

**$Q_{coolingcoil}$ =216.33 KW**

# 3rd Floor Psychometric Calculations:



GTH = 160.267 kw
GSH = 99.28 kw
GLH = 60.988 kw
GSHF = 0.619

RSH = 55.275 kw
RLH = 21.835 kw
RTH = 77.11 kw
RSHF = 0.716

OASH = 44.003 kw
OALH = 39.153 kw
OATH = 83.156 kw

$CMM_{v-max}$ = 121.996 $m^3/min$

**For All rooms (without room 3-53 "kitchen")**

GTH = 130.882 kw
GSH = 79.96 kw
GLH = 50.921 kw
GSHF = 0.61

RSH = 37.113 kw
RLH = 12.432 kw
RTH = 49.545 kw
RSHF = 0.749

OASH = 42.847 kw
OALH = 38.489 kw
OATH = 81.336 kw

$CMM_{v-max}$ = 118.396 $m^3/min$

**For Room (3-53)**

GTH = 29.238 kw
GSH = 19.171 kw
GLH = 10.067 kw
GSHF = 0.65568

RSH = 18.162 kw
RLH = 9.403 kw
RTH = 27.565 kw
RSHF = 0.659

OASH = 1.009 kw
OALH = 0.664 kw
OATH = 1.673 kw
$CMM_{v-max}$ = 3.6 $m^3/min$

| | | | |
|---|---|---|---|
| $T_{R1}$ = 24 °C | $h_{R1}$ = 48 | kj/kg | |
| $T_{R2}$ = 26 °C | $h_{R2}$ = 26 | kj/kg | |
| $T_{S1}$ = 12.6 °C | $h_{S1}$ = 32.7 | kj/hg | ***"Assumed"*** |
| $T_{S2}$ = 15 °C | $h_{S2}$ = 35.5 | kj/kg | |
| $T_M$ = 33.7 °C | $\rho_{S2}$ = 1.2102 | $kg/m^3$ | |

Mixing Ratio = 0.55
$T_{ADP}$ = 9 °C
BPF = 0.145

<u>The air supplied to rooms (without room 3-53 "kitchen")</u>

$RTH = \dot{m}_d * (h_{r1} - h_{s2})$
$49.545 = \dot{m}_d *(48 - 35.5)$
$\dot{m}_d = 3.963$ kg/s
$\dot{q}_d = \dot{m}_d / \rho_{S2} = 3.275\ m^3/s$
$CMM_D = 3.275 * 60 = 196.511\ m^3/min$

*<u>For room (3-53 "kitchen")</u>*
$RTH = \dot{m}_d * (h_{r1} - h_{s2})$
$27.565 = \dot{m}_d *(53 - 35.5)$
$\dot{m}_d = 1.575$ kg/s
$\dot{q}_d = \dot{m}_d / \rho S2 = 1.3\ m^3/s$
$CMM_d = 1.3 * 60 = 78.093\ m^3/min$

$CMM_{d\text{-}tot} = CMM_{d\text{-}R1} + CMM_{d\text{-}R2}$
$CMM_{d\text{-}tot} = 196.511 + 78.093 = 274.604\ m^3/min$
$CMM_{v\text{-}max} = 121.996\ m^3/min$
$CMM_{v\text{-}max} / CMM_{d\text{-}tot} = 121.996 / 274.604 = 0.444$ "old mixing ratio"

***"Assume new mixing ratio = 55%"***

$CMM\ o = 0.55 * CMM_{d\text{-}tot}$
$CMM\ o = 0.55*274.604 = 151.0326\ m^3/min$

*<u>For outside air</u>*

OASH = .0204*CMMd (To – Tr)
OASH= .0204*151.03 (41.47 – 24)
OASH= 54.65 KW

OALH= 50*CMMo*(Wo – Wr)
OALH= 50*151.03*(6.23*10-3)
OALH= 47.06 KW

OATH= OASH + OALH
OATH= 101.68 KW

GSH= RSH+OASH
GSH= 55.25 + 54.65
GSH= 109.91 KW

GTH = RTH+OATH
GTH = 77.11+ 101.68
GTH = 178.79 KW

GTH = 51.08 TR

GSHF = GSH/GTH
GSHF = 0.61

Reheat = $m_{td}$*(hs2- hs1)
Rehear = 3.96 * (35.5 – 32.7)
Reheat = 11.1 Kw

ERSH = RSH+BPF*OASH
ERSH = 55.27+ 0.145*39.15
ERSH = 61.69 KW

ERLH = RLH+BPF*OALH
ERLH = 21.83+ 0.145*39.15
ERLH = 27.54 KW

ERSHF = (RSH + Reheat) / (RSH + RLH + Reheat )
ERSHF = 0.725

$\mathbf{Q}_{coolingcoil}$ **=** $\dot{m}_d*(h_m-h_{s1})$
**=** 5.538*(66.69 -32.7)

$\mathbf{Q}_{coolingcoil}$ **=188.24 KW**

Chapter Four

# Air Distribution

## 4.1 Introduction

The object of good air distribution in HVAC systems is to create the proper combination of temperature, humidity and air motion, in the occupied zone of the conditioned room from the floor to 2m above floor level. To obtain comfort conditions within this zone, standard limits have been established as acceptable *effective draft temperature.* This term includes air temperature, air motion, relative humidity, and their physiological effects on the human body. Any variation from accepted standards of one of these elements causes discomfort to occupants. Lack of uniform conditions within the space or excessive fluctuation of conditions in the same part of the space may produce similar effects.

## 4.2 Air Diffusion Performance Index (ADPI):

ADPI is a measure of cooling mode conditions. If many measurements of air velocity and air temperature were made throughout the occupied zone of an office, the ADPI would be defined as the percentage of locations where measurements were taken that meet the specifications on effective draft temperature and air velocity - the *effective draft temperature* (-1.7℃ and + 1.1℃) and air velocity is less than (0.35m/s) - If the ADPI is maximum (approaching 100 percent), the most desirable conditions are achieved.

The following cooling zone design criteria for the various air diffusion devices maximize the ADPI and comfort. These criteria also account for airflow rate, outlet size, manufacturer's design qualities, and dimensions of the room for which the system is designed.

## 4.3 Definitions

### A. Throw

The *throw* of a jet is the distance from the outlet device to a point in the airstream where the maximum velocity in the stream cross section has been reduced to a selected terminal velocity. For all devices, the terminal velocity, $V_t$ was selected as 0.25 except in the case of ceiling slot diffusers, where the terminal velocity was selected as 0.5 *m/*s.

### B. Throw Distance

The *throw distance* of a jet is denoted by the symbol Tv, where the subscript indicates the terminal velocity for which the throw is given.

### C. Characteristic Room Length

The *characteristic room length* (L) is the distance from the outlet device to the nearest boundary wall in the principal horizontal direction of the airflow. However, where air injected into the room does not impinge on a wall surface but mixes with air from a neighboring outlet, the characteristic length (L) is one-half the distance between outlets, plus the distance the mixed jets must travel downward to reach the occupied zone. Table 1 summarizes definitions of characteristic length for various devices.

| Diffuser Type | Characteristic Length, *L* |
|---|---|
| High Sidewall Grille | Distance to wall perpendicular to jet |
| Circular Ceiling Diffuser | Distance to closest wall or intersecting air jet |
| Sill Grille | Length of room in the direction of the jet flow |
| Ceiling Slot Diffuser | Distance to wall or midplane between outlets |
| Light Troffer Diffusers | Distance to midplane between outlets, plus distance from ceiling to top of occupied zone |
| Perforated, Louvered Ceiling Diffusers | Distance to wall or midplane between outlets |

Table 1: characteristic room length for diffusers

## 4.4 Design Conditions

The quantity of air must be known from other design specifications. If it is not known, the solution must be obtained by a trial and error technique. The devices for which data were obtained are:

(1) High sidewall grille,
(2) Sill grille,
(3) Two and four-slot ceiling diffusers,
(4) Cone type circular ceiling diffusers,
(5) Light troffer diffusers, and
(6) Square-faced perforated and louvered ceiling diffusers.

Table 2 summarizes the results of the recommendations on values of TV/L by giving the value of Tv/L where the ADPI is a maximum for various loads, as well as a range of values TV/L where ADPI is above a minimum specified value.

## 4.5 Outlet Type Selection

No criteria have been established for choosing among the six types of outlets to obtain an optimum ADPI. All outlets tested, when used according to these recommendations, can have ADPI values that are satisfactory [greater than 90 percent for loads less than 126 W/m2].

## 4.6 Design Procedure

a) Determine the air volume requirements and room size.
b) Select the tentative outlet type and location within room.
c) Determine the room's characteristic length (L) (Table 1).
d) Select the recommended Tv/L ratio from Table 2.
e) Calculate the throw distance (Tv) by multiplying the recommended Tv/L ratio from Table 2 by the room length (L).
f) Locate the appropriate outlet size from manufacturer's catalog.
g) Ensure that this outlet meets other imposed specifications, such as noise and static pressure.

| Terminal Device | Room Load W/m$^2$ | $T_{0.25}/L$ for Max. ADPI | Maximum ADPI | For ADPI Greater Than | Range of $T_{0.25}/L$ |
|---|---|---|---|---|---|
| High | 250 | 1.8 | 68 | — | — |
| Sidewall | 190 | 1.8 | 72 | 70 | 1.5-2.2 |
| Grilles | 125 | 1.6 | 78 | 70 | 1.2-2.3 |
| | 65 | 1.5 | 85 | 80 | 1.0-1.9 |
| Circular | 250 | 0.8 | 76 | 70 | 0.7-1.3 |
| Ceiling | 190 | 0.8 | 83 | 80 | 0.7-1.2 |
| Diffusers | 125 | 0.8 | 88 | 80 | 0.5-1.5 |
| | 65 | 0.8 | 93 | 90 | 0.7-1.3 |
| Sill Grille | 250 | 1.7 | 61 | 60 | 1.5-1.7 |
| Straight | 190 | 1.7 | 72 | 70 | 1.4-1.7 |
| blades | 125 | 1.3 | 86 | 80 | 1.2-1.8 |
| | 65 | 0.9 | 95 | 90 | 0.8-1.3 |
| Sill Grille | 250 | 0.7 | 94 | 90 | 0.8-1.5 |
| Spread | 190 | 0.7 | 94 | 80 | 0.6-1.7 |
| blades | 125 | 0.7 | 94 | — | — |
| | 65 | 0.7 | 94 | — | — |
| Ceiling | 250 | 0.3* | 85 | 80 | 0.3-0.7 |
| Slot | 190 | 0.3* | 88 | 80 | 0.3-0.8 |
| Diffusers (for $T_{100}/L$) | 125 | 0.3* | 91 | 80 | 0.3-1.1 |
| | 65 | 0.3* | 92 | 80 | 0.3-1.5 |
| Light | 190 | 2.5 | 86 | 80 | <3.8 |
| Troffer | 125 | 1.0 | 92 | 90 | <3.0 |
| Diffusers | 65 | 1.0 | 95 | 90 | <4.5 |
| Perforated and Louvered Ceiling Diffusers | 35-160 | 2.0 | 96 | 90 | 1.4-2.7 |
| | — | — | — | 80 | 1.0-3.4 |

Table 2: ADPI Selection guide

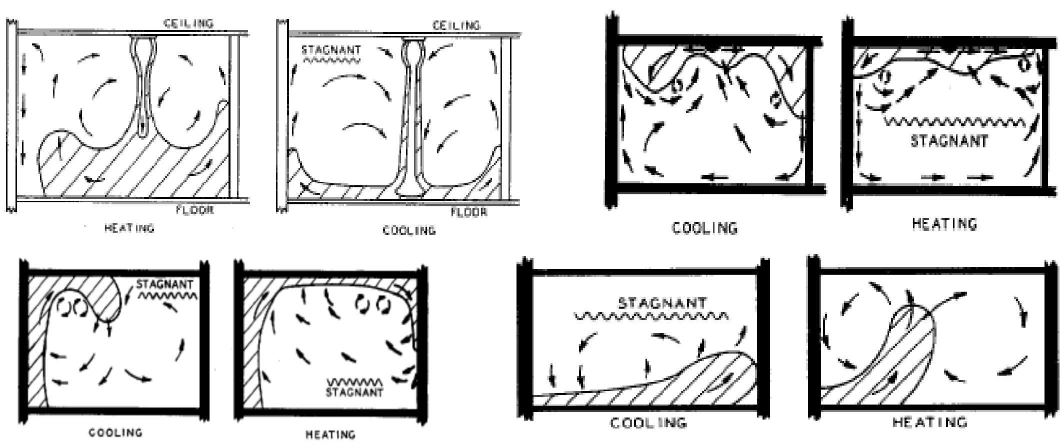
## 4.7 Outlet Location

The building's use, size and construction type must be considered in designing the air distribution system, and in selecting the type and location of the supply outlets. Location and selection of the supply outlets is further influenced by the interior design of the building, local sources of heat gain or loss, and outlet performance and design. Local sources of heat gain or loss promote convection currents or cause stratification and may, therefore, determine both the type and location of the supply outlets. Outlets should be
located to neutralize any undesirable convection currents set up by a concentrated load. If a concentrated heat source is located at the occupancy level of the room, the heating effect can be counteracted by directing cool air toward the heat source or by locating an exhaust or return grille adjacent to the heat source. The second method is more economical, rather than dissipated into the conditioned space. Where lighting loads are heavy [54 W/m2] and ceilings relatively high [above 4.6m], the outlets should be located below the lighting load, and the stratified warm air should be removed by an exhaust or return fan. An exhaust fan is recommended if the wet-bulb temperature of the air is above that of the outdoors; a return fan is recommended if it is below this temperature.

These methods reduce the requirements for supply air. Enclosed lights produce more savings than exposed lights, since a considerable portion of the energy is radiant.

| Type of Outlet | Floor Space l/s per Sq. Metre | Approximate Maximum Air Changes/Hour For (3 m) Ceiling Height |
|---|---|---|
| Grilles & Registers | 3 to 6 | 7 |
| Slot Diffusers | 4 to 10 | 12 |
| Perforated Panel | 5 to 15 | 18 |
| Ceiling Diffuser | 5 to 25 | 30 |
| Perforated Ceiling | 5 to 50 | 60 |

Table 3: guide for selection of supply outlets




## 4.8 Selection Procedures

The following procedure is generally used in selecting outlet locations and types:

a) Determine the amount of air to be supplied to each room.

b) Select the type and quantity of outlets for each room, considering such factors as air quantity required, distance available for throw or radius of diffusion, structural characteristics, and architectural concepts. Table 3 is based on experience and typical ratings of various outlets. It may be used as a guide to the outlets applicable for use with various room air loadings. Special conditions, such as ceiling heights greater than the normal 2.4 to 3.6 m and exposed duct mounting, as well as product modifications and unusual conditions of room occupancy, can modify this table. Manufacturers' rating data should be consulted for final determination of the suitability of the outlets used.

c) Locate outlets in the room to distribute the air as uniformly as possible. Outlets may be sized and located to distribute air in proportion to the heat gain or loss in various portions of the room.

d) Select proper outlet size from manufacturers' ratings according to air quantities, discharge velocities, distribution patterns, and sound levels. Note manufacturers' recommendations with regard to use. In an open space configuration, the interaction of airstreams from multiple diffuser sources may alter single diffuser throw data or single diffuser air temperature air velocity data, and it may not be sufficient to predict particular levels of air motion in a space. Also, obstructions to the primary air distribution pattern require special consideration.

## Return & Exhaust Inlets

To summarize the procedure for inlet location and selection:

a) Determine room return and an exhaust air quantity from design load calculations.

b) Select type and quantity of inlets for each room evaluating:
   1) Inlet airflow
   2) Inlet velocity
   3) Architectural requirements

c) Locate inlets to enhance room air circulation and to remove undesirable air (considering air temperature and contamination).

d) Select proper inlet size from manufacturer's catalog data considering:
   1) Inlet airflow
   2) Inlet velocity
   3) Pressure loss
   4) Sound level

# Ground Floor

## Supply Diffusers Selection

Square Louver Face Ceiling Diffuser
From Air Diffusion catalogs

*For First machine*

| | | | | | Catalogue | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Room | L/S | No_ | act. Th | L/S/diff | diffuser | Th | L/S | dB | ΔP (Pa) |
| 0-13 | 63.31575 | 1 | 3.6 | 63.31575 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-15 | 60.1875 | 1 | 2.9 | 60.1875 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-23 | 369.7577 | 6 | 3 | 61.62629 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-41 | 120.0239 | 2 | 2.5 | 60.01196 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-42 | 120.5279 | 2 | 2.5 | 60.26396 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-43 | 124.9683 | 2 | 2.5 | 62.48416 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-44 | 120.5279 | 2 | 2.5 | 60.26396 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-45 | 124.9683 | 2 | 2.5 | 62.48416 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-46 | 120.5279 | 2 | 2.5 | 60.26396 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-47 | 56.87568 | 1 | 2.1 | 56.87568 | 150*150 | 3 | 57 | 17 | 14 |
| 0-48 | 60.59744 | 1 | 2.9 | 60.59744 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-49 | 120.5279 | 2 | 2.5 | 60.26396 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-50 | 124.9683 | 2 | 2.5 | 62.48416 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-51 | 120.5279 | 2 | 2.5 | 60.26396 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-52 | 124.9683 | 2 | 2.5 | 62.48416 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-53 | 120.5279 | 2 | 2.5 | 60.26396 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-54 | 124.564 | 2 | 2.5 | 62.28201 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-55 | 75.0072 | 1 | 2.8 | 75.0072 | 200*200 | 3 | 81 | <15 | 10 |
| 0-59 | 190.8456 | 2 | 1.8 | 95.42279 | 200*200 | 3.7 | 102 | 21 | 16 |
| 0-60 | 121.8485 | 2 | 1.8 | 60.92426 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-61 | 141.0012 | 2 | 1.8 | 70.5006 | 250*250 | 2.7 | 95 | <15 | 7 |
| 0-62 | 173.7462 | 2 | 1.9 | 86.8731 | 200*200 | 3.7 | 102 | 21 | 16 |
| 0-63 | 283.7302 | 2 | 3.1 | 141.8651 | 250*250 | 4.3 | 159 | 24 | 17 |
| 0-66 | 25.96661 | 1 | 1 | 25.96661 | 150*150 | 2.1 | 34 | <15 | 5 |
| 0-67 | 44.56576 | 1 | 1 | 44.56576 | 150*150 | 2.7 | 46 | <15 | 9 |

*For second machine*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0-17 | 2271.177 | 16 | 3.5 | 141.9486 | 250*250 | 4.3 | 159 | 24 | 17 |
| 0-20 | 1873.076 | 10 | 6 | 187.3076 | 250*250 | 4.6 | 191 | 31 | 23 |

**Return Diffusers Selection**

*For First machine*

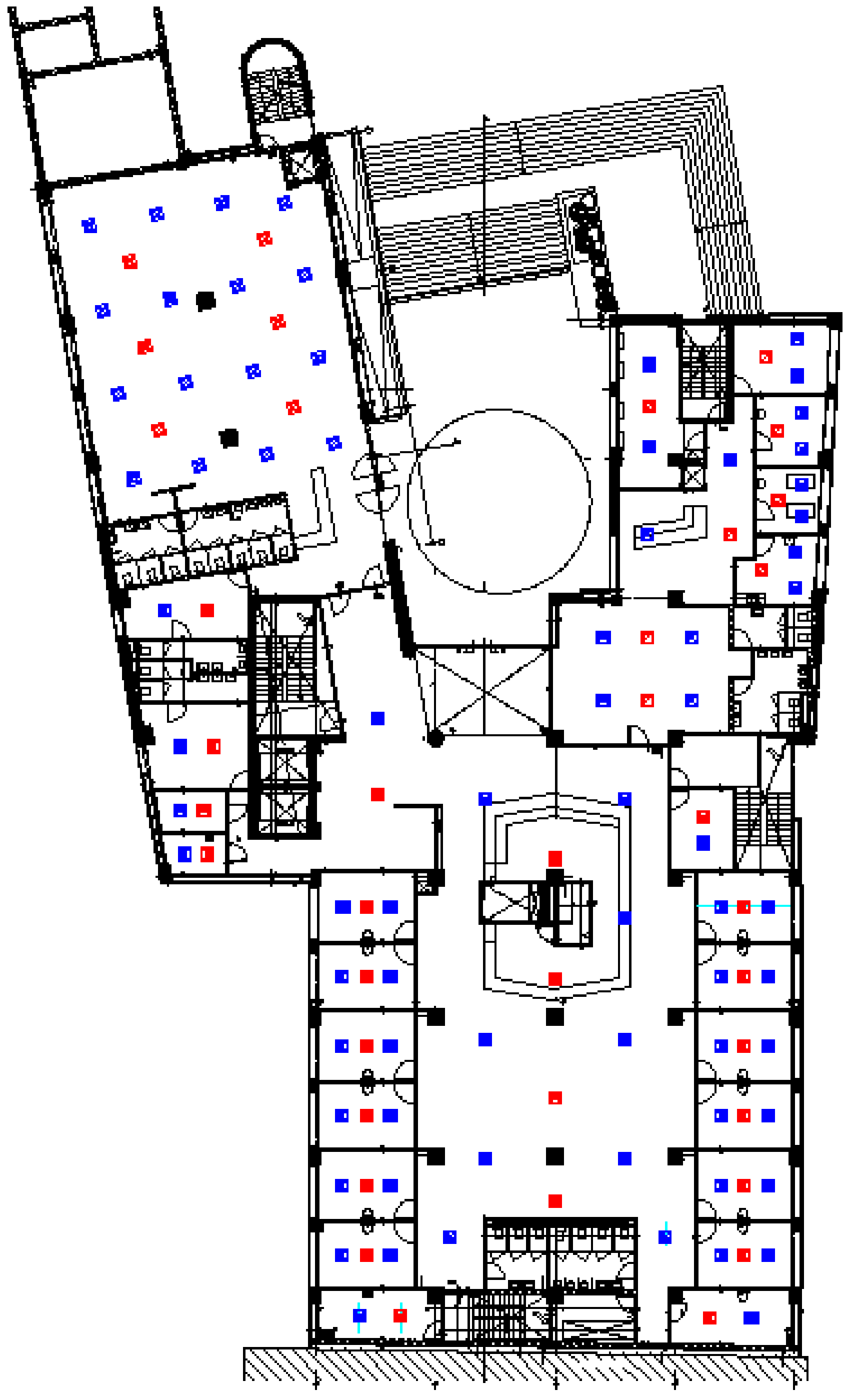
| | | | | | Catalogue | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Room | L/S | No_ | act. Th | L/S/diff | diffuser | Th | L/S | dB | ΔP (Pa) |
| 0-13 | 63.31575 | 1 | 3.6 | 63.31575 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-15 | 60.1875 | 1 | 2.9 | 60.1875 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-23 | 369.7577 | 6 | 3 | 61.62629 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-41 | 120.0239 | 2 | 2.5 | 60.01196 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-42 | 120.5279 | 2 | 2.5 | 60.26396 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-43 | 124.9683 | 2 | 2.5 | 62.48416 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-44 | 120.5279 | 2 | 2.5 | 60.26396 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-45 | 124.9683 | 2 | 2.5 | 62.48416 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-46 | 120.5279 | 2 | 2.5 | 60.26396 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-47 | 56.87568 | 1 | 2.1 | 56.87568 | 150*150 | 3 | 57 | 17 | 14 |
| 0-48 | 60.59744 | 1 | 2.9 | 60.59744 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-49 | 120.5279 | 2 | 2.5 | 60.26396 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-50 | 124.9683 | 2 | 2.5 | 62.48416 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-51 | 120.5279 | 2 | 2.5 | 60.26396 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-52 | 124.9683 | 2 | 2.5 | 62.48416 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-53 | 120.5279 | 2 | 2.5 | 60.26396 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-54 | 124.564 | 2 | 2.5 | 62.28201 | 150*150 | 3.4 | 69 | 23 | 19 |
| 0-55 | 75.0072 | 1 | 2.8 | 75.0072 | 200*200 | 3 | 81 | <15 | 10 |
| 0-59 | 190.8456 | 2 | 1.8 | 95.42279 | 200*200 | 3.7 | 102 | 21 | 16 |
| 0-60 | 121.8485 | 2 | 1.8 | 60.92426 | 200*200 | 2.4 | 61 | <15 | 6 |
| 0-61 | 141.0012 | 2 | 1.8 | 70.5006 | 250*250 | 2.7 | 95 | <15 | 7 |
| 0-62 | 173.7462 | 2 | 1.9 | 86.8731 | 200*200 | 3.7 | 102 | 21 | 16 |
| 0-63 | 283.7302 | 2 | 3.1 | 141.8651 | 250*250 | 4.3 | 159 | 24 | 17 |
| 0-66 | 25.96661 | 1 | 1 | 25.96661 | 150*150 | 2.1 | 34 | <15 | 5 |
| 0-67 | 44.56576 | 1 | 1 | 44.56576 | 150*150 | 2.7 | 46 | <15 | 9 |

*For second machine*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0-17 | 2271.177 | 16 | 3.5 | 141.9486 | 250*250 | 4.3 | 159 | 24 | 17 |
| 0-20 | 1873.076 | 10 | 6 | 187.3076 | 250*250 | 4.6 | 191 | 31 | 23 |

## Air quantity for ventilated rooms

| Room | Room no. | A ($m^2$) | H (m) | ζ (time/hr) | CMM | CMM tot |
|---|---|---|---|---|---|---|
| stairs | 0_9 | 12.10 | 3.90 | 2.00 | 1.57 | 30.52 |
| stairs | 0_6 | 12.96 | 3.90 | 2.00 | 1.68 | |
| stairs | 0_7 | 11.80 | 3.90 | 2.00 | 1.53 | |
| Outside stair case | 0_8 | 14.42 | 3.9 | 2.00 | 1.87 | |
| main stairs | 0_5 | 26.47 | 3.90 | 2.00 | 3.44 | |
| Staff toilet F | 0_14 | 10.00 | 2.60 | 5.00 | 2.17 | |
| Staff toilet M | 0_16 | 7.55 | 2.60 | 5.00 | 1.64 | |
| toilet (F) | 0_19 | 17.95 | 2.60 | 5.00 | 3.81 | |
| toilet (M) | 0_21 | 10.30 | 2.60 | 5.00 | 2.23 | |
| toilet (F) | 0_18 | 11.70 | 2.60 | 5.00 | 2.54 | |
| toilet (M) | 0_26 | 14.34 | 2.60 | 5.00 | 3.11 | |
| toilet (M) | 0_22 | 14.34 | 2.60 | 5.00 | 3.10 | |
| toilet (F) | 0_25 | 8.39 | 2.60 | 5.00 | 1.82 | |



**Ground floor supply and return ducts layout**

# 1st Floor

## Supply Diffusers Selection

Square Louvre Face Ceiling Diffuser

From Air Diffusion catalogs

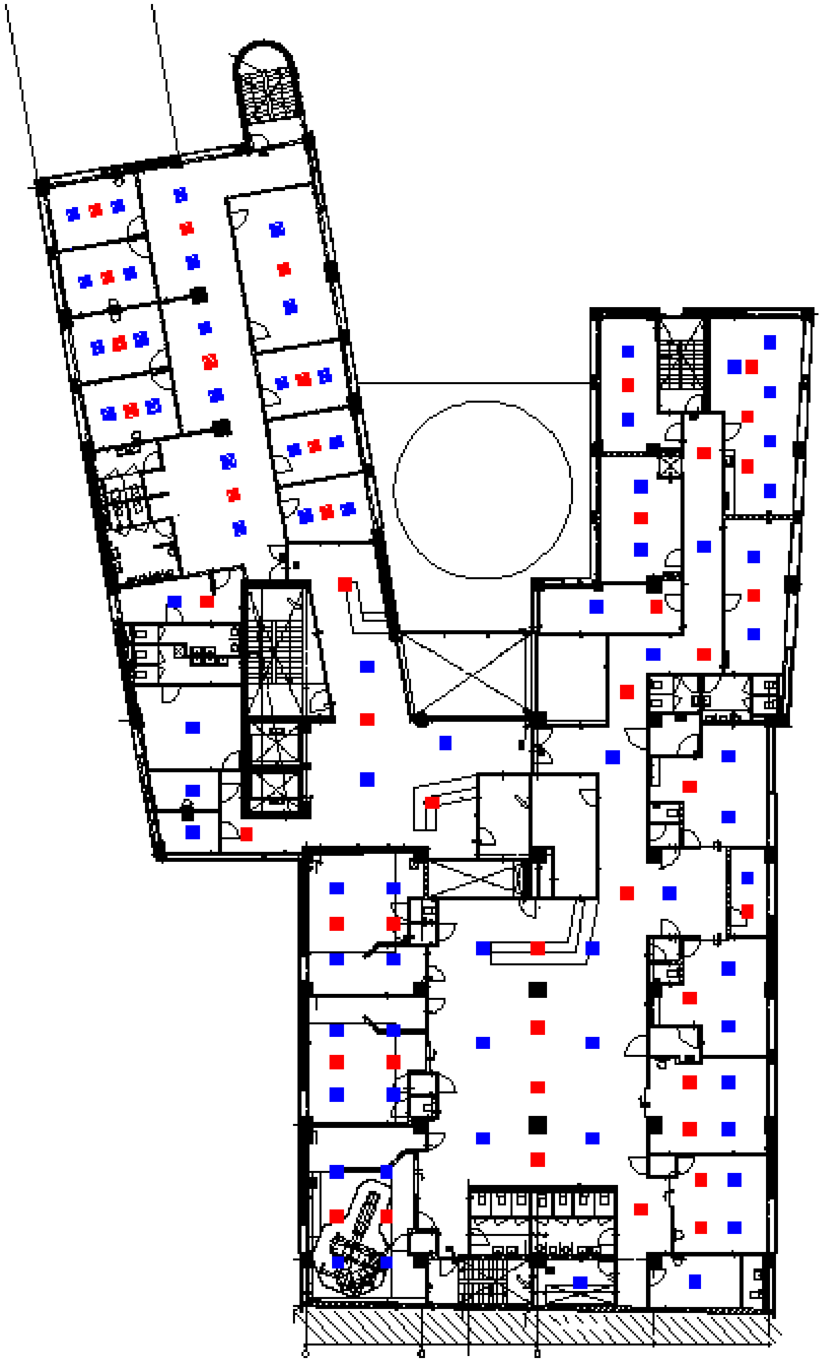
| | | | | | Catalogue | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Room | L/S | No_ | act. Th | L/S/diff | diffuser | Th | L/S | dB | ΔP (Pa) |
| 13 | 65.26 | 1 | 4.4 | 65.26 | 150*150 | 3.4 | 69 | 23 | 19 |
| 15 | 40.54 | 1 | 2.3 | 40.54 | 150*150 | 2.7 | 46 | <15 | 9 |
| 41 | 71.86 | 1 | 2.1 | 71.86 | 200*200 | 3 | 81 | <15 | 10 |
| 42 | 78.66 | 1 | 2.1 | 78.66 | 200*200 | 3 | 81 | <15 | 10 |
| 44+43 | 279.95 | 4 | 3 | 69.99 | 200*200 | 3 | 81 | <15 | 10 |
| 45+46 | 275.88 | 4 | 3 | 68.97 | 200*200 | 3 | 81 | <15 | 10 |
| 47+48 | 318.06 | 4 | 2.7 | 79.52 | 200*200 | 3 | 81 | <15 | 10 |
| 49 | 107.72 | 1 | 2.8 | 107.72 | 250*250 | 3.7 | 127 | 17 | 11 |
| 50 | 167.39 | 2 | 2.6 | 83.69 | 250*250 | 2.7 | 95 | <15 | 7 |
| 51 | 212.25 | 2 | 2.5 | 106.12 | 250*250 | 3.7 | 127 | 17 | 11 |
| 52+53 | 163.41 | 2 | 3.1 | 81.70 | 250*250 | 2.7 | 95 | <15 | 7 |
| 55 | 98.29 | 1 | 2 | 98.29 | 200*200 | 3.7 | 102 | 21 | 16 |
| 56 | 160.09 | 2 | 3.2 | 80.04 | 200*200 | 3 | 81 | <15 | 10 |
| 61 | 270.16 | 2 | 3.2 | 135.08 | 300*300 | 3 | 137 | <15 | 8 |
| 62 | 585.62 | 5 | 2.7 | 117.12 | 250*250 | 3.7 | 127 | 17 | 11 |
| 63 | 227.31 | 2 | 3 | 113.65 | 250*250 | 3.7 | 127 | 17 | 11 |
| 64 | 182.20 | 2 | 3.4 | 91.10 | 200*200 | 3.7 | 102 | 21 | 16 |
| 65 | 45.12 | 1 | 2.3 | 45.12 | 150*150 | 2.7 | 46 | <15 | 9 |
| 67 | 165.81 | 2 | 2.31 | 82.90 | 250*250 | 2.7 | 95 | <15 | 7 |
| 68 | 165.81 | 2 | 2.31 | 82.90 | 250*250 | 2.7 | 95 | <15 | 7 |
| 69 | 165.81 | 2 | 2.31 | 82.90 | 250*250 | 2.7 | 95 | <15 | 7 |
| 70 | 308.46 | 2 | 4.16 | 154.23 | 200*200 | 4.6 | 163 | 36 | 39 |
| 71 | 154.83 | 2 | 2.41 | 77.42 | 200*200 | 3 | 81 | <15 | 10 |
| 72 | 140.77 | 2 | 2.41 | 70.38 | 200*200 | 3 | 81 | <15 | 10 |
| 73 | 140.77 | 2 | 2.41 | 70.38 | 200*200 | 3 | 81 | <15 | 10 |
| 74 | 144.54 | 2 | 2.41 | 72.27 | 200*200 | 3 | 81 | <15 | 10 |
| 75 | 71.33 | 1 | 2.5 | 71.33 | 200*200 | 3 | 81 | <15 | 10 |
| 11 | 128.70 | 3 | 2 | 42.90 | 150*150 | 2.7 | 46 | <15 | 9 |
| 12+17+18+19 | 840.23 | 6 | 3.6 | 140.04 | 250*250 | 4.3 | 159 | 24 | 17 |
| 22+54 | 1468.69 | 7 | 5.1 | 209.81 | 250*250 | 4.9 | 222 | 35 | 33 |
| 66+10+40 | 290.91 | 3 | 3 | 96.97 | 200*200 | 3.7 | 102 | 21 | 16 |

