بسم الله الرحمن الرحيم

Palestine Polytechnic University

Collage of Engineering & Technology
Mechanical Engineering Department

Graduation Project

Mechanical systems design for a hotel is committed to green building standards

Project team

Mohammad Sweity **Jihad Shalaldeh**

Project Supervisor :

Dr. Ishaq Sider

Hebron – Palestine

2011

Palestine Polytechnic University
(PPU)

Hebron-Palestine

Mechanical systems design for a hotel is committed to green building standards

Project Team

Mohammad Sweity Jihad Shalaldeh

According to the project supervisor and according to the agreement of the Testing committee members, this project is submitted to the Department of Mechanical Engineering at college of engineering and technology in partial fulfillment of the requirements of (B.A) the bachelor's degree.

Department Head Signature

Name: ____________

Supervisor Signature

Name: ________________

Supervisor Signature

Name: ___________________

May- 2011

Dedication

To our parents and families ...

To our supervisor Dr. Ishaq sider…

To our instructors and colleagues…

To our friends ….

To whom their guidance and support made this work possible …

To who carry candle of science to light his avenue to live…

Acknowledgements

Our thanks firstly to our supervisor Dr. Ishaq sider .He guides and support until made this work possible. His constant encouragement, intuitive wisdom , and resolute leadership were instrumental in completing this work .

Our wishes and thanks to Eng. Mohammad Awad and Eng . Kazem Osaily . And this work would not exist without their inspiration .

Thanks for every one helped to made this work successful.

And finally , our ultimate thanks to all lecturers, doctors, engineers, and to the great edifice of science, (Palestine Polytechnic University), for their effort and guidance which helped building characters to become successful engineers .

Abstract

يهدف هذا المشروع إلى تصميم الخدمات الميكانيكية لفندق سياحي ملتزم بمعاير الأبنية الخضراء. يتكون الفندق من ٩ طوابق بمساحة إجمالية مع الساحات الخارجية تقدر ب ٣٨ دونما يشتمل على تصميم شبكات المياه وشبكات الصرف الصحي و تسخين المياه عن طريق الطاقة الشمسية و نظام تكييف الهواء موفر للطاقة. ويتعلق المشروع بتصميم نظام إخماد الحريق و شبكات الغاز و نظام الري حول المبنى.

This project aims to design of mechanical systems for a tourist hotel that is consists of 9 floors and total area committed to green building standard. The hotel about 38 acres, the design include water networks, Sewage system water heating by solar energy, energy-saving air conditioning system. Also the project concerns design of fire fighting system, Gas networks and the irrigation system around the building.

Table of contents

List of Tables

List of figure

CHAPTER ONE

INTRODUCTION

1.1 Project Background

Human still thinking how to improve his life to be easy so as to be better, this is the reason of spread industry and technology, and life became more easier than previous mode.

So HVAC engineers developing the heating and ventilation air conditioning engineering and mechanical services technology in buildings to attainment the comfort for human without affect on the environment or abandon pollutions on atmosphere .
In this project we would design mechanical services for a hotel located in hebron city in Palestine and is committed to green building standards .

1.2 Project Scope

The scope of the project is to develop a green buildings in my Arabic countries to prevent the increase a percentage of global warming This includes the following main topics:

1. Design variable refrigerant volume air conditioning system
2. Design heating system for water depends on the solar energy by using a solar collectors.
3. We use two systems for sewage disposal system; the first is gray water system this means the wastewater with minor pollution discharged from bathtubs , sinks , lavatories , dishwashers , and washing machines , the second system is black water system , this means wastewater with major pollution from toilets and urinals .
4. Design of irrigation systems for all trees and Greenland around a hotel .
5. Providing the HVAC engineers with important information that said “the HVAC engineer accountable to protect the environment from pollution”
6. Creating bridges between engineering education and the society.

1.3 Project Goals and Objectives.

The overall aim of the project is to develop mechanical services design in hotels in Palestine , and the aim objective is:

1. Design variable refrigerant volume air conditioning system.
2. Applying the HVAC engineering principles in the project.
3. Design fire alarm and fighting system for building.
4. Design supply water system and waste water system for building.
5. Design gas piping for building .
6. Design heating system of water for building by using solar energy.
7. Design of irrigation systems for all trees and Greenland around a hotel.
8. Draw the all last services mechanical on AutoCAD program in detail .

1.4 Project Choice Justification.

1. This project will create sufficient experience for the student, which would assist them in having an employment opportunity after graduation.
2. Such a project provides the opportunity to apply what have been studied in five years in the engineering collage.
3.The availability of obtaining funds from computer soft ware prushing the required project component.

1.5 Project Implementation Plan.

This project intended to sustain a high level of scientific value, however, the project has got tasks, goals and objectives, in addition to the time table, thus when they are achieved; and then the project has accomplished that level.

1.6 Main Tasks and Activities .

The main tasks for the first semester include:

1. Reviewing and studying the thermodynamic and HVAC and fire alarm system and mechanical systems for architects and principle of irrigation and practice , solar energy and environment books .
2. Visiting some buildings such as Alahli hospital in Hebron city and collecting important data about mechanical services design.
3. Studying program software in HVAC design.

In the second semester, the following tasks are planned:

1. Design fire alarm and fighting system for building.
2. Design supply water system and waste water system for building.
3. Design solar heating water system for building .
4. Design gas piping system for building .
5. Design of irrigation systems for all trees and Greenland around a hotel
6. Draw the all last services mechanical on AutoCAD program in detail .
7. Learning a new computer program such as duct size software and carrier software or other computer program that can be used for this purpose.
8. Preparing documentation, summarizing the results and recommendations, and making presentation about the project.

1.7 Time Table.

The time table for the second semester is illustrated in (Table 1.1)

Table 1.1: The time table for 2nd semester

Objective	Week #															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Estimate goals of project	■	■	■	■												
Planning and Setting Project Concepts and Goals					■	■	■									
Establishing Scientific Background							■	■	■	■	■	■	■			
studying the mechanical Services books										■	■	■	■	■		
Visiting some buildings And some engineer												■	■	■	■	
analyzing data											■	■	■	■	■	
HVAC calculation														■	■	
Writing Report									■	■	■	■	■	■	■	
Presentation																■

1.8 Hotel Description.

The hotel is situated in Hebron city in west bank in Palestine and consists of nine stories ; basement , ground , first , second , third , fourth , fifth, sixth , and seventh floor , and the total area of hotel floors with surrounding area is about 38000 m² .and it contains the following departments such as maintenance, food, laundry, stores, and offices, refrigeration stores ,kitchens ,Bakery, Apartments, Suites, Massage room , computer center, Staff dining, swimming pools and others .

