Design of Mechanical Systems For Abed Almalek

Hotel In Hebron

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Dedication

We gift this graduation project

to who carry candle of science

to light his avenue

of live

To all students & who

wish to look for

the future

To who love the knowledge &

looking for all is new

in this world

To our parents & our friends

& to every one

help us

Acknowledgement

First and for most we should offer our thanks obedience and gratitude to Allah

Our Appreciation to

Palestine Polytechnic University

College of engineering And Technology

Department Of mechanical engineering

Our thanks go first our adviser DR.Mohammad Awad . His guidance and support made this work possible . His constant encouragement , intuitive wisdom, and resolute leadership was instrumental in completing this work.

We wish to thank DR. Kazem Osaily , DR. Ishaq sider . we sincerely believe that this work would not exist without their inspiration.

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Abstract

The aim from this project is to be familiar with the mechanical services in residential buildings, which provide the comfortable live for people, and help them to do their daily activates

Air conditioning, water supply, drainage, swimming pool are the most important mechanical works that must be done during building construction.

For heating and cooling system we use chiller and heat pump to reach temperature degree for comfort human , the system work on electrical source .

It implies the controlling and maintaining of the following four atmospheric can that effect the human comfort .

1. Temperature of the space
2. Humidity or the moisture contents of the air
3. Purity and quality of the inside air
4. Air velocity and air circulation within the space

Satisfy the human comfort we will provide the inner rooms by split units .

So to make the estimation will be done for the system after design and it`s drawings on the real drawings to make the specifications dimensions and quantities for all mechanical parts used in this hotel.

in this semester we will complete heating and cooling calculations , plumping system ,fire fighting and drawing it in Auto CAD.

Chapter 1

Introduction

1.1 project objectives

1.2 project benefits

1.3 project Description

1.4 Project Outline

1.5 Budget

In this project, is made to make the best air conditioning, heating, plumbing, water treatment systems to cover the requirements in hotel in Hebron .

The term air conditioning implies much more than the control of the inside temp of a given space.

It implies the controlling and maintaining off the following four atmospheric conditions that effect the human comfort ..

1) Temp of the space air.
2) Humidity or the moisture contents of that air.
3) Purity and quality of the inside air.
4) Air velocity and air circulation within the space .

1.1 project objectives

1) Design HVAC system for all floors.
2) Design domestic water system and design grid of pipes to sewage and drainage systems.
3) To prepare the required drawings for the above mentioned systems.
4) To select the required equipments and parts .
5) Design Fire fighting system

1.2 Project benefits

1) The main benefit is to fulfill the graduation requirements of Palestine Polytechnic University, and be familiar with all mechanical design of system installed in building to be ready in working in this field after graduation.

2) it will be this project to prepare a full document for mechanical systems in this hotel .

So documents include :

1) Cooling load calculation for air conditioning system.

2) Heating load calculations for heating system.

3) Calculations for flow and pipes for plumbing system.

4) Preparing the required drawings.

5) Selection of the required equipment`s and parts.

1.3 Hotel Description:

The hotel named Abed Almalek is located in Hebron city, It consists of five stories, with a total area of 8303 (m^2).

every floors area is 1500m^2 except the basement floor its area 803 m^2

The hotel contain rooms freezer, food store, office ....

1.4 Project Outline:

Chapter One:-Introduction

Includes the overview about project, project objectives and benefits.

Chapter Two:-HVAC System

Includes comfort conditions inside hotel, psychometric characteristics, heat transfer through building and calculation of the overall heat transfer coefficients for all structures of hotel. It presents cooling and heating loads calculations for all space in hotel.

Chapter three : Heating System

Work to account the heat load , then choose the system , which through it we can provide appropriate temperature for the peoples inside the hotel, then provide comfort psychological .

Chapter four:-Plumping System

Includes overview about plumbing systems, water distribution system (cold and hot water) and how potable water shall be distributed inside hotel by using suitable pipes and how the pipes could be designed, also this chapter contains the procedures to calculate the required quantity of potable water for daily usage to know the quantity of tanks that required to store this quantity, designing the storm and rain water drainage system.

1.5Budget:

Table (1-1) : Budget One.

Task	Cost (NIS)
Using Internet	90
Printing Papers	600
Reprinting Paper	100
Buying Books	50
Total	840

Table (1-2) : Time table.

Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Plumping system																
Drainage system																
HVAC system																
Fire fighting system																
Drawing																
Printing Final Copy																

Chapter 2

HVAC System

2.1HVAC system classification

2.1.1Fan-Coil Unit

2.1.2 Split Unit

2.2 Human Comfort

2.2.1 Factors Affecting Human Comfort

2.2.2 ASHRAE Comfort Chart

2.3Cooling load

2.3.1Data analysis.

2.3.2Over All Heat Transfer Coefficient (U)

2.4 Sample Calculation of Cooling Load

2.4.1 Heat gain from Bedroom walls

2.4.2 Heat gain from solar transmitted through glass

2.4.3 Sensible heat gain occupants

2.4.4 Latent heat gain occupants

2.4.5 Heat gain from lights

2.4.6 Heat gain from infiltration

2.4.7Cooling load Calculation for all room at ground floor

2.4.8 Cooling load Calculation For all Room at First Floor

2.4.9 Cooling load Calculation For all Room at Second Floor

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2.4.11 Cooling load Calculation For all Room at Forth Floor

2.1 HVAC system classification

HVAC systems are classified into two basic categories: all-water system, and split DX, listed HVAC system types are used in this project.

All-water system or water based system use a single chiller plant or chiller plus boiler to produce water which is then pumped around a building to, most commonly, fan coil units; a fan blows air over a coil containing the water, which then cools or heats the room air .The heat rejected by a condenser to the water is then pumped back to the chiller unit where it is rejected by a condenser to external air .The water is then chilled or heated and pumped back to the room units.

Unitary Packaged System -similar in nature to individual systems but serve more rooms or even more than one floor, have an air system consisting of fans, coil, filters, ductwork and outlets.

2.1.1 Fan-Coil Unit

In all internal spaces between different section in the Hotel, a fan coils with duct system were installed to serve this area. Each duct contains a number of grills that's covered the total cooling and heating load.

Fan coils units were selected based on several factors, the most important of them its ability, to provide adequate air flow to provide the required cooling in summer and heating required in winter.

2.1.2 Split Unit

In all internal space in basement floor in the embassy, a split unit will install to serve this area.

2.2 Human Comfort

The process of comfort heating and air conditioning is simply a transfer of energy from one substance to another. This energy can be classified as either sensible or latent heat energy.

Sensible Heat is heat energy that, when added to or removed from a substance, results in a measurable change in dry-bulb temperature.

Latent Heat content of a substance are associated with the addition or removal of moisture. Latent heat can also be defined as the “hidden” heat energy that is absorbed or released when the phase of a substance is changed. For example, when water is converted to steam, or when Steam is converted to water.

The necessity for comfort air conditioning stems from the fact that the metabolism of the human body normally generates more heat than it needs. This heat is transferred by convection and radiation to the environment surrounding the body. The average adult, seated and working, generates excess heat at the rate of approximately 450 Btu/hr. [132 W]. About 60% of this heat is transferred to the surrounding environment by convection and radiation, and 40% is released by perspiration and respiration. As the level of physical activity increases, the body generates more heat in proportion to the energy expended. When engaged in heavy labor, as in a factory for example, the body generates 1.450 Btu/hr. [425 W]. At this level of activity, the proportions reverse and about 40% of this heat is transferred by convection and radiation and 60% is released by perspiration and respiration.

In order for the body to feel comfortable, the surrounding environment must be of suitable temperature and humidity to transfer this excess heat. If the temperature of the air surrounding the body is too high, the body feels uncomfortably warm. The body responds by increasing the rate of perspiration in order to increase the heat loss through evaporation of body moisture. Additionally, if the surrounding air is too humid, the air is nearly saturated and it is more difficult to evaporate body moisture. If the temperature of the air surrounding the body is too low, however, the body loses more heat than it can produce. The body responds by constricting the blood vessels of the skin to reduce heat loss.

2.2.1 Factors Affecting Human Comfort

1. Dry Air:

The dry air is a complex mixture of several gases such as nitrogen ,oxygen ,carbon dioxide and other gases such as argon ,carbon monoxide and neon .It does not contain water vapor .The presence of nitrogen in the air represents about 78% by volume while the oxygen occupies about 21% by volume .The other gases represent less than 1%.

2. Moist Air:

The moist air is mechanical mixture of dry air and water vapor. Thus, when moist air is cooled, it loses moisture due to the condensation of the water vapor in the air.

3. Humidity:

The moisture content of the air is referred to as its humidity. This moisture content can be expressed in terms of volume, masses, and moles of pressure.

4. Saturation:

Saturation indicates the maximum amount of water vapor that can exist in one cubic meter of air at a given temperature. It does not depend on the mass and pressure of the air which may simultaneously exist in the same space.

5. Partial Pressure:

Low pressure air-water vapor mixture follows closely the Gibbs-Dalton law of partial pressure. This law states that the total pressure of a mixture of gases is the sum of the partial pressure of each of its constituent gas occupies the entire volume and has the same temperature of the mixture.

6. Dry Bulb Temperature:

Dry bulb temperature is the air temperature that is measured by an accurate thermometer or thermocouple where the measuring instrument is shielded to reduce the effect of direct radiation.

7. Wet Bulb Temperature:

The air temperature measured, using a wetted thermometer bulb, is known as wet bulb temperature. When unsaturated air passes over a wet thermometer bulb, water evaporates from the wetted bulb. Vaporizing latent heat is absorbed by the vaporizing water and thus causes the temperature of the wetted thermometer bulb to fall. The instrument used to measure the wet bulb temperature is called psychometric.

8. Dew-Point Temperature:

The dew-point temperature is the saturation temperature corresponding to the partial pressure of the water vapor in the surrounding air. When the dew-point temperature is reached, condensation starts as the moist cooled at constant pressure .Further cooling results in more condensation of water vapor. Moreover, at the dew-point temperature or below, the air is said to be saturated because the air is mixed with the maximum possible amount of water vapor.

9. Humidity:

The humidity ratio w, is defined as the mass of water vapor associated with unit mass of dry air

10. Relative Humidity:

The relative humidity is the ratio of actual partial pressure of the water vapor in the air PV, partial pressure of the water vapor.

2.2.2ASHRAE Comfort Chart:

Research studies have been conducted to show that, with a specific amount of air movement, thermal comfort can be produced with certain combinations of dry-bulb temperature and relative humidity. When plotted on a psychometric chart, these combinations form a range of conditions for delivering acceptable thermal comfort to 80% of the people in a space. This “comfort zone” and the associated assumptions are defined by ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy. Determining the desired condition of the space is the first step in estimating the cooling and heating loads for the space. In this hospital, we will choose 78ºF [25.6ºC] dry-bulb temperature and 50% relative humidity as the desired indoor condition during the cooling season.