## Return Diffusers Selection

| Room | L/S | No_ | L/S/diff | Cataloge | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | diffuser | L/S | dB | ΔP (mm water) | ΔP |
| 15 | 13.27 | 1 | 13.27 | 150*150 | 35 | <15 | 1.524 | 15.0 |
| 44+43 | 305.29 | 2 | 152.65 | 450*225 | 159 | 17 | 1.524 | 15.0 |
| 45+46 | 300.89 | 2 | 150.45 | 450*225 | 159 | 17 | 1.524 | 15.0 |
| 47+48 | 347.29 | 2 | 173.65 | 375*300 | 177 | 17 | 1.524 | 15.0 |
| 50 | 183.70 | 2 | 91.85 | 300*225 | 106 | 15 | 1.524 | 15.0 |
| 51 | 233.20 | 2 | 116.60 | 375*150 | 118 | 23 | 2.626 | 25.8 |
| 52+53 | 176.59 | 1 | 176.59 | 375*300 | 177 | 17 | 1.524 | 15.0 |
| 55 | 98.29 | 1 | 98.29 | 450*150 | 106 | 15 | 1.524 | 15.0 |
| 56 | 173.29 | 1 | 173.29 | 375*300 | 177 | 17 | 1.524 | 15.0 |
| 61 | 270.16 | 1 | 270.16 | 600*300 | 283 | 21 | 1.524 | 15.0 |
| 62 | 585.62 | 3 | 195.21 | 600*225 | 212 | 19 | 1.524 | 15.0 |
| 63 | 227.31 | 1 | 227.31 | 375*300 | 236 | 27 | 2.794 | 27.4 |
| 64 | 182.20 | 1 | 182.20 | 525*225 | 186 | 18 | 1.524 | 15.0 |
| 65 | 49.50 | 1 | 49.50 | 225*150 | 53 | <15 | 1.524 | 15.0 |
| 67 | 165.81 | 1 | 165.81 | 375*300 | 177 | 17 | 1.524 | 15.0 |
| 68 | 165.81 | 1 | 165.81 | 375*300 | 177 | 17 | 1.524 | 15.0 |
| 69 | 165.81 | 1 | 165.81 | 375*300 | 177 | 17 | 1.524 | 15.0 |
| 70 | 308.46 | 1 | 308.46 | 525*375 | 310 | 21 | 1.524 | 15.0 |
| 71 | 154.83 | 1 | 154.83 | 450*225 | 159 | 17 | 1.524 | 15.0 |
| 72 | 140.77 | 1 | 140.77 | 300*300 | 142 | 16 | 1.524 | 15.0 |
| 73 | 140.77 | 1 | 140.77 | 300*300 | 142 | 16 | 1.524 | 15.0 |
| 74 | 144.54 | 2 | 72.27 | 450*225 | 159 | 17 | 1.524 | 15.0 |
| 11 | 124.19 | 3 | 41.40 | 150*150 | 47 | 17 | 2.032 | 19.9 |
| 12+17+18+19 | 706.19 | 3 | 235.40 | 375*300 | 236 | 27 | 2.794 | 27.4 |
| 22+54 | 1199.14 | 6 | 199.86 | 600*225 | 212 | 19 | 1.524 | 15.0 |
| 66+10+40 | 207.22 | 3 | 69.07 | 300*150 | 71 | <15 | 1.524 | 15.0 |

## Air quantity for ventilated rooms

| ROOM | ROOM NO | A (m2) | H (m) | ζ (time/hr) | CMM | CMM tot |
|---|---|---|---|---|---|---|
| main stairs case | 1_5 | 26.47 | 3.90 | 2.00 | 3.44 | 28.33 |
| stairs case | 1_6 | 12.96 | 3.90 | 2.00 | 1.68 | |
| stairs case | 1_7 | 11.80 | 3.90 | 2.00 | 1.53 | |
| outside stairs case | 1_8 | 12.60 | 3.90 | 5.00 | 4.10 | |
| Staff toilet F | 1_14 | 10.00 | 2.60 | 5.00 | 2.17 | |
| Staff toilet M | 1_16 | 7.55 | 2.60 | 5.00 | 1.64 | |
| toilet (F) | 1_20 | 5.00 | 2.60 | 5.00 | 1.08 | |
| toilet (M) | 1_21 | 13.22 | 2.60 | 5.00 | 2.86 | |
| toilet (F) | 1_23 | 10.30 | 2.60 | 5.00 | 2.23 | |
| toilet (M) | 1_24 | 14.33 | 2.60 | 5.00 | 3.10 | |
| toilet (F) | 1_25 | 5.36 | 2.60 | 5.00 | 1.16 | |
| Room toilet | 1_43 | 1.50 | 2.60 | 5.00 | 0.33 | |
| Room toilet | 1_45 | 1.50 | 2.60 | 5.00 | 0.33 | |
| Room toilet | 1_56 | 1.50 | 2.60 | 5.00 | 0.33 | |
| Room toilet | 1_53 | 1.50 | 2.60 | 5.00 | 0.33 | |
| toilet (M) | 1_26 | 9.34 | 2.60 | 5.00 | 2.02 | |



1st floor supply and return ducts layout

# 2nd Floor

## Supply Diffusers Selection

Square Louver Face Ceiling Diffuser
From Air Diffusion catalogs

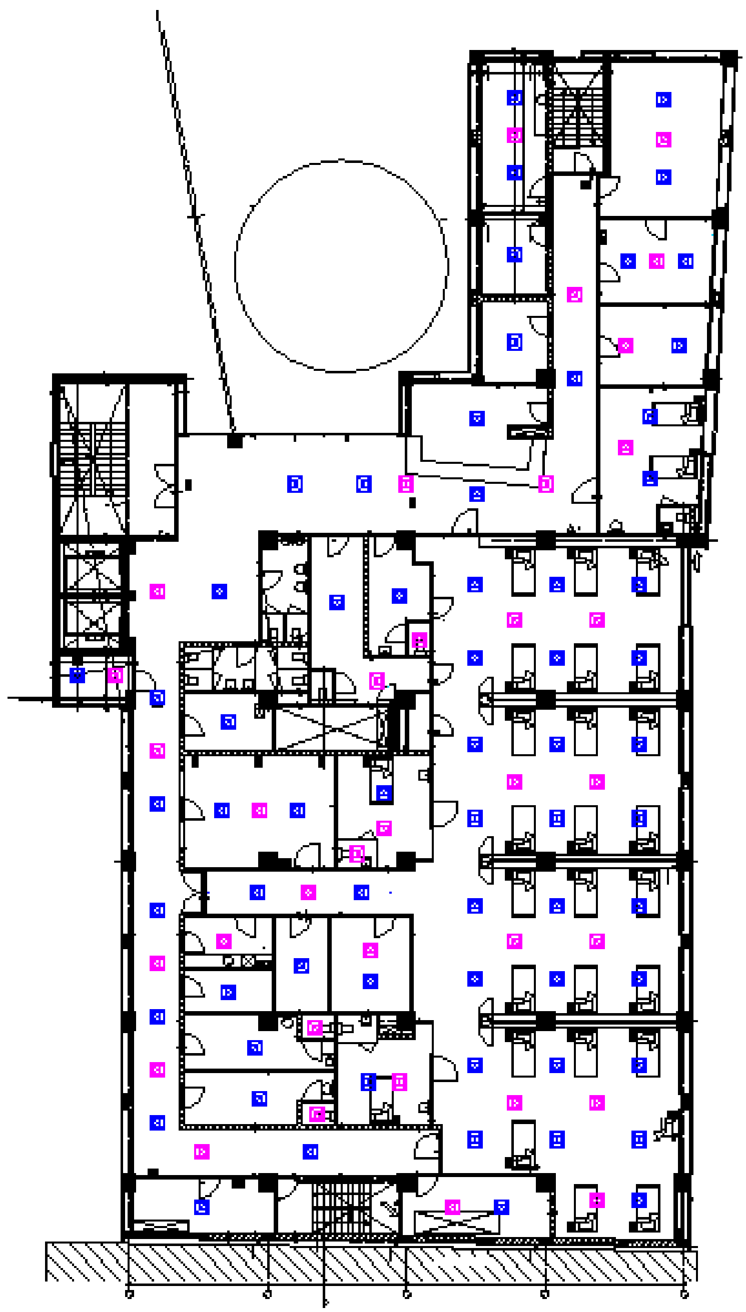
| | | | | | From Catalogue | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Room | L/S | No_ | $Thr_{act}$ | L/S/diff | Size | Thr | L/S | dB | ΔP (Pa) |
| 2_10 | 374.5 | 5 | 3.2 | 74.90 | 200*200 | 3 | 81 | <15 | 10 |
| 2_12 | 213.7 | 7 | 2 | 30.53 | 150*150 | 2.1 | 34 | <15 | 5 |
| 2_13 | 44.2 | 1 | 2.4 | 44.16 | 150*150 | 2.7 | 46 | <15 | 9 |
| 2_15 | 44.2 | 1 | 2.4 | 44.16 | 150*150 | 2.7 | 46 | <15 | 9 |
| 2_18 | 41.5 | 1 | 2.8 | 41.47 | 150*150 | 2.7 | 46 | <15 | 9 |
| 2_20 | 50.4 | 1 | 2.5 | 50.41 | 200*200 | 2.4 | 61 | <15 | 6 |
| 2_41 | 65.4 | 1 | 1.6 | 65.39 | 150*150 | 3.4 | 69 | 23 | 19 |
| 2_42 | 41.5 | 1 | 2.6 | 41.47 | 150*150 | 2.7 | 46 | <15 | 9 |
| 2_43 | 106.9 | 2 | 3.4 | 53.45 | 150*150 | 3 | 57 | 17 | 14 |
| 2_45 | 29.7 | 1 | 1.8 | 29.68 | 150*150 | 2.1 | 34 | <15 | 5 |
| 2_46 | 65.1 | 1 | 2.4 | 65.07 | 150*150 | 3.4 | 69 | 23 | 19 |
| 2_47 | 85.8 | 1 | 2.8 | 85.81 | 250*250 | 2.7 | 95 | <15 | 7 |
| 2_48 | 60.5 | 1 | 2.4 | 60.48 | 200*200 | 2.4 | 61 | <15 | 6 |
| 2_49 | 6495.1 | 27 | 3.4 | 240.56 | 375*375 | 4.2 | 286 | 21 | 13 |
| 2_50 | 64.0 | 1 | 2.4 | 64.00 | 150*150 | 3.4 | 69 | 23 | 19 |
| 2_51 | 64.0 | 1 | 3.4 | 64.00 | 150*150 | 3.4 | 69 | 23 | 19 |
| 2_52 | 133.3 | 2 | 2.7 | 66.65 | 150*150 | 3.4 | 69 | 23 | 19 |
| 2_53 | 137.0 | 1 | 2.4 | 136.98 | 300*300 | 3 | 137 | <15 | 8 |
| 2_54 | 165.8 | 2 | 3.4 | 82.90 | 150*150 | 3.7 | 91 | 33 | 35 |
| 2_54a | 273.9 | 2 | 2.6 | 136.95 | 300*300 | 3 | 137 | <15 | 8 |
| 2_55 | 246.7 | 2 | 3 | 123.34 | 250*250 | 3.7 | 127 | 17 | 11 |
| 2_56 | 102.8 | 1 | 3 | 102.82 | 250*250 | 3.7 | 127 | 17 | 11 |
| 2_57 | 100.4 | 1 | 3 | 100.42 | 200*200 | 3.7 | 102 | 21 | 16 |
| 2_58 | 48.4 | 1 | 2.8 | 48.42 | 150*150 | 2.7 | 46 | <15 | 9 |

**Return Diffusers Selection**

| | | | | From Catalogue | | | |
|---|---|---|---|---|---|---|---|
| **Room** | **L/S** | **No_** | **L/S/diff** | **Size** | **L/S** | **dB** | **ΔP (Pa)** |
| **2_10** | 555.04 | 3 | 185.0133 | 525*225 | 186 | 18 | 1.524 |
| **2_12** | 256.66 | 5 | 51.332 | 225*150 | 34 | <15 | 1.524 |
| **2_18** | 36 | 1 | 36 | 150*150 | 35 | <15 | 1.27 |
| **2_20** | 44.9 | 1 | 44.9 | 150*150 | 47 | 17 | 2.032 |
| **2_41** | 71.94 | 1 | 71.94 | 300*150 | 71 | <15 | 1.524 |
| **2_43** | 106.9 | 1 | 106.9 | 300*225 | 106 | 15 | 1.524 |
| **2_44** | 71.5 | 1 | 71.5 | 225*225 | 79 | <15 | 1.524 |
| **2_47** | 85.8 | 1 | 85.81 | 375*150 | 88 | <15 | 1.524 |
| **2_49** | 6410.8 | 10 | 641.08 | 600*525 | 661 | 2.794 | 34 |
| **2_50** | 64.9 | 1 | 64.9 | 300*150 | 71 | <15 | 1.524 |
| **2_51** | 64.35 | 1 | 64.35 | 300*150 | 71 | <15 | 1.524 |
| **2_52** | 127.8 | 1 | 127.8 | 372*225 | 133 | 16 | 1.524 |
| **2_53** | 123.3 | 1 | 123.3 | 525*150 | 124 | 16 | 1.524 |
| **2_54** | 149.22 | 1 | 149.22 | 450*225 | 159 | 17 | 1.524 |
| **2_54a** | 246.51 | 1 | 246.51 | 525*300 | 137 | 20 | 1.524 |
| **2_55** | 246.7 | 1 | 246.7 | 525*300 | 248 | 20 | 1.524 |
| **2_57** | 100.4 | | 100.42 | 200*200 | 102 | 21 | 16 |

## Air quantity for ventilated rooms

| ROOM | ROOM NO | A (m2) | H (m) | ζ (time/hr) | CMM | CMM tot |
|---|---|---|---|---|---|---|
| main stairs | 2_5 | 36.80 | 3.93 | 2.00 | 4.82 | 17.16 |
| staircase | 2_6 | 12.96 | 3.90 | 2.00 | 1.68 | |
| Staff toilet F | 2_14 | 1.5 | 2.6 | 5.00 | 0.33 | |
| Staff toilet F | 2_16 | 1.5 | 2.6 | 5.00 | 0.33 | |
| toilet (F) | 2_19 | 1.50 | 2.60 | 5.00 | 0.33 | |
| toilet (M) | 2_21 | 1.50 | 2.60 | 5.00 | 0.33 | |
| staff toilet (F) | 2_22 | 11.38 | 2.60 | 5.00 | 2.47 | |
| staff toilet (M) | 2_23 | 9.47 | 2.60 | 5.00 | 2.05 | |
| Kitchenette | 2_44 | 8.90 | 2.60 | 10.00 | 3.86 | |
| Room toilet | 2_50 | 1.5 | 2.6 | 5.00 | 0.33 | |
| Room toilet | 2_51 | 1.5 | 2.6 | 5.00 | 0.33 | |
| Room toilet | 2_52 | 1.5 | 2.6 | 5.00 | 0.33 | |



**2nd floor supply and return ducts layout**

# 3rd floor

## Supply Diffusers Selection

Square Louvre Face Ceiling Diffuser

From Air Diffusion catalogs

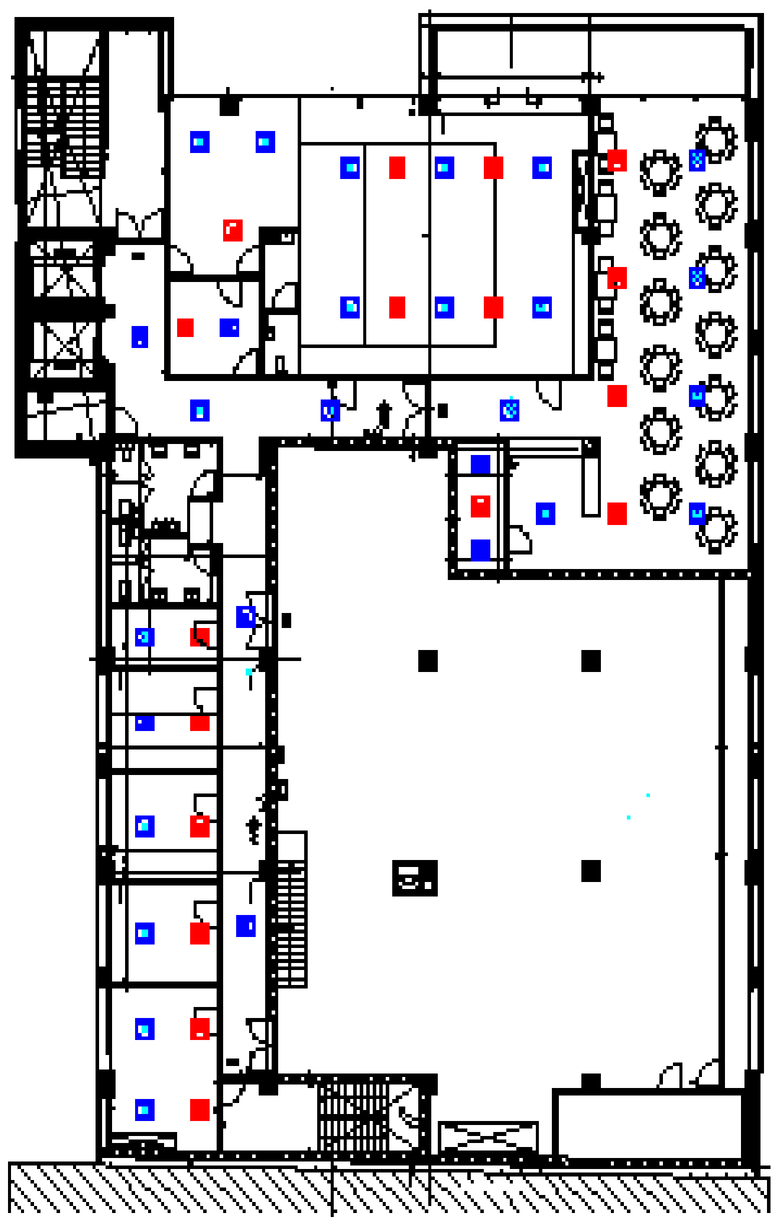
| | | | | | From Catalogue | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Room | L/S | No_ | $Thr_{act}$ | L/S/diff | Size | Th | L/S | dB | ΔP (Pa) |
| 3_10 | 139.2 | 5 | 2 | 27.83 | 150*150 | 2.1 | 34 | <15 | 5 |
| 3_40 | 117.4 | 2 | 2.5 | 58.693 | 200*200 | 2.4 | 61 | <15 | 6 |
| 3_41 | 49.31 | 1 | 2.4 | 49.314 | 200*200 | 2.4 | 61 | <15 | 6 |
| 3_43 | 100.4 | 1 | 2.7 | 100.4 | 200*200 | 3.7 | 102 | 21 | 16 |
| 3_44 | 103.7 | 1 | 2.7 | 103.7 | 250*250 | 3.7 | 127 | 17 | 11 |
| 3_45 | 142.5 | 1 | 2.1 | 142.46 | 250*250 | 4.3 | 159 | 24 | 17 |
| 3_46 | 100.4 | 1 | 2.7 | 100.4 | 200*200 | 3.7 | 102 | 21 | 16 |
| 3_47 | 104.8 | 2 | 2.7 | 52.414 | 200*200 | 2.4 | 61 | <15 | 6 |
| 3_51 | 1564 | 6 | 4 | 260.75 | 375*375 | 4.2 | 286 | 21 | 13 |
| 3_53 | 1302 | 2 | 1.5 | 650.78 | 535*535 | 6.1 | 726 | 38 | 23 |
| 3_54 | 853.1 | 6 | 3.7 | 142.18 | 250*250 | 4.3 | 159 | 24 | 17 |

## Return Diffusers Selection

| | | | | From Catalogue | | | |
|---|---|---|---|---|---|---|---|
| Room | L/S | No_ | L/S/diff | Size | L/S | dB | ΔP (Pa) |
| 3_10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3_40 | 86.302 | 1 | 86.30 | 375*150 | 88 | <15 | 1.524 |
| 3_41 | 49.3142 | 1 | 49.31 | 225*150 | 53 | <15 | 1.524 |
| 3_43 | 73.3829 | 1 | 100.40 | 300*225 | 106 | 15 | 1.524 |
| 3_44 | 76.6801 | 1 | 103.70 | 250*250 | 106 | 15 | 1.524 |
| 3_45 | 113.872 | 1 | 142.46 | 300*300 | 142 | 16 | 1.524 |
| 3_46 | 73.3829 | 1 | 100.40 | 300*225 | 106 | 15 | 1.524 |
| 3_47 | 50.7924 | 2 | 25.40 | 225*150 | 53 | <15 | 1.524 |
| 3_51 | 1064.49 | 4 | 266.12 | 525*525 | 433 | 23 | 1.524 |
| 3_53 | 1801.56 | 1 | 1801.56 | 600*600 | 1321 | 53 | 8.382 |
| 3_54 | 853.067 | 4 | 213.27 | 375*375 | 212 | 19 | 1.524 |

## Air quantity for ventilated rooms

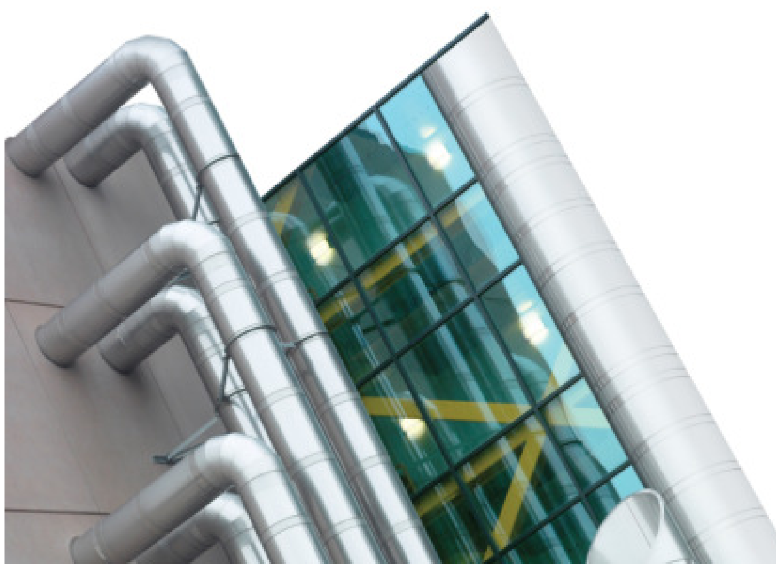
| ROOM | NO of ROOM | A (m2) | H (m) | ζ (time/hr) | CMM | CMM tot |
|---|---|---|---|---|---|---|
| elevator | 3_01 | 6.84 | 2.30 | 3.00 | 1.057977 | 19.99 |
| elevator | 3_02 | 6.84 | 2.30 | 3.00 | 1.057977 | |
| main stairs | 3_05 | 36.80 | 3.93 | 2.00 | 6.483976 | |
| staircase | 3_06 | 18.15 | 3.93 | 2.00 | 3.197939 | |
| staff toilet (F) | 3_11 | 9.16 | 2.60 | 5.00 | 2.669377 | |
| staff toilet (M) | 3_12 | 10.44 | 2.60 | 5.00 | 3.04239 | |
| sanitary facility | 3_42 | 6.40 | 2.60 | 5.00 | 1.865067 | |
| cleaners store | 3_48 | 5.98 | 2.30 | 2.00 | 0.616638 | |



**3rd floor supply and return ducts layout**

Chapter five

# Duct Design



# Duct design fundamentals

## 5.1 Duct system air flow

A more complicated system may include a fan, ductwork, air control dampers, cooling coils, heating coils, filters, diffusers, sound attenuation, turning vanes, etc. The fan is the component or "air pump" in the system which provides energy to the airstream to overcome the resistance to flow of the other components.

## 5.2 Design methods

There is no design method that will automatically provide the most economical duct system for all conditions. Duct systems have been designed using one or more of the following methods or their variations (some of which are obsolete):

* Equal friction.
* Static regain.
* Extended plenum or semi-extended plenum (modification of equal friction or other design methods.)
* T-Method.
* Velocity reduction.
* Total pressure.
* Constant velocity.
* Residential system design method.

## 5.3 Equal Friction Method (commonly used)

The equal friction method of duct sizing (where the pressure loss per meter of duct is the same for the entire system) is probably the most universally used means of sizing lower pressure supply air, return air and exhaust air duct systems. It normally is not used for higher pressure systems. With supply air duct systems, this design method "automatically" reduces air velocities in the direction of the airflow, thus reducing the possibility of generating noise (against the air flow in return or exhaust duct systems).The major disadvantage of the equal friction method is that there is no provision for equalizing pressure drops in duct branches (except in symmetrical layouts)

## 5.4 System Pressures

It is important to distinguish between static pressure and total pressure. *Static pressure* is commonly used as the basic pressure for duct system design, but *total pressure* determines the actual amount of energy that must be supplied to the system to maintain airflow. Total pressure always decreases in the direction of airflow. But static pressure may decrease, then increase in direction of airflow (as it does in Figure 5-1), and may go through several more increases and decreases in the course of the system. It can become negative (below atmospheric) on the discharge side of the fan, as demonstrated by Points G and H (in Figure 5-1). The distinction must be made between static pressure loss (sections BC or FG) and static pressure change as a result of conversion of velocity pressure (section C or G).

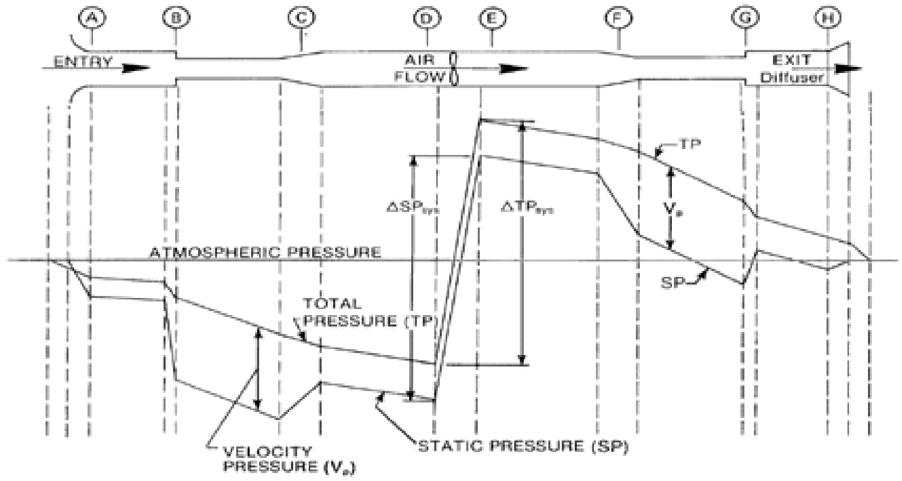



**Figure 5-1 PRESSURE CHANGES DURING FLOW IN DUCTS**

## 5.5 Straight Duct Losses

### 5.5.1. Duct Friction Losses

Pressure drop in a straight duct section is caused by surface friction, and varies with the velocity, the duct size and length, and the interior surface roughness, Friction loss is most readily determined from Air Duct Friction Charts.

### 5.5.2. Circular Equivalents

HVAC duct systems usually are sized first as round ducts. Then, if rectangular ducts are desired, duct sizes are selected to provide flow rates equivalent to those of the round ducts originally selected.

## 5.6 Dynamic Losses

Wherever turbulent flow is present, brought about by sudden changes in the direction or magnitude of the velocity of the air flowing, a greater loss in total pressure takes place than would occur in a steady flow through a similar length of straight duct having a uniform cross-section

### 5.6.1. Duct Fitting Loss Coefficients

The dynamic loss coefficient "C" is dimensionless and represents the number of velocity heads lost at the duct transition or bend (in terms of velocity pressure). Values of the dynamic loss coefficient for elbows and other duct elements have been determined by laboratory testing, and can be found in the tables.

### 5.6.2. Pressure Losses in Elbows

Dynamic-loss coefficients for elbows are nearly independent of the air velocity and are affected by the roughness of the duct walls only in the case of the bends.

### A. Splitter vanes

Smooth radius rectangular duct elbows (with radius throat and heel) have a reasonably low loss coefficient when the R/W ratio is equal to 1.0 or higher.

### B. Turning vanes

#### B.1. Single vs. Double Thickness

Turning vanes still indicates that using double thickness turning vanes instead of single thickness vanes increases the pressure loss of elbows.

#### B.2. Trailing Edges

Actually have a *higher loss* than vanes without them. And when the vanes are accidentally installed with the airflow reversed, much higher losses develop.

### 5.6.3. Pressure Losses in Divided-Flow Fittings

### A. Straight-through sections

Whenever air is diverted to a branch, there will be a velocity reduction in the straight-through section immediately following the branch. If no friction or dynamic losses occurred at the junction, there would be no loss in total pressure and the change in velocity pressure would be completely converted into a regain (rise) in static pressure.

### B. Diverted flow sections

The loss in a diverted flow section (tee or wye) depends on the ratio of the velocity of the diverted flow to the total flow, the areas of the inlets and exits and the takeoff geometry. The total pressure loss coefficients for a variety of branch configurations for round and rectangular ductwork are shown in tables.

### 5.6.4. Losses Due to Area Changes

Experimental investigations of pressure changes and of pressure losses at changes of the area in duct cross sections indicate that the excess pressure loss over the normal friction loss is a dynamic one, due to a faster stream expanding into a slower stream, as determined by the actual areas occupied by the flow, rather than by the areas of the duct.

## 5.7 Design Objectives

1. Design the duct system to convey the design airflow from the fan to the terminal devices in the most efficient manner as allowed by the building structure.
2. Consider energy conservation in the fan selection, duct configuration, duct wall heat gain or loss, etc.
3. Special consideration should be given to the need for sound attenuation and breakout noise.
4. Testing, adjusting and balancing equipment and dampers should be shown on the drawings.
5. Locations of all life safety devices such as fire dampers, smoke dampers, etc. should be shown on the drawings.
6. The designer should consider the pressure losses that occur from tie rods and other duct obstructions.
7. If the ductwork is well designed and constructed, at least 75 to 90 percent of the original velocity pressure can be regained.
8. Round ducts generally are preferred for higher pressure systems.
9. Branch takeoffs and fittings with low loss coefficients should be used. Both **$90^0$** and **$45^0$** duct takeoffs can be used. However, the use of conical tees or angular takeoffs can reduce pressure losses.
10. Use of the Duct Design Calculators would aid the duct design process, especially when making changes in the field

## 5.8 Fan Sizing

With the various elements of the HVAC duct system selected, the duct system laid out, and the sizing finalized, the designer now must calculate the total pressure of the systems which the fan(s) must overcome. These, in combination with the pressure loss data for duct system components and apparatus, enable the designer to sum up the total pressure requirements for the fan(s). Estimated system air leakage must be added to the system airflow at this time.