1.9 second semester budget.

The budget for the second semester is illustrated in (Table 1.2).

Table 1.2: The budget for 2nd semester

Task	Cost(NIS)
Using Internet	90
Printing Papers	1000
Reprinting Paper	500
Buying Books	40
Total	1640

1-10 Contents of The Project

This proposal contain seven chapters and are distributed as following:-

Chapter One:- Introduction

Includes the overview about project , project objectives.

Chapter Two:- Air Conditioning System

Includes an overview about HVAC system ,VRV system and heating load calculation procedures .

Chapter three:- Design of Special Hazard And Fire Alarm System.

Includes an overview about special hazard and fire alarm system

Chapter Four:- Plumbing System

Include overview about plumbing systems ,water distribution system(cold and hot water), and how potable water should be reached inside hotel by using suitable pipes .

Chapter five :- **Localized Irrigation**

Includes an overview about principle of sprinkler irrigation and drip irrigation.

Chapter Six :- **Gas Piping Design**

Includes an overview about gas piping design method.

CHAPTER TWO

AIR CONDITIONIN SYSTEM USING (VRV) SYSTEM

2.1 Introduction:

The main objective of air conditioning is to maintain the environment in enclosed spaces at conditions that induce the feeling of comfort to all occupants of the spaces . this feeling of comfort is influenced by a number of air related parameters which are the temperature inside the conditioned space ,humidity ,air motion and its speed and the air purity .
The purity of air and its quality include the absence of odors ,toxic, and suspended particles ,such as dust and dirt .

In selecting a suitable air conditioning system for a particular application , consideration should also be known as following:-

- System constraints : Cooling load, Zoning requirements, Heating and ventilation
- Architectural Constraints : Size and appearance of terminal devices, acceptable noise level, Space available to house equipment and its location relative to the conditioned space, acceptability of components obtruding into the conditioned space
- Financial Constraints : Capital cost, Operating cost, Maintenance cost

2.2 variable refrigerant volume system .

2.2.1 introduction about VRV:

VRV is variable control of capacity by inverter, refrigerant volume can be controlled or modulating by electronic expansion valve, VRV system can control each zone alone with regard to other spaces, A variation of this system, often referred to as a multisplit, includes multiple indoor units connected to a single condensing unit.

This system also ductless which means heat is transferred to or from the space directly by circulating refrigerant to evaporators located near or within the conditioned space . In contrast, conventional systems transfer heat from the space to the refrigerant by circulating air (in ducted systems) or water (in chillers) throughout the building.

2.2.2 VRV Benefits

VRF systems have several key benefits, including:

• **Installation Advantages.** Chillers often require cranes for installation, but VRF systems are light weight and modular. Each module can be transported easily and fits into a standard elevator. Multiples of these modules can be used to achieve cooling capacities of hundreds of tons. Each module (or set of two) is an independent refrigerant loop, but they are controlled by a common control system.

An additional installation advantage is that the piping connections between outdoor and indoor unit have total length of (1000 m), which is make the system applicable in large and higher buildings , and the number of indoor unit that connected to one outdoor unit reaches to (64) .

• **Maintenance and Commissioning**

VRV systems with their standardized configurations and sophisticated electronic controls are aiming toward near plug-and-play commissioning.

Because they are DX systems, maintenance costs for a VRV should be lower than for water-cooled , chillers, so water treatment issues are avoided. Normal maintenance for a VRV, similar to that of any DX system, consists mainly of changing filters and cleaning coils.

• **Comfort.** Many zones are possible, each with individual setpoint control. Because VRF systems use variable speed compressors with wide capacity modulation capabilities, they can maintain precise temperature control, generally within ±1°F (±0.6°C), according to manufacturers' literature.

• **Energy Efficiency.** The energy efficiency of VRV systems derives from several factors. The VRV essentially eliminates duct losses, which are often estimated to be between 10% to 20% of total airflow in a ducted system. VRV systems typically include two to three compressors, one of which is variable speed, in each condensing unit, enabling wide capacity modulation. This approach yields high part-load efficiency, which translates into high seasonal energy efficiency, because HVAC systems typically spend most of their operating hours in the range of 40% to 80% of maximum capacity, so through using inverter technology and control of each zone seperatly the operating cost be lower with using modulating valve that control the amount of flowing refrigerent with changing load .

2.2.3 Applications

VRV systems are generally best suited to buildings with diverse, multiple zones requiring individual control, such as office buildings, hospitals, or hotels. A VRV system does not compete well with rooftop systems in a large low-rise building such as a big box retail store. Although VRF heat pumps operate at ambient temperatures as low as 0°F (–18°C), as in all heat pumps, their efficiency drops off considerably at low temperatures, so they are less cost effective compared to gas heating in very cold climates.

2.3 heating and cooling load :

heating load: it is in winter and it is the rate at which heat must be added to the space in order to maintain the desired conditions in the space.
cooling load: it is in summer and it is the rate at which heat must be removed from space in order to maintain the desired conditions in the space.

2.4 cooling load sources:

The cooling loads for a given space consist of the following heat gains:

(1) Heat gains that transmitted through building structures such as walls, floors and ceiling that are adjacent to unconditioned spaces .The heat transmitted is caused by temperature difference that exists on both sides of structures.

(2) Heat gain due to solar effect which include:

(a) Solar radiation transmitted through the glass and absorbed by inside surfaces and furniture.

(b) Solar radiation absorbed by walls, glass windows, glass doors and roofs that are exposed to solar radiation

(3) Sensible and latent heat gains brought into the space as a result of infiltration of air through windows and doors.

(4) Sensible heat produced in space by lights, appliances, motors and other miscellaneous heat gains(not calculated, added to the factor of safety).

(5) Latent heat produced from cooking, hot baths, (not calculated ,added to the factor of safety).