2.3 Cooling load

2.3.1Data analysis:

T_o =Outside design temperature 34 ℃ from Palestine code

T_{in} =Inside design temperature 24℃

Temperature for Unheated space = T_{in} + 2/3*(T_{out} –T_{in}) = 30.6 ℃ Equation (2.1)

Outside relative humidity = 40 %

Inside design relative humidity = 50 %

Max wind speed = 1.4 [m/s]

Day of calculations = 21st day of July

Latitude = 32^o North

(CLTD) corr = (CLTD+ LM) K + (25.5-Ti) + (To, m - 29.4) f Equation (2.2)

Where:

CLTD: cooling load temperature deference correction, (from appendix A) Table (1).

LM: latitude correction factor, (from appendix B) Table (2).

K: color adjustment=1 for dark roof and 0.5 for light roof surface.

f: roof fan factor equal 0.75 because there is an attic.

Ti: inside design wall temp.

T_{om}: out design door main temperature.

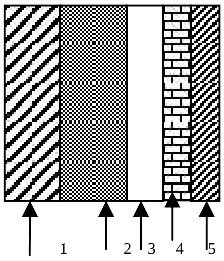
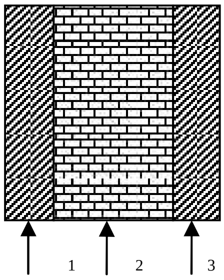
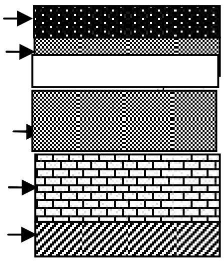
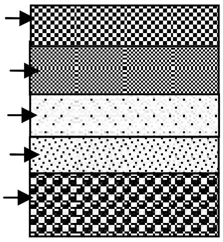
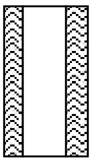
2.3.2 Over All Heat Transfer Coefficient (U).

$$U = \frac{1}{R_{th}} = \frac{1}{\frac{1}{h_i}+\frac{\Delta x_1}{k_1}+\frac{\Delta x_2}{k_2}+\cdots+1/h_0}$$ Equation (2.3)

h_i: Convection coefficient (surface conductance) of inside wall, floor, or ceiling ($h_i = 9.37\ W/m^2.C^0$) code Palestinian.

h_0: Convection coefficient (surface conductance) of outside wall, floor, or roof ($h_0 = 22.7\ W/m^2.C^0$)code Palestinian

Table 2.2 Overall Heat Transfer Coefficients.

	Construction detail	Construction material	Material thickness [m]	Thermal conduction [W/m.°C]	U [$W/m^2.^oC$]
Outside walls		1- stone 2-Concrete 3-Insulation (polyethren) 4- Block 5- plaster	0.07 0.2 0.03 0.01 0.03	1.7 1.75 0.04 0.95 1.2	0.86
Inside walls		1- plaster 2- Block 3- plaster	0.02 0.01 0.02	1.2 0.95 1.2	2.64
Roof		1- Asphalt 2- Concrete 3- Insulation 4- Concrete 5- Block 6- plaster	0.02 0.05 0.02 0.06 0.18 0.02	0.81 1.75 0.04 1.75 0.95 1.2	1.08
ground		1-Tiles 2- Concrete 3- Mortar 4- Sand 5- rocks	0.02 0.12 0.02 0.1 0.5	1.1 1.75 1.2 0.7 1.05	1.146
Windows		-	-	-	3.2
doors		1-wood	0.04	0.17	3.1

2.4 Sample Calculation of Cooling Load

2.4.1 Heat gain from Bedroom walls

Table 2.3 heat gain from Bedroom walls

Surface	Area (m^2)	U $\frac{w}{m^2.C}$	ΔT (C)	Q watt
W-wall	16.10	2.64	9.46	327.45
S-wall	14.18	2.64	9.46	288.40
N-wall	14.18	2.64	9.46	288.40
Ceiling	27.43	1.08	9.46	280.24
Floor	27.43	1.08	9.46	280.24
Q Total				**1464.74**

Table 2.4CLTD from Bedroom wall

Surface	CLTD	LM	Corrected (cltd)	AREA m^2	U $\frac{w}{m^2.C}$	Q watt
E-wall	18	0	22	15.17	1.20	400.48
Q total						**400.48**

2.4.2 Heat gain from solar transmitted through glass

$$Q_g = A * SHG * SC * CLF$$ Equation (2.4)

Table 2.5 Heat gain from solar transmitted through glass

Surface	mA^2	SHG	SC	SLF	Q watt
glass-S	2.82	630	0.25	0.21	**85.32**

2.4.3 Sensible heat gain from occupants

$$Q_{oc,sens} = \frac{2*\ 70}{1000} * CLF_{oc} = 0.87 * 2 * \frac{70}{1000} = 0.1218\ kwatt$$ Equation (2.5)

CLF_{oc}From table (11).see appendix B
sensible heat due to person table (12) .see appendix A

2.4.4 Latent heat gain from occupants

$$Q_{oc,latent} = 2 * \frac{30}{1000} = 0.06\ kwatt$$ Equation (2.6)

2.4.5 Heat gain from lights

CLF $_{light}$ = 0.8

$$Q_{light} = \#\ of light * \frac{Aciling}{1000} * 0.8 = 2*(4.2*4.2)/1000=0.034\ kW$$ Equation (2.7)

2.4.6 Heat gain from infiltration

$$Q_{inf} = \frac{V_f}{V_{outside}} * \quad h_o - h_i$$ Equation (2.8)

From psychometric chart we get:-

- $V_{outside} = 0.95\ m^3$/kg
- $h_o = 90\ \frac{kj}{kg}$
- $h_i = 47.8 \frac{kj}{kg}$
- $V_f = 6.7\ m^3/kg$

$Q_{inf,window} = 0.31\ kwatt$

$$Q_{inf,doors} = \frac{6.7}{0.91} * \quad 90 - 47.8 \quad = 0.31\ kW$$

Table 2.6 Total load

Type of calculation	Load (kW)
heat gain from Bedroom walls	1.460
heat gain from Bedroom walls	0.410
Heat gain from solar transmitted through glass	0.085
Sensible heat gain occupants	0.121
Latent heat gain occupants	0.060
Heat gain from lights	0.034
Heat gain from infiltration (w + d)	0.620
Total load	**2.780**

2.4.7 Cooling load Calculation for all rooms at ground floor

Table 2.7 load for all rooms at ground floor

Name of Room	Load for room (kW)	Name of Room	Load for room (kW)
Restaurant	6.21	**Office 3**	2.35
Saloon	15.34	**Office 4**	2.50
Reception	4.53	**Office 5**	2.46
Meeting room	3.40	**Office 6**	2.38
Office 1	2.30	**Office 7**	2.40
Office 2	2.45	**Office 8**	2.35
Total load			**52.50**

2.4.8 Cooling load Calculation For all Rooms at First Floor

Table 2.7 load for all rooms at first floor

Name of Room	Load for room (kW)	Name of Room	Load for room (kW)
Room 1	2.78	**Room 12**	3.73
Room 2	2.80	**Room 13**	2.65
Room 3	2.80	**Room 14**	2.67
Room 4	3.75	**Room 15**	2.68
Room 5	2.91	**Room 16**	2.67
Room 6	2.91	**Room 17**	2.85
Room 7	2.78	**Room 18**	2.85
Room 8	2.79	**Room 19**	3.10
Room 9	2.80	**Room 20**	2.77
Room 10	2.82	**Room 21**	2.78
Room 11	3.77	**Room 22**	2.75
Total load			**65.54**

2.4.9 Cooling load Calculation For all Rooms at Second Floor

Table 2.8 load for all rooms at second floor

Name of Room	Load for room (kW)	Name of Room	Load for room (kW)
Room 1	2.78	**Room 12**	3.73
Room 2	2.80	**Room 13**	2.65
Room 3	2.80	**Room 14**	2.67
Room 4	3.75	**Room 15**	2.68
Room 5	2.91	**Room 16**	2.67
Room 6	2.91	**Room 17**	2.85
Room 7	2.78	**Room 18**	2.85
Room 8	2.79	**Room 19**	3.10
Room 9	2.80	**Room 20**	2.77
Room 10	2.82	**Room 21**	2.78
Room 11	3.77	**Room 22**	2.75
Total load			**65.54**

2.3.10 Cooling load Calculation For all Rooms at Third Floor

Table 2.9 load for all rooms at third floor

Name of Room	Load for room (kW)	Name of Room	Load for room (kW)
Room 1	2.78	**Room 12**	3.73
Room 2	2.80	**Room 13**	2.65
Room 3	2.80	**Room 14**	2.67
Room 4	3.75	**Room 15**	2.68
Room 5	2.91	**Room 16**	2.67
Room 6	2.91	**Room 17**	2.85
Room 7	2.78	**Room 18**	2.85
Room 8	2.79	**Room 19**	3.10
Room 9	2.80	**Room 20**	2.77
Room 10	2.82	**Room 21**	2.78
Room 11	3.77	**Room 22**	2.75
Total load			**66.32**

2.4.11 Cooling load Calculation For all Rooms at Fourth Floor

Table 2.10 load for all rooms at fourth floor

Name of Room	Load for room (kW)	Name of Room	Load for room (kW)
Room 1	2.78	**Room 12**	3.73
Room 2	2.80	**Room 13**	2.65
Room 3	2.80	**Room 14**	2.67
Room 4	3.75	**Room 15**	2.68
Room 5	2.91	**Room 16**	2.67
Room 6	2.91	**Room 17**	2.85
Room 7	2.78	**Room 18**	2.85
Room 8	2.79	**Room 19**	3.10
Room 9	2.80	**Room 20**	2.77
Room 10	2.82	**Room 21**	2.78
Room 11	3.77	**Room 22**	2.75
Total load			**67.64**

Total load for all building = 317.4 KW

Chapter 3

Heating system

3.1 Introduction

3.2 General procedure

3.2.1Heat Loss By Infiltration

3.2.2 Design conditions selection

3.3 Heat gain calculation

3.4 Sample Calculation of heating Load

3.4.1 Heat gain for outside wall

3.4.2 Heat gain for inside wall

3.4.3 Heat gain For Roof

3.4.4 Heat gain For Floor

3.4.5 Heat gain For Window # 1

3.4.6 Heat gain for Window # 2

3.4.7 Heat gain for door

3.4.8 Heat gain For Infiltration Due Windows # 1

3.4.9 Heat gain For Infiltration Due Windows # 2 .

3.4.10 Heating load Calculation for all room at ground floor

3.4.11Heating load Calculation For all Room at First Floor

3.4.12Heating load Calculation For all Room at Second Floor

3.3.13Heating load Calculation For all Room at Third Floor

3.4.14Heating load Calculation For all Room at Fourth Floor

3.1 Introduction

The residential buildings have a special important in Palestine, due to the increasing in the Population growth, and the lack of lands that owned by citizens as a result of the occupation authorities policies that assimilate in confiscation of lands, and restrictions that prevent the ability of people from build freely in many lands; so that the phenomena of many floor residential building's has become a familiar mean to end this suffering.