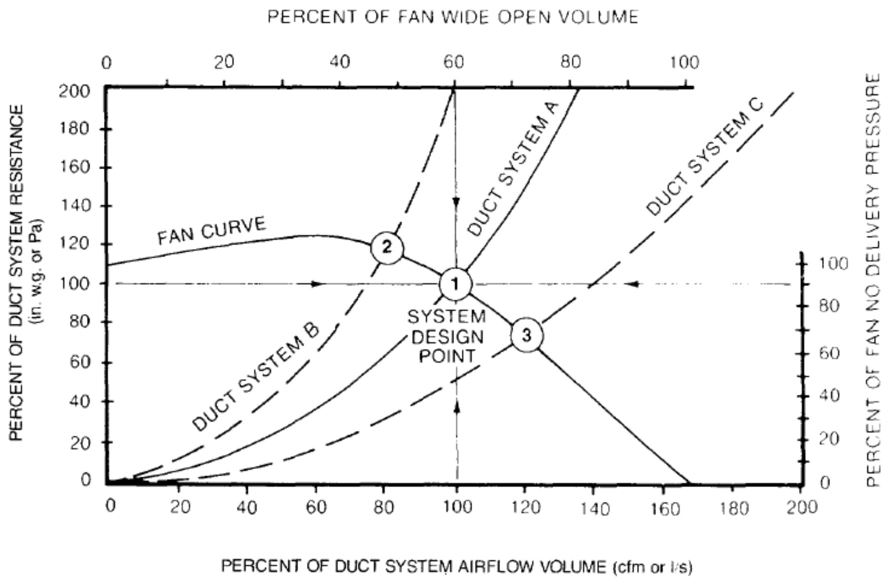



**Figure 5-2 INTERACTION OF SYSTEM CURVES AND FAN CURVE** (1)

### ► *Fan total pressure estimations FTP :*

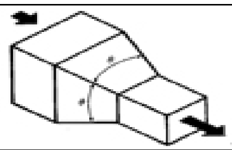
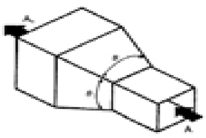
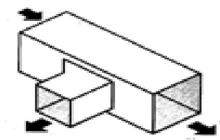
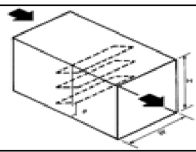
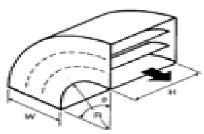
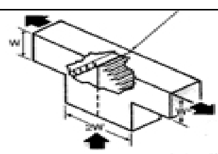
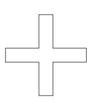
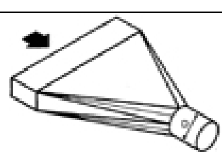
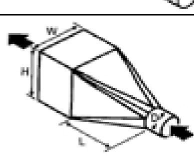
$$FTP = (\Delta P / L) * (L + L_{equivalent}) + 0.5\rho V2 + \Delta P_{equipments} \qquad \textbf{Eqn (5-1)}$$

***Where:***

***FTP:*** is the fan total pressure .
$L_{equivalent}$**:** is the equivalent length for each fitting in the duct.
$0.5\,\rho\, V^2$**:** is the dynamic head at the exit of the selected duct.
$\Delta P_{equipments}$**:** is the total pressure drop over the machine equipments.
$L_{equivalent}$**:** is the equivalent length for the fittings installed in system duct and indicated

$$Fan\ power = FTP * Q\ (m^3/s) \qquad \textbf{Eqn (5-2)}$$

## Table (5-1): Elements Used In Duct Network

| Element Shape | Name | Symbol | $L_{eq}$ (m) |
|---|---|---|---|
|  | Duct | D | L |
|  | Contraction | C | 2.5 |
|  | Expansion | E | 6 |
|  | Tee 45$^{o}$ | Tt | Main: 3<br>Branch: 18 |
|  | Volume control Damper | D | 15 |
|  | Elbow | e | 5 |
|  | Flexible Connection | flex | 5.7 |
|  | Tee | Ty | 22 |
|  | Cross connection | Tx | Main: 3<br>Branch: 18 |
|  | Transition rectangular to round | Conv C | 1.5 |
|  | Transition round to rectangular | Conv E | 6 |

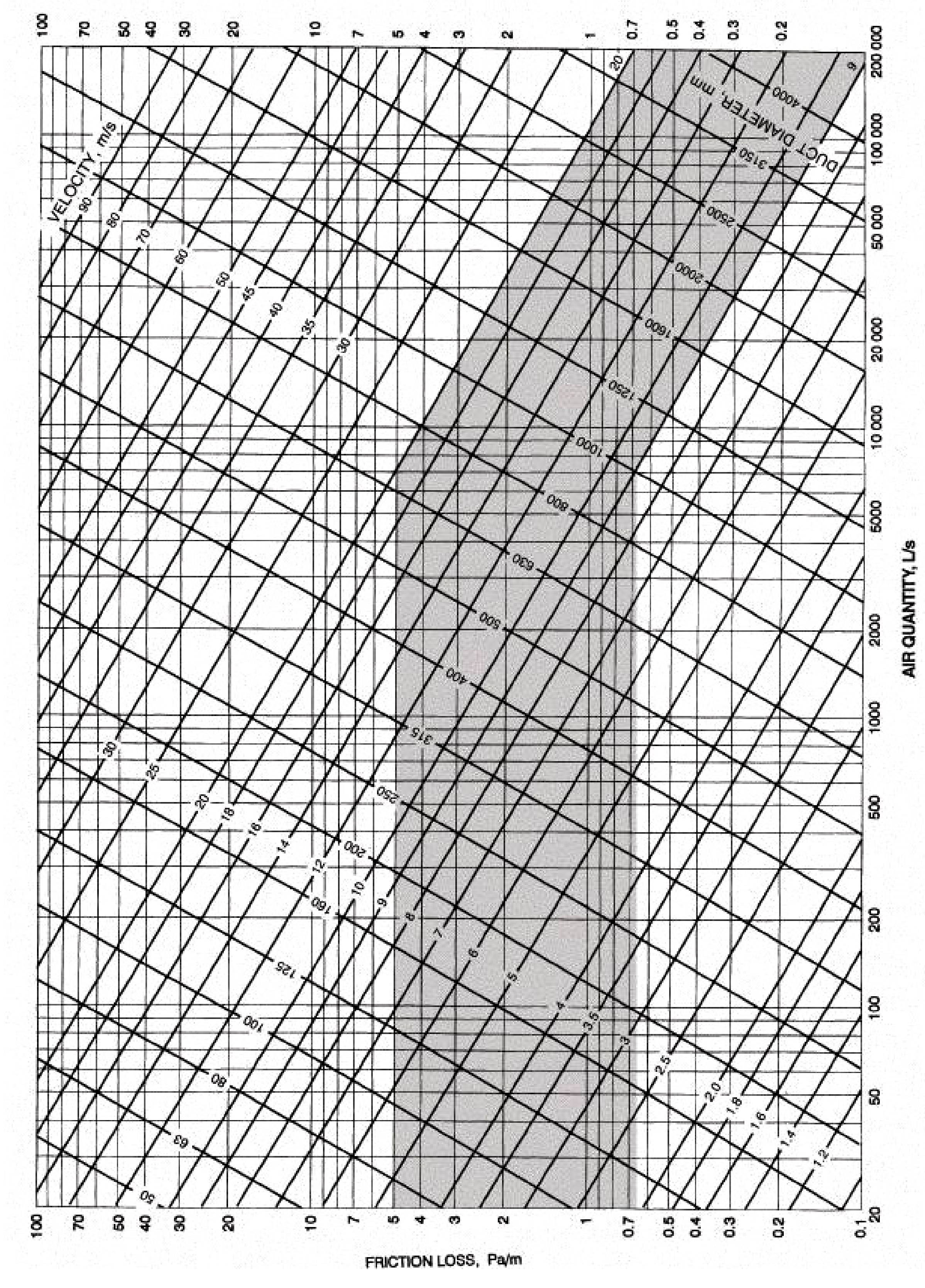



Fig.(3-5)Friction Chart for Round Duct ($\rho = 1.20\ kg/m^3$ and $\varepsilon = 0.09\ mm$)

# Ground floor duct design

By equal friction method (and pf/m = .95 Pa/m constant through the duct network)

*"For Machine 1"*

| Duct Name | Type | Q (L/s) | V (m/s) | L (mm) | D (mm) | W (mm) | H(mm) | ∆P(Pa) |
|---|---|---|---|---|---|---|---|---|
| D0 | Rec | 3195 | 8.14 | 2019 | - | 650 | 650 | 1.92 |
| D1 | Rec | 3195 | 8.14 | 1375 | - | 650 | 650 | 1.31 |
| D2 | Rec | 3195 | 8.14 | 855 | - | 650 | 650 | 0.81 |
| $D_{riser}$ | Rec | 3195 | 8.14 | 9942 | - | 650 | 650 | 9.44 |
| D3 | Rec | 3195 | 8.14 | 3643 | - | 650 | 650 | 3.46 |
| D4 | Rec | 3195 | 8.14 | 4786 | - | 650 | 650 | 4.55 |
| D5 | Rec | 122 | 3.66 | 1127 | - | 200 | 175 | 1.07 |
| D6 | Rec | 122 | 3.66 | 2517 | - | 200 | 175 | 2.39 |
| D7 | Rec | 122 | 3.66 | 150 | - | 200 | 175 | 0.14 |
| D8 | Rec | 122 | 3.66 | 424 | - | 200 | 175 | 0.40 |
| D9 | Rec | 61 | 3.07 | 316 | - | 150 | 140 | 0.30 |
| D10 | Rec | 61 | 3.07 | 608 | - | 150 | 140 | 0.58 |
| D11 | Rec | 1550 | 6.85 | 3480 | - | 500 | 475 | 3.31 |
| D12 | Rec | 126 | 3.69 | 880 | - | 200 | 200 | 0.84 |
| D13 | Rec | 126 | 3.69 | 2043 | - | 200 | 200 | 1.94 |
| D14 | Rec | 126 | 3.69 | 337 | - | 200 | 200 | 0.32 |
| D15 | Rec | 126 | 3.69 | 1003 | - | 200 | 200 | 0.95 |
| D16 | Rec | 63 | | | | | | |
| D17 | Rec | 63 | | | | | | |
| D18 | Rec | 1424 | 6.71 | 2878 | - | 475 | 475 | 2.73 |
| D19 | Rec | 122 | 3.66 | 795 | - | 200 | 175 | 0.76 |
| D20 | Rec | 122 | 3.66 | 2379 | - | 200 | 175 | 2.26 |
| D21 | Rec | 122 | 3.66 | 280 | - | 200 | 175 | 0.27 |
| D22 | Rec | 122 | 3.66 | 940 | - | 200 | 175 | 0.89 |
| D23 | Rec | 61 | 3.07 | 90 | - | 150 | 140 | 0.09 |
| D24 | Rec | 61 | 3.07 | 225 | - | 150 | 140 | 0.21 |
| D25 | Rec | 1302 | 6.57 | 2980 | - | 475 | 450 | 2.83 |
| D26 | Rec | 126 | 3.69 | 875 | - | 200 | 200 | 0.83 |
| D27 | Rec | 126 | 3.69 | 2171 | - | 200 | 200 | 2.06 |
| D28 | Rec | 126 | 3.69 | 280 | - | 200 | 200 | 0.27 |
| D29 | Rec | 126 | 3.69 | 940 | - | 200 | 200 | 0.89 |
| D30 | Rec | 63 | | | | | | |
| D31 | Rec | 63 | 3.09 | 170 | - | 150 | 150 | 0.16 |
| D32 | Rec | 1176 | 6.41 | 2980 | - | 450 | 425 | 2.83 |
| D33 | Rec | 122 | 3.66 | 1160 | - | 200 | 175 | 1.10 |
| D34 | Rec | 122 | 3.66 | 2275 | - | 200 | 200 | 2.16 |
| D35 | Rec | 122 | 3.66 | 220 | - | 200 | 175 | 0.21 |
| D36 | Rec | 122 | 3.66 | 915 | - | 200 | 175 | 0.87 |
| D37 | Rec | 61 | 3.07 | 350 | - | 150 | 140 | 0.33 |
| D38 | Rec | 61 | | | | | | |
| D39 | Rec | 61 | 3.07 | 2015 | - | 150 | 140 | 1.91 |
| D40 | Rec | 61 | 3.07 | 1210 | - | 150 | 140 | 1.15 |
| D41 | Rec | 61 | 3.07 | 2235 | - | 150 | 140 | 2.12 |

| Duct Name | Type | Q (L/s) | V (m/s) | L (mm) | D (mm) | W (mm) | H(mm) | ∆P(Pa) |
|---|---|---|---|---|---|---|---|---|
| D42 | Rec | 61 | 3.07 | 675 | - | 150 | 140 | 0.64 |
| D43 | Rec | 1487 | 6.78 | 2377 | - | 475 | 475 | 2.26 |
| D44 | Rec | 126 | 3.6 | 820 | - | 200 | 200 | 0.78 |
| D45 | Rec | 126 | 3.6 | 2384 | - | 200 | 200 | 2.26 |
| D46 | Rec | 126 | 3.6 | 950 | - | 200 | 200 | 0.90 |
| D47 | Rec | 63 | | | | | | |
| D48 | Rec | 63 | 3 | 188 | - | 150 | 150 | 0.18 |
| D49 | Rec | 1361 | 6.6 | 5727 | - | 475 | 450 | 5.44 |
| D50 | Rec | 75 | 3.2 | 435 | - | 175 | 150 | 0.41 |
| D51 | Rec | 75 | 3.2 | 335 | - | 175 | 150 | 0.32 |
| D52 | Rec | 75 | 3.2 | 426 | - | 175 | 150 | 0.40 |
| D53 | Rec | 75 | 3.2 | 204 | - | 175 | 150 | 0.19 |
| D54 | Rec | 1286 | 6.5 | 783 | - | 450 | 450 | 0.74 |
| D55 | Rec | 372 | 4.8 | 2426 | - | 300 | 275 | 2.30 |
| D56 | Rec | 372 | 4.8 | 1192 | - | 300 | 275 | 1.13 |
| D57 | Rec | 372 | 4.8 | 1235 | - | 300 | 275 | 1.17 |
| D58 | Rec | 372 | 4.8 | 1659 | - | 300 | 275 | 1.58 |
| D59 | Rec | 372 | 4.8 | 815 | - | 300 | 275 | 0.77 |
| D60 | Rec | 62 | 3 | 562 | - | 150 | 140 | 0.53 |
| D61 | Rec | 62 | 3 | 432 | - | 150 | 140 | 0.41 |
| D62 | Rec | 248 | 4.3 | 2008 | - | 250 | 250 | 1.91 |
| D63 | Rec | 124 | 3.6 | 1762 | - | 200 | 200 | 1.67 |
| D64 | Rec | 62 | 3 | 527 | - | 150 | 140 | 0.50 |
| D65 | Rec | 62 | 3 | 486 | - | 150 | 140 | 0.46 |
| D66 | Rec | 124 | 3.6 | 4522 | - | 200 | 200 | 4.30 |
| D67 | Rec | 62 | 3 | 516 | - | 150 | 140 | 0.49 |
| D68 | Rec | 62 | 3 | 2838 | - | 150 | 140 | 2.70 |
| D69 | Rec | 62 | 3 | 5200 | - | 150 | 140 | 4.94 |
| D70 | Rec | 914 | 6 | 2412 | - | 400 | 400 | 2.29 |
| D71 | Rec | 914 | 6 | 3070 | - | 400 | 400 | 2.92 |
| D72 | Rec | 914 | 6 | 6041 | - | 400 | 400 | 5.74 |
| D73 | Rec | 192 | 4.1 | 211 | - | 225 | 225 | 0.20 |
| D74 | Rec | 192 | 4.1 | 241 | - | 225 | 225 | 0.23 |
| D75 | Rec | 192 | 4.1 | 434 | - | 225 | 225 | 0.41 |
| D76 | Rec | 192 | 4.1 | 1022 | - | 225 | 225 | 0.97 |
| D77 | Rec | 96 | 3.4 | 80 | - | 175 | 175 | 0.08 |
| D78 | Rec | 96 | | | | | | |
| D79 | Rec | 722 | 5.6 | 1363 | - | 375 | 350 | 1.29 |
| D80 | Rec | 122 | 3.6 | 443 | - | 200 | 175 | 0.42 |
| D81 | Rec | 122 | 3.6 | 373 | - | 200 | 175 | 0.35 |
| D82 | Rec | 122 | 3.6 | 714 | - | 200 | 175 | 0.68 |
| D83 | Rec | 122 | 3.6 | 327 | - | 200 | 175 | 0.31 |
| D84 | Rec | 61 | | | | | | |
| D85 | Rec | 61 | | | | | | |
| D86 | Rec | 600 | 5.4 | 3900 | - | 350 | 325 | 3.71 |
| D87 | Rec | 142 | 3.7 | 423 | - | 200 | 200 | 0.40 |
| D88 | Rec | 142 | 3.7 | 456 | - | 200 | 200 | 0.43 |

| Duct Name | Type | Q (L/s) | V (m/s) | L (mm) | D (mm) | W (mm) | H(mm) | ∆P(Pa) |
|---|---|---|---|---|---|---|---|---|
| D89 | Rec | 142 | 3.7 | 454 | - | 200 | 200 | 0.43 |
| D90 | Rec | 71 | 3.1 | 90 | - | 175 | 150 | 0.09 |
| D91 | Rec | 71 | | | | | | |
| D92 | Rec | 284 | 4.5 | 2000 | - | 275 | 250 | 1.90 |
| D93 | Rec | 284 | 4.5 | 320 | - | 275 | 250 | 0.30 |
| D94 | Rec | 284 | 4.5 | 1035 | - | 275 | 250 | 0.98 |
| D95 | Rec | 284 | 4.5 | 405 | - | 275 | 250 | 0.38 |
| D96 | Rec | 142 | 3.7 | 629 | - | 200 | 200 | 0.60 |
| D97 | Rec | 142 | 3.7 | 810 | - | 200 | 200 | 0.77 |
| D98 | Rec | 174 | 3.9 | 2577 | - | 225 | 225 | 2.45 |
| D99 | Rec | 174 | 3.9 | 182 | - | 225 | 225 | 0.17 |
| D100 | Rec | 174 | 3.9 | 182 | - | 225 | 225 | 0.17 |
| D101 | Rec | 174 | 3.9 | 470 | - | 225 | 225 | 0.45 |
| D102 | Rec | 174 | 3.9 | 590 | - | 225 | 225 | 0.56 |
| D102a | Rec | 87 | | | | | | |
| D102b | Rec | 87 | | | | | | |
| D103 | Rec | 993 | 6.1 | 9490 | - | 425 | 400 | 9.02 |
| D104 | Rec | 179 | 4 | 678 | - | 225 | 225 | 0.64 |
| D105 | Rec | 122 | 3.6 | 505 | - | 200 | 175 | 0.48 |
| D106 | Rec | 122 | 3.6 | 1110 | - | 200 | 175 | 1.05 |
| D107 | Rec | 122 | 3.6 | 915 | - | 200 | 175 | 0.87 |
| D108 | Rec | 61 | 3 | 446 | - | 150 | 140 | 0.42 |
| D109 | Rec | 61 | | | | | | |
| D110 | Rec | 57 | 3 | 2244 | - | 150 | 140 | 2.13 |
| D111 | Rec | 57 | 3 | 745 | - | 150 | 140 | 0.71 |
| D112 | Rec | 57 | 3 | 810 | - | 150 | 140 | 0.77 |
| D113 | Rec | 57 | 3 | 97 | - | 140 | 140 | 0.09 |
| D114 | Rec | 814 | 5.8 | 3085 | - | 400 | 375 | 2.93 |
| D115 | Rec | 126 | 3.6 | 1700 | - | 200 | 175 | 1.62 |
| D116 | Rec | 126 | 3.6 | 1050 | - | 200 | 175 | 1.00 |
| D117 | Rec | 126 | 3.6 | 778 | - | 200 | 175 | 0.74 |
| D118 | Rec | 63 | | | | | | |
| D119 | Rec | 63 | 3 | 430 | - | 150 | 150 | 0.41 |
| D120 | Rec | 688 | 5.6 | 3194 | - | 375 | 350 | 3.03 |
| D121 | Rec | 122 | 3.6 | 1581 | - | 200 | 175 | 1.50 |
| D122 | Rec | 122 | 3.6 | 1200 | - | 200 | 175 | 1.14 |
| D123 | Rec | 122 | 3.6 | 640 | - | 200 | 175 | 0.61 |
| D124 | Rec | 61 | | | | | | |
| D125 | Rec | 61 | 3 | 555 | - | 150 | 140 | 0.53 |
| D126 | Rec | 566 | 5.3 | 2840 | - | 350 | 325 | 2.70 |
| D127 | Rec | 126 | 3.6 | 1624 | - | 200 | 175 | 1.54 |
| D128 | Rec | 126 | 3.6 | 760 | - | 200 | 175 | 0.72 |
| D129 | Rec | 126 | 3.6 | 867 | - | 200 | 200 | 0.82 |
| D130 | Rec | 63 | | | | | | |
| D131 | Rec | 63 | 3 | 364 | - | 150 | 150 | 0.35 |
| D132 | Rec | 440 | 5 | 3152 | - | 325 | 300 | 2.99 |
| D133 | Rec | 122 | 3.6 | 1692 | - | 200 | 175 | 1.61 |

| Duct Name | Type | Q (L/s) | V (m/s) | L (mm) | D (mm) | W (mm) | H(mm) | ∆P(Pa) |
|---|---|---|---|---|---|---|---|---|
| D134 | Rec | 122 | 3.6 | 925 | - | 200 | 175 | 0.88 |
| D135 | Rec | 122 | 3.6 | 795 | - | 200 | 175 | 0.76 |
| D136 | Rec | 61 | | | | | | |
| D137 | Rec | 61 | 3 | 260 | - | 150 | 140 | 0.25 |
| D138 | Rec | 318 | 4.6 | 2742 | - | 275 | 275 | 2.60 |
| D139 | Rec | 122 | 3.6 | 1777 | - | 200 | 175 | 1.69 |
| D140 | Rec | 122 | 3.6 | 795 | - | 200 | 175 | 0.76 |
| D141 | Rec | 122 | 3.6 | 1160 | - | 200 | 175 | 1.10 |
| D142 | Rec | 61 | | | | | | |
| D143 | Rec | 61 | 3 | 240 | - | 150 | 150 | 0.23 |
| D144 | Rec | 196 | 4.1 | 3063 | - | 225 | 225 | 2.91 |
| D145 | Rec | 196 | 4.1 | 10147 | - | 225 | 225 | 9.64 |
| D146 | Rec | 45 | 2.8 | 400 | - | 140 | 125 | 0.38 |
| D147 | Rec | 45 | 2.8 | 450 | - | 140 | 125 | 0.43 |
| D148 | Rec | 45 | 2.8 | 462 | - | 140 | 125 | 0.44 |
| D149 | Rec | 151 | 3.8 | 1675 | - | 225 | 200 | 1.59 |
| D150 | Rec | 26 | 2.4 | 470 | - | 110 | 100 | 0.45 |
| D151 | Rec | 26 | 2.4 | 325 | - | 110 | 100 | 0.31 |
| D152 | Rec | 26 | 2.4 | 732 | - | 110 | 100 | 0.70 |
| D153 | Rec | 125 | 3.6 | 3032 | - | 200 | 200 | 2.88 |
| D154 | Rec | 64 | 3.1 | 612 | - | 150 | 150 | 0.58 |
| D155 | Rec | 64 | 3.1 | 268 | - | 150 | 150 | 0.25 |
| D156 | Rec | 64 | 3.1 | 782 | - | 150 | 150 | 0.74 |
| D157 | Rec | 61 | 3 | 6661 | - | 150 | 140 | 6.33 |
| D158 | Rec | 61 | 3 | 612 | - | 150 | 140 | 0.58 |
| D159 | Rec | 61 | 3 | 300 | - | 150 | 140 | 0.29 |
| D160 | Rec | 61 | 3 | 1524 | - | 150 | 140 | 1.45 |

**single element "Machine 1"**

| Element | Symbol | Q(L/s) | Input Dim | | Output Dim | | L(mm) | L $_{eq}$ (m) | ∆P (Pa) |
|---|---|---|---|---|---|---|---|---|---|
| | | | W (mm) | H (mm) | W (mm) | H(mm) | | | |
| Contraction | c1 | 1550 | 500 | 650 | 500 | 475 | 51 | 2.5 | 2.42 |
| | c2 | 1424 | 500 | 475 | 475 | 475 | 70 | 2.5 | 2.44 |
| | c3 | 1302 | 475 | 475 | 475 | 450 | 50 | 2.5 | 2.42 |
| | c4 | 1176 | 475 | 450 | 450 | 425 | 70 | 2.5 | 2.44 |
| | c5 | 993 | 425 | 425 | 425 | 400 | 51 | 2.5 | 2.42 |
| | c6 | 814 | 425 | 400 | 400 | 375 | 134 | 2.5 | 2.50 |
| | c7 | 688 | 400 | 375 | 375 | 350 | 70 | 2.5 | 2.44 |
| | c8 | 566 | 375 | 350 | 350 | 325 | 70 | 2.5 | 2.44 |
| | c9 | 440 | 350 | 325 | 325 | 300 | 70 | 2.5 | 2.44 |
| | c10 | 318 | 325 | 300 | 275 | 275 | 100 | 2.5 | 2.47 |
| | c11 | 196 | 275 | 275 | 225 | 225 | 100 | 2.5 | 2.47 |
| | c12 | 151 | 225 | 225 | 225 | 200 | 50 | 2.5 | 2.42 |
| | c13 | 125 | 225 | 200 | 200 | 200 | 70 | 2.5 | 2.44 |
| | c14 | 61 | 200 | 200 | 150 | 140 | 100 | 2.5 | 2.47 |
| | c15 | 3195 | 800 | 800 | 650 | 650 | 211 | 2.5 | 2.58 |

| Element | Symbol | Q(L/s) | Input Dim | | Output Dim | | L(mm) | L eq (m) | ΔP (Pa) |
|---|---|---|---|---|---|---|---|---|---|
| | | | W (mm) | H (mm) | W (mm) | H(mm) | | | |
| Expansion | E1 | 61 | 150 | 140 | 250 | 200 | 160 | 6 | 5.85 |
| Conv-Cont | conv-c1 | 61 | 150 | 140 | D=160 | | 240 | 1.5 | 1.65 |
| Conv-Expn | conv-E1 | 61 | D=125 | | 150 | 140 | 190 | 6 | 5.88 |
| Rec-elbow | e1 | 3195 | 650 | 650 | 650 | 650 | 1555 | 5 | 6.23 |
| | e2 | 196 | 225 | 225 | 225 | 225 | 534 | 5 | 5.26 |
| | e3 | 61 | 150 | 140 | 150 | 140 | 353 | 5 | 5.09 |
| | e4 | 61 | 150 | 140 | 150 | 140 | 341 | 5 | 5.07 |
| | e5 | 3195 | 650 | 650 | 650 | 650 | 1650 | 5 | 6.32 |
| | e6 | 3195 | 650 | 650 | 650 | 650 | 2187 | 5 | 6.83 |
| | e7 | 3195 | 650 | 650 | 650 | 650 | 1675 | 5 | 6.34 |
| | e8 | 3195 | 650 | 650 | 650 | 650 | 1385 | 5 | 6.07 |
| | e9 | 3195 | 650 | 650 | 650 | 650 | 1359 | 5 | 6.04 |
| | e10 | 3195 | 650 | 650 | 650 | 650 | 1261 | 5 | 6.95 |
| | e11 | 3195 | 650 | 650 | 650 | 650 | 2264 | 5 | 6.90 |
| | e12 | 3195 | 650 | 650 | 650 | 650 | 2127 | 5 | 6.77 |

**Double elements "Machine 1"**

| Element | Symbol | Type | Input specifications | | | Output specifications | | | L (mm) | L eq (mm) | ΔP (Pa) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Q (L/s) | W (mm) | H (mm) | Q (L/s) | W (mm) | H (mm) | | | |
| Branch Tee 90° | Tt1 | main | 1550 | 500 | 475 | 1424 | 500 | 475 | 600 | 3 | 3.42 |
| | | | | | | | | | | | |
| | Tt2 | main | 1424 | 475 | 475 | 1302 | 475 | 475 | 575 | 3 | 3.40 |
| | | | | | | | | | | | |
| | Tt3 | main | 1302 | 475 | 450 | 1176 | 475 | 450 | 575 | 3 | 3.40 |
| | | | | | | | | | | | |
| | Tt4 | | | | | | | | | | |
| | | br-D114 | 993 | 425 | 400 | 814 | 425 | 400 | 525 | 18 | 17.60 |
| | Tt5 | main | 814 | 400 | 375 | 688 | 400 | 375 | 500 | 3 | 3.33 |
| | | | | | | | | | | | |
| | Tt6 | main | 688 | 375 | 350 | 566 | 375 | 350 | 475 | 3 | 3.30 |
| | | | | | | | | | | | |
| | Tt7 | main | 566 | 350 | 325 | 440 | 350 | 325 | 450 | 3 | 3.28 |
| | | | | | | | | | | | |
| | Tt8 | main | 440 | 325 | 300 | 318 | 325 | 300 | 425 | 3 | 3.25 |
| | | | | | | | | | | | |
| | Tt9 | main | 318 | 275 | 275 | 196 | 275 | 275 | 375 | 3 | 3.21 |
| | | | | | | | | | | | |
| | Tt10 | | | | | | | | | | |
| | | br-D149 | 196 | 225 | 225 | 151 | 225 | 225 | 325 | 18 | 17.41 |
| | Tt11 | main | 151 | 225 | 200 | 125 | 225 | 200 | 325 | 3 | 3.16 |
| | | | | | | | | | | | |
| | Tt12 | main | 125 | 200 | 200 | 61 | 200 | 200 | 300 | 3 | 3.14 |
| | | | | | | | | | | | |
| Cross connection | X1 | | | | | | | | | | |
| | | br-D111 | 3195 | 650 | 650 | 1550 | 500 | 650 | 700 | 18 | 17.77 |
| | | | | | | | | | | | |
| | X2 | | | | | | | | | | |
| | | br-D103 | 1176 | 450 | 425 | 993 | 425 | 425 | 475 | 18 | 17.55 |
| | | | | | | | | | | | |

**Devices**

| Name | ∆P |
|---|---|
| VAV | 25 |
| Flex connection | 5.7 |
| Filter | 70 |
| Coil | 80 |
| Mix Damper | 25 |
| Damper,c,v | 15 |
| diffuser | 9 |