(6) Sensible and latent heat produced by occupants(not calculated ,added to the factor of safety)

The heating load sources that affect on the air conditioning system design can be made-up of many components, including the follow:

2.4.1 Solar Radiation:

Solar radiation received at the earth's surface on a plane perpendicular to the sun rays may reach at hourly value 900 W/m² on a clear day. This value of solar radiation intensity occurs when the sun is directly over head. Solar radiation intensity decreases as the suns angle of altitude α, decreases. The altitude angle is the angle that the sun rays make with horizontal line in a vertical plane.

Time of the day and altitude of the location are also factors that affect the direct radiation.

2.4.2 Heat gain through sunlit walls and roofs:

Direct and diffused solar radiation that is absorbed by walls and roofs resulting in raising the temperature of these surfaces. Amount of radiation absorbed by walls and roofs depend upon the time of the day, building orientation, type of wall construction and presence of shading.

The calculation of this type of heat gain can be obtained by using the following relation for the heat transmission through the walls.

$$U = \frac{1}{\sum_{n=1}^{i} R_{Th}} = \frac{1}{R_1 + R_2 + \dots + Ri}$$

Where R_{Th} are the thermal resistances of the various sections [m².c°/w.]

The transmitted heating load can be calculated from the relation:

$Q = U \times A \times \Delta T$

→Where:

Q: Heat flow through the walls, ceiling, floor, by conduction. (Watt)

U: Over all heat transfer coefficient ($W/m^2.K$).

A: is the effective Area that heat transmitted through it (m^2).

ΔT: the total equivalent temperature difference which take in consideration the increase of wall temperature due to Absorption of solar radiation.

But in cooling load the value of ΔT is called cooling load temperature difference (CLTD) , and can be obtained for roofs from specials tables .

The value CLTD extracted from (Table[A-8,A-13,A-18] Appendix A) needs to be corrected so that the actual value is found for different cases, and hence it will be called corrected CLTD and can be calculated from the following equation

$(CLTD)_{corr} = (CLTD + LM) K + (25.5 - T_i) + (T_{o,m} - 29.4) f$

→Where:

LM: Latitude correction factor which can obtain from table (3.2 Appendix A) for horizontal and vertical surfaces .

K: color adjustment factor such that k=1.0 for dark colored roof, and k=0.65 for permanently light colored roofs.

$(25.5-T_i)$: a correction factor for indoor design temperature where Ti is The room design temperature °c

$(T_{o,m} - 29.4)$: a correction factor for outdoor mean temperature $T_{o,m}$

It is related to the out door design temperature $T_{o,m}$ according to the relation:

$T_{o,m} = T_o - DR/2$

DR: the daily temperature range which equal to the difference between the Average maximum and Average minimum temperature for the Warmest month of the summer season.

F : attic or roof fan factor such that f=1.0 if there is no attic or roof fan , f = 0.75 if there is an attic or roof fan.

Over all heat transfer coefficient depends on the layers which the building is consist of and the indoor and outdoor convection heat transfer coefficient.

So Over all heat transfer coefficient can be calculated by applying the following equation:

$$U = \frac{1}{\frac{1}{hfin} + \sum \frac{\Delta x}{k} + \frac{1}{hf_{out}}}$$

→Where:

U: Over all heat transfer coefficient (W/m².K).

K: conduction heat transfer coefficient (W/m .K).

x: Layer thickness (m).

h_{fin}: Indoor convection heat transfer coefficient (W/m².K).

h_{fout}: Outdoor convection heat transfer coefficient (W/m².K).

2.4.3 Heat transfer through glass:

Solar radiation which falls on glass has three components which are:

(1) Transmitted component: it represents the largest component, which is transmitted directly into the interior of the building or the space. This component represents about 42 to 87% of incident solar radiation, depending on the glass transmissibility value.

(2) Absorbed component: This component is absorbed by the glass itself and raises its temperature. About 5 to 50% of solar radiation is absorbed by the glass depending on the absorptive value of glass

(3) Reflected component: This component is reflected by glass to the outside of the building. About 8% of the solar energy is reflected back by the glass

The amount of solar radiation that can be transmitted through glass depends upon the following factor:

(1) Type of glass. (Single, double or insulation glass)

(2) Availability of shading (such as drapes, Venetian blinds, construction overhang, wing walls, etc)

(3) Time of the day

(4) Orientation of glass area (north, northeast, east orientation, etc)

(5) Solar radiation intensity and incident angle

(6) Latitude angle of the location.

2.4.3.1 Transmission Heat Gain:

Heat gain due to solar transmission through glass windows and doors is estimated by using special tables where the following factors are selected:

(a) Solar heat gain factor (SHG): this factor represents the amount of solar energy that would be received by floor, furniture and the inside walls of the room and can be extracted from (table [A-9] Appendix A) .

(b) Shading coefficient (SC): this factor accounts for different shading effects of the glass wall or window and can be extracted from special tables for single and double glass without inside shading or for single and double glass as well as for insulating glass with internal shading from (table [A-10,A-11] Appendix A).

(c) Cooling load factor (CLF): this represent the effects of the internal walls, floor, and furniture on the instantaneous cooling load, and can be extracted from (table [A-19, A-20 Appendix A) for glass without interior shading or from others table for glass with interior shading.

The transmitted cooling load can be calculated from the relation :

$Q_{tr} = A\,(SHG)\,(SC)\,(CLF)$

2.4.3.2 Convection Heat Gain:

The value of the convection heat gain by the glass can be calculated from the equation :

Q conv. = U*A *(CLTD) corr

Where : CLTD is the temperature difference for the glass and can be extracted from table(3.8 Appendix A). its designed for inside room temperature of 25.5°C and outside mean temperature of 29.4°C if room temperature is different from 25.5°C then the difference (25.5-Ti) will be added to the value of CLTD. On the other hand if (To, m -29.4) is different from 29.4°C then a correction value of (To, m -29.4) is used.

2.4.4 Heating Gain Due To Equipment:

Sensible and latent heat loads arising from various equipment and appliances that are installed in a conditioned space. The indicated heat dissipation rates from such equipments and appliances should be inclined when the cooling load is estimated. Care must be taken when considering such dissipation rates all sensible or latent or partly sensible and partly latent.