This project contains a full mechanical design for a residential building, and swimming pool as it would be shown in the coming chapters of the project.

The mechanical systems including Air conditioning systems, central heating systems, water supply systems, drainage system.

The scope of the project is to study and design the different mechanical systems needed.
Inside the residential building, this includes the following main topics:

1. Study the different mechanical systems inside the residential buildings.
2. Theoretical calculations and design of HVAC system.
3. Theoretical calculations and design of plumping system.
4. Theoretical calculations and design of Central Heating System.
5. To be familiar with the mechanical drawing for the different mechanical systems.

Because of the human is the most variable thing that we have, the mechanical design should be complementary psychological and health comfort factors, which help him to complete his duties as required.

3.2 General procedure

The amount of heat loss through a roof, an exterior wall, or a window depends on the area of the surface, the overall heat transfer coefficient of the surface, and the dry-bulb temperature difference from one side of the surface to the other.

The equation used to predict the heat loss by conduction is:

$Q = U \times A \times \Delta T$ [2-11]

Q = the rate at which heat transfer in watts [W].

U = overall heat-transfer coefficient of the surface [$W/m^2.K$].

A = Area of the layer which heat flow through, which in our project may be an area of wall, window, or ceiling…,[m^2].

ΔT = desired indoor dry-bulb temperature (Ti) minus the design outdoor dry bulb temperature (T_o), [°C].

3.2.1 Heat Loss By Infiltration

Infiltration is the leakage of outside air through cracks and clearances around the windows and doors. The amount of infiltration depends mainly on the tightness of the windows and doors on the outside wind velocity or the pressure difference between the outside and inside the heat load due to infiltration is given by**:**

$$\mathbf{Q_{inf} = \frac{V_{inf}}{V_{outside}} * \ h_o - h_i} \qquad \text{Equation (3.1)}$$

$$\mathbf{V_{inf} = K*L*(0.613(s1 * s2 * v)\text{^}2)^{2/3}} \qquad \text{Equation (3.2)}$$

Q_{inf}:the infiltration heat load [w].

V_{inf}:the volumetric flow rate of infiltrated air [m^3/s].

$V_{outside}$:the outside volumetric flow rate [$m^3/Kg \ \ dry\, air$].

$h_{o,}h_i$: $are\ the\ outside\ and\ inside\ enthapies\ of\ infiltrated\ air,$
$respectively$ [kj/kg].

K: the coefficient of infiltration air for windows.

L:the crack length [m].

s_1:The factor that depends on the topography of the location of the building, (from appendix A) Table(10).

s_2:Another coefficient that depends on the height of the building and terrain of its location, (from appendix A) Table(10).

V_o: The measured wind speed [m/s].

These include dry-bulb temperature (T_{out}) , relative humidity out (Φ_{out}) and average air speed (v) . These values are usually tabulated weather station reports.

3.2.2 air ventilation calculation: Ventilation Calculation Methods:-

Airflow for general ventilation can be calculated by;

• Area Method • Air Change Method • Occupancy Method Air changes per hour, or air change rate, abbreviated ACH or ac/h, is a measure of the air volume added to or removed from a space (normally a room or house) divided by the volume of the space. If the air in the space is either uniform or perfectly mixed, air changes per hour is a measure of how many times the air within a defined space is replaced. Air change rate per hour can be expressed as;

ACR = 60 x CFM / V (3.21) ACR = air change rate per hour.

CFM = air flow through the room (Cubic Feet per Minute).

V = volume of the room (Cubic Feet).

3.2.2 Design conditions selection

values for outdoor design conditions Table 3.1

Season	T_{out} (℃)	Φ_{out}%	$v_{out}\ (m^3/kg\ dry\ air)$	h_{out} (kJ/kg)
Heating	5	40	0.86	32.9

Table 3.2 values for indoor design conditions

Season	T_{in} (℃)	Φ_{in}%	h_{in} (kJ/kg)
Heating	24	60	10

3.3 Heat gain calculations

The heat gain can be found from walls, roof, ceiling, and interior walls, windows, doors.

Equation (3.3) $$Q = U * A * \Delta T$$

Where:

Q = the rate at which heat transfer in watts.

A = Area of the layer (m²) which heat flow through, which in our project may be an area of wall, window, or ceiling…

ΔT = the temperature difference in °C or °K.

3.4 Sample Calculation of heating Load

3.4.1 Heat gain from outside wall

$$Qwall = U * A * \Delta T$$

Q wall = 1.2 *15.17 * (24 - 5) = 345.87 W

3.4.2 Heat gain from inside wall

Q wall = 2.15 *14.18 * 10 = 304.87 W

3.4.3 Heat gain from roof

Q wall = 1.08 *27.44 * 19 = 563.06 W

3.4.4 Heat gain from floor

Q wall = 1.08 *27.44 * 10 = 296.35 W

3.4.5 Heat gain for Window # 1

Q wall = 3.2 * 2.82* 19 = 171.45 W

3.4.6 Heat gain from Window # 2

Q wall = 3.2 * 0.42* 19 = 25.53 W

3.4.7 Heat gain from door

Q wall = 2.4 * 1.89* 10 = 45.36 W

3.4.8 Heat gain From Infiltration Due Windows # 1 .

Table 3.3 heat gain by infiltration For window

Window type	Area $[m^2]$	k	s_1	s_2	l [m]	V_o [m/s]	V_{inf} [m^3/s]	Q_{inf} [W]
Aluminum Window #1	0.42	0.43	1	0.86	3.3	5	0.00198	52.9

$l_1 = (0.6 * 2) + (0.7 * 3)$ = 3.3 m , for sliding window

V_{inf}= 0.43*3.3$[0.613(1 * 0.86 * 5)^2]^2\ _3$ = 0.00198 m^3/s

$Q_{inf} = \frac{0.00198}{0.86} * 1000(32.9 - 10)$ = 52.9 w

3.4.9 Heat gain From Infiltration Due Windows # 2 .

Table 3.4 heat gain by infiltration For Windows # 2 .

Window type	Area $[m^2]$	k	s_1	s_2	l [m]	V_o [m/s]	V_{inf} [m^3/s]	Q_{inf} [W]
Aluminum Window #2	2.4	0.43	1	0.86	7.6	5	0.0045	119.82

$l_1 = (2 * 2) + (1.2 * 3)$ = 7.6m , for sliding window

V_{inf}= 0.43*7.6 $[0.613(1 * 0.86 * 5)^2]^2\ _3$ = 0.0045 m^3/s

$Q_{inf} = \frac{0.0045}{0.86} * 1000(32.9 - 10)$ = 119.82

Table 3.5 Total load

Type of calculation	Load (W)
Heat gain for outside wall	345.87
Heat gain For inside wall	304.87
Heat gain For Roof	563.06
Heat gain For Floor	296.35
Heat gain For Window # 1	171.45
Heat gain for Window # 2	25.53
Heat gain for door	45.36
Heat gain For Infiltration Due Windows # 1	52.9
Heat gain For Infiltration Due Windows # 2	119.82
Total load	**1925.21**

Total load = 1.925 kW

3.4.10 Heating load Calculation for all rooms at ground floor

Table 3.6 load for all rooms at ground floor

Name of Room	Load for room (kW)	Name of Room	Load for room (kW)
Restaurant	3.65	Office 3	1.55
Saloon		Office 4	1.70
Reception	3.73	Office 5	1.66
Meeting room	2.60	Office 6	1.58
Office 1	1.50	Office 7	1.60
Office 2	1.65	Office 8	1.55
Total load			**42.20**

2.4.11 Heating load Calculation For all Rooms at First Floor

Table 3.7 load for all rooms at first floor

Name of Room	Load for room (kW)	Name of Room	Load for room (kW)
Room 1	2.05	**Room 12**	2.97
Room 2	2.07	**Room 13**	1.95
Room 3	2.10	**Room 14**	1.90
Room 4	2.95	**Room 15**	2.08
Room 5	2.11	**Room 16**	1.88
Room 6	2.10	**Room 17**	1.89
Room 7	1.97	**Room 18**	2.04
Room 8	2.01	**Room 19**	2.45
Room 9	2.08	**Room 20**	1.97
Room 10	2.02	**Room 21**	1.97
Room 11	2.97	**Room 22**	1.90
Total			**52.43**

2.4.12 Heating load Calculation For all Rooms at Second Floor

Table 3.8 load for all rooms at second floor

Name of Room	Load for room (kW)	Name of Room	Load for room (kW)
Room 1	1.95	**Room 12**	2.83
Room 2	2.04	**Room 13**	1.87
Room 3	2.04	**Room 14**	1.92
Room 4	2.95	**Room 15**	1.89
Room 5	2.11	**Room 16**	1.92
Room 6	2.11	**Room 17**	2.02
Room 7	2.04	**Room 18**	2.05
Room 8	2.09	**Room 19**	2.37
Room 9	1.97	**Room 20**	1.96
Room 10	2.02	**Room 21**	1.86
Room 11	2.87	**Room 22**	1.92
Total			**52.43**

2.3.13 Heating load Calculation For all Rooms at Third Floor

Table 3.9 load for all rooms at third floor

Name of Room	Load for room (kW)	Name of Room	Load for room (kW)
Room 1	1.96	**Room 12**	2.89
Room 2	1.91	**Room 13**	1.85
Room 3	1.87	**Room 14**	1.97
Room 4	2.96	**Room 15**	1.88
Room 5	2.01	**Room 16**	1.87
Room 6	2.01	**Room 17**	2.05
Room 7	1.91	**Room 18**	2.05
Room 8	1.95	**Room 19**	2.52
Room 9	2.00	**Room 20**	1.86
Room 10	2.02	**Room 21**	1.96
Room 11	2.89	**Room 22**	1.90
Total			**53.05**

2.4.14 Heating load Calculation For all Rooms at Fourth Floor

Table 3.10 load for all rooms at fourth floor

Name of Room	Load for room (kW)	Name of Room	Load for room (kW)
Room 1	1.86	**Room 12**	2.83
Room 2	1.91	**Room 13**	1.85
Room 3	1.97	**Room 14**	1.97
Room 4	2.96	**Room 15**	1.88
Room 5	2.01	**Room 16**	1.87
Room 6	2.25	**Room 17**	2.05
Room 7	1.91	**Room 18**	2.05
Room 8	1.95	**Room 19**	2.87
Room 9	2.11	**Room 20**	1.86
Room 10	2.02	**Room 21**	1.96
Room 11	2.89	**Room 22**	1.97
Total			**56.49**

Chapter 4

Plumping system

4.1.1 Introduction

The main goal of plumping design for building is to safely and reliably provide domestic water , cooking gas and water for fire fitting and to remove sanitary wastes .