## For longest path *For* Machine 1 ∆P = 537.81 Pa

## *For "Machine 2"*

| Duct Name | Type | Q (L/s) | V (m/s) | L (mm) | D (mm) | W (mm) | H(mm) | ∆P(Pa) |
|---|---|---|---|---|---|---|---|---|
| D1 | Rec | 4152 | 8.7 | 3600 | - | 700 | 700 | 3.42 |
| D2 | Rec | 4152 | 8.7 | 9942 | - | 700 | 700 | 9.44 |
| D3 | Rec | 2272 | 7.5 | 6627 | - | 600 | 550 | 6.30 |
| D4 | Rec | 2272 | 7.5 | 3041 | - | 600 | 550 | 2.89 |
| D5 | Rec | 2272 | 7.5 | 2032 | - | 600 | 550 | 1.93 |
| D6 | Rec | 2272 | 7.5 | 4175 | - | 600 | 550 | 3.97 |
| D7 | Rec | 2272 | 7.5 | 2630 | - | 600 | 550 | 2.50 |
| D8 | Rec | 2272 | 7.5 | 3707 | - | 600 | 550 | 3.52 |
| D9 | Rec | 1136 | 6.3 | 5763 | - | 450 | 425 | 5.47 |
| D10 | Rec | 1136 | 6.3 | 260 | - | 450 | 425 | 0.25 |
| D11 | Rec | 142 | 3.8 | 435 | - | 200 | 200 | 0.41 |
| D12 | Rec | 142 | 3.8 | 147 | - | 200 | 200 | 0.14 |
| D13 | Rec | 852 | 5.9 | 3836 | - | 400 | 375 | 3.64 |
| D14 | Rec | 142 | 3.8 | 436 | - | 200 | 200 | 0.41 |
| D15 | Rec | 142 | 3.8 | 419 | - | 200 | 200 | 0.40 |
| D16 | Rec | 568 | 5.4 | 3886 | - | 350 | 325 | 3.69 |
| D17 | Rec | 142 | 3.8 | 309 | - | 200 | 200 | 0.29 |
| D18 | Rec | 142 | 3.8 | 270 | - | 200 | 200 | 0.26 |
| D19 | Rec | 284 | 4.5 | 3893 | - | 275 | 250 | 3.70 |
| D20 | Rec | 142 | 3.8 | 427 | - | 200 | 200 | 0.41 |
| D21 | Rec | 142 | 3.8 | 612 | - | 200 | 200 | 0.58 |
| D22 | Rec | 1136 | 6.3 | 368 | - | 450 | 425 | 0.35 |
| D23 | Rec | 142 | 3.8 | 145 | - | 200 | 200 | 0.14 |
| D24 | Rec | 142 | 3.8 | 228 | - | 200 | 200 | 0.22 |
| D25 | Rec | 852 | 5.9 | 3836 | - | 400 | 375 | 3.64 |
| D26 | Rec | 142 | 3.8 | 179 | - | 200 | 200 | 0.17 |

| Duct Name | Type | Q (L/s) | V (m/s) | L (mm) | D (mm) | W (mm) | H(mm) | ∆P(Pa) |
|---|---|---|---|---|---|---|---|---|
| D27 | Rec | 142 | 3.8 | 313 | - | 200 | 200 | 0.30 |
| D28 | Rec | 568 | 5.4 | 3886 | - | 350 | 325 | 3.69 |
| D29 | Rec | 142 | 3.8 | 265 | - | 200 | 200 | 0.25 |
| D30 | Rec | 142 | 3.8 | 527 | - | 200 | 200 | 0.50 |
| D31 | Rec | 284 | 4.5 | 3339 | - | 275 | 250 | 3.17 |
| D32 | Rec | 142 | 3.8 | 368 | - | 200 | 200 | 0.35 |
| D33 | Rec | 142 | 3.8 | 539 | - | 200 | 200 | 0.51 |
| D34 | Rec | 1880 | 7.2 | 998 | - | 550 | 500 | 0.95 |
| D35 | Rec | 1880 | 7.2 | 1706 | - | 550 | 500 | 1.62 |
| D36 | Rec | 1880 | 7.2 | 668 | - | 550 | 500 | 0.63 |
| D37 | Rec | 1880 | 7.2 | 2479 | - | 550 | 500 | 2.36 |
| D38 | Rec | 1880 | 7.2 | 2262 | - | 550 | 500 | 2.15 |
| D39 | Rec | 376 | 4.8 | 1756 | - | 300 | 275 | 1.67 |
| D40 | Rec | 188 | 4.1 | 1094 | - | 225 | 225 | 1.04 |
| D41 | Rec | 188 | 4.1 | 1335 | - | 225 | 225 | 1.27 |
| D42 | Rec | 376 | 4.8 | 6332 | - | 300 | 275 | 6.02 |
| D43 | Rec | 188 | 4.1 | 2588 | - | 225 | 225 | 2.46 |
| D44 | Rec | 188 | 4.1 | 4874 | - | 225 | 225 | 4.63 |
| D45 | Rec | 1128 | 6.3 | 1448 | - | 450 | 425 | 1.38 |
| D46 | Rec | 188 | 4.1 | 2219 | - | 225 | 225 | 2.11 |
| D47 | Rec | 188 | 4.1 | 537 | - | 225 | 225 | 0.51 |
| D48 | Rec | 188 | 4.1 | 1988 | - | 225 | 225 | 1.89 |
| D49 | Rec | 188 | 4.1 | 775 | - | 225 | 225 | 0.74 |
| D50 | Rec | 752 | 5.7 | 2309 | - | 375 | 375 | 2.19 |
| D51 | Rec | 752 | 5.7 | 12418 | - | 375 | 375 | 11.80 |
| D52 | Rec | 376 | 4.8 | 3537 | - | 300 | 275 | 3.36 |
| D53 | Rec | 188 | 4.1 | 4873 | - | 225 | 225 | 4.63 |
| D54 | Rec | 188 | 4.1 | 826 | - | 225 | 225 | 0.78 |
| D55 | Rec | 376 | 4.8 | 1730 | - | 300 | 275 | 1.64 |
| D56 | Rec | 188 | 4.1 | 697 | - | 225 | 225 | 0.66 |
| D57 | Rec | 188 | 4.1 | 4296 | - | 225 | 225 | 4.08 |
| D58 | Rec | 188 | 4.1 | 2151 | - | 225 | 225 | 2.04 |

**single element "Machine 2"**

| Element | Symbol | Q(L/s) | Input Dim | | Output Dim | | L(mm) | L eq (m) | ∆P (Pa) |
|---|---|---|---|---|---|---|---|---|---|
| | | | W (mm) | H(mm) | W(mm) | H(mm) | | | |
| Contraction | c1 | 1128 | 550 | 500 | 450 | 425 | 160 | 2.5 | 2.53 |
| | c2 | 752 | 450 | 425 | 375 | 375 | 130 | 2.5 | 2.50 |
| | c3 | 376 | 375 | 375 | 300 | 275 | 130 | 2.5 | 2.50 |
| | c4 | 188 | 300 | 275 | 225 | 225 | 130 | 2.5 | 2.50 |
| | c5 | 1880 | 700 | 700 | 550 | 500 | 221 | 2.5 | 2.58 |
| | c6 | 4152 | 800 | 800 | 700 | 700 | 161 | 2.5 | 2.53 |
| Expansion | E1 | 1880 | 500 | 550 | 850 | 500 | 460 | 6 | 6.14 |
| Conv-Cont | conv-c1 | 188 | 225 | 225 | D=225 | | 337 | 1.5 | 1.75 |
| Conv-Expn | conv-E1 | 1880 | D=400 | | 550 | 500 | 600 | 6 | 6.27 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Rec-elbow | e1 | | | | | | | | |
| | e2 | | | | | | | | |
| | e3 | 1880 | 550 | 500 | 550 | 500 | 1304 | 5 | 5.99 |
| | e4 | 1880 | 550 | 500 | 550 | 500 | 1296 | 5 | 5.98 |
| | e5 | 752 | 375 | 375 | 375 | 375 | 880 | 5 | 5.59 |
| | e6 | 376 | 300 | 275 | 300 | 275 | 652 | 5 | 5.37 |
| | e7 | 376 | 300 | 275 | 300 | 275 | 652 | 5 | 5.37 |
| | e8 | 376 | 300 | 275 | 300 | 275 | 652 | 5 | 5.37 |
| | e9 | 376 | 300 | 275 | 300 | 275 | 652 | 5 | 5.37 |
| | e10 | 4152 | 700 | 700 | 700 | 700 | 1833 | 5 | 6.49 |
| | e11 | 4152 | 700 | 700 | 700 | 700 | 1833 | 5 | 6.49 |
| | e12 | 4152 | 700 | 700 | 700 | 700 | 1942 | 5 | 6.59 |
| | e13 | 4152 | 700 | 700 | 700 | 700 | 1926 | 5 | 6.58 |
| | e14 | 4152 | 700 | 700 | 700 | 700 | 1362 | 5 | 6.04 |
| | e15 | 4152 | 700 | 700 | 700 | 700 | 1910 | 5 | 6.56 |
| | e16 | 4152 | 700 | 700 | 700 | 700 | 1950 | 5 | 6.60 |

**Double elements "Machine 2"**

| Element | Symbol | Type | Input specsefications | | | Output specsefications | | | L(mm) | L eq (mm) | ΔP(Pa) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Q (L/s) | W (mm) | H (mm) | Q (L/s) | W (mm) | H (mm) | | | |
| Wye Tee | Ty1 | br-D53 | 376 | 300 | 275 | 188 | 300 | 275 | 400 | 22 | 21.28 |
| | | | | | | | | | | | |
| | Ty2 | | | | | | | | | | |
| | | Br-D35 | 4152 | 700 | 700 | 1880 | 550 | 500 | 800 | 22 | 21.66 |
| Branch Tee 90° | Tt1 | | | | | | | | | | |
| | | br-D52 | 752 | 375 | 375 | 376 | 375 | 375 | 475 | 18 | 17.55 |
| Cross connection | X1 | | | | | | | | | | |
| | | br-D45 | 1880 | 550 | 500 | 1128 | 550 | 500 | 600 | 18 | 17.67 |
| | | | | | | | | | | | |
| | X2 | main | 1128 | 550 | 500 | 752 | 450 | 425 | 500 | 3 | 3.33 |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

**Devices**

| Name | ΔP |
|---|---|
| VAV | 25 |
| Flex connection | 5.7 |
| Filter | 70 |
| Coil | 80 |
| Mix Damper | 25 |
| Damper,c,v | 15 |
| diffuser | 23 |

**For longest path** *For Machine 2* **ΔP = 703.5 Pa**

# 1st Floor Supply duct design

By equal friction method (and pf/m = .95 Pa/m constant through the duct network)

| Duct Name | Type | Q (L/s) | V (m/s) | L (mm) | D (mm) | W (mm) | H(mm) | ∆P (Pa) |
|---|---|---|---|---|---|---|---|---|
| D0 | Rec | 7571 | 10.03 | 5270 | - | 900 | 900 | 5.01 |
| D1 | Rec | 7571 | 10.03 | 3492 | - | 900 | 900 | 3.32 |
| D2 | Rec | 7571 | 10.03 | 1479 | - | 900 | 900 | 1.41 |
| D3 | Rec | 3906 | 8.56 | 2076 | - | 700 | 700 | 1.97 |
| D4 | Rec | 3906 | 8.56 | 1126 | - | 700 | 700 | 1.07 |
| D5 | Rec | 1470 | 6.76 | 1224 | - | 475 | 475 | 1.16 |
| D6 | Rec | 210 | 4.19 | 5291 | - | 250 | 225 | 5.03 |
| D7 | Rec | 1260 | 6.51 | 743 | - | 450 | 450 | 0.71 |
| D8 | Rec | 210 | 4.19 | 445 | - | 250 | 225 | 0.42 |
| D9 | Rec | 210 | 4.19 | 2222 | - | 250 | 225 | 2.11 |
| D10 | Rec | 840 | 5.9 | 4745 | - | 400 | 375 | 4.51 |
| D11 | Rec | 210 | 4.19 | 588 | - | 250 | 225 | 0.56 |
| D12 | Rec | 210 | 4.19 | 2333 | - | 250 | 225 | 2.22 |
| D13 | Rec | 420 | 4.98 | 4683 | - | 300 | 300 | 4.45 |
| D14 | Rec | 210 | 4.19 | 72 | - | 250 | 225 | 0.07 |
| D15 | Rec | 210 | 4.19 | 2309 | - | 250 | 225 | 2.19 |
| D16 | Rec | 2436 | 7.64 | 1047 | - | 600 | 550 | 0.99 |
| D17 | Rec | 2436 | 7.64 | 1260 | - | 600 | 550 | 1.20 |
| D18 | Rec | 587 | 5.4 | 2169 | - | 350 | 325 | 2.06 |
| D19 | Rec | 129 | 3.71 | 1035 | - | 200 | 200 | 0.98 |
| D20 | Rec | 129 | 3.71 | 491 | - | 200 | 200 | 0.47 |
| D21 | Rec | 43 | 2.8 | 281 | - | 140 | 125 | 0.27 |
| D22 | Rec | 43 | 2.8 | 1501 | - | 140 | 125 | 1.43 |
| D23 | Rec | 86 | 3.35 | 1316 | - | 175 | 175 | 1.25 |
| D24 | Rec | 86 | 3.35 | 6008 | - | 175 | 175 | 5.71 |
| D25 | Rec | 43 | 2.8 | 945 | - | 140 | 125 | 0.90 |
| D26 | Rec | 43 | 2.8 | 4484 | - | 140 | 125 | 4.26 |
| D27 | Rec | 458 | 5.08 | 7464 | - | 325 | 300 | 7.09 |
| D28 | Rec | 46 | | | | | | |
| D29 | Rec | 412 | 4.95 | 5097 | - | 300 | 300 | 4.84 |
| D30 | Rec | 184 | 4.05 | 463 | - | 225 | 225 | 0.44 |
| D31 | Rec | 184 | 4.05 | 558 | - | 225 | 225 | 0.53 |
| D32 | Rec | 92 | 3.41 | 293 | - | 175 | 175 | 0.28 |
| D33 | Rec | 92 | 3.41 | 341 | - | 175 | 175 | 0.32 |
| D34 | Rec | 228 | 4.28 | 3203 | - | 250 | 225 | 3.04 |
| D35 | Rec | 114 | 3.59 | 379 | - | 200 | 175 | 0.36 |
| D36 | Rec | 114 | 3.59 | 3171 | - | 200 | 175 | 3.01 |
| D37 | Rec | 1849 | 7.15 | 4167 | - | 550 | 500 | 3.96 |
| D38 | Rec | 825 | 5.88 | 2428 | - | 400 | 375 | 2.31 |
| D39 | Rec | 99 | 3.47 | 892 | - | 175 | 175 | 0.85 |
| D40 | Rec | 726 | 5.69 | 5178 | - | 375 | 350 | 4.92 |
| D41 | Rec | 164 | 3.94 | 609 | - | 225 | 200 | 0.58 |
| D42 | Rec | 164 | 3.94 | 275 | - | 225 | 200 | 0.26 |

| Duct Name | Type | Q (L/s) | V (m/s) | L (mm) | D (mm) | W (mm) | H(mm) | ∆P (Pa) |
|---|---|---|---|---|---|---|---|---|
| D43 | Rec | 82 | 3.31 | 161 | - | 175 | 150 | 0.15 |
| D44 | Rec | 82 | 3.31 | 60 | - | 225 | 200 | 0.06 |
| D45 | Rec | 562 | 5.35 | 5096 | - | 350 | 325 | 4.84 |
| D46 | Rec | 214 | 4.21 | 438 | - | 250 | 225 | 0.42 |
| D47 | Rec | 214 | 4.21 | 529 | - | 250 | 225 | 0.50 |
| D48 | Rec | 107 | | | | | | |
| D49 | Rec | 107 | | | | | | |
| D50 | Rec | 348 | 4.75 | 4639 | - | 275 | 275 | 4.41 |
| D51 | Rec | 168 | 3.96 | 449 | - | 225 | 200 | 0.43 |
| D52 | Rec | 168 | 3.96 | 670 | - | 225 | 200 | 0.64 |
| D53 | Rec | 84 | | | | | | |
| D54 | Rec | 84 | | | | | | |
| D55 | Rec | 180 | 4.03 | 3786 | - | 225 | 225 | 3.60 |
| D56 | Rec | 108 | | | | | | |
| D57 | Rec | 72 | 3.2 | 5032 | - | 175 | 150 | 4.78 |
| D58 | Rec | 1024 | 6.19 | 1883 | - | 425 | 400 | 1.79 |
| D59 | Rec | 162 | 3.93 | 309 | - | 425 | 400 | 0.29 |
| D60 | Rec | 162 | 3.93 | 348 | - | 225 | 200 | 0.33 |
| D61 | Rec | 81 | 3.29 | 541 | - | 175 | 150 | 0.51 |
| D62 | Rec | 81 | 3.29 | 263 | - | 175 | 150 | 0.25 |
| D63 | Rec | 862 | 5.94 | 9261 | - | 400 | 375 | 8.80 |
| D64 | Rec | 272 | 4.47 | 1144 | - | 275 | 250 | 1.09 |
| D65 | Rec | 272 | 4.47 | 927 | - | 275 | 250 | 0.88 |
| D66 | Rec | 136 | 3.76 | 512 | - | 200 | 200 | 0.49 |
| D67 | Rec | 136 | 3.76 | 775 | - | 200 | 200 | 0.74 |
| D68 | Rec | 560 | 5.34 | 5826 | - | 350 | 325 | 5.53 |
| D69 | Rec | 560 | 5.34 | 898 | - | 350 | 325 | 0.85 |
| D70 | Rec | 560 | 5.34 | 929 | - | 350 | 325 | 0.88 |
| D71 | Rec | 118 | | | | | | |
| D72 | Rec | 118 | | | | | | |
| D73 | Rec | 354 | 4.77 | 4827 | - | 300 | 275 | 4.59 |
| D74 | Rec | 118 | | | | | | 0.00 |
| D75 | Rec | 236 | 4.31 | 129 | - | 250 | 225 | 0.12 |
| D76 | Rec | 118 | | | | | | |
| D77 | Rec | 118 | | | | | | |
| D78 | Rec | 3665 | 8.43 | 3434 | - | 700 | 650 | 3.26 |
| D79 | Rec | 291 | 4.54 | 241 | - | 275 | 250 | 0.23 |
| D80 | Rec | 291 | 4.54 | 1057 | - | 270 | 250 | 1.00 |
| D81 | Rec | 97 | | | | | | |
| D82 | Rec | 194 | 4.11 | 1500 | - | 225 | 225 | 1.43 |
| D83 | Rec | 97 | 3.45 | 1500 | - | 175 | 175 | 1.43 |
| D84 | Rec | 97 | 3.45 | 3690 | - | 175 | 175 | 3.51 |
| D85 | Rec | 97 | 3.45 | 87 | - | 175 | 175 | 0.08 |
| D86 | Rec | 3374 | 8.27 | 2917 | - | 650 | 650 | 2.77 |
| D87 | Rec | 2498 | 7.69 | 3793 | - | 600 | 575 | 3.60 |
| D88 | Rec | 79 | | | | | | |
| D89 | Rec | 2419 | 7.63 | 1477 | - | 570 | 570 | 1.40 |

| Duct Name | Type | Q (L/s) | V (m/s) | L (mm) | D (mm) | W (mm) | H(mm) | ∆P (Pa) |
|---|---|---|---|---|---|---|---|---|
| D90 | Rec | 72 | | | | | | 0.00 |
| D91 | Rec | 2347 | 7.57 | 2641 | - | 575 | 575 | 2.51 |
| D92 | Rec | 66 | | | | | | |
| D93 | Rec | 2281 | 7.52 | 5954 | - | 575 | 550 | 5.66 |
| D94 | Rec | 41 | 2.77 | 526 | - | 125 | 125 | 0.50 |
| D95 | Rec | 2240 | 7.49 | 1457 | - | 575 | 550 | 1.38 |
| D96 | Rec | 846 | 5.91 | 1002 | - | 400 | 375 | 0.95 |
| D97 | Rec | 846 | 5.91 | 1135 | - | 400 | 375 | 1.08 |
| D98 | Rec | 145 | | | | | | |
| D99 | Rec | 705 | 5.65 | 1761 | - | 375 | 350 | 1.67 |
| D100 | Rec | 144 | 3.81 | 467 | - | 375 | 350 | 0.44 |
| D101 | Rec | 564 | 5.35 | 3302 | - | 350 | 325 | 3.14 |
| D102 | Rec | 143 | | | | | | |
| D103 | Rec | 423 | 4.98 | 2745 | - | 300 | 300 | 2.61 |
| D104 | Rec | 142 | | | | | | |
| D105 | Rec | 282 | 4.51 | 3235 | - | 275 | 250 | 3.07 |
| D106 | Rec | 141 | | | | | | |
| D107 | Rec | 141 | 3.79 | 2624 | - | 200 | 200 | 2.49 |
| D108 | Rec | 808 | 5.85 | 1619 | - | 400 | 375 | 1.54 |
| D109 | Rec | 808 | 5.85 | 2900 | - | 400 | 375 | 2.76 |
| D110 | Rec | 332 | 4.69 | 2488 | - | 375 | 375 | 2.36 |
| D111 | Rec | 166 | 3.96 | 402 | - | 225 | 200 | 0.38 |
| D112 | Rec | 166 | 3.96 | 820 | - | 225 | 200 | 0.78 |
| D113 | Rec | 83 | | | | | | |
| D114 | Rec | 83 | | | | | | |
| D115 | Rec | 166 | 3.96 | 430 | - | 225 | 200 | 0.41 |
| D116 | Rec | 166 | 3.96 | 490 | - | 225 | 200 | 0.47 |
| D117 | Rec | 83 | | | | | | |
| D118 | Rec | 83 | | | | | | |
| D119 | Rec | 476 | 5.13 | 3120 | - | 325 | 300 | 2.96 |
| D120 | Rec | 166 | 3.95 | 2621 | - | 225 | 200 | 2.49 |
| D121 | Rec | 166 | 3.95 | 272 | - | 225 | 200 | 0.26 |
| D122 | Rec | 166 | 3.95 | 450 | - | 225 | 200 | 0.43 |
| D123 | Rec | 83 | | | | | | |
| D124 | Rec | 83 | | | | | | |
| D125 | Rec | 310 | 4.62 | 6808 | - | 275 | 275 | 6.47 |
| D126 | Rec | 310 | 4.62 | 1393 | - | 275 | 275 | 1.32 |
| D127 | Rec | 310 | 4.62 | 711 | - | 275 | 275 | 0.68 |
| D128 | Rec | 155 | 3.88 | 267 | - | 225 | 200 | 0.25 |
| D129 | Rec | 155 | 3.88 | 740 | - | 225 | 200 | 0.70 |
| D130 | Rec | 586 | 5.4 | 770 | - | 350 | 325 | 0.73 |
| D131 | Rec | 586 | 5.4 | 10297 | - | 350 | 325 | 9.78 |
| D132 | Rec | 288 | 4.53 | 1444 | - | 275 | 250 | 1.37 |
| D133 | Rec | 146 | 3.83 | 683 | - | 200 | 200 | 0.65 |
| D134 | Rec | 146 | 3.83 | 675 | - | 200 | 200 | 0.64 |
| D135 | Rec | 73 | 3.21 | 141 | - | 175 | 150 | 0.13 |
| D136 | Rec | 73 | | | | | | |

| Duct Name | Type | Q (L/s) | V (m/s) | L (mm) | D (mm) | W (mm) | H(mm) | ∆P (Pa) |
|---|---|---|---|---|---|---|---|---|
| D137 | Rec | 142 | 3.8 | 240 | - | 200 | 200 | 0.23 |
| D138 | Rec | 142 | 3.8 | 258 | - | 200 | 200 | 0.25 |
| D139 | Rec | 71 | 3.19 | 177 | - | 175 | 150 | 0.17 |
| D140 | Rec | 71 | | | | | | |
| D141 | Rec | 298 | 4.57 | 6468 | - | 275 | 250 | 6.14 |
| D142 | Rec | 298 | 4.57 | 1540 | - | 275 | 250 | 1.46 |
| D143 | Rec | 142 | 3.8 | 732 | - | 200 | 200 | 0.70 |
| D144 | Rec | 142 | 3.8 | 660 | - | 200 | 200 | 0.63 |
| D145 | Rec | 71 | | | | | | |
| D146 | Rec | 71 | | | | | | |
| D147 | Rec | 156 | 3.89 | 240 | - | 225 | 200 | 0.23 |
| D148 | Rec | 156 | 3.89 | 310 | - | 225 | 200 | 0.29 |
| D149 | Rec | 78 | | | | | | |
| D150 | Rec | 78 | | | | | | |
| D151 | Rec | 876 | 5.96 | 3863 | - | 400 | 400 | 3.67 |
| D152 | Rec | 280 | 4.5 | 777 | - | 275 | 250 | 0.74 |
| D153 | Rec | 280 | 4.5 | 620 | - | 275 | 250 | 0.59 |
| D154 | Rec | 140 | 3.79 | 1730 | - | 200 | 200 | 1.64 |
| D155 | Rec | 70 | 3.18 | 205 | - | 175 | 150 | 0.19 |
| D156 | Rec | 70 | 3.18 | 460 | - | 175 | 150 | 0.44 |
| D157 | Rec | 140 | 3.79 | 1520 | - | 200 | 200 | 1.44 |
| D158 | Rec | 70 | 3.18 | 205 | - | 175 | 150 | 0.19 |
| D159 | Rec | 70 | 3.18 | 460 | - | 175 | 150 | 0.44 |
| D160 | Rec | 596 | 5.43 | 7067 | - | 350 | 325 | 6.71 |
| D161 | Rec | 276 | 4.49 | 777 | - | 275 | 250 | 0.74 |
| D162 | Rec | 276 | 4.49 | 705 | - | 275 | 250 | 0.67 |
| D163 | Rec | 138 | 3.77 | 1145 | - | 200 | 200 | 1.09 |
| D164 | Rec | 69 | 3.17 | 204 | - | 175 | 150 | 0.19 |
| D165 | Rec | 69 | 3.17 | 460 | - | 175 | 150 | 0.44 |
| D166 | Rec | 138 | 3.77 | 1692 | - | 200 | 200 | 1.61 |
| D167 | Rec | 69 | 3.17 | 204 | - | 175 | 150 | 0.19 |
| D168 | Rec | 69 | 3.17 | 460 | - | 175 | 150 | 0.44 |
| D169 | Rec | 320 | 4.65 | 7538 | - | 275 | 275 | 7.16 |
| D170 | Rec | 320 | 4.65 | 777 | - | 275 | 275 | 0.74 |
| D171 | Rec | 320 | 4.65 | 648 | - | 275 | 275 | 0.62 |
| D172 | Rec | 160 | 3.91 | 2034 | - | 225 | 200 | 1.93 |
| D173 | Rec | 80 | 3.29 | 161 | - | 175 | 150 | 0.15 |
| D174 | Rec | 80 | 3.29 | 400 | - | 175 | 150 | 0.38 |
| D175 | Rec | 160 | 3.91 | 2247 | - | 225 | 200 | 2.13 |
| D176 | Rec | 80 | 3.29 | 32 | - | 175 | 150 | 0.03 |
| D177 | Rec | 80 | 3.29 | 288 | - | 175 | 150 | 0.27 |

**single element for longest path**

| Element | Symbol | Q(L/s) | Input Dim | | Output Dim | | L(mm) | $L_{eq}$ (m) | ΔP (Pa) |
|---|---|---|---|---|---|---|---|---|---|
| | | | W (mm) | H(mm) | W (mm) | H(mm) | | | |
| Contraction | c1 | 3906 | 1050 | 750 | 700 | 700 | 462 | 2.5 | 2.81 |
| | c2 | 2436 | 700 | 700 | 600 | 550 | 419 | 2.5 | 2.77 |
| | c3 | 1849 | 600 | 550 | 550 | 500 | 230 | 2.5 | 2.59 |
| | c4 | 1024 | 550 | 500 | 425 | 400 | 191 | 2.5 | 2.56 |
| | c5 | 862 | 425 | 400 | 400 | 375 | 147 | 2.5 | 2.51 |
| | c6 | 560 | 400 | 375 | 350 | 325 | 100 | 2.5 | 2.47 |
| | c7 | 354 | 350 | 325 | 300 | 275 | 100 | 2.5 | 2.44 |
| | c8 | 236 | 300 | 275 | 250 | 225 | 100 | 2.5 | 2.47 |
| | c9 | 560 | 325 | 350 | 350 | 325 | 70 | 6 | 5.77 |
| Expansion | E1 | 560 | 325 | 350 | 350 | 325 | 70 | 6 | 5.77 |
| | E2 | 7571 | 800 | 800 | 900 | 900 | 161 | 6 | 5.85 |
| conv-cont | conv-c1 | 118 | 250 | 225 | D=210 | | 315 | 1.5 | 1.72 |
| Rec-elbow | e1 | 3906 | 700 | 700 | 700 | 700 | 1649 | 5 | 6.32 |
| | e2 | 2436 | 600 | 550 | 600 | 550 | 1413 | 5 | 6.09 |
| | e3 | 560 | 350 | 325 | 350 | 325 | 824 | 5 | 5.53 |
| | e4 | 7571 | 900 | 900 | 900 | 900 | 2132 | 5 | 6.78 |
| | e5 | 7571 | 900 | 900 | 900 | 900 | 2125 | 5 | 6.77 |
| | e6 | 7571 | 900 | 900 | 900 | 900 | 2162 | 5 | 6.80 |
| | e7 | 7571 | 900 | 900 | 900 | 900 | 2121 | 5 | 6.76 |

**Double elements for longest path**

| Element | Symbol | Type | Input specsefications | | | Output specsefications | | | L(mm) | $L_{eq}$ (m) | ΔP(Pa) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Q (L/s) | W (mm) | H (mm) | Q (L/s) | W (mm) | H (mm) | | | |
| Wye Tee | Ty1 | | | | | | | | | 22 | 20.90 |
| | | br-D3 | 7571 | 1050 | 750 | 3906 | 1050 | 750 | 1150 | 22 | 21.99 |
| | Ty2 | | | | | | | | | 22 | 20.90 |
| | | br-D58 | 1849 | 550 | 500 | 1024 | 550 | 500 | 615 | 22 | 21.62 |
| | Ty3 | | | | | | | | | 22 | 20.90 |
| | | br-D75 | 354 | 300 | 275 | 236 | 300 | 275 | 345 | 22 | 21.23 |
| | Ty4 | | | | | | | | | 22 | 20.90 |
| | | br-D77 | 236 | 250 | 225 | 118 | 250 | 225 | 300 | 22 | 21.19 |
| Branch Tee 90° | Tt1 | | | | | | | | | 3 | 2.85 |
| | | br-D16 | 3906 | 700 | 700 | 2436 | 700 | 700 | 753 | 18 | 17.82 |
| | Tt2 | | | | | | | | | 3 | 2.85 |
| | | br-D37 | 2436 | 600 | 550 | 1849 | 600 | 550 | 700 | 18 | 17.77 |
| | Tt3 | main | 1024 | 425 | 400 | 862 | 425 | 400 | 525 | 3 | 3.35 |
| | | | | | | | | | | 18 | 17.10 |
| | Tt4 | main | 862 | 400 | 375 | 560 | 400 | 375 | 500 | 3 | 3.33 |
| | | | | | | | | | | 18 | 17.10 |
| | Tt5 | | | | | | | | | 3 | 2.85 |
| | | br-D73 | 560 | 350 | 325 | 354 | 350 | 350 | 325 | 18 | 17.41 |

**Devices**

| Name | ∆P |
|---|---|
| Heater | 25 |
| Flex connection | 5.7 |
| Filter | 70 |
| Coil | 80 |
| Mix Dumper | 25 |
| diffuser | 11 |