2.4.5 Heating Gain Due To Lights:

Heat gains due to light are sensible loads. Such loads must be carefully analyzed specially for supermarkets, department stores and other commercial applications that are usually brightly illuminated. The peak lighting heat gains for some application such as hospitals, restaurants and office will not occur simultaneously with the peak heat gain from other source. This fact should be considered when calculating the peak load for a certain application.

The heat gain due to fluorescent lamps is obtained by multiplying the rated voltage of lamp by 1.2 while that for ordinary lamp is obtained from its rated voltage directly. Lighting intensity differs from one application to another. It ranges from 10 to 30 W/m2 of floor area for apartments, hospitals, hotels etc. and from 30 to 60 W/m2 for class rooms, offices, barbershop and similar application. These lighting intensities can be used to estimate the heat gain from lights if the exact lighting power is not known.

the following equation can be used to calculate the heat gain due to the lights :

Q Lt. = P Lt (Fu Fb) (CLF) Lt

→Where:

P Lt: the lamp rated power in watts

Fu: fraction of lamp that are in use

Fb: the ballast factor that equal 1.2 for fluorescent lamp and 1.0 for

Ordinary lamp

(CLF) Lt: the light cooling load factor

From table(3.10 Appendix A) gives the light cooling load factor for two types of fixture arguments.

2.5 Heat and human comfort

The indoor design requirement are chosen to meet human body needs , so human body feeling with relax under known condition of temperature and relative humidity , in order to know these conditions of comfort it is very essential to understand the principle of heat transfer and body temperature .

The normal body temperature is 37.2 ^{o}C which is mostly higher than ambient temperature thus heat is transferred from the human body to ambient air by the difference in temperature . for reaching equilibrium the human body must generate heat equal to the heat loss by the body , the following equation describe the heat balance :

$M - P = E + R + C + S$

Where :

M : metabolic rate .

P : mechanical work done by the body .

E : rate of total evaporation loss .

R : is the rate of heat dissipated by radiation from the body .

C : is the rate of heat dissipated by convection from the body .

S : rate of heat storage of human body .

The amount of heat generated by the body depends on the type of personals activity, this heat is produced by metabolizing the food we eat , the process is known as metabolism , 1 met = seated quiet person (100 W if body surface area is 1.7 m^2)

2.6 Cooling load calculation:

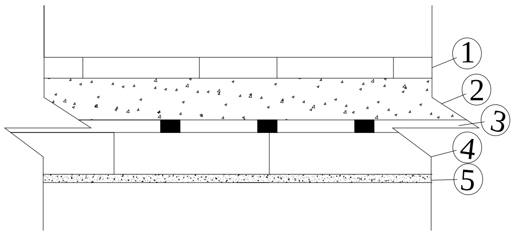
Table [2-1] contains some assumptions needed for the next calculations:

season location	summer	
	Db Degrees (^oC)	RH (%)
Inside design condition	24	50
Outside design condition	39	45

2.6.1 calculate over all heat transfer coefficient for various sections in the building:-

Note : all values of thermal conductivity for various material are taken from Heating and Air Conditioning book (Mohammad A.Alsaad , Mahmoud A. Hammad) .

1) calculate over all heat transfer coefficient for outside walls :-



section (A-A) Construction of outside wall

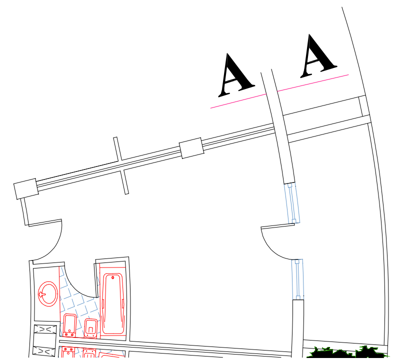


Fig (2-1) section in outside wall

Table (2-2) The thermal conductivity & thickness (x) for the out side walls

Layer #	Material	K (w/m.k)	$\Delta x\,(m)$	Rth [m2. °C/w]
	Inside air film			0.12
1	Stone	2.2	0.05	0.023
2	Concrete	1.75	0.1	0.057
3	Polyurethane	0.025	0.03	1.2
4	Block	0.7	0.1	0.143
5	plaster	1.2	0.02	0.016
	Outside air film			0.06
	U = 0.62 [w/m2. °C]			

$$U = \frac{1}{\frac{1}{hfin} + \sum \frac{\Delta x}{k} + \frac{1}{hf_{out}}} = \frac{1}{0.12 + \frac{0.05}{2.2} + \frac{0.1}{1.75} + \frac{0.03}{0.025} + \frac{0.1}{0.7} + \frac{0.02}{1.2} + 0.06}$$

$$U = \frac{1}{1.6} = 0.62 W / m^2.C$$

2) calculate over all heat transfer coefficient for inside walls :-

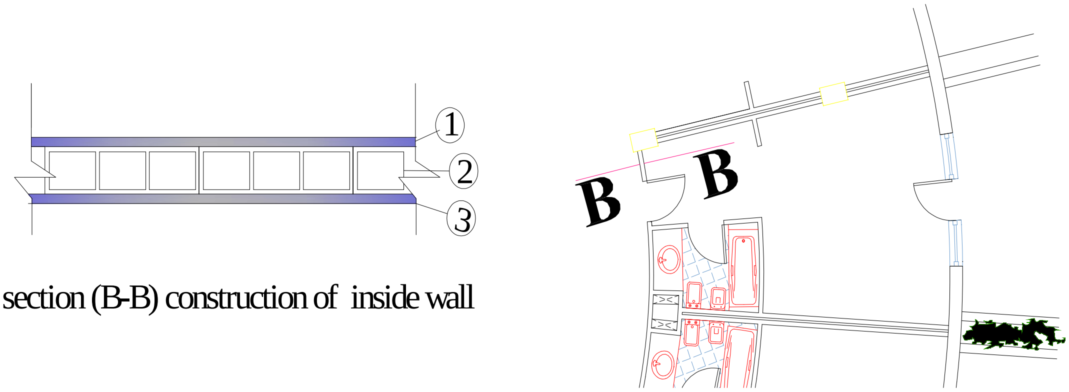
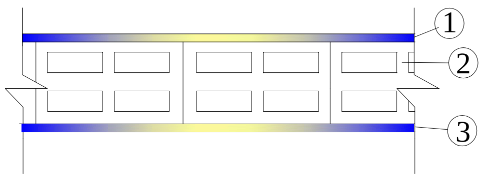