Plumping consist of two things which are water supply system and drainage distribution system Water supply system , there are two basic types of water distribution systems for building

1) up feed distribution system

2) down feed distribution system

In this project the down feed distribution system we will use . the supply of water for the building is received from a public street main usually 35 psi for residential buildings , this water enters the well of the villa and then by using pumps which pumping the water to the tanks called gravity tanks which located on the roof .

The water from the gravity tank on the roof surface provides the fixtures that are located in the floors below .minimum pressure required in the top floor is usually 15 psi for flush tank and

maximum pressure on the lowest floor should not exceed 50 psi otherwise pressure reducing valves are used to reduce the pressure

4.1.2 Calculations for hot and cold water

To determine the pipe size for cold and hot water we must calculate the water supply fixture unit (WFSU) for each fixture and fixture unit total on Each pipe ran out and determine the minimum pressure required flow in the closes to fallowing, we can determine the required pipe in each section using the friction head loss data calculated and the friction head chart .

This table will show the water supply fixture unit for the basement plane :

We use flush tank fixture unit (general).

Table 4.1 WSFU for Riser 1

Fixture unit	No. of units	WSFU from table 9-3	Total No. of WSFU for cold water	Total No. of WSFU for hot water	Total load for No. of WSFU
Lavatory(General)	4	2*3/4	6	6	8
Shower (General)	4	4*3/4	12	12	16
WC (General) flush meter	4	10	40	----	40
Total			**∑ 58**	**∑ 18**	**∑ 64**

For first floor by using table(5) for estimating demand : (see appendix (A)) ,

By using interpolation the required flow is 56.4 gpm for total load

For cold water by interpolation the required flow is 54.4gpm

For hot water by interpolation the required flow is 33.4gpm

The total load water demand needed = 56.4gpm

Table 4.2 WSFU for Riser 2

Fixture unit	No. of units	WSFU from table 9-3	Total loud for No. of WSFU	Total No. of WSFU for hot water	Total load for No. of WSFU
Lavatory(General)	4	2*3/4	8	6	8
Shower (Genera)	4	4*3/4	16	12	16
WC (General) flush meter	4	10	40	----	40
Total			**∑ 58**	**∑ 18**	**∑ 64**

For first floor by using table(5) for estimating demand : (see appendix (A)) ,

By using interpolation the required flow is 56.4gpm for total load

For cold water by interpolation the required flow is 54.4gpm

For hot water by interpolation the required flow is 33.4gpm

The total load water demand needed = 56.4gpm

Table 4.3 WSFU for Riser 3

Fixture unit	No. of units	WSFU from table 9-3	Total No. of WSFU for cold water	Total No. of WSFU for hot water	Total load for No. of WSFU
Lavatory(General)	8	2*3/4	12	12	16
Shower (General)	8	4*3/4	24	24	32
WC (General) flush meter	8	10	80	----	80
Total			**∑ 116**	**∑ 36**	**∑128**

For first floor by using table(5) for estimating demand : (see appendix (A)) ,

By using interpolation the required flow is 75.6gpm for total load

For cold water by interpolation the required flow is 72.8gpm

For hot water by interpolation the required flow is 44.6gpm

The total load water demand needed = 75.6gpm

Table 4.4 WSFU for Riser 4

Fixture unit	No. of units	WSFU from table 9-3	Total No. of WSFU for cold water	Total No. of WSFU for hot water	Total load for No. of WSFU
Lavatory(General)	8	2*3/4	12	12	16
Shower (General)	8	4*3/4	24	24	32
WC (General) flush meter	8	10	80	----	80
Total			**∑ 116**	**∑ 36**	**∑ 128**

For first floor by using table(5) for estimating demand : (see appendix (A)) ,

By using interpolation the required flow is 75.6gpm for total load

For cold water by interpolation the required flow is 72.8gpm

For hot water by interpolation the required flow is 44.6gpm

The total load water demand needed = 75.6gpm

Table 4.5 WSFU for Riser 5

Fixture unit	No. of units	WSFU from table 9-3	Total loud for No. of WSFU	Total No. of WSFU for hot water	Total load for No. of WSFU
Lavatory(General)	8	2*3/4	16	12	24
Shower (General)	8	4*3/4	32	24	48
WC (General) flush meter	8	10	80	----	80
Total			**∑ 116**	**∑ 36**	**∑128**

For first floor by using table(5) for estimating demand : (see appendix (A)) ,

By using interpolation the required flow is 75.6gpm for total load

For cold water by interpolation the required flow is 72.8gpm

For hot water by interpolation the required flow is 44.6gpm

The total load water demand needed = 75.6gpm

Table 4.6 WSFU for Riser 6

Fixture unit	No. of units	WSFU from table 9-3	Total No. of WSFU for cold water	Total No. of WSFU for hot water	Total load for No. of WSFU
Lavatory(General)	10	2*3/4	15	15	20
Shower (General)	8	4*3/4	24	24	32
WC (General) flush meter	10	10	100	----	100
Total			**∑ 139**	**∑ 39**	**∑ 152**

For first floor by using table(5) for estimating demand : (see appendix (A)) ,

By using interpolation the required flow is 81gpm for total load

For cold water by interpolation the required flow is 77.8gpm

For hot water by interpolation the required flow is 46.4gpm

The total load water demand needed = 81gpm

Table 4.7 WSFU for Riser 7

Fixture unit	No. of units	WSFU from table 9-3	Total loud for No. of WSFU	Total No. of WSFU for hot water	Total load for No. of WSFU
Lavatory(General)	8	2*3/4	16	12	24
Shower (General)	8	4*3/4	32	24	48
WC (General) flush meter	8	10	80	----	80
Total			**∑ 116**	**∑ 36**	**∑128**

For first floor by using table(5) for estimating demand : (see appendix (A)) ,

By using interpolation the required flow is 75.6gpm for total load

For cold water by interpolation the required flow is 72.8gpm

For hot water by interpolation the required flow is 44.6gpm

The total load water demand needed = 75.6gpm

Table 4.8 WSFU for Riser 8

Fixture unit	No. of units	WSFU from table 9-3	Total No. of WSFU for cold water	Total No. of WSFU for hot water	Total load for No. of WSFU
Lavatory(General)	10	2*3/4	15	15	20
Shower (General)	8	4*3/4	24	24	32
WC (General) flush meter	10	10	100	----	100
Total			**∑ 139**	**∑ 39**	**∑ 152**

For first floor by using table(5) for estimating demand : (see appendix (A)) ,

By using interpolation the required flow is 81gpm for total load

For cold water by interpolation the required flow is 77.8gpm

For hot water by interpolation the required flow is 46.4gpm

The total load water demand needed = 81gpm

Table 4.9 WSFU for Riser 9

Fixture unit	No. of units	WSFU from table 9-3	Total loud for No. of WSFU	Total No. of WSFU for hot water	Total load for No. of WSFU
Lavatory(General)	8	2*3/4	24	12	24
Shower (General)	8	4*3/4	48	24	48
WC (General) flush meter	8	10	80	----	80
Total			**∑ 116**	**∑ 36**	**∑128**

For first floor by using table(5) for estimating demand : (see appendix (A)) ,

By using interpolation the required flow is 75.6gpm for total load

For cold water by interpolation the required flow is 72.8gpm

For hot water by interpolation the required flow is 44.6gpm

The total load water demand needed = 75.6gpm

Table 4.10 WSFU for Riser 10

Fixture unit	No. of units	WSFU from table 9-3	Total No. of WSFU for cold water	Total No. of WSFU for hot water	Total load for No. of WSFU
Lavatory(General)	8	2*3/4	12	12	24
Shower (General)	8	4*3/4	24	24	48
WC (General) flush meter	8	10	80	----	80
Total			**∑ 116**	**∑ 36**	**∑ 128**

For first floor by using table(5) for estimating demand : (see appendix (A)) ,

By using interpolation the required flow is 75.6gpm for total load

For cold water by interpolation the required flow is 72.8gpm

For hot water by interpolation the required flow is 44.6gpm

The total cold and hot water demand needed = 75.6gpm

Table 4.11 WSFU for Riser 11

Fixture unit	No. of units	WSFU from table 9-3	Total No. of WSFU for cold water	Total No. of WSFU for hot water	Total loud for No. of WSFU
Lavatory(General)	10	2*3/4	15	15	20
Shower (General)	8	4*3/4	24	24	32
WC (General) flush meter	10	10	100	----	100
Total			**∑ 139**	**∑ 39**	**∑ 152**

For first floor by using table(5) for estimating demand : (see appendix (A)) ,

By using interpolation the required flow is 81gpm for total load

For cold water by interpolation the required flow is 77.8gpm

For hot water by interpolation the required flow is 46.4gpm

The total loud water demand needed = 81gpm

Table 4.12 WSFU for Riser 12

Fixture unit	No. of units	WSFU from table 9-3	Total No. of WSFU for cold water	Total No. of WSFU for hot water	Total loud for No. of WSFU
Lavatory(General)	8	2*3/4	12	12	24
Shower (General)	8	4*3/4	24	24	48
WC (General) flush meter	8	10	80	----	80
Total			**∑ 116**	**∑ 36**	**∑ 128**

For first floor by using table(5) for estimating demand : (see appendix (A)) ,

By using interpolation the required flow is 75.6gpm for total load

For cold water by interpolation the required flow is 72.8gpm

For hot water by interpolation the required flow is 44.6gpm

The total loud water demand needed = 75.6gpm

4.2 Calculate static head for fourth floor

From third floor to fourth : highest = 3.05 m = 10ft

1m = 3.28 ft

Lavatory outlet above basement level = 1m = 3.28 ft

tank outlet above roof surface= 3m = 9ft

So the static head in this case = floor to floor height + tank outlet height – lavatory out let height Equation (3.1)

static head =10 + 9 – 3.28 = 15.72ft

So then the static pressure = static head * 0.433 psi = 15.72 *0.433 = 7 psi

We need to pump , because the longitudinal frictionless than the friction

4.3 Total equivalent length

4.3.1 Total equivalent length For cold water.

Total length from tank fourth floor to roof floor through risers = 3.05m = 10ft

The horizontal distance from tank water outlet to riser =78 m = 236.4 ft

Total length from riser to the collector = 1 m = 3.28 ft

Total length from collector to lavatory outlet =3 m = 9.84ft

Total length from faucet outlet to ground level = 1 m = 3.28 ft

So the total length from tank outlet to the farthest outlet at the fourth floor

= 10+78+1+3+1 = 93 m = 281.8ft

To calculate total equivalent length we assumed 50% additional equivalent length to account for fittings therefore the total equivalent length as follow :

Total equivalent length = total length * 1.5 = 93 *1.5

= 155.1 m =422.7 ft Equation (3.2)

in the lavatory fixture is(15 psi) for flush valve from table 9.1

Friction head = static pressure – minimum flow pressure

Friction head = 7 – 8 = -1 psi

we need pump because the friction head is negative

the amount of pump is 15 psi

after it the friction head = pump pressure + static pressure – minimum flow pressure

= 15 + 7 - 8 = 14 psi .