**For longest path ∆P = 614.92 Pa**

# 2nd Floor supply duct design

By equal friction method (and pf/m = .95 Pa/m constant through the duct network)

| Duct Name | Type | Q L/s | V (m/s) | L(mm) | D (mm) | W (mm) | H (mm) | ∆P (Pa) |
|---|---|---|---|---|---|---|---|---|
| D0 | Rec | 9080 | 10.47 | 1306 | - | 1200 | 750 | 1.24 |
| D1 | Rec | 1755 | 7.05 | 1653 | - | 550 | 500 | 1.57 |
| D2 | Rec | 1755 | 7.05 | 876 | - | 525 | 500 | 0.83 |
| D3 | Rec | 1163 | 6.38 | 11870 | - | 450 | 425 | 11.28 |
| D4 | Rec | 1163 | 6.38 | 4844 | - | 450 | 425 | 4.60 |
| D5 | Rec | 134 | 3.74 | 610 | - | 200 | 200 | 0.58 |
| D6 | Rec | 134 | 3.74 | 297 | - | 200 | 200 | 0.28 |
| D7 | Round | 67 | 3.14 | 353 | 180 | - | - | 0.34 |
| D8 | Round | 67 | 3.14 | 715 | 180 | - | - | 0.68 |
| D9 | Rec | 1029 | 6.2 | 3639 | - | 425 | 425 | 3.46 |
| D10 | Rec | 137 | 3.765 | 677 | - | 200 | 200 | 0.64 |
| D11 | Round | 137 | 3.77 | 1359 | 224 | - | - | 1.29 |
| D12 | Rec | 101 | 3.486 | 266 | - | 175 | 175 | 0.25 |
| D12a | Round | 101 | 3.49 | 1042 | 200 | - | - | 0.99 |
| D13 | Rec | 791 | 5.8 | 2264 | - | 375 | 375 | 2.15 |
| D14 | Rec | 274 | 4.47 | 617 | - | 250 | 250 | 0.59 |
| D14a | Round | 137 | 3.765 | 151 | 250 | - | - | 0.14 |
| D14b | Round | 137 | 3.77 | 211 | 250 | - | - | 0.20 |
| D15 | Rec | 103 | 3.5 | 870 | - | 200 | 200 | 0.83 |
| D16 | Round | 103 | 3.5 | 698 | 224 | - | - | 0.66 |
| D17 | Rec | 414 | 4.95 | 2588 | - | 300 | 300 | 2.46 |
| D18 | Rec | 166 | 3.95 | 522 | - | 225 | 225 | 0.50 |
| D19 | Rec | 166 | 3.95 | 1394 | - | 225 | 225 | 1.32 |
| D20 | Round | 83 | 3.317 | 1095 | 200 | - | - | 1.04 |
| D21 | Round | 83 | 3.32 | 1133 | 200 | - | - | 1.08 |
| D22 | Rec | 248 | 4.367 | 3232 | - | 250 | 250 | 3.07 |
| D23 | Rec | 248 | 4.37 | 669 | - | 250 | 250 | 0.64 |
| D24 | Rec | 248 | 4.37 | 1261 | - | 250 | 250 | 1.20 |
| D25 | Round | 124 | 3.67 | 1167 | 200 | - | - | 1.11 |
| D26 | Round | 124 | 3.67 | 786 | 200 | - | - | 0.75 |
| D27 | Round | 103 | 3.5 | 691 | 224 | - | - | 0.66 |
| D28 | Rec | 375 | 4.839 | 461 | - | 350 | 325 | 0.44 |
| D29 | Round | 75 | 3.2 | 1058 | 180 | - | - | 1.01 |
| D30 | Rec | 300 | 4.579 | 1815 | - | 275 | 250 | 1.72 |
| D31 | Round | 75 | 3.2 | 1083 | 180 | - | - | 1.03 |
| D32 | Rec | 225 | 4.26 | 2352 | - | 250 | 250 | 2.23 |
| D33 | Rec | 150 | 3.85 | 1848 | - | 200 | 200 | 1.76 |
| D34 | Rec | 150 | 3.85 | 537 | - | 200 | 200 | 0.51 |
| D35 | Round | 75 | 3.2 | 290 | 180 | - | - | 0.28 |
| D36 | Round | 75 | 3.2 | 830 | 180 | - | - | 0.79 |
| D37 | Round | 75 | 3.2 | 4914 | 180 | - | - | 4.67 |
| D38 | Round | 75 | 3.2 | 5629 | 180 | - | - | 5.35 |

| Duct Name | Type | Q L/s | V (m/s) | L(mm) | D (mm) | W (mm) | H (mm) | ∆P (Pa) |
|---|---|---|---|---|---|---|---|---|
| D39 | Rec | 217 | 4.22 | 1488 | - | 250 | 225 | 1.41 |
| D40 | Rec | 217 | 4.22 | 2090 | - | 250 | 225 | 1.99 |
| D41 | Rec | 186 | 4.065 | 700 | - | 225 | 225 | 0.67 |
| D42 | Rec | 186 | 4.07 | 3214 | - | 225 | 225 | 3.05 |
| D44 | Rec | 186 | 4.07 | 2155 | - | 225 | 225 | 2.05 |
| D45 | Rec | 155 | 3.88 | 4179 | - | 225 | 225 | 3.97 |
| D46 | Rec | 124 | 3.67 | 4216 | - | 225 | 200 | 4.01 |
| D47 | Rec | 93 | 3.41 | 4241 | - | 200 | 175 | 4.03 |
| D48 | Rec | 62 | 3.08 | 4291 | - | 175 | 150 | 4.08 |
| D49 | Round | 31 | 2.57 | 1519 | 125 | - | - | 1.44 |
| D50 | Round | 31 | 2.57 | 294 | 125 | - | - | 0.28 |
| D51 | Round | 31 | 2.57 | 352 | 125 | - | - | 0.33 |
| D52 | Round | 31 | 2.57 | 4921 | 125 | - | - | 4.67 |
| D53 | Rec | 6600 | 9.7 | 135 | - | 850 | 850 | 0.13 |
| D54 | Rec | 51 | 2.93 | 868 | - | 140 | 140 | 0.82 |
| D55 | Rec | 6549 | 9.688 | 2046 | - | 850 | 850 | 1.94 |
| D56 | Rec | 42 | 2.787 | 807 | - | 125 | 125 | 0.77 |
| D56a | Round | 42 | 2.79 | 1029 | 150 | - | - | 0.98 |
| D57 | Round | 6507 | 9.67 | 77 | 925 | - | - | 0.07 |
| D58 | Rec | 1446 | 6.736 | 604 | - | 475 | 475 | 0.57 |
| D59 | Rec | 964 | 6.102 | 1996 | - | 425 | 400 | 1.90 |
| D61 | Rec | 482 | 5.148 | 2895 | - | 325 | 300 | 2.75 |
| D63 | Rec | 5061 | 9.109 | 2795 | - | 775 | 775 | 2.66 |
| D64 | Rec | 1446 | 6.736 | 741 | - | 475 | 475 | 0.70 |
| D65 | Round | 241 | 4.336 | 1028 | 280 | - | - | 0.98 |
| D66 | Round | 241 | 4.34 | 836 | 280 | - | - | 0.79 |
| D67 | Rec | 964 | 6.102 | 1346 | - | 425 | 400 | 1.28 |
| D68 | Rec | 482 | 5.148 | 2895 | - | 325 | 300 | 2.75 |
| D69 | Rec | 241 | 4.34 | 453 | 280 | - | - | 0.43 |
| D70 | Rec | 241 | 4.34 | 426 | 280 | - | - | 0.40 |
| D71 | Rec | 3615 | 8.403 | 2707 | - | 750 | 700 | 2.57 |
| D72 | Rec | 482 | 5.148 | 3735.5 | - | 350 | 350 | 3.55 |
| D73 | Rec | 241 | 1.967 | 3735.5 | - | 350 | 350 | 3.55 |
| D74 | Rec | 3133 | 8.12 | 1487 | - | 700 | 700 | 1.41 |
| D75 | Rec | 1446 | 6.736 | 566 | - | 475 | 475 | 0.54 |
| D76 | Rec | 241 | 4.34 | 734 | - | 475 | 475 | 0.70 |
| D77 | Round | 241 | 4.34 | 700 | 300 | - | - | 0.67 |
| D78 | Rec | 964 | 6.102 | 1596 | - | 425 | 400 | 1.52 |
| D79 | Round | 241 | 4.34 | 291 | 300 | - | - | 0.28 |
| D80 | Round | 241 | 4.34 | 391 | 300 | - | - | 0.37 |
| D81 | Rec | 482 | 5.148 | 2895 | - | 325 | 300 | 2.75 |
| D82 | Round | 241 | 4.34 | 265 | 300 | - | - | 0.25 |
| D83 | Round | 241 | 4.34 | 400 | 300 | - | - | 0.38 |
| D84 | Rec | 1687 | 6.992 | 5691 | - | 525 | 500 | 5.41 |
| D85 | Rec | 1205 | 6.444 | 1921 | - | 450 | 450 | 1.82 |
| D87 | Round | 241 | 4.34 | 123 | 280 | - | - | 0.12 |
| D88 | Round | 241 | 4.34 | 160 | 300 | - | - | 0.15 |

| Duct Name | Type | Q L/s | V (m/s) | L(mm) | D (mm) | W (mm) | H (mm) | ∆P (Pa) |
|---|---|---|---|---|---|---|---|---|
| D89 | Rec | 723 | 5.688 | 847 | - | 375 | 350 | 0.80 |
| D90 | Round | 241 | 4.34 | 3192 | 280 | - | - | 3.03 |
| D91 | Round | 241 | 4.34 | 696 | 280 | - | - | 0.66 |
| D92 | Rec | 482 | 5.148 | 722 | - | 325 | 300 | 0.69 |
| D93 | Round | 241 | 4.34 | 134 | 280 | - | - | 0.13 |
| D94 | Round | 241 | 4.34 | 192 | 280 | - | - | 0.18 |
| D95 | Rec | 725 | 5.692 | 991 | - | 375 | 350 | 0.94 |
| D96 | Rec | 683 | 5.609 | 3225 | - | 375 | 375 | 3.06 |
| D97 | Rec | 66 | 3.129 | 132 | - | 150 | 150 | 0.13 |
| D98 | Rec | 66 | 3.129 | 692 | - | 150 | 150 | 0.66 |
| D99 | Rec | 617 | 5.47 | 4400 | - | 350 | 350 | 4.18 |
| D100 | Rec | 64 | 3.1 | 7743 | - | 150 | 150 | 7.36 |
| D101 | Rec | 553 | 5.326 | 1270 | - | 350 | 325 | 1.21 |
| D102 | Rec | 108 | 3.546 | 633 | - | 175 | 175 | 0.60 |
| D103 | Round | 54 | 2.97 | 2800 | 150 | - | - | 2.66 |
| D104 | Round | 54 | 2.97 | 435 | 150 | - | - | 0.41 |
| D105 | Rec | 445 | 5.048 | 2625 | - | 325 | 300 | 2.49 |
| D106 | Rec | 152 | 3.864 | 5499 | - | 250 | 225 | 5.22 |
| D107 | Round | 66 | 3.129 | 378 | 180 | - | - | 0.36 |
| D108 | Rec | 86 | 3.347 | 2326 | - | 200 | 200 | 2.21 |
| D109 | Rec | 86 | 3.347 | 387 | - | 175 | 150 | 0.37 |
| D110 | Round | 86 | 3.347 | 538 | 180 | - | - | 0.51 |
| D111 | Rec | 293 | 4.55 | 3035 | - | 250 | 225 | 2.88 |
| D112 | Rec | 30 | 2.55 | 829 | - | 125 | 100 | 0.79 |
| D113 | Rec | 263 | 4.43 | 1952 | - | 225 | 225 | 1.85 |
| D114 | Rec | 45 | 2.83 | 1657 | - | 125 | 100 | 1.57 |
| D115 | Round | 45 | 2.83 | 590 | 150 | - | - | 0.56 |
| D116 | Rec | 218 | 4.22 | 1740 | - | 200 | 200 | 1.65 |
| D117 | Rec | 45 | 2.83 | 1915 | - | 150 | 125 | 1.82 |
| D118 | Round | 45 | 2.83 | 417 | 150 | - | - | 0.40 |
| D119 | Rec | 173 | 3.99 | 1258 | - | 175 | 175 | 1.20 |
| D120 | Rec | 112 | 3.578 | 8643 | - | 150 | 125 | 8.21 |
| D121 | Rec | 64 | 3.105 | 432 | - | 175 | 150 | 0.41 |
| D122 | Rec | 64 | 3.105 | 237 | - | 175 | 150 | 0.23 |
| D123 | Rec | 48 | 2.88 | 2468 | - | 150 | 140 | 2.34 |
| D124 | Rec | 48 | 2.88 | 2229 | - | 150 | 125 | 2.12 |
| D125 | Rec | 48 | 2.88 | 230 | - | 150 | 125 | 0.22 |
| D126 | Round | 48 | 2.88 | 490 | 160 | - | - | 0.47 |
| D127 | Rec | 61 | 3.06 | 1564 | - | 150 | 150 | 1.49 |
| D128 | Rec | 61 | 3.06 | 972 | 160 | - | - | 0.92 |
| D129 | Rec | 61 | 3.06 | 236 | 160 | - | - | 0.22 |
| D130 | Rec | 61 | 3.06 | 167 | 160 | - | - | 0.16 |
| D131 | Rec | 9080 | 10.47 | 11372 | - | 950 | 950 | 10.80 |
| D132 | Rec | 9080 | 10.47 | 2142 | - | 950 | 950 | 2.03 |

## Single element for longest path

| Element | Symbol | Q | Input Dim | | Output Dim | | L(mm) | $L_{eq}$ (m) | ΔP (Pa) |
|---|---|---|---|---|---|---|---|---|---|
| | | | W (mm) | H (mm) | W (mm) | H (mm) | | | |
| Contraction | c1 | 617 | 375 | 350 | 350 | 350 | 70 | 2.5 | 2.44 |
| | c2 | 553 | 350 | 350 | 350 | 325 | 337 | 2.5 | 2.70 |
| | c3 | 445 | 350 | 325 | 325 | 300 | 325 | 2.5 | 2.68 |
| | c4 | 392 | 325 | 300 | 250 | 225 | 275 | 2.5 | 2.64 |
| | c5 | 263 | 250 | 225 | 225 | 225 | 237 | 2.5 | 2.60 |
| | c6 | 218 | 225 | 225 | 200 | 200 | 212 | 2.5 | 2.58 |
| | c7 | 173 | 200 | 200 | 175 | 175 | 187 | 2.5 | 2.55 |
| | c8 | 112 | 175 | 175 | 150 | 125 | 150 | 2.5 | 2.52 |
| | c9 | 48 | 200 | 200 | 150 | 140 | 100 | 2.5 | 2.47 |
| | c10 | 9080 | 975 | 950 | 1200 | 750 | 311 | 2.5 | 2.67 |
| | c11 | 725 | 375 | 950 | 375 | 350 | 362 | 2.5 | 2.72 |
| Expansion | E1 | 112 | 150 | 125 | 200 | 200 | 100 | 6 | 5.80 |
| | E2 | 48 | 150 | 125 | 250 | 200 | 187 | 6 | 5.88 |
| | E3 | 9080 | 800 | 800 | 950 | 950 | 221 | 6 | 5.91 |
| Rec-elbow | e1 | 48 | 150 | 140 | 150 | 140 | 353 | 5 | 5.09 |
| | e2 | 48 | 150 | 125 | 150 | 125 | 863 | 5 | 5.57 |
| | e3 | 9080 | 950 | 950 | 950 | 950 | 2862 | 5 | 7.47 |
| | e4 | 9080 | 950 | 950 | 950 | 950 | 2086 | 5 | 6.73 |
| | e5 | 9080 | 950 | 950 | 950 | 950 | 2513 | 5 | 7.14 |
| | e6 | 9080 | 950 | 950 | 950 | 950 | 2238 | 5 | 6.88 |

## Double and triple element for longest path

| Element | Symbol | Type | Input specs | | | Output specs | | | L(mm) | $L_{eq}$(mm) | ΔP (Pa) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Q (L/s) | W (mm) | H (mm) | Q(L/s) | W(mm) | H(mm) | | | |
| Branch Tee 90° | Tt1 | main | 725 | 375 | 350 | 683 | 375 | 375 | 475 | 3 | 3.30 |
| | | | | | | | | | | | |
| | Tt2 | | | | | | | | | | |
| | | br-D99 | 683 | 375 | 375 | 617 | 350 | 350 | 475 | 18 | 17.55 |
| | Tt3 | main | 617 | 350 | 350 | 553 | 350 | 325 | 450 | 3 | 3.28 |
| | | | | | | | | | | | |
| | Tt4 | main | 553 | 350 | 325 | 445 | 325 | 300 | 450 | 3 | 3.28 |
| | | | | | | | | | | | |
| | Tt5 | main | 445 | 325 | 300 | 293 | 250 | 225 | 425 | 3 | 3.25 |
| | | | | | | | | | | | |
| | Tt6 | main | 293 | 250 | 225 | 263 | 225 | 225 | 350 | 3 | 3.18 |
| | | | | | | | | | | | |
| | Tt7 | main | 263 | 225 | 225 | 218 | 200 | 200 | 325 | 3 | 3.16 |
| | | | | | | | | | | | |
| | Tt8 | | | | | | | | | | |
| | | br-D117 | 218 | 200 | 200 | 45 | 150 | 125 | 300 | 18 | 17.39 |
| | Tt9 | | | | | | | | | | |
| | | br-D120 | 173 | 175 | 175 | 112 | 150 | 125 | 275 | 18 | 17.36 |
| | Tt10 | main | 112 | 200 | 200 | 48 | 200 | 200 | 300 | 3 | 3.14 |
| | | | | | | | | | | | |
| Cross connection | X1 | | | | | | | | | | |
| | | br-D95 | 9080 | 1200 | 750 | 725 | 375 | 950 | 1022 | 18 | 18.07 |
| | | | | | | | | | | | |

**Devices for longest path**

| Name | ∆P |
|---|---|
| V.A.V. | 25 |
| Flex connection | 5.7 |
| Filter | 70 |
| Coil | 80 |
| Mix Dumper | 25 |
| diffuser | 9 |

**For longest path ∆P = 432.43 Pa**

# $3^{rd}$ floor Supply duct design

By equal friction method (and pf/m = .95 Pa/m constant through the duct network)

| Duct Name | Type | Q (L/s) | V (m/s) | L (mm) | D (mm) | W (mm) | H(mm) | ∆P(Pa) |
|---|---|---|---|---|---|---|---|---|
| D00 | Rec | 4598 | 8.9 | 2457 | - | 750 | 725 | 2.33 |
| D1 | Rec | 4598 | 8.9 | 1992 | - | 750 | 725 | 1.89 |
| D2 | Rec | 1566 | 6.867 | 600 | - | 500 | 490 | 0.57 |
| D3 | Rec | 1566 | 6.87 | 2116 | - | 500 | 490 | 2.01 |
| D4 | Round | 261 | 4.42 | 1114 | 280 | - | - | 1.06 |
| D5 | Round | 261 | 4.42 | 1664 | 280 | - | - | 1.58 |
| D6 | Rec | 1044 | 6.22 | 2539 | - | 425 | 425 | 2.41 |
| D7 | Round | 261 | 4.42 | 1164 | 280 | - | - | 1.11 |
| D8 | Round | 261 | 4.42 | 3419 | 280 | - | - | 3.25 |
| D9 | Rec | 522 | 5.25 | 2824 | - | 325 | 325 | 2.68 |
| D10 | Round | 261 | 4.42 | 1038 | 273 | - | - | 0.99 |
| D11 | Round | 261 | 4.42 | 3037 | 280 | - | - | 2.89 |
| D12 | Round | 261 | 4.42 | 1364 | 280 | - | - | 1.30 |
| D13 | Rec | 3023 | 8.05 | 5214 | - | 630 | 625 | 4.95 |
| D14 | Rec | 1302 | 6.56 | 1600 | - | 460 | 450 | 1.52 |
| D15 | Round | 651 | 5.54 | 1432 | 400 | - | - | 1.36 |
| D16 | Rec | 1721 | 7.02 | 1805 | - | 510 | 500 | 1.71 |
| D17 | Rec | 976 | 6.12 | 1137 | - | 425 | 410 | 1.08 |
| D18 | Rec | 858 | 5.93 | 519 | - | 400 | 395 | 0.49 |
| D19 | Rec | 286 | 4.52 | 581 | - | 265 | 250 | 0.55 |
| D20 | Round | 143 | 3.8 | 1064 | 224 | - | - | 1.01 |
| D21 | Round | 143 | 3.8 | 1257 | 224 | - | - | 1.19 |
| D22 | Rec | 572 | 5.37 | 1530 | - | 350 | 335 | 1.45 |
| D23 | Round | 143 | 3.8 | 600 | 224 | - | - | 0.57 |
| D24 | Round | 143 | 3.8 | 1089 | 224 | - | - | 1.03 |
| D25 | Rec | 286 | 4.52 | 3024 | - | 265 | 250 | 2.87 |
| D26 | Round | 143 | 3.8 | 1135 | 224 | - | - | 1.08 |
| D27 | Round | 143 | 3.8 | 1135 | 224 | - | - | 1.08 |
| D28 | Rec | 118 | 3.62 | 1442 | - | 185 | 175 | 1.37 |
| D29 | Rec | 118 | 3.62 | 4206 | - | 185 | 175 | 4.00 |
| D30 | Rec | 118 | 3.62 | 443 | - | 185 | 175 | 0.42 |
| D31 | Rec | 118 | 3.62 | 1029 | - | 185 | 175 | 0.98 |
| D32 | Round | 59 | 3.04 | 222 | 160 | - | - | 0.21 |
| D33 | Round | 59 | 3.04 | 1012 | 160 | - | - | 0.96 |
| D34 | Rec | 745 | 5.73 | 805 | - | 375 | 375 | 0.76 |
| D35 | Rec | 745 | 5.73 | 1017 | - | 375 | 375 | 0.97 |
| D36 | Rec | 140 | 3.78 | 3351 | - | 200 | 200 | 3.18 |
| D37 | Rec | 140 | 3.78 | 4919 | - | 200 | 200 | 4.67 |
| D38 | Rec | 28 | 2.5 | 508 | - | 110 | 100 | 0.48 |
| D39 | Rec | 112 | 3.57 | 1590 | - | 180 | 175 | 1.51 |
| D40 | Rec | 56 | 3 | 5942 | - | 145 | 125 | 5.64 |
| D41 | Round | 28 | 2.5 | 2392 | 200 | - | - | 2.27 |

| Duct Name | Type | Q (L/s) | V (m/s) | L (mm) | D (mm) | W (mm) | H(mm) | ∆P(Pa) |
|---|---|---|---|---|---|---|---|---|
| D42 | Round | 28 | 2.5 | 2082 | 200 | - | - | 1.98 |
| D43 | Round | 28 | 2.5 | 4559 | 200 | - | - | 4.33 |
| D44 | Rec | 56 | 3 | 1248 | - | 145 | 125 | 1.19 |
| D45 | Round | 28 | 2.5 | 1996 | 200 | - | - | 1.90 |
| D46 | Round | 28 | 2.5 | 701 | 200 | - | - | 0.67 |
| D47 | Rec | 605 | 5.44 | 1598 | - | 350 | 340 | 1.52 |
| D48 | Rec | 311 | 4.62 | 3113 | - | 300 | 300 | 2.96 |
| D49 | Rec | 207 | 4.17 | 2945 | - | 250 | 250 | 2.80 |
| D50 | Rec | 106 | 3.52 | 3524 | - | 200 | 200 | 3.35 |
| D51 | Round | 53 | 2.95 | 854 | 200 | - | - | 0.81 |
| D52 | Round | 53 | 2.95 | 555 | 200 | - | - | 0.53 |
| D53 | Round | 101 | 3.48 | 656 | 200 | - | - | 0.62 |
| D54 | Round | 104 | 3.51 | 744 | 200 | - | - | 0.71 |
| D55 | Round | 101 | 3.48 | 727 | 200 | - | - | 0.69 |
| D56 | Round | 143 | 3.8 | 459 | 200 | - | - | 0.44 |
| D57 | Rec | 193 | 4.1 | 1868 | - | 250 | 250 | 1.77 |
| D58 | Rec | 50 | 2.91 | 6277 | - | 150 | 150 | 5.96 |
| D59 | Rec | 50 | 2.91 | 3752 | - | 150 | 150 | 3.56 |
| D60 | Rec | 50 | 2.91 | 3194 | - | 150 | 150 | 3.03 |
| D61 | Round | 50 | 2.91 | 1780 | 200 | - | - | 1.69 |

**Single element longest three paths**

| Element | Symbol | Q | Input Dim | | Output Dim | | L(mm) | $L_{eq}$ (m) | ∆P (Pa) |
|---|---|---|---|---|---|---|---|---|---|
| | | | W (mm) | H(mm) | W(mm) | H(mm) | | | |
| Contraction | c0 | 4598 | | | 750 | 725 | 700 | 2.5 | 3.04 |
| | c4 | 3023 | 750 | 725 | 630 | 625 | 687 | 2.5 | 3.0277 |
| | c6 | 1721 | 630 | 625 | 510 | 500 | 565 | 2.5 | 2.9118 |
| | c7 | 976 | 510 | 500 | 425 | 410 | 460 | 2.5 | 2.812 |
| | c12 | 118 | 425 | 410 | 185 | 125 | 300 | 2.5 | 2.66 |
| | c13 | 745 | 510 | 500 | 375 | 375 | 442 | 2.5 | 2.7949 |
| | c14 | 140 | 375 | 375 | 200 | 200 | 287.5 | 2.5 | 2.6481 |
| | c16 | 112 | 200 | 200 | 180 | 175 | 187.5 | 2.5 | 2.5531 |
| | c18 | 56 | 180 | 175 | 145 | 125 | 165 | 2.5 | 2.5318 |
| | c19 | 605 | 375 | 375 | 350 | 340 | 357.5 | 2.5 | 2.7146 |
| | c29 | 193 | 350 | 340 | 250 | 250 | 275 | 2.5 | 2.6363 |
| | c31 | 50 | 250 | 250 | 150 | 150 | 171.5 | 2.5 | 2.5379 |
| | c32 | 50 | D=400 | | D=200 | | 200 | 2.5 | 2.565 |
| Expansion | E7 | 118 | 185 | 175 | 850 | 500 | 512 | 6 | 6.1864 |
| | E8 | 140 | 200 | 200 | 850 | 500 | 525 | 6 | 6.1988 |
| | E15 | 50 | 150 | 150 | 850 | 500 | 500 | 6 | 6.175 |
| | E16 | 56 | 145 | 125 | 200 | 200 | 175 | 6 | 5.8663 |
| conv-cont | conv-c14 | 118 | D=400 | | 185 | 175 | 600 | 1.5 | 1.995 |
| | conv-c16 | 59 | D=160 | | 185 | 175 | 240 | 1.5 | 1.653 |
| | conv-c17 | 140 | D=400 | | 200 | 200 | 600 | 1.5 | 1.995 |
| | conv-c19 | 28 | D=200 | | 200 | 200 | 300 | 1.5 | 1.71 |
| conv-cont | conv-c21 | 28 | D=200 | | 200 | 200 | 300 | 1.5 | 1.71 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Rec-elbow | e0 | 4598 | 750 | 725 | 750 | 725 | 1255 | 5 | 5.9423 |
| | e00 | 4598 | 750 | 725 | 750 | 725 | 1255 | 5 | 5.9423 |
| | e2 | 118 | 185 | 175 | 185 | 175 | 864 | 5 | 5.5708 |
| | e3 | 118 | 185 | 175 | 185 | 175 | 864 | 5 | 5.5708 |
| | e4 | 118 | 185 | 175 | 185 | 175 | 864 | 5 | 5.5708 |
| | e9 | 50 | 150 | 150 | 150 | 150 | 864 | 5 | 5.5708 |
| | e10 | 50 | 150 | 150 | 150 | 150 | 864 | 5 | 5.5708 |
| | e11 | 50 | 150 | 150 | 150 | 150 | 864 | 5 | 5.5708 |
| | e12 | 745 | 375 | 375 | 375 | 375 | 2000 | 5 | 6.65 |
| | e13 | 745 | 375 | 375 | 375 | 375 | 2000 | 5 | 6.65 |
| | e14 | 28 | D=200 | | D=200 | | 314 | 3 | 3.1483 |
| | e15 | 28 | D=200 | | D=200 | | 314 | 3 | 3.1483 |
| | e16 | 28 | D=200 | | D=200 | | 314 | 3 | 3.1483 |
| | e17 | 28 | D=200 | | D=200 | | 314 | 3 | 3.1483 |

### Double elements longest three paths

| Element | Symbol | Type | Input specsefications | | | Output specsefications | | | L(mm) | $L_{eq}$ (m) | ΔP(Pa) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Q(L/s) | W(mm) | H(mm) | Q(L/s) | W(mm) | H(mm) | | | |
| Wye Tee | Ty4 | br-D33 | 118 | 185 | 175 | 28 | 185 | 175 | 285 | 22 | 21.17 |
| | | br-D32 | 118 | 185 | 175 | 112 | 185 | 175 | 285 | 22 | 21.17 |
| | Ty5 | br-D38 | 140 | 200 | 200 | 28 | 200 | 200 | 300 | 22 | 21.19 |
| | | br-D39 | 140 | 200 | 200 | 112 | 200 | 200 | 300 | 22 | 21.19 |
| Branch Tee 90° | Tt1 | main | 4598 | 750 | 725 | 1566 | 750 | 725 | 850 | 3 | 3.66 |
| | | br-D13 | 4598 | 750 | 725 | 261 | 750 | 725 | 850 | 18 | 17.91 |
| | Tt3 | main | 3023 | 630 | 625 | 1721 | 630 | 625 | 730 | 3 | 3.54 |
| | | br-D14 | 3023 | 630 | 625 | 1302 | 630 | 625 | 730 | 18 | 17.79 |
| | Tt5 | main | 1721 | 510 | 500 | 745 | 510 | 500 | 630 | 3 | 3.45 |
| | | br-D17 | 1721 | 510 | 500 | 976 | 510 | 500 | 630 | 18 | 17.70 |
| | Tt6 | main | 976 | 425 | 410 | 858 | 425 | 410 | 525 | 3 | 3.35 |
| | | br-D28 | 976 | 425 | 410 | 118 | 425 | 410 | 525 | 18 | 17.60 |
| | Tt7 | main | 745 | 375 | 375 | 605 | 375 | 375 | 475 | 3 | 3.30 |
| | | br-D36 | 745 | 375 | 375 | 140 | 375 | 375 | 475 | 18 | 17.55 |
| | Tt8 | main | 112 | 180 | 175 | 56 | 180 | 175 | 280 | 3 | 3.12 |
| | | br-D40 | 112 | 180 | 175 | 56 | 180 | 175 | 280 | 18 | 17.37 |
| | Tt9 | main | 56 | 200 | 200 | 28 | 200 | 200 | 300 | 3 | 3.14 |
| | | br-cc22 | 56 | 200 | 200 | 28 | 200 | 200 | 300 | 18 | 17.39 |
| | Tt12 | main | 193 | 250 | 250 | 50 | 250 | 250 | 350 | 3 | 3.18 |
| | | br-c29 | 193 | 250 | 250 | 143 | 250 | 250 | 350 | 18 | 17.43 |
| Cross connection | X4 | main | 605 | 350 | 340 | 101 | 200 | 340 | 350 | 3 | 3.18 |
| | | br-D48 | 605 | 350 | 340 | 311 | 300 | 340 | 350 | 18 | 17.43 |
| | | br-D57 | 605 | 350 | 340 | 193 | 300 | 340 | 350 | 18 | 17.43 |

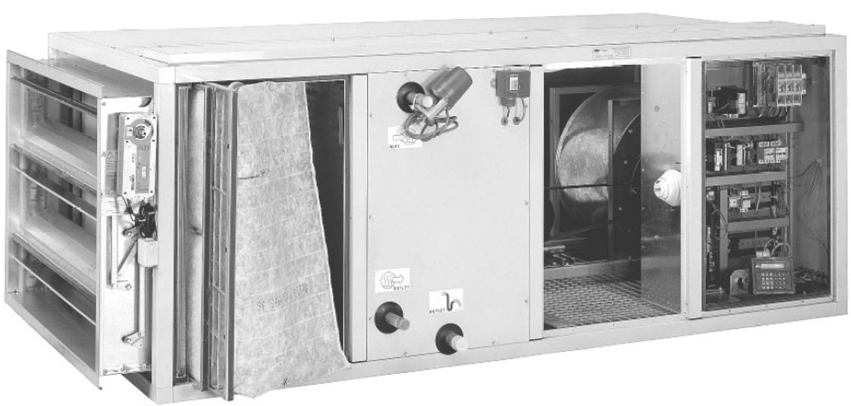
**Devices for longest path**

| Name | ∆P |
|---|---|
| V.A.V. | 25 |
| Flex connection | 5.7 |
| Filter | 70 |
| Coil | 80 |
| Mix Dumper | 25 |
| diffuser | 9 |

## For longest path ∆P = 407 Pa

Chapter Six

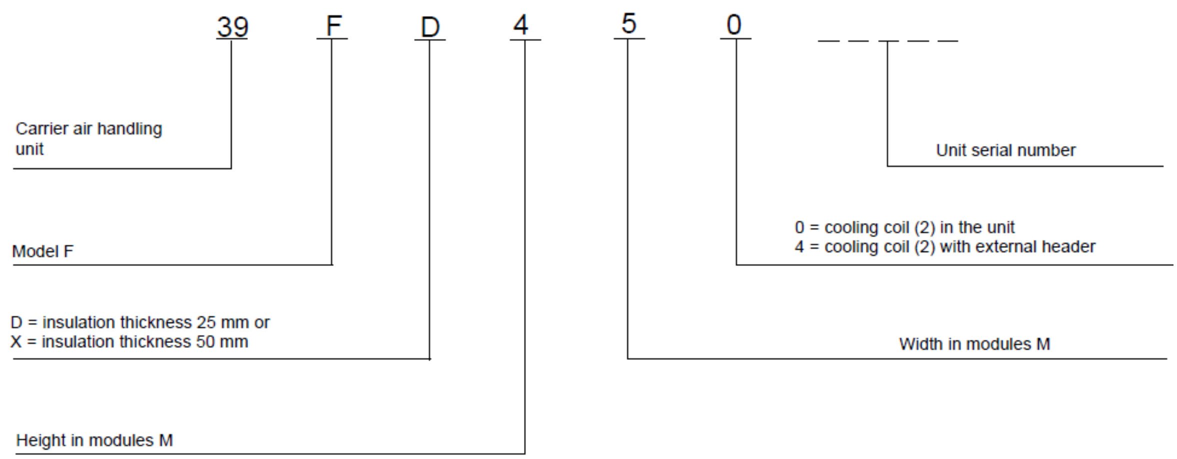
# Units Selection



## 6.1 Air Handling Units Selection:

***<u>From Carrier Catalogs</u>***

| Floor No | Air Handling Unit Data | | | | | |
|---|---|---|---|---|---|---|
| | Model | Q (l/s) | V (m/s) | L (mm) | H (mm) | W (mm) |
| **Ground 1** | 39FD350 | 3135 | 3.15 | 3830 | 995 | 1625 |
| **Ground 2** | 39FD450 | 4144 | 3.15 | 3830 | 1310 | 1625 |
| **1st floor** | 39FD480 | 7536 | 3.15 | 2255 | 1310 | 2570 |
| **2nd floor** | 39FD670 | 9054 | 3.15 | 3200 | 1940 | 2255 |
| **3rd floor** | 39FD450 | 4576 | 3.15 | 3830 | 1310 | 1625 |