Fig (2-2) section in inside wall

Table[2-3] construction of inside wall

Layer #	Material	K (w/m^2.C)	$\Delta x (m)$	Rth [m2. °C/w]
	Inside air film			0.12
1	Plaster	1.2	0.02	0.016
2	Block	0.7	0.1	0.14
3	Plaster	1.2	0.02	0.016
	Outside air film			0.12
	U = 2.4 [w/m2. °C]			

3) calculate over all heat transfer coefficient for inside thick wall :-



section (C-C) construction of inside thick wall

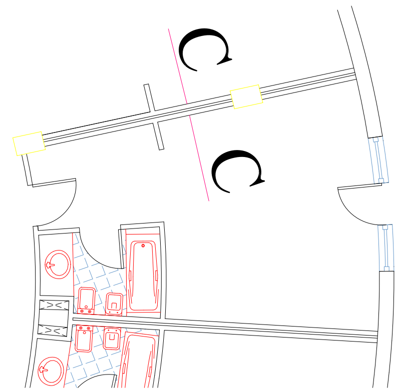
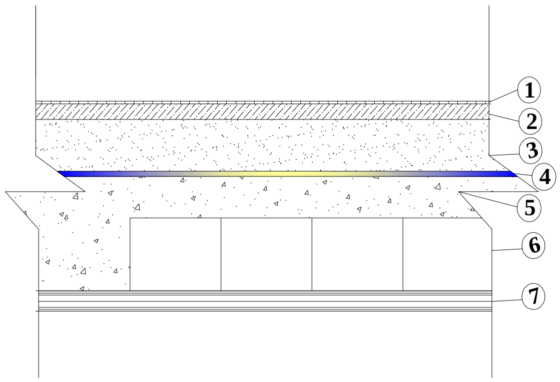


Fig (2-3) section in inside thick wall

Table [2-4] construction of inside thick wall

Layer #	Material	K(w/m^2.C)	$\Delta x(m)$	Rth [m2. °C/w]
	Inside air film			0.12
1	Plaster	1.2	0.02	0.016
2	Block	0.75	0.2	0.266
3	Plaster	1.2	0.02	0.016
	Outside air film			0.12
	U = 1.9 [w/m2. °C]			

4) calculate over all heat transfer coefficient for ceiling between two floor :-



section(D-D) construction of cieling between two floors

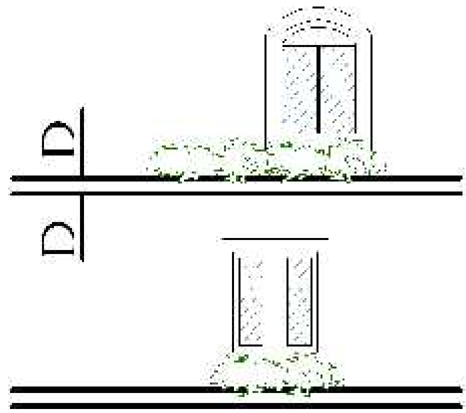
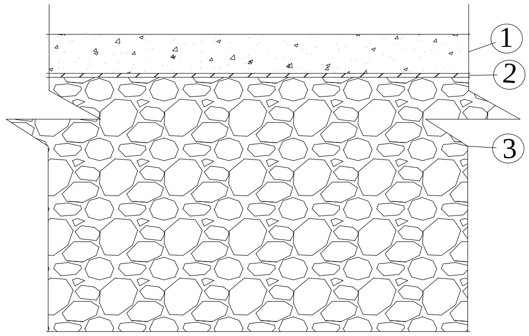


Fig (2-4) section in ceiling between two floor

Table [2-5] construction of ceiling between two floor

Layer #	Material	K(w/m^2.C)	$\Delta x(m)$	Rth [m2. °C/w]
	Inside air film			0.12
1	Tiles	0.99	0.005	
2	mortar	1.4	0.03	
3	sand	0.3	0.1	
4	Bitumen	0.18	0.01	
5	Concrete	1.75	0.08	
6	Block	0.95	0.14	
7	Plaster	1.2	0.02	
	Outside air film			0.12
	U = 1.16 [w/m2. °C]			

5) calculate over all heat transfer coefficient for ground :-

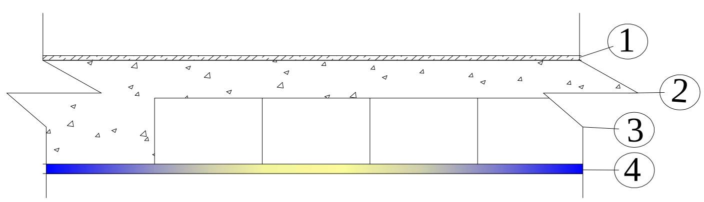


section(E-E) construction in ground

Table [2-6] construction of ground

Layer #	Material	K (w/m^2.C)	$\Delta x (m)$	Rth [m2. °C/w]
	Inside air film			0.10
1	Concrete	1.75	0.1	0.06
2	Bitumen	0.18	0.01	0.055
3	Soil and stones	1.3	0.65	0.5
	Outside air film			----
	U = 1.39 [w/m2. °C]			

6) calculate over all heat transfer coefficient for ceiling (roof) :-



section(F-F) in cieling roof

Table [2-7] construction of ceiling

Layer #	Material	K(w/m^2.C)	$\Delta x(m)$	Rth [m2. °C/w]
	Inside air film			0.15
1	Asphalt	0.7	0.01	0.014
2	Concrete	1.75	0.08	0.05
3	Cement block	0.95	0.14	0.15
4	Plaster	1.2	0.02	0.016
	Outside air film			0.04
	U = 2.4 [w/m2. °C]			

Table [2-8] over all heat transfer coefficient for each section in the building

#	Type of section	over all heat transfer coefficient [w/m2. °C]
1	Outside wall	0.62
2	Inside wall	2.4
3	Inside thick wall	1.9
4	Ceiling between two floor	1.16
5	Ground	1.39
6	Ceiling (roof)	2.4
7	Steel doors	5.8
8	Wood doors	2.8
9	Glass window (double)	3
10	Single glass	5.5

2.6.2 calculating the value of (CLTD)corrected :

the hotel which will be conditioned having a light colored walls the glass window with interior shading with thickness of 6 mm double , and the latitude angle is (32) , the inside design condition as: 24 C db & 50%RH , the outdoor mean temperature is (32C) , CLTD corrected will be calculated for the parts that having heat gain due to solar effects from the following equation :

CLTD corrected = (CLTD+LM)k+(25.5-Tin)+(To,m-29.4)f

So there is a parameter in this equation is unknown which is CLTD , table [2-9] shows the values of CLTD for walls through there direction .