4.3.2 Total equivalent length For hot water.

Total length from tank fourth floor to roof floor through risers = 3.05m = 10ft

The horizontal distance from tank water outlet to riser =78 m = 236.4 ft

Total length from riser to the collector = 1 m = 3.28 ft

Total length from collector to lavatory outlet =3 m = 9.84ft

Total length from faucet outlet to ground level = 1 m = 3.28 ft

So the total length from tank outlet to the farthest outlet at the fourth floor

= 10+78+1+3+1 = 93 m = 281.8ft

To calculate total equivalent length we assumed 50% additional equivalent length to account for fittings therefore the total equivalent length as follow :

Total equivalent length = total length * 1.5 = 93 *1.5 = 155.1 m = 422.7 ft

The minimum flow pressure

the minimum required flow pressure at the most remote outlet on the fourth floor (lavatory) is 15 psi.

4.4 Calculation of friction head

4.4.1 calculate the friction head for hot water .

we can calculate the friction head from the following equation :

static pressure =pump pressure + Friction head + minimum flow Equation(3.3)

Friction head =15 +7 – 8 = 14 psi

Uniform friction loss = 14 / 422.7 = 14 / (4.22/100) = 3.31(psi/100ft) from fig .2 for steel pipe

flow rate = 42 gpm

friction head loss =3.31 psi /100ft

pipe size = 3/4” for all riser

4.4.2 calculate the friction head for cold water

friction/100ft = available friction head/ total equivalent length

friction/100ft = 14 psi /422*100 ft =   3.31 psi/100ft

so for basement flow rate (42gpm) and friction head loss (3.31 psi/100ft) , from figure 9.5 for steel pipes (see appendix (A)) .

The size of a well :

All water 60.8 m^3\h.

Size :60.8 m^3\h * 8 h   in day *3 days = 1459.2 m^3.

Selection the pump for domestic water is from grandfoss catalogue to rise the water from well to roof

pump:

TPE Series 2000

Single - stage, centrifugal pumps - electronically controlled

[Technical data

Flow, Q: max. 230 m^3/h

Head, H: max. 41 m

Liquid temp.: –25°C to +120°C

Op. press: max. 16 bar

Applications

Circulation of hot or cold water in

• Heating systems

• Domestic hot water systems
• Cooling and air-conditioning systems

Features and benefits

• Low-energy
• Adaptation to existing operating conditions
• Simple installation

Options

• Wireless remote control, R100
• Communication via GENIbus, BACnet MS/TP, LON, Modbus RTU or Profibus DP
• Twin-head versions

we put the pump after hot tank to keep water circulated

the pump from gandfos

ALPHA2, UPS Selectric,
UPS Series 100

Circulator pumps, canned-rotor type

Technical data

Flow, Q: max. 10 m³/h

Head, H: max. 12 m

Liquid temp.: +15°C to +110°C

Op. press: max. 10 bar

Applications

Circulation of hot or cold water in

• Heating systems
• Domestic hot water systems
• Cooling and air-conditioning systems

Features and benefits

• Maintenance-free
• Low-noise
• Low-energy
• Wide range

Options

• Automatic performance adjustment
• Display of actual power consumption
• Simple installation - external plug for electrical connection
• Single-speed or 2- or 3-speed performance adjustment
• Twin-head versions

4.5 sanitary drainage system

4.5.1 Introduction

In this system we use to dispose the waste water from the building fixtures through stacks to the manholes

4.6 Sanitary Drainage and Waste Water Disposal

Its function to carries away the contaminated water and solids produced by domestic uses of water from lavatories, sinks, water closet, and other sanitary fixtures.

4.6.1 Components of the drainage system

Drainage system consist from many components which will illustrated below and appearing Obviously .

A- Drain pipe

It is used to carry the waste water , and classified according to location and job as follows :-

- **Branch piping :**all horizontal drainage pipes that drain water from the fixtures to the stack. Branches are designed to run maximum 50% of its complete fill with a recommended velocity 2 fps.

- **Stacks :**all vertical drainage pipe that drain water from branches to building pipes are called stacks. Designed to run in the range of 25% to 33% of fill maximum with velocity 16 fps.

- **Soil pipe :** piping carrying effluent from water closets, urinals and bidets (black water).

- **Waste pipes :** piping carrying waste water from other fixtures (gray water).

- **Building piping:** piping connecting terminals of stacks to manhole.

- **Sewer piping :** piping between manholes.

B- Traps

The basic function of the trap is to provide a water seal between the drainage piping that connects to the outside sewer and the fixture, this water seal prevents entry into the building of odors, sewer gas and vermin from the sewer via the fixture.

Every plumping fixture must be trapped except for a few special cases such as fixtures with indirect (air-gap) and certain fixtures that discharge through interceptor. The only fixture that is self trapped is the water closet.

All traps operate on the principle of siphon age as water is added to the inlet end, an equal amount of water leaves the outlet end provided the pressure at both ends are approximately equal.

The maximum allowable pressure difference between inlet and outlet of the trap is (1 inch) water about (0.036 psi) , it can't be deeper because the trap will not self clean properly , it will retain foreign bodies and very soon become blocked .

There are many types of traps such as : integral trap , P - trap, drum trap, bell trap and S trap. The length of the trap arm may not exceed .

Table 4.13Maximum length of the trap arm

Diameter of the trap arm (in)	Maximum trap arm (in)
1 ¾	3.5
1 ½	5
2	8
3	10
4	12

C-Vents

The importance of vents are:-

- Provide an air vent at each fixture trap, this ensure atmospheric pressure on the outlet side of the fixture trap (equalize the pressure at both side of the trap) so prevent the trap seal .
-
- Provides safe path to exhaust sewer gases and foul odors , building vent piping acts as a sewer vent in the absence of a building and street level fresh air vent.
- It fills the drainage piping with fresh air , that reduces odors , corrosion and formation of slime in piping.

There are some Rules governing vent piping and they are :-

1- The diameter of a vent pipe may not be less than (1 ½) or half the size of the drain pipe that it vents, whichever is large.

2- A relief vent may not be less than half the size of the drain pipe to which it is connected.

3- When fixtures other than water closets discharge downstream from a water closet in to a fixture shall be individually vented, this procedure called re-venting.

4.6.2 Hydraulics of gravity flow

Unlike water piping that flows fill in the pipe and under pressure , drainage flows at zero pressure and only partially full, the flow caused by gravity due to the slope of all drainage piping. For a given type of a pipe (friction) the variables in drainage flow are slope and depth of liquid.

When these two factors are known the flow velocity and flow quantity can be calculated, because the calculations are complex ,that required in plumping design.

The code requires that horizontal drainage piping be installed with a uniform slope of not less than (¼ inch/ ft (1.8%) for piping diameter less or equal 3 inch) , and (1/8 inch/ft (1%) for piping diameter greater or equal 4 inch).

The reason that large pipes can be installed at a less slope than small pipes is the greater diameter pipe has greater flow velocity, so it required less slope than small diameter pipe.

Horizontal branch drain are designed to run at a max (50%) fill . Stacks are designed to run at a max (25-30%) fill., and building drains and sewer drain may run at somewhat higher (over 50%) fill.

The flow in vertical pipes (stacks) depends on:-

A- pipe size.

B- Amount of fluid (flow rate).

C- Velocity.

D- Direction of the fluid entering the stack.

F- Pipe wall friction (roughness of the pipe wall).

At the base of a stack with a sharp 90 bend, waste water undergoes a rapid change in velocity . Within 10 stack pipe diameter, a horizontal jump occurs in which the water plies up causing large pressure variation , this condition can be avoided by using long radius elbows, or large horizontal drain , or additional vents.

4.6.3 Procedure of drainage piping sizing

Step 1 : Draw isometric of the entire system showing all fixtures.

Step 2: Assign drainage fixtures units to each fixture, if a fixture is not listed specifically , base the drainage fixture unit (dfu) requirements on its trap size. Minimum fixture trap sizes With respect to drainage requirements not due to fixture , such as non-recirculated cooling water or process water, use the conversion of (1gpm = 2 dfu) .

Step 3: Total the drainage fixture units in each drainage pipe and mark them on the drawing.

Step 4: Determine the required size of the horizontal fixture branches and stacks .

Step 5 : Determine the size and the slope of the building drain and its branches, and the building sewer .

Step 6:- Determine the size and slope found in step 5 meet the requirements of the code .

Table 4.14 dfu for fourth floor

Fixture unit	dfu value Table 10-2 Horizontal branch	Diameter of pipe (inch) Table 10.4
Bath tub group (wc , lavatory , shower) stack A stack G	 6 6	 2 2
Bath tub group (wc , lavatory , shower) stack B Branch 1 Branch 2	6 6 6	2 2 2

stack C, stack D ,stack E , stack F ,stack H , stack I , stack J , stack K , stack L, stack M is similar to stack B.

Table 4.15 dfu for third floor

Fixture unit	dfu value table 10-2 Horizontal branch	Diameter of pipe (inch) Table 10.4
Bath tub group (wc , lavatory , shower) stack A stack G	 6 6	2 2
Bath tub group (wc , lavatory , shower) stack B Branch 1 Branch 2	6 6 6	2 2 2

stack C, stack D ,stack E , stack F, stack H , stack I , stack J , stack K , stack L, stack M is similar to stack B.

Table 4.16dfu for second floor

Fixture unit	dfu value table 10-2 Horizontal branch	Diameter of pipe (inch) Table 10.4
Bath tub group (wc , lavatory , shower) stack A	6	2
stack G	6	2
Bath tub group (wc , lavatory , shower) stack B	6	2
Branch 1	6	2
Branch 2	6	2

stack C, stack D ,stack E , stack F ,stack H , stack I , stack J , stack K , stack L, stack M is similar to stack B**.**

Table 4.17 dfu for first floor

Fixture unit	dfu value table 10-2 Horizontal branch	Diameter of pipe (inch) Table 10.4
Bath tub group (wc , lavatory , shower) stack A	6	2
stack G	6	2
Bath tub group (wc , lavatory , shower) stack B	6	2
Branch 1	6	2
Branch 2	6	2

stack C, stack D ,stack E , stack F ,stack H , stack I , stack J , stack K , stack L, stack M is similar to stack B**.**

Table 4.18dfu for ground floor

Fixture unit	dfu value table 10-2 Horizontal branch	Diameter of pipe (inch) Table 10.4
Bath tub group (wc , lavatory , shower) stack K	6	2
Bath tub group (wc , lavatory , shower) stack F	6	2
Bath tub group (wc , lavatory , shower) stack I	6	2
Kitchen sink(general) Stack A	3	1 1/2

Table 4.19dfu for basement floor

Fixture unit	dfu value table 10-2 Horizontal branch	Diameter of pipe (inch) Table 10.4
Bath tub group (wc , lavatory , shower) stack G Branch 1 Branch 2	9 9	2 1/2 2 1/2
Bath tub group (wc , lavatory , shower) stack I Branch 1 Branch 2	16 16	3 3

Table 4.20 sizing of stack A

Stack A	Total dfu value horizontal branches	Diameter of Stack (inch) Table 10.4
From roof to fourth floor	6	2
From fourth floor to third floor	12	2 1/2
From third floor to second floor	18	3
From second floor to first floor	24	4
From first floor to ground floor	27	4

Table 4.21 sizing of stack G

Stack G	Total dfu value horizontal branches	Diameter of Stack (inch) Table 10.4
From roof to fourth floor	6	2
From fourth floor to third floor	12	2 1/2
From third floor to second floor	18	3
From second floor to first floor	24	4
From first floor to ground floor to basement floor	42	4

Table 4.22 sizing of stack B

Stack B	Total dfu value horizontal branches	Diameter of Stack (inch) Table 10.4
From roof to fourth floor	12	2
From fourth floor to third floor	24	2 1/2
From third floor to second floor	36	3
From second floor to first floor	48	4

stack H ,stack C ,stack D ,stack L ,stack E ,stack M ,stack F is similar to stack B.