## 6.2 Cooling Coils Selection :

| Floor No | Cooling Coil Data | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Q (l/s) | V (m/s) | Face Area ($m^2$) | Fins Pitch (mm) | PBF | ADP ($^oC$) | Cooling Capacity (KW) | No Of Rows | Water Temp.Rise ($^oC$) | Water Press. Drop (KPa) |
| **G -1** | 3135 | 3.15 | 1.44 | 3 | 0.3 | | 160.6 | 4 | 7 | 24.7 |
| **G -2** | 4144 | 3.15 | 1.68 | 3 | 0.18 | | 229.5 | 6 | 7 | 33.2 |
| **1st** | 7536 | 3.15 | 3.3 | 3 | 0.29 | | 372 | 4 | 8 | 31 |
| **2nd** | 9054 | 3.15 | 3.59 | 3 | 0.29 | | 460.4 | 6 | 10 | 22.5 |
| **3rd** | 4576 | 3.15 | 2.07 | 3 | 0.16 | | 272.8 | 6 | 8 | 34.2 |

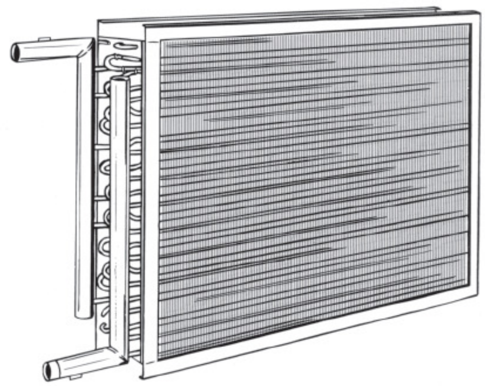


Fig (6-1): Cooling Coil

## 6.2 Filters Selection :

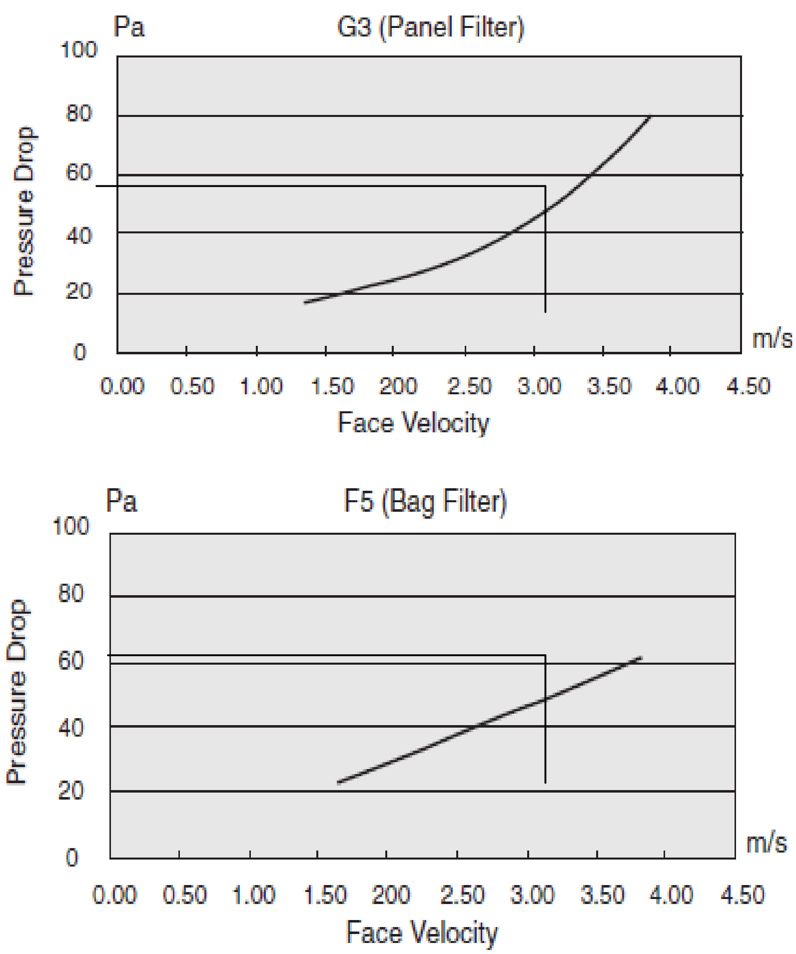



Fig (6-2): Filter Rating and Performance for Panel and Bag Filter

| AHU | Filter Data “Panel Filter” | | | | | | |
|---|---|---|---|---|---|---|---|
| | V (m/s) | Press. Drop (Pa) | Cell Quantity | Filter Size | | Frame Size | |
| | | | | H(mm) | W(mm) | H(mm) | W(mm) |
| G -1 | 3.15 | 50 | 2 | 390 | 493 | 410 | 510 |
| G -2 | 3.15 | 50 | 2 | 493 | 595 | 510 | 510 |
| 1st | 3.15 | 50 | 2 | 595 | 595 | 605 | 605 |
| 2nd | 3.15 | 50 | 2 | 493 | 493 | 510 | 605 |
| 3rd | 3.15 | 50 | 2 | 493 | 493 | 510 | 605 |

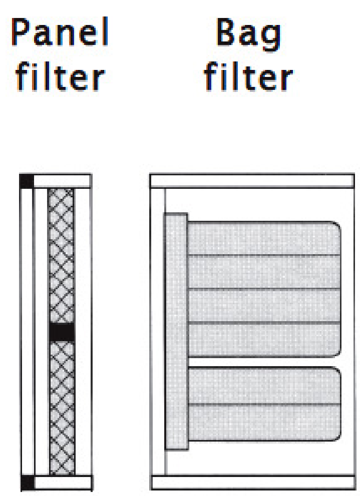
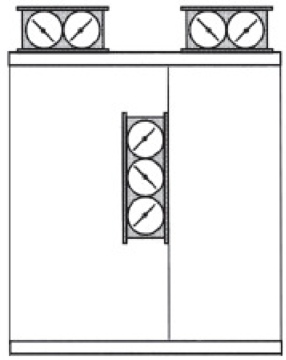



**Fig (6-3): Panel and Bag Filter**

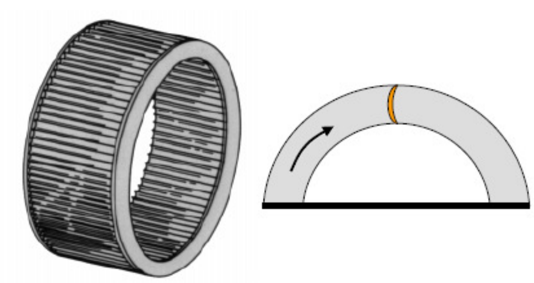
## 6.3 Mixing damper selection :

| A H U | Mixing Damper Data | | |
|---|---|---|---|
| | H(mm) | W(mm) | Weight(kg) |
| G-1 | 578 | 1625 | 44.8 |
| G-2 | 578 | 1625 | 44.8 |
| 1st | 893 | 2386 | 80.6 |
| 2st | 893 | 2255 | 83.5 |
| 3st | 735 | 1625 | 48.3 |




**Fig(6-4) Fresh and mixing and exhaust damper**

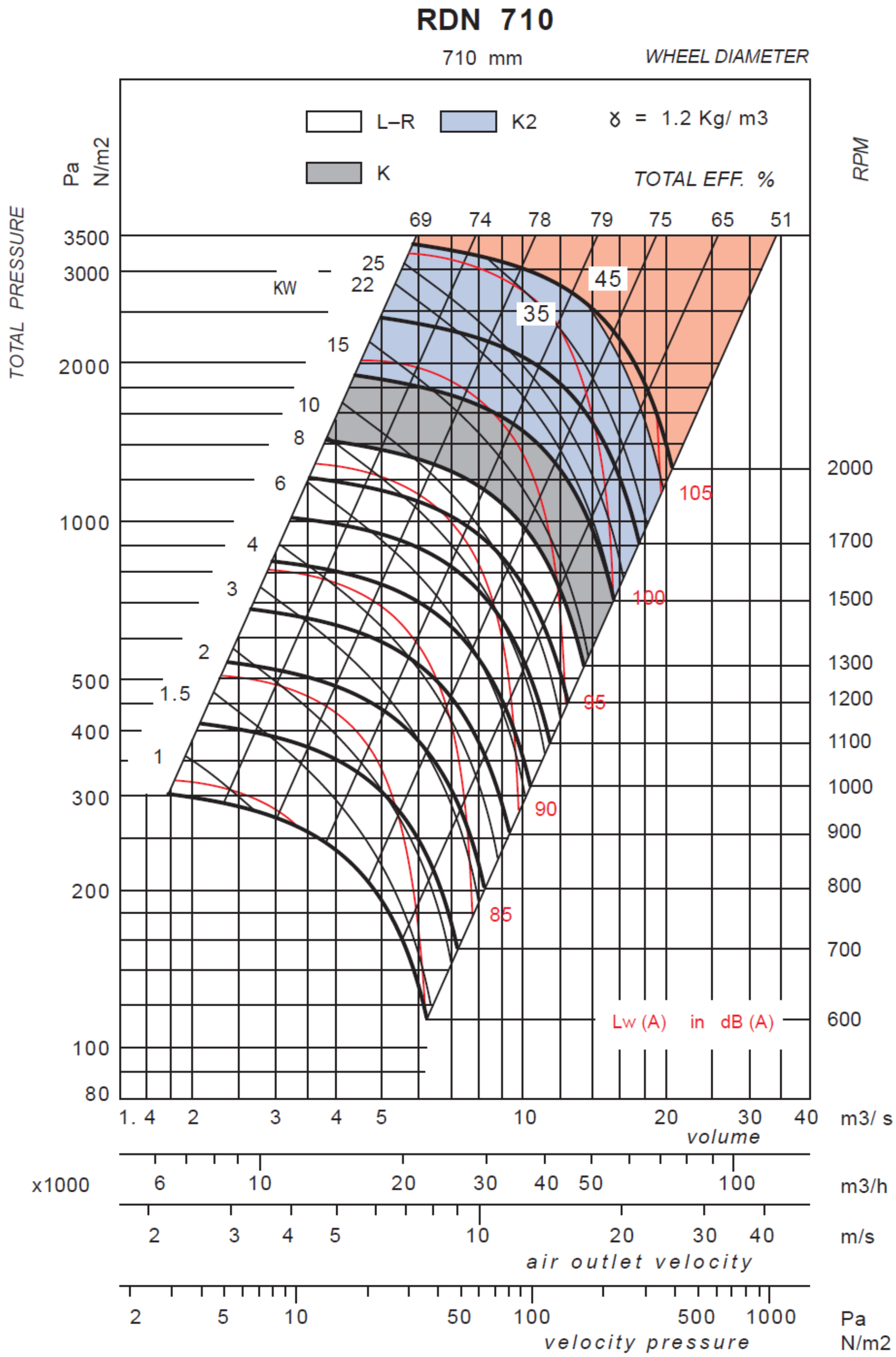
## 6.4 Fans Selection :



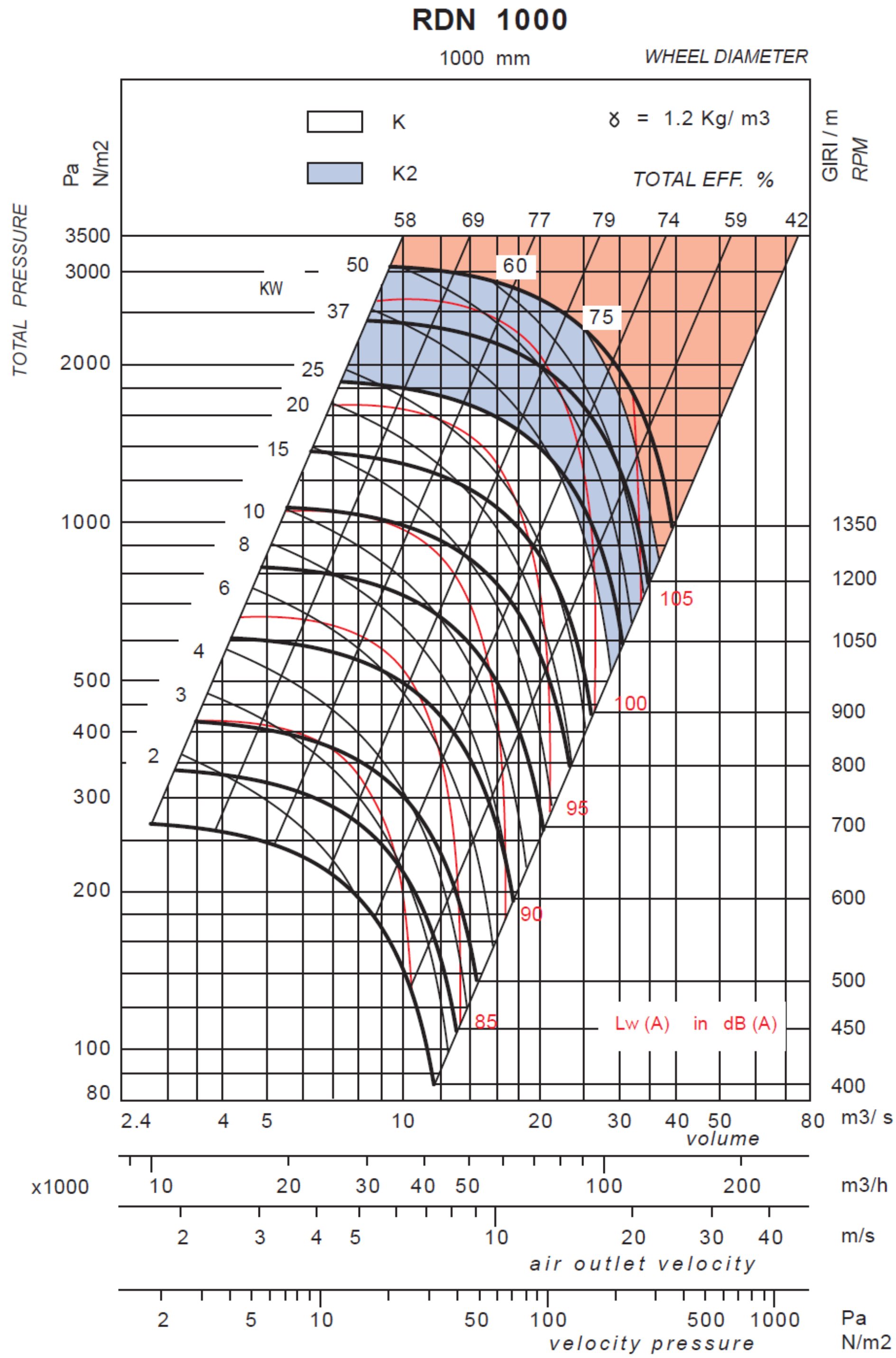
**Forward curved fan** **Centrifugal fan**

### *Supply fan (Backward Blade Fane)*

| AHD | Backward Blade Fane | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Q (L/S) | Q (m3/s) | P.D (pa) | V (m/s) | D (mm) | RPM | η | Motor power(kw) |
| G-1 | 3135 | 3.135 | 537.8 | 4 | 710 | 800 | 74 | 2.2 |
| G-2 | 4144 | 4.144 | 703.5 | 3.15 | 1000 | 700 | 58 | 7 |
| 1st | 7536 | 7.536 | 614.9 | 4.8 | 1000 | 630 | 75 | 6 |
| 2nd | 9054 | 9.054 | 432.4 | 5.5 | 1000 | 550 | 79 | 5 |
| 3rd | 4576 | 4.576 | 407 | 3.15 | 1000 | 500 | 65 | 2.5 |



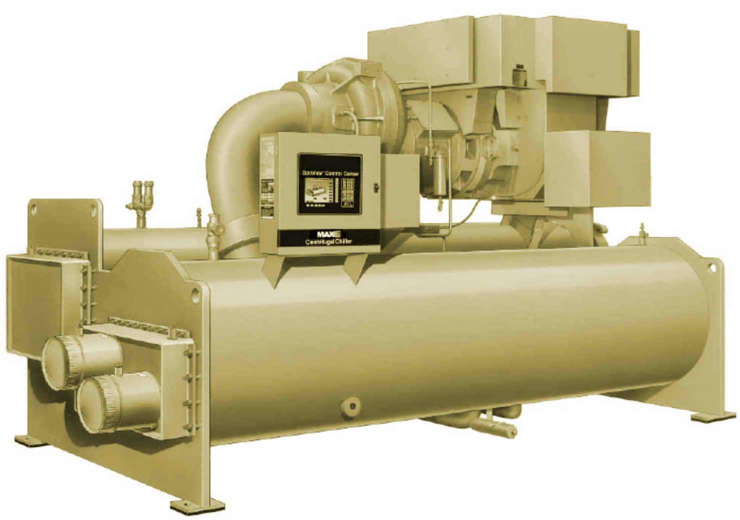

**(Fig 6-5) Performance curve for backward blade fan with diameter 710 mm**




**(Fig. 6.6) Performance curve for backward blade fan with diameter 1000mm**

Chapter Seven

# Chilled Water System



## 1. Chilled water systems description

A chilled water system is a means by which heat, generated in a space or by a process, is conveyed from that space and ultimately released to the outside.

***System functions*:**

Basically, a chilled water system circulates the chilled water through a loop piping system. Pumps force the water from the water chiller through the heat transfer components and back to the chiller via the piping system. Heat is transferred to the chilled water as it circulates through the heat transfer device that causes the temperature of the chilled water to increase. The portion of the system that supplies the water from the chiller to the heat transfer equipment is typically designated the chilled water supply system. Once the water is through this heat transfer equipment, the piping system delivering it back to the chiller is termed the chilled water

## 2. Chilled water systems major components

Chilled water systems are generally comprised of the following major system components:

a. *Chillers*. The most common chilled water air-conditioning system is a single compressor and refrigerant circuit using a water-cooled condenser. It is relatively simple and compact. Compression type refrigeration liquid chilling equipment ranges in size from quite small to those with capacities in the thousands of tons (1 ton equals 12,000 BTU per hour of cooling). The three categories of chillers are those which use reciprocating compressors, centrifugal compressors, and rotary screw type compressors. Control of water chillers is typically based on the return water temperature. The return water temperature indicates the cooling load in the facility at any given time. The warmer the chilled water return temperature, the larger the facility cooling loads.
b. *Pumps*. The type of pump used to distribute chilled water through the chilled water system varies with the system design. There are two basic types of pumps: positive displacement and centrifugal.
c. *Expansion tanks*. Expansion tanks are used in chilled water systems to allow for thermal expansion of the chilled water that, if not for the expansion tank, could damage the piping system.
d. *Control valves*. Control valves are used in chilled water systems to control the flow of chilled water through the piping system. The control system positions the valve through a valve operator or actuator that is directly attached to the valve stem. The valve operator or actuator uses electricity, compressed air, or hydraulic fluid to move the valve stem through its operating range
e. *Strainers*. Strainers are defined as closed vessels with cleanable screen elements designed to remove and retain foreign particles down to 0.001 inch diameter from various flow fluids. A strainer differs from a filter in that strainers trap particles that are typically visible to the naked eye. Strainers are typically installed in chilled water systems on the inlet (suction) side of the distribution pumps.
f. *Air separators*. All chilled water systems use air separators to remove air (gas) bubbles that have become entrained in the water.
g. *Valves*. Valves installed in the chilled water system are used to control water flow and to isolate equipment for ease of maintenance. Most valves in a chilled water system are manually operated with a handwheel or lever operator.

- Valves are typically installed at the following:

*(a)* On the inlet and outlet connection of each piece of equipment, including chillers pumps, reducing valves, control valves, tanks, coils, and other equipment that requires periodic maintenance.

*(b)* On the supply and return branch lines at the point of connection to the main supply and return piping headers.

*(c)* Drain valves are installed at low points in the water distribution system to facilitate draining of the system.

*(d)* Vent valves should be installed at all high points in the chilled water piping system for manual venting of air from the system and to help in the draining of the piping.

The most common types of valves utilized in chilled water systems include gate, ball, butterfly, globe, check, and pressure regulating valves. The general characteristics of these valves are described below. Illustrations of these valves are located on figures 7-1 and 7-2.

*(a)* Gate valves are identified by a wedge-shaped disk that is raised to open or lowered to lose the valve. Gate valves are intended to operate fully open or fully closed, and have very low resistance to flow in the open position, since the disk rises out of the flow path. The gate valve should not be operated in the partially open position, as this may cause vibration and premature wear on the disk. The gate valve may be used for shutoff service where a slow closure is acceptable and where an absolute bubble tight closure is not a critical consideration.

*(b)* Ball valves use a ball as the opening/closing mechanism to control fluid flow. The ball is rotated 90 degrees from full open to full closed; therefore, it is well-suited for applications which require quick or frequent opening and closing.

*(c)* Butterfly valves in the chilled water system are most common in the larger sizes due to the ease of operation, low cost, and superior shutoff characteristics. Like the ball valve, a 90-degree rotation of the operating mechanism results in valve travel from closed to full open. The butterfly valve is well-suited for both on/off service or throttling service.

*(d)* Globe valves are primarily used for throttling service and are not well-suited for full flow applications due to the high resistance to flow designed into the valve. The standard valve consists of a round disk or tapered plug that seat against a round opening. Unlike the gate and ball valves, globe valves must be installed in the proper direction of flow. Flow should enter through the disk seat and push up against the valve disk. Reverse installation will result in valve chatter, vibration, and premature valve failure.

*(e)* Check valves are used in the chilled water system to prevent reversal of flow at pumps and equipment.

*(f)* Water pressure regulating valves are used in the chilled water system to limit the water supply pressure to equipment within acceptable levels. The two common types of water pressure regulating valves include the direct-acting type and the pilot-operated type.

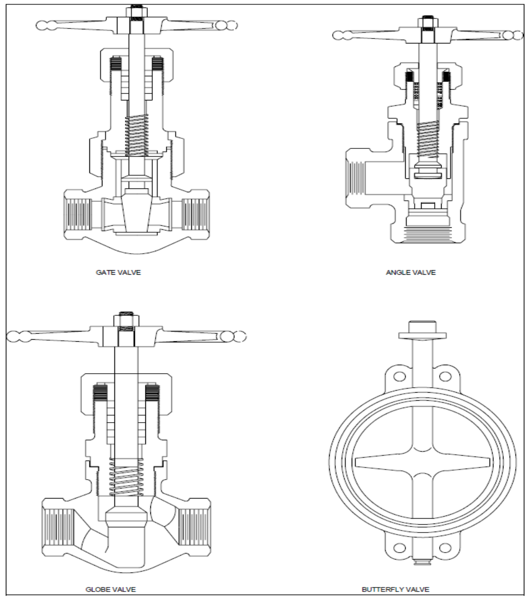



***Figure 7.1. Typical valves used in water service***

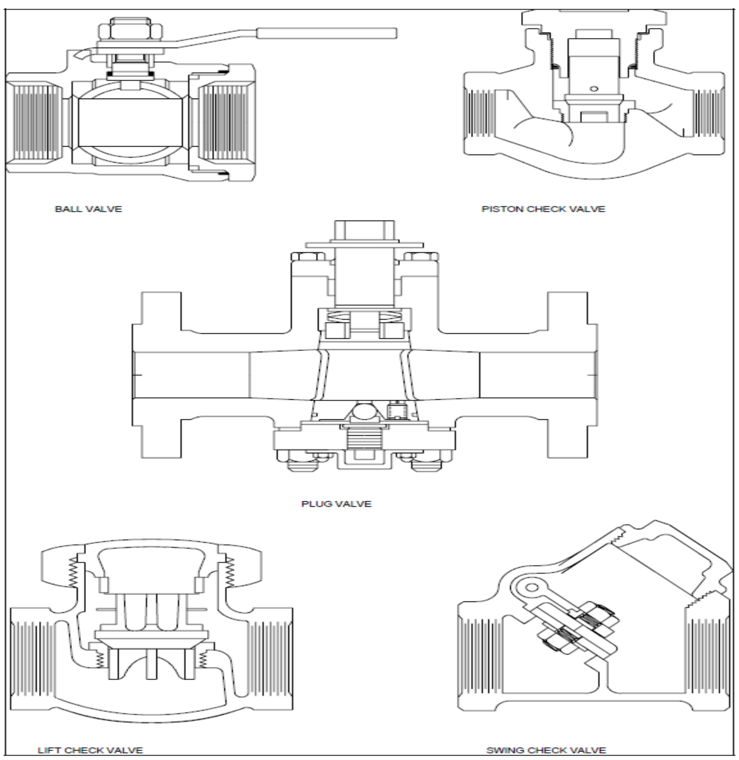



***Figure 7.2. Typical valves used in water service***

**Water piping design:**

There is a friction loss in pipe through which water is flowing.
These losses depends the following factors:

1- Water velocity
2-Water length and diameter
3-Interior surface roughness

To properly design a water piping system, the engineer must evaluate not only the pipe friction loss but also through valves, fitting

**Water Velocity and Pressure Drop**

The velocity should not exceed 2.4 (m/s) in order to avoid noise and corrosion
The pressure drop should not exceed 500 (pa/L).
Corrosion results in an increase in the friction factor and a in the effective diameter.

**Design procedure:**

Using Darcy formula in Hardy-Cross method using Excel as follows:

$h_l = KQ^n$ Eqn (7.1)

Where:

n=2

$K = \frac{8*f*L}{g*\prod^2*D^5}$ Eqn (7.2)

$f = \frac{0.3086}{[\log(\frac{6.9}{Re}+\left(\frac{\frac{\epsilon}{d}}{3.7}\right)^{1.11})]^2}$ Eqn (7.3)

$Re = \frac{V*D}{v}$ Eqn (7.3)

$\frac{dh_l}{dQ} = n * K * |Q^{n-1}|$ Eqn (7.4)

$\Delta Q = \frac{-\sum h_l}{\sum dh_l/dQ}$ Eqn (7.5)

$\sum h_l = 0.0$ Eqn (7.6)

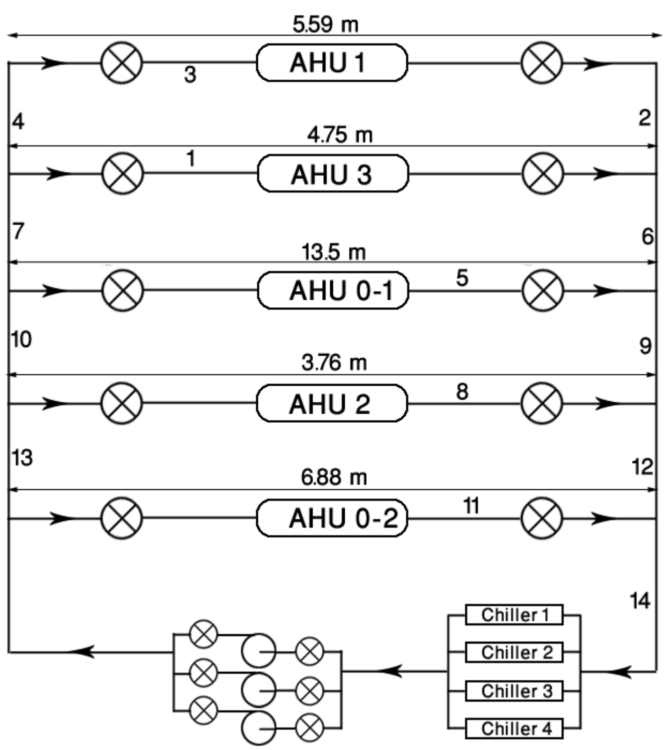



***Fig. (7.3) Simple diagram of water system***

Assume $H_p$ and iterate Gives the solution as following:

**Table (7.1): Standard Diameter of Pipes:**

| pipe | Qw (m3/s) | d (m) | d (in) | standard d (in) | nominal size | d (m) | v (m/s) |
|---|---|---|---|---|---|---|---|
| 1 | 0.005602 | 0.054531 | 2.146902 | 2.469 | 2.5 | 0.062713 | 1.814652 |
| 2 | 0.008109 | 0.126587 | 4.983753 | 5.047 | 5 | 0.128194 | 0.628602 |
| 3 | 0.008109 | 0.065607 | 2.582947 | 3.068 | 3 | 0.077927 | 1.701107 |
| 4 | 0.008109 | 0.126587 | 4.983753 | 5.047 | 5 | 0.128194 | 0.628602 |
| 5 | 0.003814 | 0.044991 | 1.771306 | 2.067 | 2 | 0.052502 | 1.762454 |
| 6 | 0.013712 | 0.126587 | 4.983753 | 5.047 | 5 | 0.128194 | 1.062881 |
| 7 | 0.013712 | 0.126587 | 4.983753 | 5.047 | 5 | 0.128194 | 1.062881 |
| 8 | 0.005151 | 0.052287 | 2.058541 | 2.067 | 2 | 0.052502 | 2.380397 |
| 9 | 0.017525 | 0.126587 | 4.983753 | 5.047 | 5 | 0.128194 | 1.3585 |
| 10 | 0.017525 | 0.126587 | 4.983753 | 5.047 | 5 | 0.128194 | 1.3585 |
| 11 | 0.007514 | 0.063153 | 2.486336 | 3.068 | 3 | 0.077927 | 1.576232 |
| 12 | 0.022676 | 0.126587 | 4.983753 | 5.047 | 5 | 0.128194 | 1.757767 |
| 13 | 0.022676 | 0.126587 | 4.983753 | 5.047 | 5 | 0.128194 | 1.757767 |
| 14 | 0.03019 | 0.126587 | 4.983753 | 5.047 | 5 | 0.128194 | 2.340225 |

**Table (7.2): Elements Loss Coefficient:**

| element | C |
|---|---|
| $90_o$ elbow | 0.75 |
| Tee main | 0.4 |
| Tee branch | 1 |
| gate valve open | 0.17 |
| globe valve | 6.4 |
| coupling | 0.04 |
| flex connection | 0.05 |