Table [2-9] CLTD values for walls

Group D walls	
July (at 16:00 PM)	
Direction	CLTD value
N	11
NE	14
E	18
SE	18
S	16
SW	21
W	23
NW	18
Roof	23

1- calculating the value of (CLTD)corrected for north wall :

CLTD corrected = (CLTD+LM)k+(25.5-Tin)+(To,m-29.4)f
= (11+0.5)*0.83+(25.5 – 24) + (32 – 29.4) *0.75
= 9.6 + 1.5 + 1.95
= 13 C .

Table [2-10] values of CLTD corrected for wall depend on direction

Wall direction	N	NE	E	SE	S	SW	W	NW	Roof
CLTD corrected (C)	13	15.5	18.4	18	15.4	20.5	22.5	18.8	27

1- calculating the value of (CLTD)corrected for north glass :
The value of CLTD for glass taken from table [9-12] in Heating and Air Conditioning book (Mohammad A.Alsaad , Mahmoud A. Hammad) .

CLTD corrected = (CLTD+LM)k+(25.5-Tin)+(To,m-29.4)f
= (8 + 0.5)*1 + (25.5 – 24) + (32 – 29.4)*1
= 8.5 + 1.5 + 2.6
= 12.6 C .

Table [2-11] values of CLTD corrected for glass depend on direction

Glass direction	N	NE /NW	E / W	SE / SW	S	Horizontal
(CLTD)corrected (C)	12.6	12.6	12.1	11.6	10.5	12.6

Table [2-12] factors for glass depend on direction

Glass	SC	SHG	CLF
N	0.2	126	0.75
NE	0.2	527	0.2
NW	0.2	527	0.73
E	0.2	678	0.17
W	0.2	678	0.82
SE	0.2	473	0.22
SW	0.2	473	0.81
S	0.2	227	0.35
Horizantal	0.2	861	0.58

2.6.3 sample of load calculations for kitchen (K1) in first floor

1- heat gain through walls, ceiling, ground

Q (west wall) = U * A * CLTD(corrected)

= 0.62 * 25.35 * 22.5

= 354 w .

Q (south west) = U * A * CLTD(corrected)

= 0.62 * 10.96 * 20.5

= 139 w .

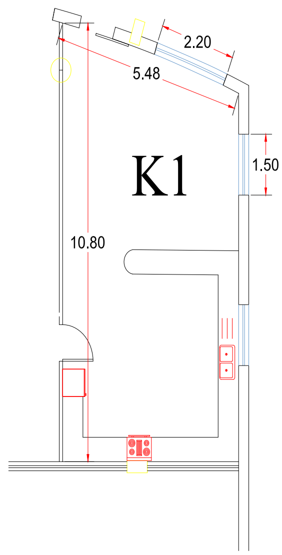


Fig (2-5) kitchen in first floor

2- heat gain from window and door :

Q (west window) = Q tr + Q conv

Q tr = A(SHG) (SC) (CLF)

= (1.95*2) (678) (0.2) (0.82)

= 434 w .

Q (conv.west) = U * A * CLTD(corrected)

= 3*(1.95*2) * 12.1

= 142 w .

Q (west) = Q tr + Q conv

= 434 + 142 = 576 w .

Q (south west window) = Q tr + Q conv

Q tr = A(SHG) (SC) (CLF)

= (2.2*2.2) (473) (0.2) (0.81)

= 370 w .

Q (conv.sw) = U * A * CLTD(corrected)

= 3*(2.2*2.2) * 11.6

= 142 w .

Q (west) = Q tr + Q conv

= 434 + 142 = 576 w .

Q (south west.door) = U * A * CLTD(corrected)

= 3 * 2 * 11.6

= 70 w .

Q tr = A(SHG) (SC) (CLF)

= (2) (473) (0.2) (0.81)

= 153 w .

Q (sliding door) = 70 + 153 = 223 w

3- heat gain through lights

Q lt = P lt (Fu*Fb) (CLF)lt* Area

= 20 (1 *1) (0.84)* 52

= 870 w .

4- heat loss due to infiltration

The heat loss due to infiltration Qinf, is calculated as follows:

$$Q_{\inf} = \frac{\dot{V}_{\inf}}{v_o}(ho - hi)$$

Vinf = no. of Air change per houre * volume of space / 3600

= 2 * 169 / 3600

= 0.094 m^3/S .

ho , hi & Vo taken @ inside and outside design conditions from psychometric chart as :

ho = 90 kj/kg , hi = 48 kj/kg , Vo = 0.91 m^3/ kg

$$Q_{\inf} = \frac{\dot{V}_{\inf}}{v_o}(ho - hi) = \frac{0.094}{0.91}(90 - 48) = 4.2KW$$

5- the sensible heat gain due to occupants Qoc1 , is calculated as :

Q oc1 = no. of people * heat gain for each person * CLF

Where CLF is obtained from table [9-16] as 0.87 for 10 hours in space

Sensible heat gain for each person is 87 w/person , and total heat gain for each person is equal = 145 w/person so

Q oc1 = no. of people * heat gain for each person * CLF

= 5 * 87 * 0.87 = 0.38 KW .

The latent heat gain due to occupant Qoc2 , is calculated as :

Qoc2 = no. of people * (145 – 87)

= 5 * 58 = 0.29 KW .

Total heat gain from occupant = sensible + latent

= 0.38 + 0.29 = 0.67 KW .

7- heat gain due to ventilation :

The general equation for the heat loss by ventilation is :

Q ven = m * Cp * (Tin – Tout)

Where :

m : mass flow rate of air (kg / s) .

C p : is the specific heat at constant pressure = 1.005 [kj/kg.k]

$$\dot{m} = \frac{\dot{V}}{v}$$

V = no. of people * out door air required for each person v : specific volume [m³/kg] taken @ Tmax=39 ºC &Φ= 45 % from the psychometric chart [v = 0.91 m³/kg].