Table 4.23 sizing of stack I

Stack I	Total dfu value horizontal branches	Diameter of Stack (inch) Table 10.4
From roof to fourth floor	12	2
From fourth floor to third floor	24	2 1/2
From third floor to second floor	36	3
From second floor to first floor	48	4
From first floor to ground floor	54	4
From ground floor to basement floor	86	4

Table 4.24 design of Branch slope of building

Branch of building drain from stack	Total dfu value from stacks	Diameter of building drain (inch) Table 10.4	Slope % table 10.5	Velocity ft/s table 10.1
Building drain A1 from stack A	27	4	1/8	1.93
Building drain B1 from stack B	48	4	1/8	1.93
Building drain C1 from stack C	48	4	1/8	1.93
Building drain D1 from stack D	48	4	1/8	1.93
Building drain E1 from stack E	48	4	1/8	1.93
Building drain F1 from stack F	48	4	1/8	1.93
Building drain G1 from stack G	42	4	1/8	1.93
Building drain H1 from stack H	48	4	1/8	1.93
Building drain I1 from stack I	86	4	1/8	1.93
Building drain J1 from stack J	48	4	1/8	1.93
Building drain K1 from stack K	48	4	1/8	1.93
Building drain L1 from stack L	48	4	1/8	1.93
Building drain M1 from stack M	48	4	1/8	1.93

for pipes with diameter ≤ 3" the minimum slope is ¼ inch/ft

for pipes with diameter ≥ 4" the minimum slope is 1/8 inch/ft

Recommendation for Velocities :

1.for branches , the recommended velocity is (2ft/s)

2.for building drains , the recommended velocity is (3ft/s)

3.for the pipes that will include the grease and oil the recommended velocity (4 ft/s)

The flow in vertical pipes (stacks) depends on :

- pipes size
- the amount of fluid (flow rate)
- velocity
- direction of the fluid entering the stacks
- pipe wall friction (roughness of the pipe wall)

velocity of water flow through drainage pipe depends on :

- pipe size
- slope

for pipes with diameter ≤ 3" the minimum slope is ¼ inch/ft

for pipes with diameter ≥ 4" the minimum slope is 1/8 inch/ft

CHAPTER 5

Fire Fighting

Fire fighting system:

Definition: a process in which substances combine chemically with oxygen from the air and typically give out bright light, heat, and smoke; combustion or burning.

Fire protection:

Definition: Fire protection is the study and practice of mitigating the unwanted effects of potentially destructive fires it involves the study of the behavior, compartmentalization, suppression and investigation of fire and its related emergencies.

:Fire Classification

Classes of Fire - A, B, C, D, and K

.Fires are classified by the types of fuel they burn

Class A

Class A Fires consist of ordinary combustibles such as wood, paper, trash or .anything else that leaves an ash. Water works best to extinguish a Class A fire

Class B

Class B Fires are fueled by flammable or combustible liquids, which include oil, gasoline, and other similar materials. Smothering effects which deplete the oxygen .supply work best to extinguish Class B fires

Class C

Class C Fires. Energized Electrical Fires are known as Class C fires. Always de-energize the circuit then use a non-conductive extinguishing agent. Such as Carbon .dioxide

Class D

Class D Fires are combustible metal fires. Magnesium and Titanium are the most common types of metal fires. Once a metal ignites do not use water in an attempt to extinguish it. Only use a Dry Powder extinguishing agent. Dry powder agents work by .smothering and heat absorption

Class K

Class K Fires are fires that involve cooking oils, grease or animal fat and can be extinguished using Purple K, the typical agent found in kitchen or galley .extinguishers

Fire fighting objective:

The objective is always to save lives and property. But innovative fire protection does more. It combines science and economics. A superior, environmentally friendly fire suppressant. Easier and more cost-effective installations. Advanced methods for protecting more challenging applications.

- **Types of Portable Firefighting Extinguishers**:

1) Foam: fire extinguishers extinguish the fire by taking away the heat element of the fire triangle. Foam agents also separate the oxygen element from the other elements.

   Water extinguishers are for Class A fires only - they should not be used on Class B or C fires. The discharge stream could spread the flammable liquid in a Class B fire or could create a shock hazard on a class C fire.

   Foam extinguishers can be used on Class A & B fires only. They are not for use on Class C fires due to the shock hazard.

2) Carbon Dioxide: Carbon dioxide fire extinguishers extinguish the fire by taking away the oxygen element of the fire triangle and also by removing the heatwith a very cold discharge. Carbon dioxide can be used on Class B & C fires. They are usually ineffective on Class A fires.

3) Clean agent extinguishers: Halogenated or Clean Agent extinguishers include the halon agents as well as the newer and less ozone depleting halocarbon agents. They extinguish the fire by interrupting the chemical reaction of the fire triangle.
4) Dry chemical extinguishers, hand and wheeled: fire extinguishers extinguish the fire primarily by interrupting the chemical reaction of the fire triangle
5) Wet chemical extinguishers: Wet Chemical is a new agent that extinguishes the fire by removing the heat of the fire triangle and prevents reigniting by creating a barrier between the oxygen and fuel elements and use in kitchen.
6) Dry Powder: extinguishers are similar to dry chemical except that they extinguish the fire by separating the fuel from the oxygen element or by removing the heat element of the fire triangle. .

Building featuring more than one occupancy may be protected on a room or area basis, with extinguishers appropriately placed for the occupancy. An example is a school, which would be expected to be protected with extinguishers rated for class hazards and light hazard occupancy, but also may contain a laboratory with a significant quantity of flammable liquid hazard, which would be protected by extinguishers rated for class B hazards and ordinary hazard occupancy.

Calculating the A-Rated extinguishers required

According to BS5306:8-2000 you should have no less than 26A (provided by 2 extinguishers) of fire protection per floor, where the floor area exceeds 100m². The A-Rating required for a single floor in a property can be calculated using the following formula:

A-Rating Required = Floor Area in M^2 X 0.065

The number of extinguishers required to cover this A-Rating can then be calculated as below: Extinguishers per floor

$$\text{Extinguishers per floor} = \frac{(\text{Floor Area } M^2 X\ 0.065)}{\textit{Extinguisher A Rating}}$$

The A-Rating of a fire extinguisher is printed onto the extinguisher body, as marked in Figure This will vary dependent on the size, make and type of extinguisher used see appendix B.

Fire hose cabinet.

A **firehose** is a high-pressure hose that carries water or other fire retardant (such as foam to a fire to extinguish it. Outdoors, it attaches either to a fire engine or a fire hydrant.

Indoors, it can permanently attach to building's standpipe or plumbing system. Hero invented it and based it on double action piston pump.

Consist of tow type:

- Hose reel a pipe which consists of rubber rolled on pulley having an arm witch use by regular people.

Figure 6. 2 fire hose

- Hose rack: a pipe which consists of Cloth-reinforced which usually use by Civil Defense Company.

Fire hose calculation and pump selection.

The pipe is manufacturing from the **steel.** We select pipe with diameter **D=4 inch** riser and branch is **D=4 inch** its loss coefficient

k=0.045 $* 10^{-3} m^3$

For riser 17.5 m Area (A)= $\frac{\pi D^2}{4} = \frac{\pi * 0.11^2}{4} = 0.009485 m^2$

Flow rate **($Q_{efectiv}$)**=100gpmwhich equal 0.00639 m^3

The velocity in the pipe defined in the equation:

$$V = \frac{Q}{A} = \frac{0.00639}{0.009485} = \mathbf{0.673\, m/s}$$

Reynolds number (Re):

μ_{water}@25°C=0.001

Re=$\frac{\rho V D}{\mu}$=$\frac{1000*0.673*0.11}{0.001}$=74030

$\frac{k}{D}$=$\frac{0.045}{11.02} = 0.004015$

from mody chart the friction factor (f)=0.03

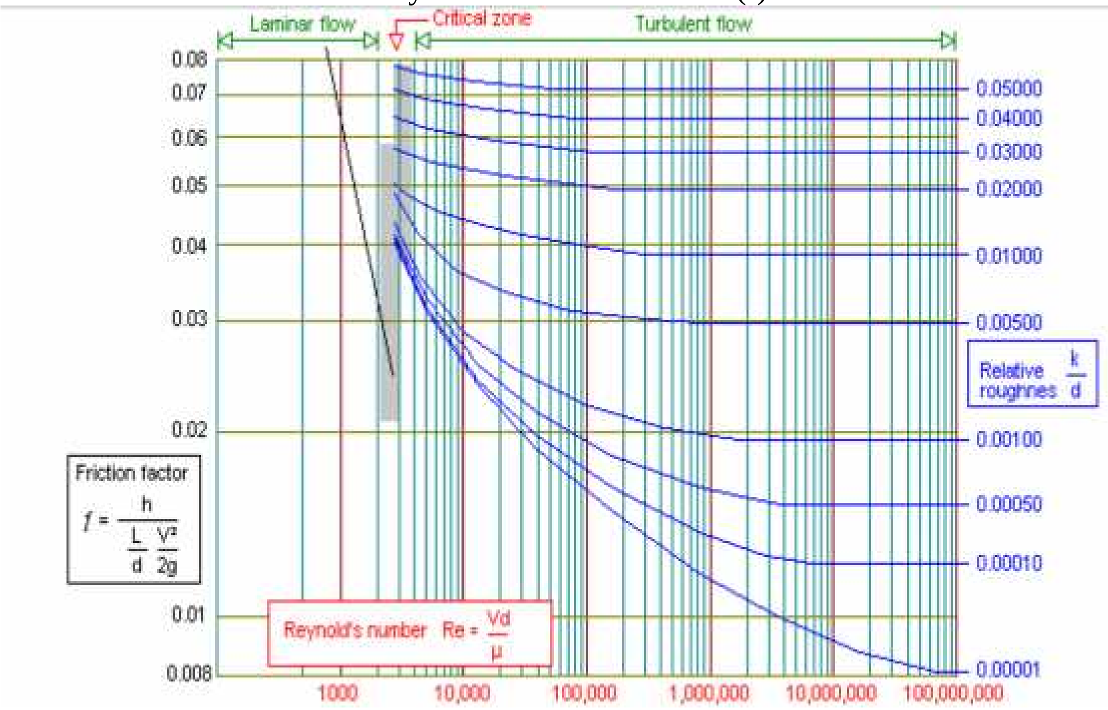


Figure 6.3 moody chart

Head loss:

$h_{fr} = \frac{flV^2}{2gd} = \frac{0.026*17.5*0.35^2}{2g*0.1524} = 0.113m$

The same calculation on branch we find $h_{fp} = 0.102$ m

Major $\boldsymbol{h_f} =$0.113 +0.102= 0.215 m.