ε= 4.5E-5 mm

v = 1E-6 $m^2/s$

Hpump = 10 m *"Initial guess"*

Hpump-actual = 7.7 m

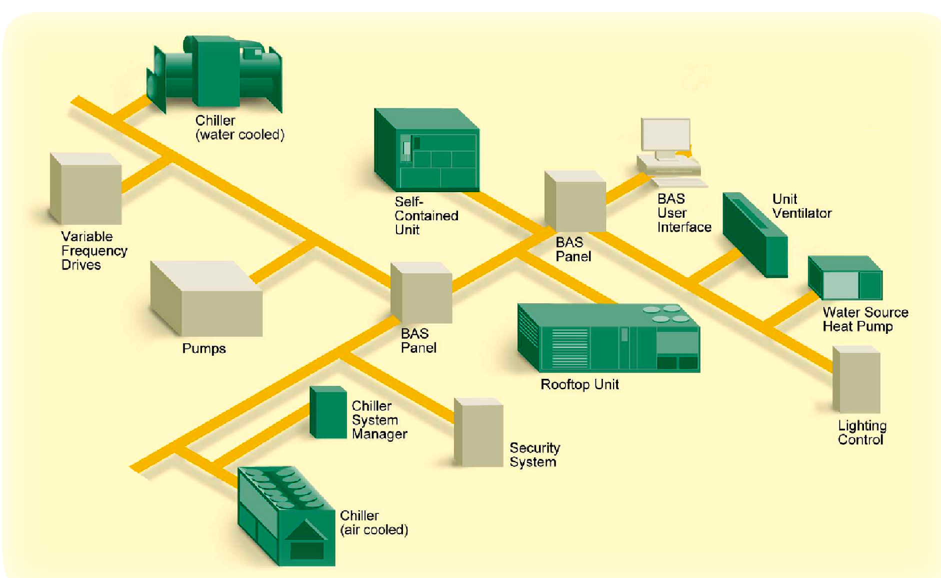
Pump Power = γ*Q*H/η = **2.28 KW**
= **3 hp**

| loop | pipe | common | D | L | Qo | V | E/D | Re | F | K | hlf | hld | hlp | dhlf/dQ | dhld/dQ | dQ | Qnew |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 0.0627 | 4.75 | 0.0056 | 1.8147 | 0.0007 | 113802 | 0.0207 | 8365.9 | 0.2626 | 0.6504 | | 93.738 | 232.2 | 9E-05 | 0.0053 |
| | 2 | | 0.1282 | 3 | -0.0081 | 0.6286 | 0.0004 | 80583 | 0.0201 | 143.84 | -0.0095 | -0.0128 | | 2.3329 | 3.1587 | | -0.008 |
| | 3 | | 0.0779 | 3.59 | -0.0081 | 1.7011 | 0.0006 | 132562 | 0.0198 | 2041.1 | -0.1342 | -0.7766 | | 33.104 | 191.53 | | -0.008 |
| | 4 | | 0.1282 | 4 | -0.0081 | 0.6286 | 0.0004 | 80583 | 0.0201 | 191.79 | -0.0126 | -0.0196 | | 3.1105 | 4.8434 | | -0.008 |
| | sum | | | | | | | | | | -0.052307035 | | | 564.0212396 | | | |
| 2 | 1 | 1 | 0.0627 | 4.75 | -0.0056 | 1.8139 | 0.0007 | 113753 | 0.0207 | 8366.3 | -0.2624 | -0.6499 | | 93.702 | 232.1 | 0.0004 | -0.0053 |
| | 5 | 3 | 0.0779 | 13.5 | 0.00381 | 0.8 | 0.0006 | 62341 | 0.0217 | 8440.7 | 0.1228 | 0.6067 | | 64.379 | 318.17 | | 0.0052 |
| | 6 | | 0.1282 | 5 | -0.01371 | 1.0629 | 0.0004 | 136255 | 0.0186 | 222.41 | -0.0418 | 0 | | 6.0992 | 0 | | -0.0133 |
| | 7 | | 0.1282 | 4.15 | -0.01371 | 1.0629 | 0.0004 | 136255 | 0.0186 | 184.6 | -0.0347 | -0.0195 | | 5.0624 | 2.8485 | | -0.0133 |
| | sum | | | | | | | | | | -0.278856505 | | | 722.366889 | | | |
| 3 | 5 | 2 | 0.0779 | 13.5 | -0.0038 | 0.7992 | 0.0006 | 62283 | 0.0217 | 8441.9 | -0.1225 | -0.6055 | | 64.327 | 317.87 | -0.001 | -0.0051 |
| | 8 | 4 | 0.0525 | 3.76 | 0.00515 | 2.3804 | 0.0009 | 124975 | 0.021 | 16390 | 0.4348 | 1.474 | | 168.84 | 572.36 | | 0.0026 |
| | 9 | | 0.1282 | 2.2 | -0.01753 | 1.3585 | 0.0004 | 174151 | 0.0181 | 95.021 | -0.0292 | 0 | | 3.3305 | 0 | | -0.0185 |
| | 10 | | 0.1282 | 3 | -0.01753 | 1.3585 | 0.0004 | 174151 | 0.0181 | 129.57 | -0.0398 | -0.0319 | | 4.5416 | 3.6408 | | -0.0185 |
| | sum | | | | | | | | | | 1.079871776 | | | 1134.90751 | | | |
| 4 | 8 | 3 | 0.0525 | 3.76 | -0.0052 | 2.3801 | 0.0009 | 124958 | 0.021 | 16390 | -0.4347 | -1.4736 | | 168.82 | 572.28 | 0.0016 | -0.0026 |
| | 11 | 5 | 0.0779 | 5.4 | 0.00751 | 1.5762 | 0.0006 | 122831 | 0.0199 | 3094.8 | 0.1747 | 0.6668 | | 46.509 | 177.47 | | 0.0169 |
| | 12 | | 0.1282 | 6.8 | -0.02268 | 1.7578 | 0.0004 | 225335 | 0.0176 | 285.84 | -0.147 | -0.1001 | | 12.963 | 8.8328 | | -0.0211 |
| | 13 | | 0.1282 | 6.881 | -0.02268 | 1.7578 | 0.0004 | 225335 | 0.0176 | 289.25 | -0.1487 | -0.1536 | | 13.118 | 13.544 | | -0.0211 |
| | sum | | | | | | | | | | -1.61624341 | | | 1013.533594 | | | |
| 5 | 14 | | 0.1282 | 69 | -0.0302 | 2.3402 | 0.0004 | 300004 | 0.0171 | 2826.7 | -2.5764 | -2.3215 | 10 | 170.68 | 153.79 | -0.0078 | -0.038 |
| | 11 | 4 | 0.0779 | 5.4 | -0.0075 | 1.5754 | 0.0006 | 122767 | 0.0199 | 3095 | -0.1746 | -0.6661 | | 46.487 | 177.38 | | -0.0169 |
| | sum | | | | | | | | | | 4.261495107 | | | 548.3366812 | | | |

| loop | pipe | common | D | L | Qo | V | E/D | Re | F | K | hlf | hld | hlp | dhlf/dQ | dhld/dQ | dQ | Qnew |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 0.06271 | 4.75 | 0.00579 | 1.87384 | 0.00072 | 117513 | 0.02059 | 8339.38 | 0.2791 | 0.69357 | | 96.4886 | 239.776 | 0.00000 | 0.00579 |
| | 2 | | 0.12819 | 3 | -0.0081 | 0.6311 | 0.00035 | 80903.7 | 0.02006 | 143.753 | -0.0095 | -0.0129 | | 2.34073 | 3.17132 | | -0.0081 |
| | 3 | | 0.07793 | 3.59 | -0.0081 | 1.70788 | 0.00058 | 133090 | 0.01975 | 2040.27 | -0.1352 | -0.7828 | | 33.2218 | 192.295 | | -0.0081 |
| | 4 | | 0.12819 | 4 | -0.0081 | 0.6311 | 0.00035 | 80903.7 | 0.02006 | 191.67 | -0.0127 | -0.0198 | | 3.12097 | 4.86269 | | -0.0081 |
| | sum | | | | | | | | | | -0.000294894 | | | 575.2766667 | | | |
| 2 | 1 | 1 | 0.06271 | 4.75 | -0.0058 | 1.87307 | 0.00072 | 117465 | 0.02059 | 8339.71 | -0.2789 | -0.693 | | 96.4528 | 239.677 | 0.00000 | -0.0058 |
| | 5 | 3 | 0.07793 | 13.5 | 0.004633 | 0.97195 | 0.00058 | 75741.5 | 0.02112 | 8207.87 | 0.1762 | 0.89553 | | 76.0595 | 386.562 | | 0.00463 |
| | 6 | | 0.12819 | 5 | -0.01393 | 1.07955 | 0.00035 | 138391 | 0.01858 | 221.973 | -0.0431 | 0 | | 6.18268 | 0 | | -0.0139 |
| | 7 | | 0.12819 | 4.15 | -0.01393 | 1.07955 | 0.00035 | 138391 | 0.01858 | 184.238 | -0.0357 | -0.0201 | | 5.13162 | 2.89321 | | -0.0139 |
| | sum | | | | | | | | | | 0.000931161 | | | 812.9591895 | | | |
| 3 | 5 | 2 | 0.07793 | 13.5 | -0.0046 | 0.9712 | 0.00058 | 75682.6 | 0.02113 | 8208.75 | -0.1759 | -0.8941 | | 76.0085 | 386.261 | 0.00000 | -0.0046 |
| | 8 | 4 | 0.0525 | 3.76 | 0.004043 | 1.86825 | 0.00086 | 98086.5 | 0.0215 | 16759.1 | 0.27388 | 0.90798 | | 135.498 | 449.213 | | 0.00404 |
| | 9 | | 0.12819 | 2.2 | -0.01856 | 1.43871 | 0.00035 | 184434 | 0.01796 | 94.4177 | -0.0325 | 0 | | 3.50478 | 0 | | -0.0186 |
| | 10 | | 0.12819 | 3 | -0.01856 | 1.43871 | 0.00035 | 184434 | 0.01796 | 128.751 | -0.0444 | -0.0358 | | 4.77924 | 3.85577 | | -0.0186 |
| | sum | | | | | | | | | | -0.000890625 | | | 1059.120697 | | | |
| 4 | 8 | 3 | 0.0525 | 3.76 | -0.004 | 1.86792 | 0.00086 | 98069.2 | 0.0215 | 16759.4 | -0.2738 | -0.9077 | | 135.477 | 449.133 | 0.00000 | -0.004 |
| | 11 | 5 | 0.07793 | 5.4 | 0.010808 | 2.26714 | 0.00058 | 176672 | 0.01923 | 2988.3 | 0.34904 | 1.37938 | | 64.5922 | 255.263 | | 0.01081 |
| | 12 | | 0.12819 | 6.8 | -0.0226 | 1.75207 | 0.00035 | 224605 | 0.0176 | 285.932 | -0.1461 | -0.0995 | | 12.9256 | 8.80423 | | -0.0226 |
| | 13 | | 0.12819 | 6.881 | -0.0226 | 1.75207 | 0.00035 | 224605 | 0.0176 | 289.338 | -0.1478 | -0.1526 | | 13.0795 | 13.4998 | | -0.0226 |
| | sum | | | | | | | | | | 0.0010253 | | | 952.774734 | | | |
| 5 | 14 | | 0.12819 | 69 | -0.0334 | 2.58985 | 0.00035 | 332003 | 0.01701 | 2803.98 | -3.1299 | -2.8432 | 7.7 | 187.363 | 170.199 | 0.00000 | -0.0334 |
| | 11 | 4 | 0.07793 | 5.4 | -0.0108 | 2.26631 | 0.00058 | 176607 | 0.01923 | 2988.39 | -0.3488 | -1.3784 | | 64.5707 | 255.17 | | -0.0108 |
| | sum | | | | | | | | | | -0.000264068 | | | 677.3023559 | | | |

Chapter Eight

# Operation Control By Building Management System (BMS)



## 8.1 Introduction

The objective of a BMS is to centralize and simplify the monitoring, operation, and management of buildings. This is done to achieve more efficient building operation at reduced labor and energy costs and provide a safe and more comfortable working environment for building occupants. In the process of meeting these objectives, the BMS has evolved from simple supervisory control to totally integrated computerized control.
Some of the advantages of a BMS are as follows:

- Simpler operation with routine and repetitive functions programmed for automatic operation
- Reduced operator training time through on-screen instructions and supporting graphic displays
- Faster and better responsiveness to occupant needs and trouble conditions
- Reduced energy cost through centralized management of control and energy management programs
- Better management of the facility through historical records, maintenance management programs, and automatic alarm reporting
- Flexibility of programming for facility needs, size, organization, and expansion requirements
- Improved operating-cost record keeping for allocating to cost centers and/or charging individual occupants
- Improved operation through software and hardware integration of multiple subsystems such as direct digital control (DDC), fire alarm, security, access control, or lighting control

## 8.2 Definitions

- **Building Control System (BCS):** A system that controls the comfort and safety of a buildings assets and environment.
- **Building Management System (BMS):** A system which centralizes the monitoring, operations, and management of a building to achieve more efficient operations.
- **Building Management and Control System (BMCS):** An integrated BMS and BCS
- **Building Automation and Control Network (BACnet) Protocol:** A BMCS communications protocol developed by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).
- **Dynamic Display Data:** Data displayed on a BMCS work station which periodically updates, such as temperature or ON/OFF status. The data updates automatically at a rate appropriate for the point or it may be updated manually.

- **Energy Management System (EMS):** A system that optimizes the operation, temperatures, and processes of an HVAC system within a building. Except for some early versions, a BCS or BMCS includes all EMS functions.

- **Hierarchical configuration:** A system in which the processors and controllers are arranged in levels or tiers, with each tier having a definite rank or order in accessing and processing data. A typical arrangement includes, in descending order, management-level processors, operations-level processors, system-level controllers, and zone-level controllers.

- **Management-level processor:** A PC or minicomputer used by management personnel to collect, store, and process data for reports on energy use, operating costs, and alarm activity. This processor can access points or data in all the lower level processors and controllers. (In most cases a separate, management-level processor is not used. Many of the functions of the management- level processor can be combined into the operations-level processor.)

- **Operations-level processor:** A PC or other device used primarily by building operation personnel for everyday building operations. This processor can access points or data in all the lower level controllers.

- **System-level controller:** A microprocessor-based controller that controls centrally located HVAC equipment such as VAV supply units, built-up air handlers, and central chiller and boiler plants. These controllers typically have an input/output (I/O) device capability, a library of control programs, and may control more than one mechanical system from a single controller. In a BMS, these controllers provide processing of point data for higher level processors and typically include energy management programs.

## 8.3 System configuration

A BMS includes the hardware configuration and communication systems needed to access data throughout a building or from remote buildings using leased telephone lines.

## 8.4 Hardware configuration

Microprocessor-based controllers have led to a hierarchical configuration in the BMS. Figure 8.1 shows several levels, or tiers, of processors.

- Management-level processors
- Operations-level processors
- System-level controllers
- Zone-level controllers

The actual levels used in a given system depend on the specific needs of the building or complex of buildings.

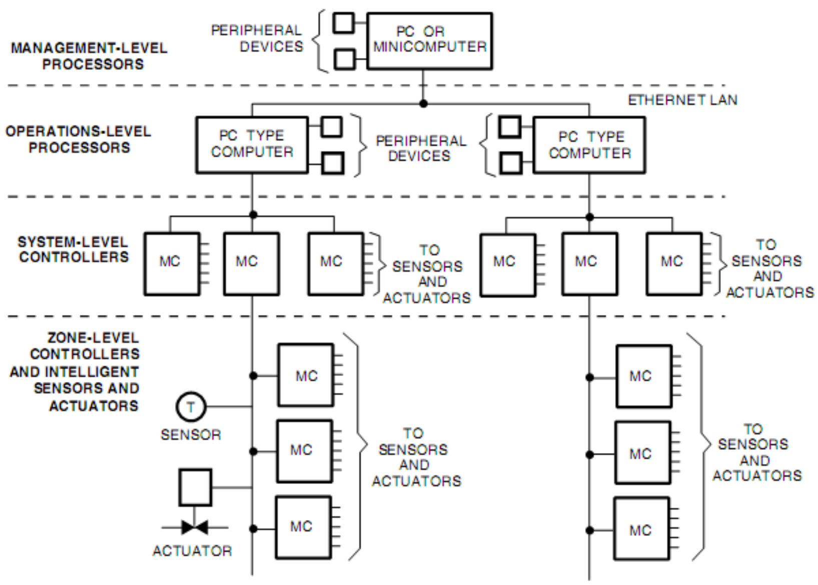



Fig.8.1 Hierarchical BMS Configuration

### 8.4.1 Zone-level controllers

Zone-level controllers are microprocessor-based controllers that provide direct digital control of zone-level equipment, including items such as VAV boxes, heat pumps, single-zone air handlers, and perimeter radiation. At the zone level, sensors and actuators interface directly with the controlled equipment. A communications bus provides networking of zone-level controllers so that point information can be shared between zone-level controllers and with processors at the system and operation level. Zone-level controllers typically have a port or communications channel for use of a portable terminal during initial setup and subsequent adjustments.

### 8.4.2 System-level controllers

Microprocessor-based system-level controllers have greater capacity than zone-level controllers in terms of number of points, DDC loops, and control programs. System-level controllers are usually applied to major pieces of mechanical equipment such as large built-up air handlers, central VAV systems, and central chiller plants. These controllers can also perform lighting control functions. Controllers at this level interface with controlled equipment directly through sensors and actuators or indirectly through communications links with zone-level controllers. System-level controllers typically have a port for connecting portable operating and programming terminals during initial setup and subsequent adjustments.

### 8.4.3 Operations-level processors

Operations-level processors interface primarily with BMCS operating personnel. The processor at this level is in most cases a PC with color operator terminal displays and plug-in function boards to accommodate additional operator terminals, printers, memory expansion, and communications links. An operations-level processor generally includes application software for:

- **System security:** Limits access and operation to authorized personnel.
- **System penetration:** Permits authorized personnel to select and retrieve system data via PC keyboard or other selection mechanism.
- **Data formatting:** Assembles random system points into logical group format for display and printout.
- **Graphics:** Builds custom graphic displays incorporating dynamic system data. Bar chart and curve plot software may be included.

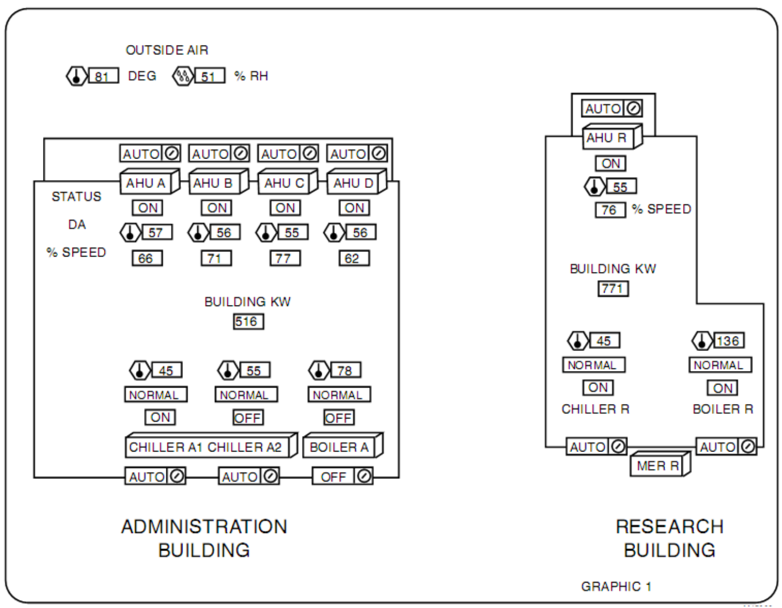



Fig.8.2 Top Level Graphic Display of a Two Building Facility.

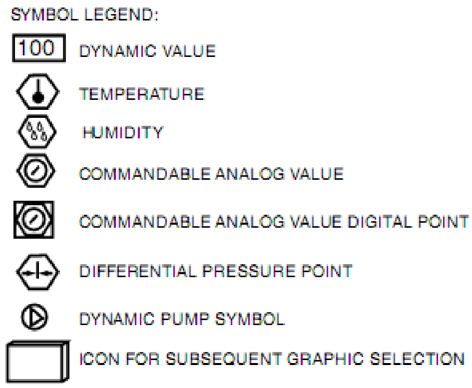
- **Standard reports:** Provides automatic, scheduled, and by-request reports of alarm and operator activity. Also provides a broad range of system and category (points- in alarm, disabled points, etc.) summary reports.
- **Custom reports:** Provides spread sheet, word processing, and a data base management capability.
- **Maintenance management:** Automatically schedules and generates work orders for equipment maintenance based either on history of equipment run time or on a calendar schedule.

### 8.4.4 Management-level processors

Management-level processors, at the top of the BMCS system hierarchy, exercise control and management over the connected subsystems. An operator at this level can request data from and issue commands to points anywhere in the system (as with most operations-level processors). Day-to-day operation is normally a function of the operations-level processor; however, complete control can be transferred to the management-level processor during emergencies or unattended periods. The management-level processor primarily collects, stores, and processes historical data such as energy use, operating costs.

## Operation

Operator access to the system is usually positioning the cursor (via a mouse) on a graphic display of a system.



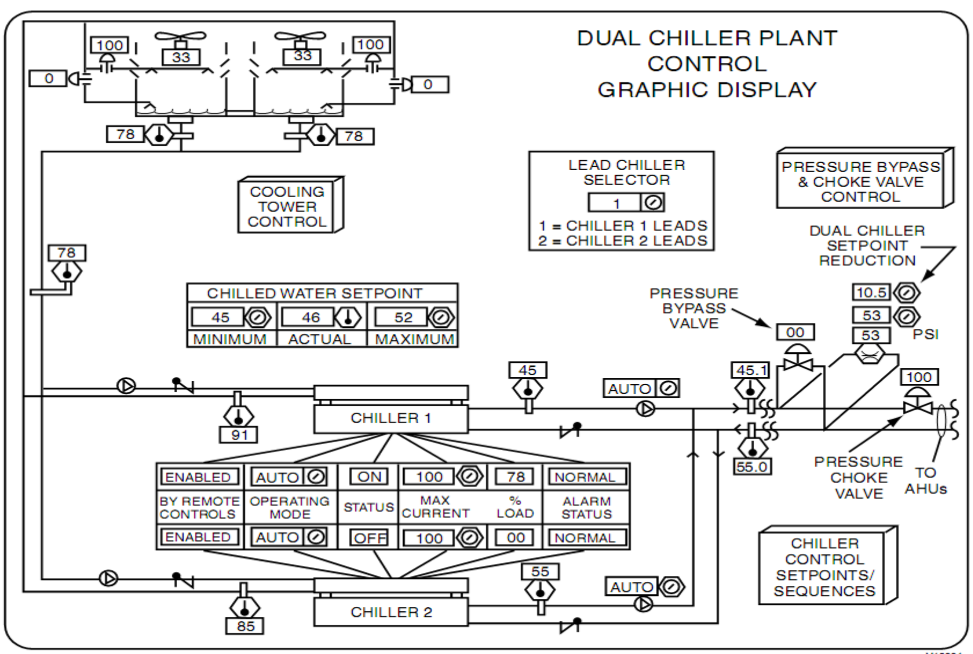




Fig.8.3 Graphic sketch for Sequence of Operation

# 8.5 Air handling system control applications

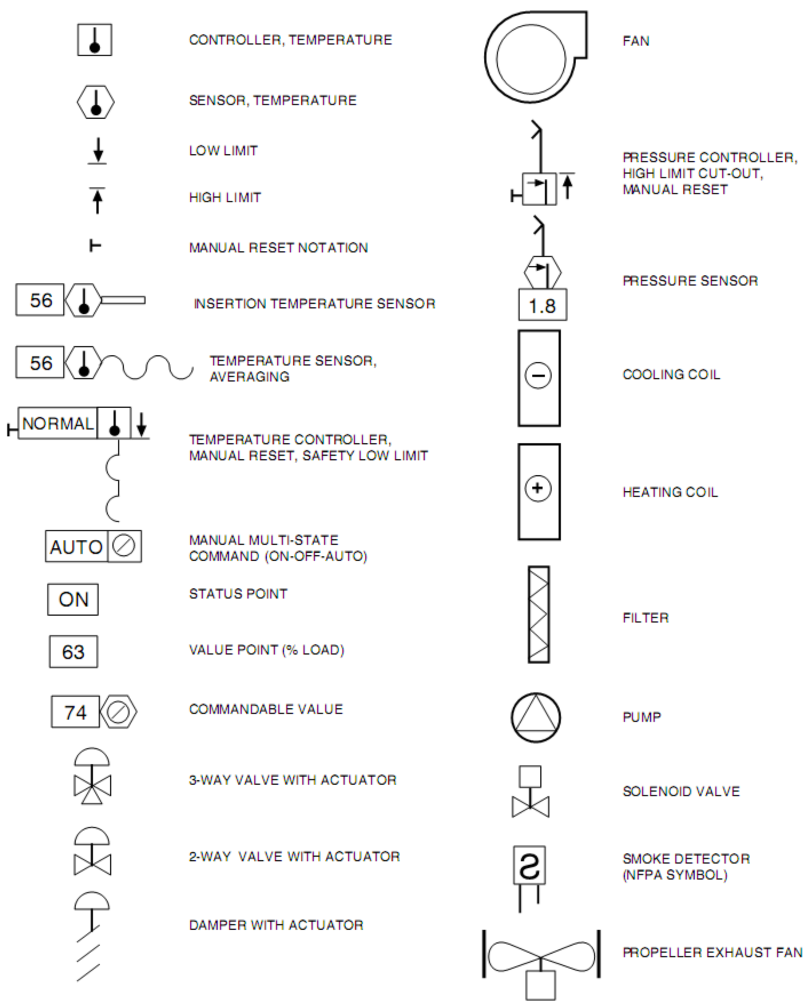
### Introduction

This section describes control applications for air handling systems commonly found in commercial buildings. The basic processes such as heating, cooling, humidification, dehumidification, and ventilation are presented individually then combined into typical air handling systems.

### Abbreviations:

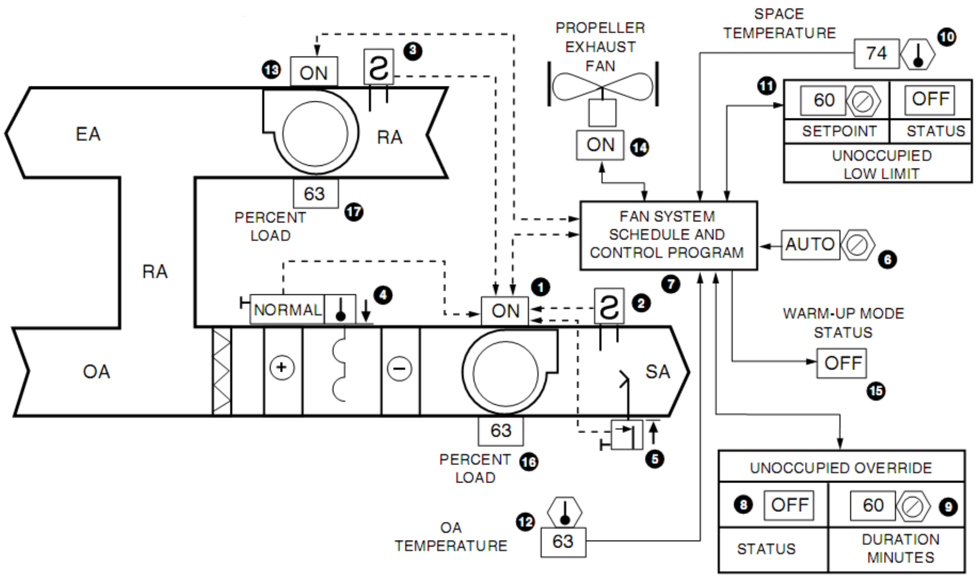
| | |
|---|---|
| AHU | —Air Handling Unit |
| BCMS | —Building Control Management System |
| CFM | —Cubic feet per minute |
| DB | —Dry Bulb |
| DDC | —Direct Digital Control |
| DP | —Dew Point |
| EA | —Exhaust Air |
| EPID | —Enhanced PID |
| F | —Fahrenheit |
| IAQ | —Indoor Air Quality |
| MA | —Mixed Air |
| MAT | —Mixed Air Temperature |
| WB | —Wet Bulb |
| N.C | —Normally Closed |
| N.O | — Normally Open |
| OA | —Outdoor Air |
| OAT | —Outdoor Air Temperature |
| P | —Proportional |
| PI | —Proportional-Integral |
| PID | —Proportional-Integral-Derivative |
| RA | —Return Air |
| RAT | —Return Air Temperature |
| RH | —Relative Humidity |
| SA | —Supply Air |
| VAV | —Variable Air Volume |

### Symbols:



## 8.5.1 Ventilation control processes

### Fan system start-stop control

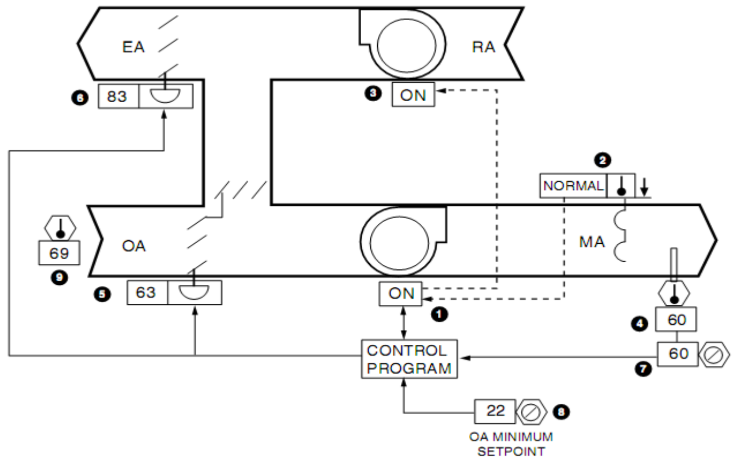



| Item | No. Function |
|---|---|
| 1 | Supply fan starts and enables return fan start and system controls. |
| 2 | SA smoke detector stops supply fan when smoke detected. |
| 3 | RA smoke detector stops supply fan when smoke detected. |
| 4 | Controller stops fan when low temperature detected. |
| 5 | SA high static pressure control stops fan when unsafe pressure exists. |
| 6 | Automatic fan system control subject to commendable ON-OFF-AUTO software point. |
| 7 | Control program turns supply, return, and exhaust fan on and off dependent upon optimized time schedule, unoccupied space temperatures, and occupant override requests. |
| 8 | Occupant override switch provides after hours operation when pressed. |
| 9 | Duration of operation for override request. |
| 10 | Space temperature (perimeter zone) inputs to optimum start-stop, unoccupied purge, and low limit programs. |
| 11 | Set point at which unoccupied low-limit program executes. |
| 12 | OA temperature input to optimum start-stop program. |
| 13 | Return fan operation enables exhaust fan control program. |
| 14 | Exhaust fan status (operator information). |
| 15 | Warm-up mode status (operator information). |
| 16 | Supply fan load (VAV type systems-operator information). |
| 17 | Return fan load (VAV type systems-operator information). |

**Features**

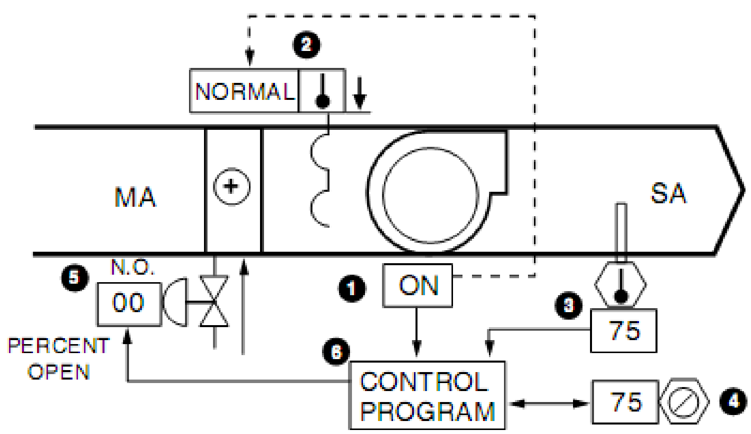
1. Smoke, low temperature and high static pressure safety shutdown (hard-wired).
2. optimized start-stop control of supply, return and exhaust fans.
3. Proof of operation interlocking and alarming on supply and return fans.
4. Software on-off-auto system command.
5. Zero ventilation/exhaust during preoccupancy operational periods.
6. May be modified for night purge and prepurge operation.
7. After-hours operation function; duration is operator adjustable.
8. Positions valves and dampers properly during off modes.
9. Night low temperature operation.