Tin & Tout is the inside and outside design temperatures .

V = no. of people * out door air required for each person

= 10 * 8 = 80 L / s = 0.08 m³/s .

$$Q_{vent} = \frac{\dot{V}_{vent}}{v_o} * Cp(Tout - Tin)$$

$$Q_{vent} = \frac{0.08}{0.91} * 1.005 * (39 - 24) = 1.3KW$$

Now the total load for kitchen (K1) = total load * 1.2

The factor (1.2) which multiplied is the other loads misilenious, machine loads .

So , Qt = (0.5+1.38+0.87+4.2+0.67+1.3) * 1.2

= 9 * 1.2 = 11 KW .

The resultant calculation of load for each space in the building(hotel) shown in the next tables .

Table [2.13] load for each space of apartment 1 in first floor

	Space #				
Part / Load source	K1	B 1	B2	O 1	E1
Wall, ceiling, ground	0.5	0.081	0.173	0.238	0.26
Window, door	1.38	0.21	0.13	0	0.045
Light	0.87	0.33	0.33	0.268	0.336
Infiltration	4.2	0.84	0.84	0.966	1.638
Occupants	0.67	0.56	0.56	0.56	0.56
Ventilation	1.3				
Total load (kw)	11	2.5	2.5	2.5	3.4

Table [2.14] load for each space of apartment 2 in first floor

	Space #				
Part / Load source	K1	B 1	B2	O 1	E1
Wall, ceiling, ground	0.416	0.082	0.081	0.267	0.274
Window, door	0.2	0.213	0.272	0	0.143
Light	0.773	0.32	0.308	0.268	0.252
Infiltration	3.78	0.798	0.756	0.966	1.218
Occupants	0.67	0.56	0.56	0.56	0.56
Ventilation	1.3				
Total load (kw)	8.5	2.4	2.4	2.5	3

Table [2.15] load for each space of apartment 3 in first floor

Part / Load source	Space #				
	K1	B 1	B2	O 1	E1
Wall, ceiling, ground	0.396	0.093	0.248	0.381	0.314
Window, door	0.758	0.82	0.322	0	0.153
Light	0.688	0.32	0.41	0.235	0.285
Infiltration	3.36	0.798	1	0.84	1.386
Occupants	0.67	0.56	0.56	0.56	0.56
Ventilation	1.3				
Total load (kw)	8.5	3	3	2.5	3

Table [2.16] load for each space of apartment 4 in first floor

Part / Load source	Space #				
	K1	E 1	O1	B1	B2
Wall, ceiling, ground	0.455	0.184	0.078	0.321	0.439
Window, door	1.2	0.113	0.24	0.352	0.352
Light	1.21	0.268	0.252	0.275	0.45
Infiltration	5.88	1.26	0.924	0.672	1.092
Occupants	0.67	0.56	0.56	0.56	0.56
Ventilation	1.3				
Total load (kw)	13	2.8	2.5	2.5	3.5

Table [2.17] load for each space of apartment 5 in first floor

Load source \ Part	Space #				
	K1	E 1	O1	B1	B2
Wall, ceiling, ground	0.217	0.134	0.322	0.321	0.076
Window, door	0.3	0.086	0	0.289	0.314
Light	0.672	0.16	0.336	0.336	0.386
Infiltration	3.318	0.756	1.218	0.798	0.924
Occupants	0.67	0.56	0.56	0.56	0.56
Ventilation	1.3				
Total load (kw)	8	2	3	2.76	2.76

Table [2.18] load for each space of apartment 6 in first floor

Load source \ Part	Space #				
	K1	E 1	O1	B1	B2
Wall, ceiling, ground	0.53	0.171	0.189	0.341	0.216
Window, door	0.559	0.105	0	0.287	0.335
Light	1.075	0.15	0.25	0.37	0.454
Infiltration	5.334	0.743	0.924	0.84	1.092
Occupants	0.67	0.56	0.56	0.56	0.56
Ventilation	1.3				
Total load (kw)	11	2	2.2	3	3.2

Table [2.19] load for each suite in first floor

Bedroom #	Heating load sources					Total load (KW)
	Wall, ceiling ...	Window, doors	Lights	Infiltration	Occupants	
1	0.9	0.19	0.437	1.092	0.27	3.5
2	0.36	1	0.437	1.092	0.27	4
3	0.35	0.788	0.437	1.092	0.27	3.5
4	0.35	0.788	0.437	1.092	0.27	3.5
5	0.35	0.788	0.437	1.092	0.27	3.5
6	0.35	0.788	0.437	1.092	0.27	3.5
7	0.734	0.276	0.437	1.092	0.27	3.4
8	0.638	0.078	0.437	1.092	0.27	3
9	0.36	0.326	0.437	1.092	0.27	3
10	0.33	0.457	0.437	1.092	0.27	3
11	0.35	0.453	0.437	1.092	0.27	3
12	0.35	0.453	0.437	1.092	0.27	3
13	0.35	0.453	0.437	1.092	0.27	3
14	0.3	0.439	0.437	1.092	0.27	3
15	0.3	0.439	0.437	1.092	0.27	3
16	0.33	0.2	0.437	1.092	0.27	2.8
17	0.38	0.078	0.437	1.092	0.27	2.8

Table [2.20] load for other spaces in first floor

Item	Space name		
Load sources	S1	S2	S3
Wall, ceiling, ground	2.92	1	0.6
Window, door	4.7	1.295	0.76
Lights	4.870	1.24	0.655
Infiltration	16.8	6.13	2.52
Occupants	1.33	2.66	0.75
Ventilation	33.5	9	3
Total (KW)	64	21.33	8.3

Because of the symmetry between first floor, second floor,third floor,and fourth floor the result of Air conditioning load will be the same but different in some spaces which include second floor and the result of it shown in the next table .