Miner losses hf (fitting), Equivalent length (in meters) of straight pipe for fittings like bends, returns tees and valves. From Table of equivalent length Table 6.1 see appendix B

We use 4 regular 90 deg tow sex inch and one four inch and one 1.5.

H_F = 2*2.7+1.8+0.7 =7.9 m losses

Total h losses = h major + h miner =0.215+7.9=8.115 m.

Factor of safety = 8.115*1.15= 9.33

Turn it into pressure P= 9.81*1000*9.33=91549.37 Pascal .

P loss =0.915bar

Total pressure = pressure require + pressure loss = 4.5+0.915=5.5 bar

And we go to the web site https://rcwapp.xyleminc.com/fp_select.asp.

Selections of other firefighting system components

1. Fire hose :

   We need a hose length of 30 meter.

   Selection : kiddeModel 31A.

2. Pump:

   Xylem Model 2.5X2.5X7F electric pumps.

Xylem Model 3X2X11F-S diesel pump.

Peerless Model J - J65F jockey pump.

3. Fire Extinguishers:

   Wet Chemical Extinguishers.

   HCFC Extinguishers.

   Carbone dioxide.

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[3] Amell.N.1996, Plumbing System, 1st edition

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APPENDIX (A)

Table(1)

TABLE 6–2 Values of infiltration air coefficient K.[2] for windows.

Window Type	Infiltration Air Coefficient K		
	Average	Minimum	Maximum
Sliding			
Iron	0.36	0.25	0.40
Aluminum	0.43	0.25	0.70
Hung			
Iron	0.25	0.10	0.60
Aluminum (side pivoted)	0.36	0.07	0.70
Aluminum (horizontal pivoted)	0.30	0.07	0.50
PVC	0.10	0.03	0.15

Table (2)

TABLE 6–4 Values of the factor S_2 of Eq. (6–7).

Location Class	Class 1			Class 2			Class 3			Class 4		
Building Height, m	A	B	C	A	B	C	A	B	C	A	B	C
3	0.47	0.52	0.56	0.55	0.60	0.64	0.63	0.67	0.72	0.73	0.78	0.83
5	0.50	0.55	0.60	0.60	0.65	0.70	0.70	0.74	0.79	0.78	0.83	0.88
10	0.58	0.62	0.67	0.69	0.74	0.78	0.83	0.88	0.93	0.90	0.95	1.00
15	0.64	0.69	0.74	0.78	0.83	0.88	0.91	0.95	1.00	0.94	0.99	1.03
20	0.70	0.75	0.79	0.85	0.90	0.95	0.94	0.98	1.03	0.96	1.01	1.06
30	0.79	0.85	0.90	0.92	0.97	1.01	0.98	1.03	1.07	1.00	1.05	1.09
40	0.89	0.93	0.97	0.95	1.00	1.05	1.01	1.06	1.10	1.03	1.08	1.12
50	0.94	0.98	1.02	1.00	1.04	1.08	1.04	1.08	1.12	1.06	1.10	1.14
60	0.98	1.02	1.05	1.02	1.06	1.10	1.06	1.10	1.14	1.08	1.12	1.15
80	1.03	1.07	1.10	1.06	1.10	1.13	1.09	1.13	1.17	1.11	1.15	1.18
100	1.07	1.10	1.13	1.09	1.12	1.16	1.12	1.16	1.19	1.13	1.17	1.20
120	1.10	1.13	1.15	1.11	1.15	1.18	1.14	1.18	1.21	1.15	1.19	1.22
140	1.12	1.15	1.17	1.13	1.17	1.12	1.16	1.19	1.22	1.17	1.20	1.24
160	1.14	1.17	1.19	1.15	1.18	1.21	1.18	1.21	1.24	1.19	1.22	1.25
180	1.16	1.19	1.20	1.17	1.20	1.23	1.19	1.22	1.25	1.20	1.23	1.26
200	1.18	1.21	1.22	1.18	1.21	1.24	1.21	1.24	1.26	1.21	1.24	1.27

Table(3)

TABLE 5–4 Overall Heat Transfer Coefficient for Windows, W/m²·°C

Material Type and Frames	Wind Speed, m/s					
	Single Glass			Double Glass, 6mm air gap		
	< 0.5	0.5 - 5.0	> 5.0	< 0.5	0.5 - 5.0	> 5.0
Wood	3.8	4.3	5.0	2.3	2.5	2.7
Aluminum	5.0	5.6	6.7	3.0	3.2	3.5
Steel	5.0	5.6	6.7	3.0	3.2	3.5
PVC	3.8	4.3	5.0	2.3	2.5	2.7

TABLE 7–8 Performance and technical data for commercial cast iron boilers of low and medium heating capacities (Selected from different manufacturers catalogues).

Output kW	No. of Sections	Water Content Liter	Mass kg	Depth mm
Low Heating Capacity Boilers				
26	4	17	140	520
34	5	21	160	520
42	6	25	190	686
50	7	29	210	686
56	8	33	245	686
Medium Heating Capacity Boilers				
49	4	32	280	510
64	5	40	330	615
79	6	47	380	720
91	7	55	430	825
110	8	62	480	930
128	9	70	530	1,035
139	10	77	580	1,140

Table(4)

Table (5)

Table 10.1 Approximate Discharge Rates and Velocities[a] in Sloping Drains Flowing Half Full[b]

Actual Inside Diameter of Pipe, in.	1/16 in./ft Slope		1/8 in./ft Slope		1/4 in./ft Slope		1/2 in./ft Slope	
	Discharge, gpm	Velocity, fps	Discharge, gpm	Velocity, fps	Discharge, gpm	Velocity, fps	Discharge, gpm	Velocity, fps
1¼							3.40	1.78
1⅜					3.13	1.34	4.44	1.90
1½					3.91	1.42	5.53	2.01
1⅝					4.81	1.50	6.80	2.12
2					8.42	1.72	11.9	2.43
2½			10.8	1.41	15.3	1.99	21.6	2.82
3			17.6	1.59	24.8	2.25	35.1	3.19
4	26.70	1.36	37.8	1.93	53.4	2.73	75.5	3.86
5	48.3	1.58	68.3	2.23	96.6	3.16	137.	4.47
6	78.5	1.78	111.	2.52	157.	3.57	222.	5.04
8	170.	2.17	240.	3.07	340.	4.34	480.	6.13
10	308.	2.52	436.	3.56	616.	5.04	872.	7.12
12	500.	2.83	707.	4.01	999.	5.67	1413	8.02

Table(6)

Table 10.4 Horizontal Fixture Branches and Stacks

Diameter of Pipe, in.	*Maximum Number of Fixture Units That May Be Connected to*			
			Stacks with More Than Three Branch Intervals	
	Any Horizontal Fixture Branch,[a] dfu	One Stack of Three Branch Intervals or Less, dfu	Total for Stack, dfu	Total at One Branch Interval, dfu
1½	3	4	8	2
2	6	10	24	6
2½	12	20	42	9
3	20[b]	48[b]	72[b]	20[b]
4	160	240	500	90
5	360	540	1100	200
6	620	960	1900	350
8	1400	2200	3600	600
10	2500	3800	5600	1000
12	3900	6000	8400	1500
15	7000			

Table (7)

North Latitude Wall Facing	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Hour of Max. CLTD	Min. CLTD	Max. CLTD	Difference CLTD
	Solar Time *h*																											
NW	14	13	12	11	10	9	8	7	6	6	5	5	6	6	6	7	9	10	12	14	15	15	15	15	22	5	15	10
	Group D Walls																											
N	8	7	7	6	5	4	3	3	3	3	4	4	5	6	6	7	8	9	10	11	11	10	10	9	21	3	11	8
NE	9	8	7	6	5	5	4	4	6	8	10	11	12	13	13	13	14	14	14	13	13	12	11	10	19	4	14	10
E	11	10	8	7	6	5	5	5	7	10	13	15	17	18	18	18	18	18	17	17	16	15	13	12	16	5	18	13
SE	11	10	9	7	6	5	5	5	5	7	10	12	14	16	17	18	18	18	17	17	16	15	14	12	17	5	18	13
S	11	10	8	7	6	5	4	4	3	3	4	5	7	9	11	13	15	16	16	16	15	14	13	12	19	3	16	13
SW	15	14	12	10	9	8	6	5	5	4	4	5	5	7	9	12	15	18	20	21	21	20	19	17	21	4	21	17
W	17	15	13	12	10	9	7	6	5	5	5	5	6	6	8	10	13	17	20	22	23	22	21	19	21	5	23	18
NW	14	12	11	9	8	7	6	5	4	4	4	4	5	6	7	8	10	12	15	17	18	17	16	15	22	4	18	14

Table (8)

TABLE 9-2 Latitude-Month correction factor LM, as applied to walls and horizontal roofs, north latitudes.

Lat.	Month	N	NNE NNW	NE NW	ENE WNW	E W	ESE WSW	SE SW	SSE SSW	S	Horizontal Roofs
16	December	−2.2	−3.3	−4.4	−4.4	−2.2	−0.5	2.2	5.0	7.2	−5.0
	Jan./Nov.	−2.2	−3.3	−3.8	−3.8	−2.2	−0.5	2.2	4.4	6.6	−3.8
	Feb./Oct.	−1.6	−2.7	−2.7	−2.2	−1.1	0.0	1.1	2.7	3.8	−2.2
	Mar/Sept.	−1.6	−1.6	−1.1	−1.1	−0.5	−0.5	0.0	0.0	0.0	−0.5
	Apr./Aug.	−0.5	0.0	−0.5	−0.5	−0.5	−1.6	−1.6	−2.7	−3.3	0.0
	May/July	2.2	1.6	1.6	0.0	−0.5	−2.2	−2.7	−3.8	−3.8	0.0
	June	3.3	2.2	2.2	0.5	−0.5	−2.2	−3.3	−4.4	−3.8	0.0
24	December	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	1.1	5.0	6.6	−9.4
	Jan./Nov.	−2.2	−3.3	−4.4	−5.0	−3.3	−1.6	−1.6	5.0	7.2	−6.1
	Feb./Oct.	−2.2	−2.7	−3.3	−3.3	−1.6	−0.5	1.6	3.8	5.5	−3.8
	Mar/Sept.	−1.6	−2.2	−1.6	−1.6	−0.5	−0.5	0.5	1.1	2.2	−1.6
	Apr./Aug.	−1.1	−0.5	0.0	−0.5	−0.5	−1.1	−0.5	−1.1	−1.6	0.0
	May/July	0.5	1.1	1.1	0.0	0.0	−1.6	−1.6	−2.7	−3.3	0.5
	June	1.6	1.6	1.6	0.5	0.0	−1.6	−2.2	−3.3	−3.3	0.5
32	December	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	1.1	5.0	6.6	−9.4
	Jan./Nov.	−2.7	−3.8	−5.0	−6.1	−4.4	−2.2	1.1	5.0	6.6	−8.3
	Feb./Oct.	−2.2	−3.3	−3.8	−4.4	−2.2	−1.1	2.2	4.4	6.1	−5.5
	Mar/Sept.	−1.6	−2.2	−2.2	−2.2	−1.1	−0.5	1.6	2.7	3.8	−2.7
	Apr./Aug.	−1.1	−1.1	−0.5	−1.1	0.0	−0.5	0.0	5.0	0.5	−0.5
	May/July	0.5	0.5	0.5	0.0	0.0	−0.5	−0.5	−1.6	−1.6	0.5
	June	0.5	1.1	1.1	0.5	0.0	−1.1	−1.1	−2.2	−2.2	1.1

Table (9)

TABLE 5–5 Overall heat transfer coefficients for wood and metal doors, W/m^2·°C.