## 8.5.2 Mixed air control




| Item No. | Function |
|---|---|
| 1-3 | Control system energizes when fan is turned on (See FAN SYSTEM START-STOP CONTROL). |
| 4 | MA temperature maintained by modulating mixing dampers. |
| 5, 6 | OA and EA dampers close and RA damper opens when fan is off, and modulate for temperature control when fan is on. |
| 7 | Set point for MA temperature control. |
| 8 | Damper control and set point for minimum ventilation damper position. |
| 9 | OA temperature, operator information. |

## 8.5.3 Heating control processes

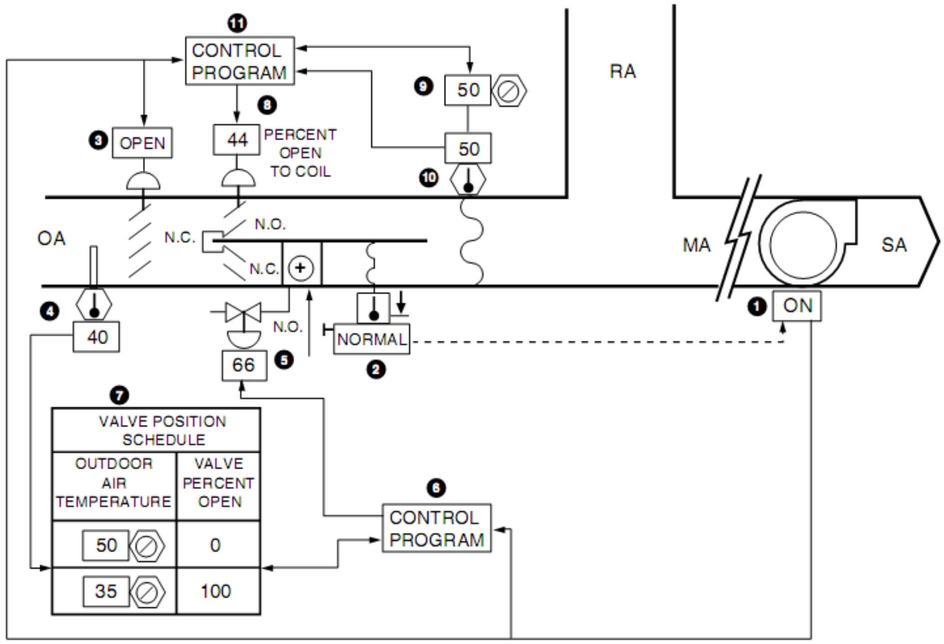



| Item No. | Function |
|---|---|
| 1-2 | Control system energizes when fan is turned on (See FAN SYSTEM START-STOP CONTROL). |
| 3,5 | SA temperature maintained by modulating the hot water valve. |
| 4 | Set point for SA temperature control. |
| 6 | Control program coordinates temperature control and fan interlock. |

**Features**

1. Air is discharged at a minimum temperature.
2. Valve opens upon loss of motive force (electricity or compressed air) and closes upon fan shutdown.

## 8.5.4 Preheat control processes
### 'with face and bypass dampers'



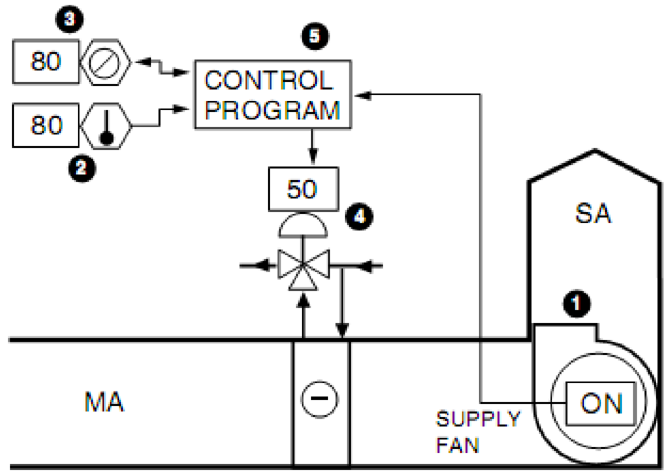

| **Item No.** | **Function** |
|---|---|
| 1-2 | Control system energizes when fan is turned on (See FAN SYSTEM START STOP CONTROL). |
| 3 | OA damper opens on fan startup, closes upon fan shutdown (in some cases the OA damper may be part of a mixed air system). |
| 4 | OA temperature determines valve position. |
| 5 | Valve controls heating medium flow to coil. |
| 6 | Control program coordinates fan interlock and valve control. |
| 7 | Valve position determined by OA temperature. |
| 8-10 | Face-and-bypass dampers controlled to maintain face-and-bypass leaving air temperature set point. |
| 11 | Control program coordinates fan interlock and face-and-bypass damper control. |

**Features**

1. Preheat coil conditions large quantities of low temperature OA before it enters the system.
2. Bypass damper controls temperature of air leaving the face-and-bypass section without endangering the preheat coil which operates in full valve open mode during freezing conditions.
3. Upon fan shutdown, valve controls at 100°F leaving air temperature in freezing weather and positions closed upon fan shutdown in non-freezing weather.

### 8.5.5 Cooling control processes

**Control of chilled water coil three-way valve**




| Item No. | Function |
|---|---|
| 1 | Control system energizes when fan is turned on (See FAN SYSTEM START-STOP CONTROL). |
| 2, 3 | Space temperature PID control loop modulates the three-way valve to maintain space temperature set point. |
| 4 | Chilled water valve directs flow through or around coil as needed to furnish proper amount of cooling. |
| 5 | Control program coordinates temperature control and fan status. |

**Features**

1. Chilled water is supplied to the coil at a constant temperature and varying volume.
2. A reasonably constant flow is maintained through the entire piping system.

## 8.6 Building Airflow System Control Applications

### 8.6.1 Introduction

There are several types of airflow control that relate directly to the control of airflow in a central air handling system. These types of airflow control include space pressurization, zone pressurization, and exhaust air control. Space or zone pressurization is used when an enclosed area within a building (e.g., a clean room, hospital space, laboratory, fire and smoke control area) must be kept at a positive or negative pressure so contaminated air does not migrate to unwanted areas. Basic types of space pressure control are static pressure, airflow tracking, and constant airflow. Exhaust air control regulates the amount of air exhausted to keep it at the minimum safe level. Space pressure control is generally required with exhaust air control, and control of airflow in a central air handling system is generally required with space pressure control and/or exhaust air control.

## 8.6.2 Definitions

**Constant Air Volume (CAV) system:**
A central fan system in which airflow in the duct is maintained at a constant volume.

**Differential:**
The difference between supply and return airflows necessary to maintain a positive or a negative pressure in an area.

**Variable Air Volume (VAV) system:**
A central fan system in which airflow in the duct varies depending on the instantaneous load requirements of the connected VAV terminal units.

## 8.6.3 Air flow control applications

### 8.6.3.1 Supply fan control for VAV systems

The supply fan control system provides adequate duct static pressure to all air terminal units. This duct static pressure at the air terminal unit is used to overcome pressure drops between the air terminal unit inlet and the controlled space. Inadequate static limits maximum airflow to less than required, while excessive duct static increases sound levels and wastes energy. The location of the duct static pressure sensor is critical for proper control of the supply fan.

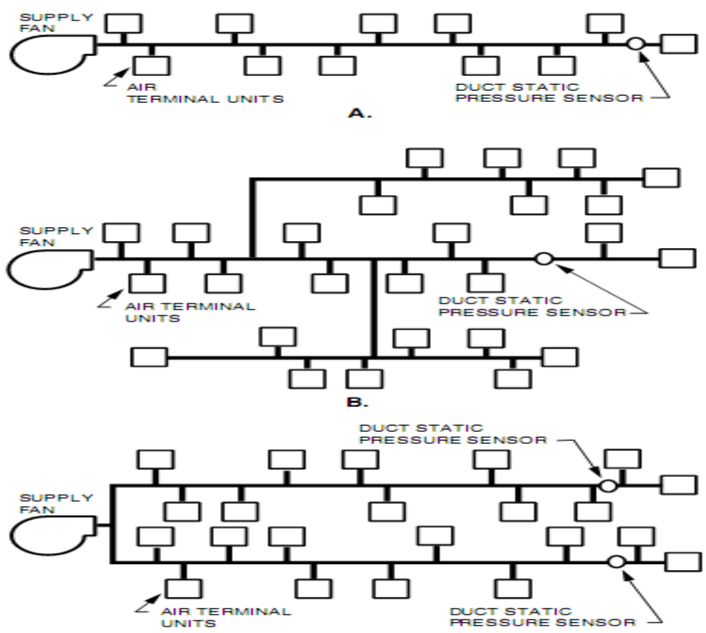



Fig 8.4: Locating Duct Static Pressure Sensor for Supply Fan Control.

If the supply duct is one simple run with short takeoffs to the air terminal units (Fig. 8.4-A), the duct static pressure sensor is located at the air terminal unit furthest from the supply fan. Typically, the supply duct is complex with multiple runs or branches. This duct layout requires a compromise in duct static pressure sensor location that is usually about 75 percent of the distance between the fan and the furthest air terminal unit (Fig. 8.4-B). In complex duct runs where multiple branches split close to the fan, sensors should be located in each end of the branch (Fig. 8.4-C). Each sensed point should have its own set point in the control loop. This avoids the assumption that branches and multi sensor locations have identical requirements. The sensed point having the lowest duct pressure relative to its own set point should control the supply fan.

### 8.6.3.2 Return fan control for VAV systems

There are four techniques to control the return fan: open loop, direct building static, airflow tracking, and duct static.

### 8.6.3.3 Open Loop Control

This type of control presumes a fixed relationship between the supply and return fans, controls the return fan in tandem with the supply fan, and changes the output of the return fan without measuring the result. Open loop control requires similar supply and return fan operating characteristics.

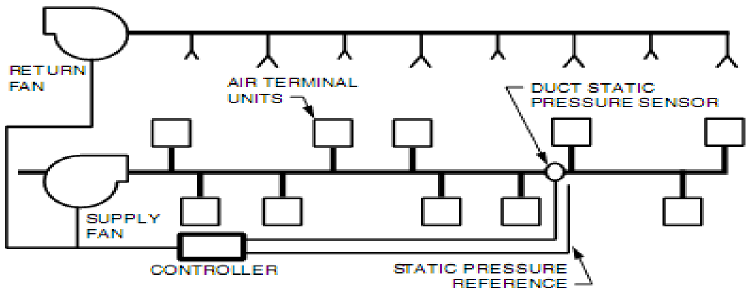



Fig.8.5 Open Loop Control

### 8.6.3.4 Direct Building Static Control

In direct building static control, the return fan responds directly to the building space static pressure referenced to the static pressure outside of the building (Fig.8.6). The location of the building space static pressure sensor should be away from doors opening to the outside, elevator lobbies, and some confined areas.

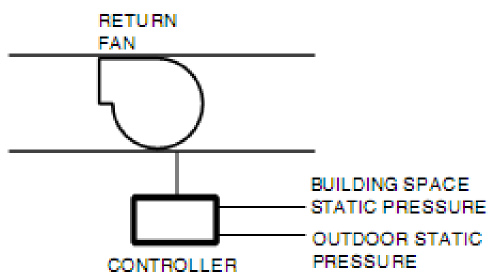



Fig.8.6 Direct Building Static Control

### 8.6.3.6 Duct Static Control

Individual space returns are damper controlled; return fan control must use this technique Duct static control is relatively simple, but individual space return controls make the entire system complex.

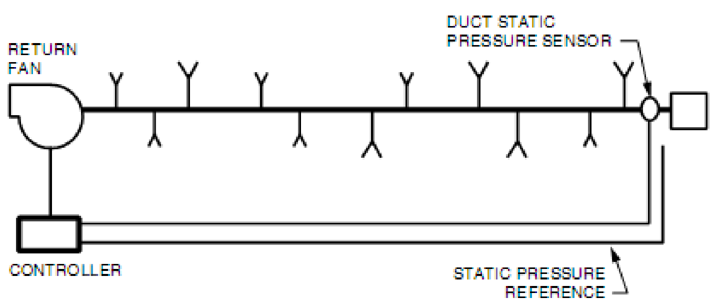



Fig.8.8. Duct Static Control

**8.6.3.7 Return damper control for VAV systems**

In systems having a return fan, when the mixed air control cycle is not operating, the outdoor air (or maximum outdoor air) and relief dampers are closed and the return damper remains fully open. When the mixed air control cycle is operating, the return damper modulates closed and outdoor air (or maximum outdoor air) and relief dampers modulate open. The return damper should be sized for twice the pressure drop of the outdoor air (or maximum outdoor air) and relief dampers.

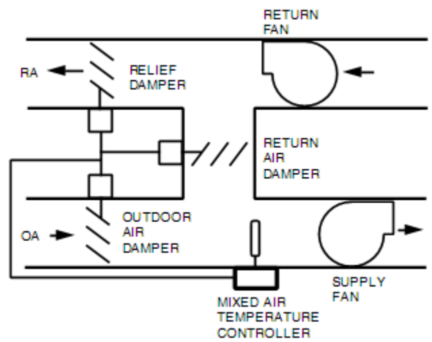



Fig.8.9. Return Air Damper Mixed Air Control Cycle.

# 8.7 Smoke Management Fundamentals

## 8.7.1 Introduction

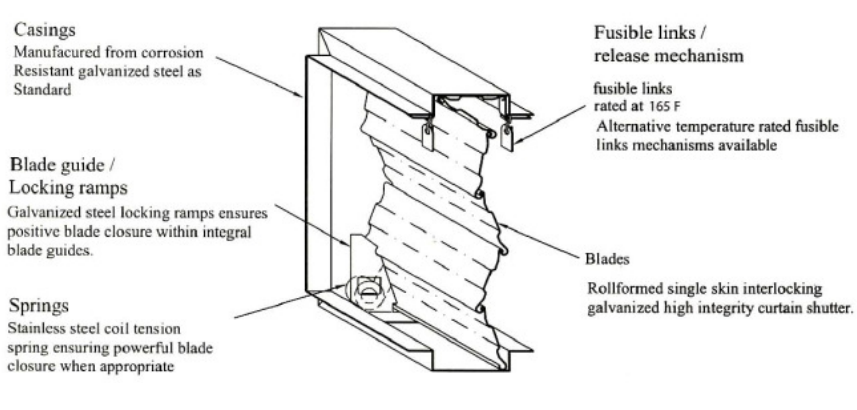
This section describes objectives, design considerations, design principles, control applications, and acceptance testing for smoke management systems. A smoke management system modifies the movement of smoke in ways to provide safety for the occupants of a building, aid firefighters, and reduce property damage. References are at the end of this section which include smoke control codes

Early smoke management systems used the concept of passive control to limit the spread of fire and smoke. This method evolved from early fire containment methods used in high rise buildings. With passive control, HVAC fans were shut down and dampers were used to prevent smoke from spreading through ductwork. This application required very-low-leakage dampers. Fire walls or barriers, used to prevent the spread of fire, were enhanced to prevent the spread of smoke.

## 8.7.2 Definitions

**Fire damper:**

A damper that meets the requirements of Standards for Fire Dampers, and resists the passage of air or fire.



**Smoke Control System:**
A system that modifies the movement of smoke in ways to provide safety for the occupants of a building, aid firefighters, and reduce property damage.

**Smoke Management System, Active:**
A system that uses fans to produce airflows and pressure differences across smoke barriers to limit and direct smoke movement.

**Smoke Management System, Passive:**
A system that shuts down fans and closes dampers to limit the spread of fire and smoke.

**Smoke Control Zone:**
An indoor space enclosed by smoke barriers, including the top and bottom, that is part of a zoned smoke control system

## 8.7.3 Design Principals

### 8.7.3.1 Cause of Smoke movement

The movement or flow of smoke in a building is caused by a combination of stack effect, buoyancy, expansion, wind velocity, and the HVAC system. See Figure 1. These items basically cause pressure differences resulting in movement of the air and smoke in a building.

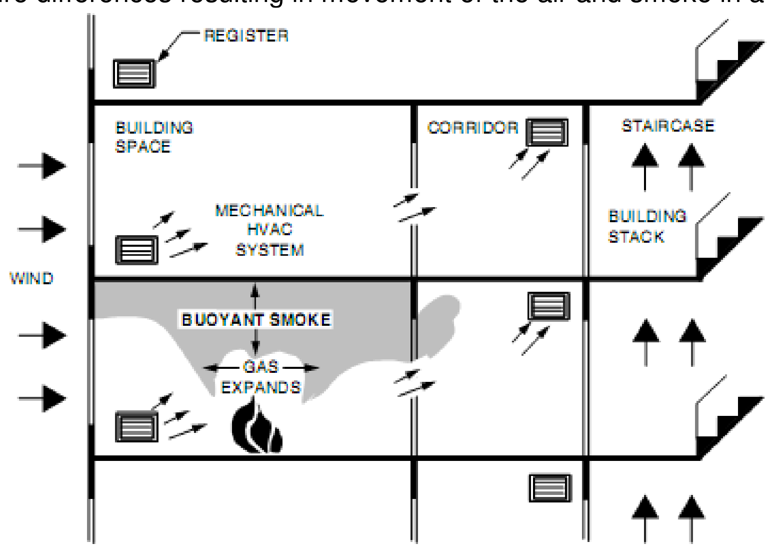



Fig.8.10. Factors Affecting the Movement of Smoke

Before controls can be applied, it is necessary to first understand the overall movement of smoke.

### 8.7.4 Control of smoke

Smoke control uses barriers within the building along with airflow produced by mechanical fans to contain the smoke. The control system results by using pressurization and airflow methods

### 8.7.4.1 Pressurization

Pressurization of nonsmoke areas can be used to contain smoke in a fire or smoke zone. Barriers are required between the nonsmoke areas and the area(s) containing the smoke and fire. For the barrier to perform correctly in a smoke control system, a static pressure difference is required across any penetrations or cracks to prevent the movement of smoke. Figure 8.11

illustrates such an arrangement with a door in a wall. The high pressure side can act as a refuge or an escape route, the low pressure side as a containment area. The high pressure prevents any of the smoke from infiltrating into the high pressure area.

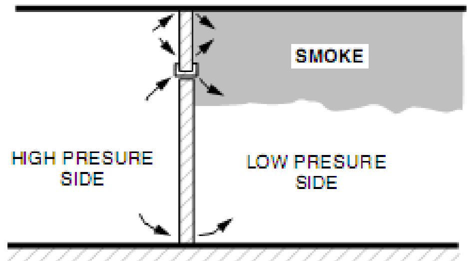



Fig.8.11. Pressurization Used to Prevent Smoke Infiltration

### 8.7.4.2 Airflow

Airflow is most commonly used to stop smoke movement through open doorways and corridors. Figure 4 illustrates a system with relatively high velocity to prevent backflow of smoke through an open doorway. Figure 8.12 illustrates a system with relatively low velocity which allows backflow of smoke. The magnitude of the velocity of the airflow required to prevent backflow depends on the energy release rate of the fire.

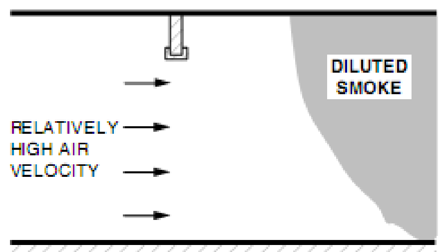



Fig.8.12. High Air Velocity Preventing Backflow of Smoke through an Open Doorway

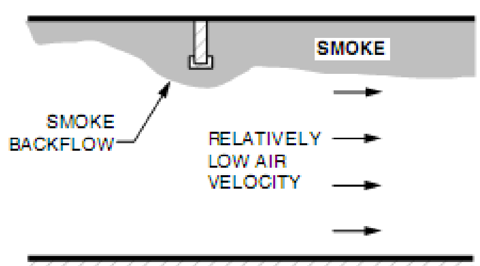



Fig.8.13. Low Air Velocity Allowing Backflow of Smoke through an Open Doorway

## 8.7.5 Control Application

Figure 8.14 illustrates a smoke control system with detectors, an initiating panel, and a communications bus to an alarm processor and remote control panels in appropriate areas of the building. A configuration similar to this will meet the requirements of UL 864, Standard for Control Units for Fire- Protective Signalling Systems, and comply with NFPA 92A recommended practice for smoke control systems. The remote control panels position dampers and operate fans to contain or

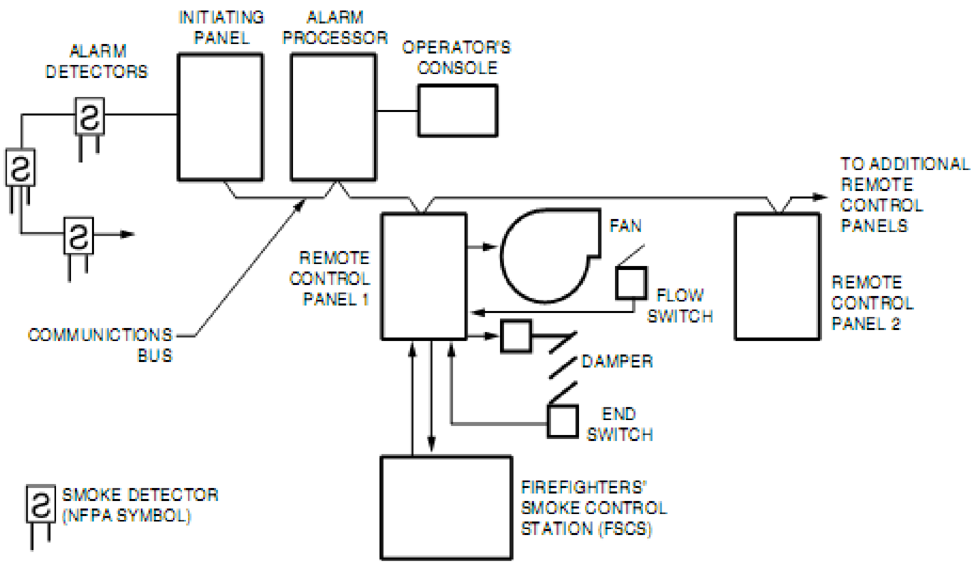



Fig.8.14. Typical Smoke Control System Meeting the Requirements of UL Standard 864 and NFPA92A

## 8.8 Individual Room Control Applications

### 8.8.1 Air Terminal Unit Control ATU

Air terminal units (ATUs) regulate the quantity and/or temperature of conditioned air delivered to satisfy the temperature
ATU controls can be as basic as a room sensor controlling a damper or as complex as a room sensor and an airflow sensor operating a damper and a reheat coil valve.re requirements of a room or space.

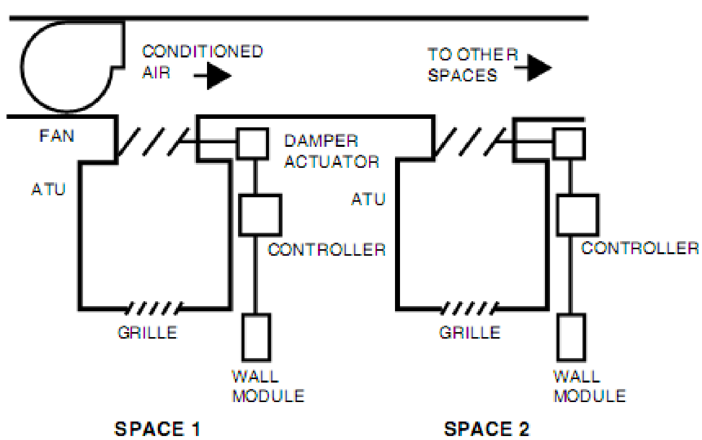



Fig.8.15. Basic Individual Room Control

### Variable Air Volume ATU

A variable air volume (VAV) ATU controls the cooling of a space by varying the amount of conditioned air supplied rather than changing the temperature of the conditioned air. Most VAV systems provide energy savings by reducing the load on the central fan when cooling loads are less than design and avoid reheating cooled air.

## Single-Duct VAV ATU

System Configuration

1. Flow control damper.
2. Damper actuator, usually electric, bidirectional.
3. A digital controller.
4. A low voltage control transformer.
5. A line voltage power source.
6. A digital communications bus for control and BMS functions.
7. An optional bus connection to the space wall module for easy access from a portable control terminal
8. A wall module.

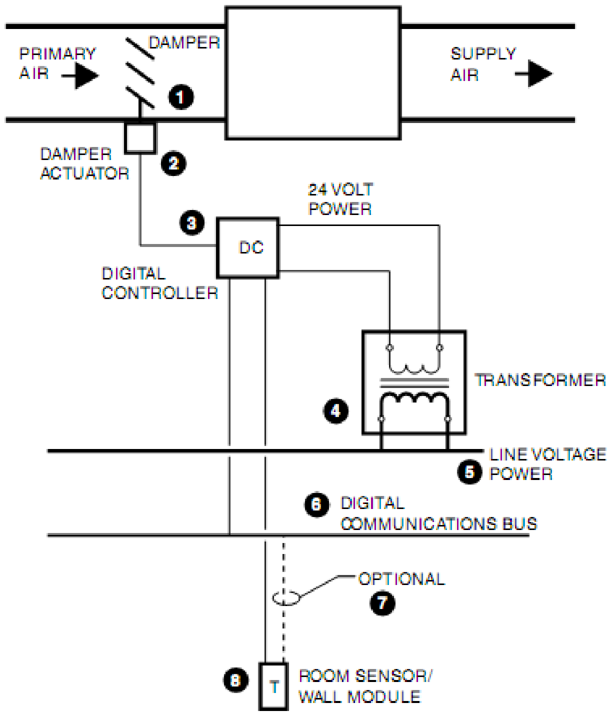



Fig.8.16 Single-Duct VAV ATU

## Throttling VAV ATU

The throttling VAV ATU (Fig.8.17) is the simplest and least expensive ATU. A room controller controls the operation of the damper actuator using PI control. The throttling VAV ATU usually has software minimum and/or maximum damper position limits for limiting air volume. Because the unit is pressure dependent, volume at any given damper position varies with the inlet duct static pressure.

The space temperature set point is the value set by the occupant on the wall module. With this option, the BMS operator may assign software limits to the set value.

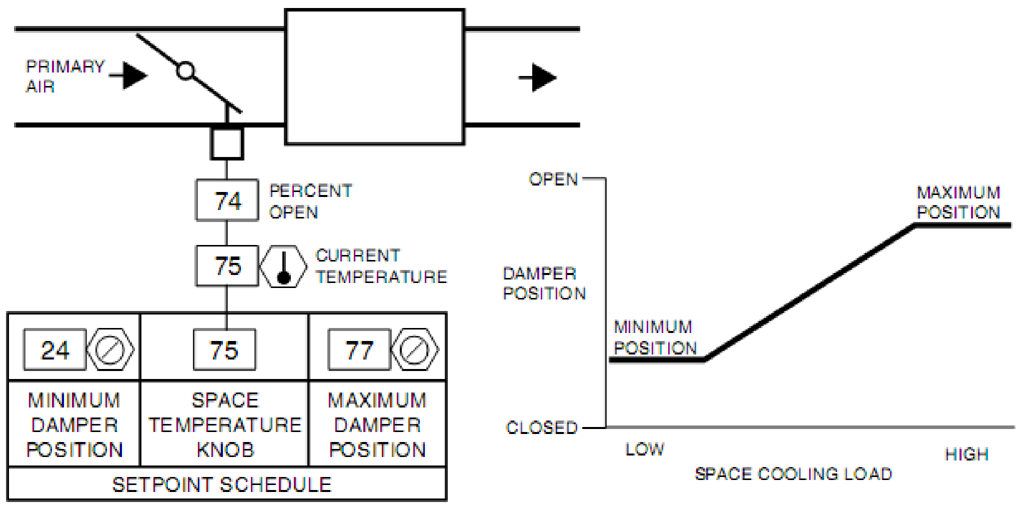
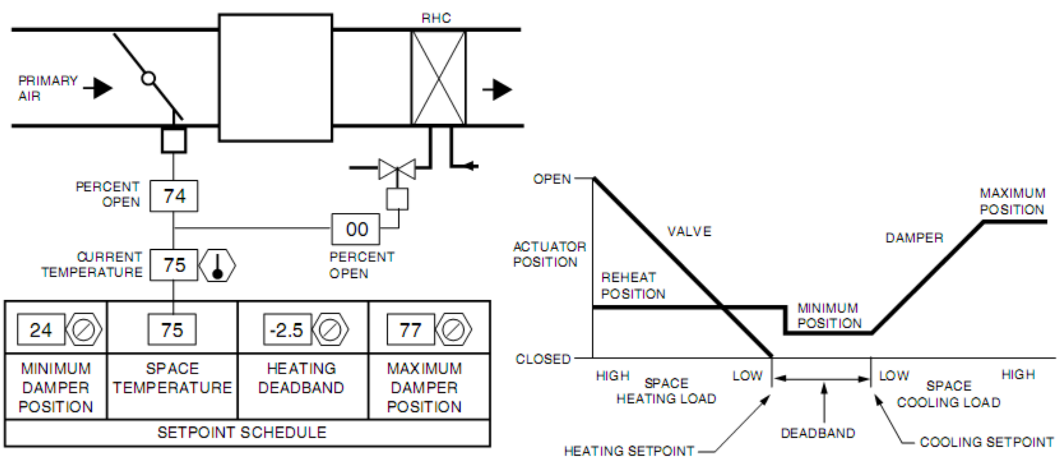



Fig.8.17 Throttling VAV Air Terminal Unit

Figure 8.18 shows a reheat coil added to a throttling VAV ATU. In this application, the temperature controller sequences the operation of the damper actuator and the control valve or reheat coil. The coil can be replaced by single or multiple stages of electric resistance heat. The damper modulates under PI control at the cooling set point and the hot water valve modulates under a separate PI control at the heating set point, with a dead band between heating and cooling.




## Variable Air Volume ATU

The variable air volume ATU (Fig.8.19) is a pressure- independent unit which delivers the required air volume to the space regardless of the supply static pressure. The amount of air delivered is derived from a space temperature PI loop. A flow sensor in the supply airflow modulates the damper actuator to control air volume. The room sensor resets the airflow set point as the space thermal load changes.

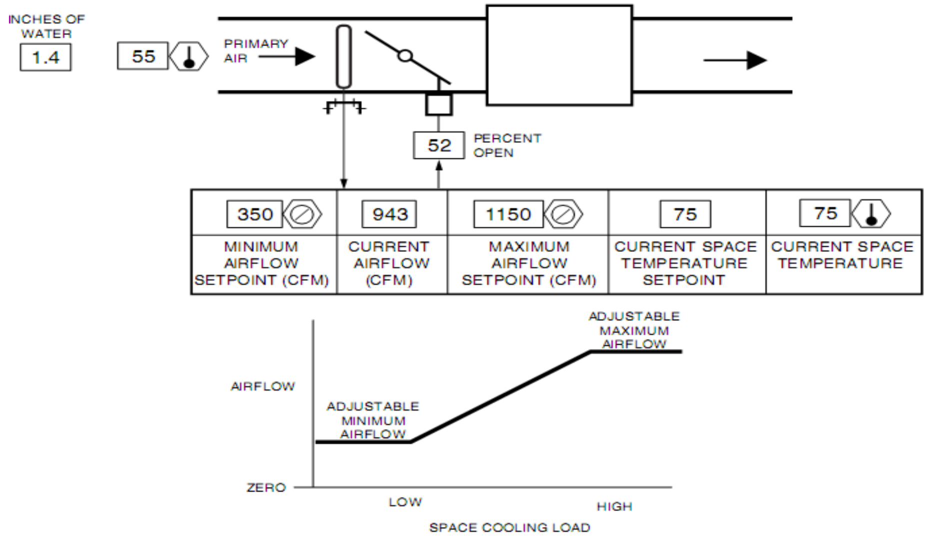



Fig.8.19. Variable Air Volume Single-Duct Air Terminal Unit

## Variable Air Volume ATU with Electric Reheat

The VAV ATU with electric reheat in Figure 8.20 adds reheat to Figure 5. Figure 6 also shows four boxes on one display. The cooling PID varies the box airflow from maximum to minimum as the cooling load drops to maintain set point. If the cooling load drops further, the space temperature drops through a dead band until the heating set point is reached, at which point the heating unit is controlled to maintain the heating set point.

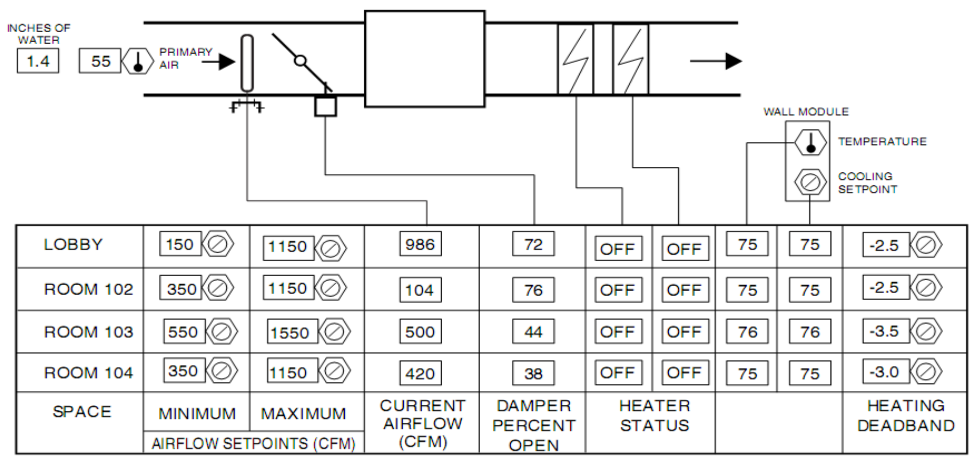



Fig.8.20 Variable Air Volume Single-Duct with Reheat Air Terminal Unit

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