Door Type	Without Storm Door	With Wood Storm Door	With Metal Storm Door
25 mm-wood	3.6	1.7	2.2
35 mm-wood	3.1	1.6	1.9
40 mm-wood	2.8	1.5	1.8
45 mm-wood	2.7	1.5	1.8
50 mm-wood	2.4	1.4	1.7
Aluminum	7.0	—	—
Steel	5.8	—	—
Steel with:			
Fiber core	3.3	—	—
Polystyrene core	2.7	—	—
Polyurethane core	2.3	—	—

Table (10)

TABLE 5–4 Overall Heat Transfer Coefficient for Windows, W/m²·°C

Material Type and Frames	Wind Speed, m/s					
	Single Glass			Double Glass, 6mm air gap		
	< 0.5	0.5 - 5.0	> 5.0	< 0.5	0.5 - 5.0	> 5.0
Wood	3.8	4.3	5.0	2.3	2.5	2.7
Aluminum	5.0	5.6	6.7	3.0	3.2	3.5
Steel	5.0	5.6	6.7	3.0	3.2	3.5
PVC	3.8	4.3	5.0	2.3	2.5	2.7

Table (11)

TABLE 9-16 Cooling load factor due to occupants $(CLF)_{occ}$, for sensible heat gain.[5]

Hours after each entry into space	Total hours in space							
	2	4	6	8	10	12	14	16
1	0.49	0.49	0.50	0.51	0.53	0.55	0.58	0.62
2	0.58	0.59	0.60	0.61	0.62	0.64	0.66	0.70
3	0.17	0.66	0.67	0.67	0.69	0.70	0.72	0.75
4	0.13	0.71	0.72	0.72	0.74	0.75	0.77	0.79
5	0.10	0.27	0.76	0.76	0.77	0.79	0.80	0.82
6	0.08	0.21	0.79	0.80	0.80	0.81	0.83	0.85
7	0.07	0.16	0.34	0.82	0.83	0.84	0.85	0.87
8	0.06	0.14	0.26	0.84	0.85	0.86	0.87	0.88
9	0.05	0.11	0.21	0.38	0.87	0.88	0.89	0.90
10	0.04	0.10	0.18	0.30	0.89	0.89	0.9	0.91
11	0.04	0.08	0.15	0.25	0.42	0.91	0.91	0.92
12	0.03	0.07	0.13	0.21	0.34	0.92	0.92	0.93
13	0.03	0.06	0.11	0.18	0.28	0.45	0.93	0.94
14	0.02	0.06	0.10	0.15	0.23	0.36	0.94	0.95
15	0.02	0.05	0.08	0.13	0.20	0.30	0.47	0.95
16	0.02	0.04	0.07	0.12	0.17	0.25	0.38	0.96
17	0.02	0.04	0.06	0.10	0.15	0.21	0.31	0.49
18	0.01	0.03	0.06	0.09	0.13	0.19	0.26	0.39

TABLE 4-2 Instantaneous heat gain from occupants in units of Watts[a].

Type of Activity	Typical Application	Total Heat Dissipation Adult Male	Total Adjusted[b] Heat Dissipation	Sensible Heat, W	Latent Heat, W
Seated at rest	*Theater:*				
	Matinee	111.5	94.0	64.0	30.0
	Evening	111.5	100.0	70.0	30.0
Seated, very light work	Offices, hotels, apartments, restaurants	128.5	114.0	70.0	44.0
Moderately active office work	Offices, hotels, apartments	135.5	128.5	71.5	57.0
Standing, light work, walking	Department store, retail store, supermarkets	157.0	143.0	71.5	71.5
Walking, seated	Drug store	157.0	143.0	71.5	71.5
Standing, walking slowly	Bank	157.0	143.0	71.5	71.5
Sedentary work	Restaurant	168.5	157.0	78.5	78.5
Light bench work	Factory	238.0	214.0	78.0	136.0
Moderate work	Small-Parts assembly	257.0	243.0	87.0	156.0
Moderate dancing	Dance halls	257.0	243.0	87.0	156.0
Walking at 1.5 m/s	Factory	286.0	285.0	107.0	178.0
Bowling (participant)	Bowling alley	428.5	414.0	166.0	248.0
Heavy work	Factory	428.5	414.0	166.0	248.0

Figure (2)

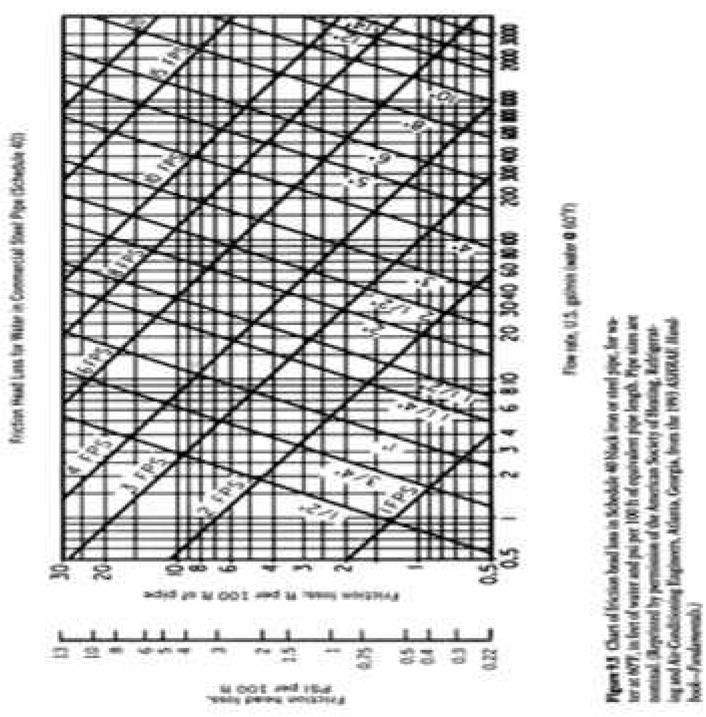
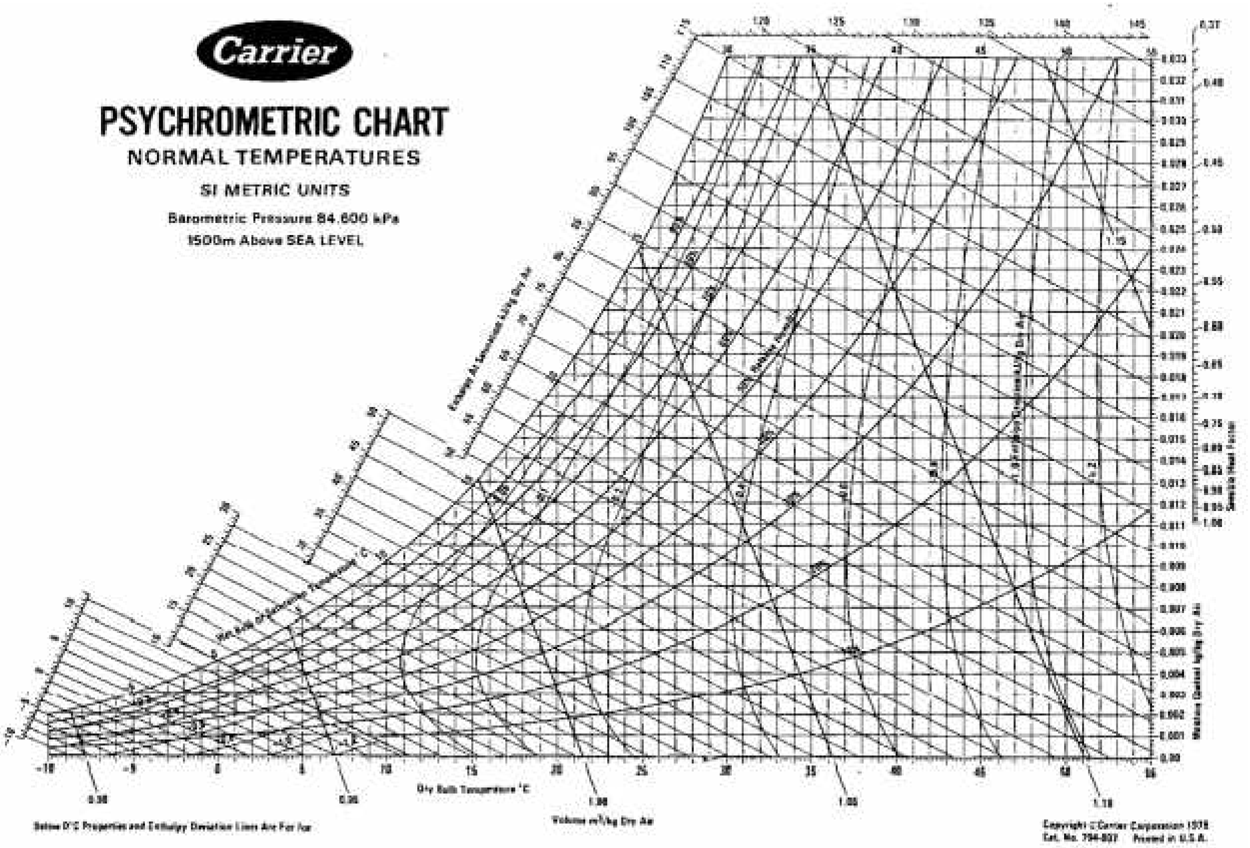


Figure (1)


Carrier
PSYCHROMETRIC CHART
NORMAL TEMPERATURES
SI METRIC UNITS
Barometric Pressure 84.600 kPa
1500m Above SEA LEVEL

pump of chiller