Table [2.21] load for spaces in second floor

Item	Space name				
Load sources	S1	S2	S3	S4	S5
Wall, ceiling, ground	21	0.45	0.45	10.6	4.75
Window, door	4.37	0	0	1.332	0.76
Lights	4.87	0.249	0.249	2.268	1.06
Infiltration	16.8	1.218	1.218	10.92	3.78
Occupants	0.75	0.397	0.397	4.6	2.5
Computers					37.8
Total (KW)	47.8	2.32	2.32	29.7	50

Note : see the AutoCAD drawing in Appendix

CHAPTER THREE

DESIGN FIRE FIGHTING SYSTEM

3.1Classifications of fire

Fires are classified as follows:

Class A fires : fires in ordinary combustible materials , including cellulosics such as wood , cloth , and paper as well as rubber and many plastics

Class B fires : fires in flammable liquids , combustible liquids , petroleum greases , tars; oils, oil-based paints , solvents , lacquers , alcohols ,and flammable gases

Class C fires : fires that involve energized electrical equipment

Class D fires : fires in combustible metals ,such as magnesium, titanium , zirconium , sodium , lithium , and potassium

Class K fires : fires in cooking appliances that involve combustible cooking media(vegetable or animal oils and fats)

3.1.1 Fire signatures .

Afire signature is any fire effect(smoke , heat , light, etc.)that can be sensed by afire detector . the amount of heat released by afire varies in accordance with the type of combustible , arrangement of the combustible , availability of oxygen, and numerous other factors.

3.1.2 Portable fire extinguishers .

Portable fire extinguishers can contain a wide variety of extinguishing agents , the potable fire extinguishers enable an individual with minimal training to extinguish an incipient fire .

A portable fire extinguisher should not be considered as the sole solution to fire protection analysis of a building but , rather, only one of many components of a total fire protection plan .

3.1.3 Types of fire extinguishers:

- water extinguishers
- water spray water extinguishers
- antifreeze solution extinguishers
- foam fire extinguishers , hand and wheeled
- carbon dioxide extinguishers
- clean agent extinguishers
- dry chemical extinguishers , hand and wheeled
- wet chemical fire extinguishers
- liquid gas – type extinguishers
- combustible metal extinguishers , hand and wheeled
- residential kitchen cooking fire extinguishers

the types of occupancies for protection by fire extinguishers are:

1. light (low) hazard occupancy:

defined as a room , space , or enclosure where the quantity and combustibility of class A combustibles and class B flammables are considered to be low(less than 1 gallon), the buildings or rooms occupied as offices , class rooms, churches, assembly halls , and guestroom areas of hotels and motels be classified as a light (low) hazard occupancy .

2. ordinary (moderate) hazard occupancy:

defined as a room , space , or enclosure where the quantity and combustibility of class A combustibles and class B flammables (1 to 5 gallon maximum) is considered to be moderate , and where fires of moderate heat release are expected, the rooms or building should be classified as ordinary(moderate) hazard occupancy when the following are encountered: dining areas , mercantile shops(shoe store or supermarket) and associated storage, light manufacturing , research operations, auto showrooms , parking garages , and workshop or support service areas (kitchens , storage areas) of light hazard occupancies

3. extra (high) hazard occupancy:

defined as a room , space , or enclosure where the combustibility of contents is of the storage , handling , or manufacturing of class A combustible material in which the quantity of class A material is high , or where large amounts of class B flammables (more than 5 gallons) are present , and where rapidly developing fires with high rates of heat release are expected

extra (high) hazard occupancies could consist of wood working , vehicle repair , air craft and boat servicing , cooking areas, individual product display showrooms, product convention center displays and storage and manufacturing processes such as painting , dipping , coating , and flammable liquid handling

4. mixed occupancies:

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 A 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.

5. specialized occupancies:

aircraft hangar

3.1.4 Travel Distance:

defined the actual walking distance from one point to another.

If a class A occupancy has a maximum travel distance of 75 feet(22.875 m), extinguishers may be spaced 150 feet (45.75 m) apart.

If a class B occupancy has a maximum travel distance from 30 feet(9.15 m) to 50 feet(15.25m) depends on type of hazard(low , moderate , high) .

If a class C occupancy are permitted to be spaced in accordance with class A or class B hazards.

If a class D occupancy has a maximum travel distance of 75 feet(22.875 m).
If a class K occupancy has a maximum travel distance of 30 feet(9.15 m).

3.2 Low Expansion Foam System Design .

Low expansion foam system are designed to protect fires primarily associated with flammable and combustible liquids.

A flammable liquid is defined a liquid having a flash point below 100 f (37.8c) and having a vapor pressure not exceeding 40 psi(2068.6 mm hg). A combustible liquid is defined as a liquid having a flash point at or above 100 F (37.8C).

Low expansion foam system are used when a blanket of foam is needed to float on the horizontal surface of a flammable or combustible liquid.

Many protection scenarios involving low expansion foam involve protection of hydrocarbon fuels and organic compounds , which contain only carbon and hydrogen (for example; methane, petroleum, coal, etc.).

3.2.1Components of Foam:

All foam contain three components:
1.air , contained within foam bubbles
2.water , delivered at a specified density in gallons per minute per square foot of applied area
3.foam concentrate, injected into the water stream at a specific predetermined percentage foam concentrate is purchased commercially in drums or barrels . when a foam concentrate is mixed with water , it creates a foam solution . foam solution flows from

the point of mixing to the hazard through a system of pipes . at the hazard a system of discharge devices is installed to facilitate mixing of the foam solution with air is called fire fighting foam.

The piping and delivery method for low – expansion foam systems varies in accordance with the application and hazard configuration.

3.2.2 Expansion Ratio .

The expansion ratio of foam is computed by measuring the volume of the foam produced after air is added to the foam solution and comparing that volume to the original volume of foam solution prior to air addition .

a low – expansion foam system, therefore, is defined as a system designed to deliver a foam solution possessing an expansion ratio of up to 20:1 to a hazard and medium-expansion foam has an expansion ratio of 20:1 to200:1.

A high –expansion foam system is defined as asystem that delivers a blanket of air –filled bubbles created by the mechanical expansion of a foam solution by air and water, with a foam to solution ratio of between 200:1 and 1000:1.

3.2.3Type of Foam .

Fire fighting foams can have a negative effect on the environment if they are not recovered and removed and disposed of properly after use.

Available foams include:

1. protein foam : has an expansion ratio of 8:1 to 10:1 and contains protein based animal additives , such as hooves bones, and feathers which provide protein for the solution
2. fluoroprotein foam: is a protein foam that contains fluorochemical additives that make the foam flow more easily with increased resistance to absorption of fuel

3. film- forming fluoroprotein foam (FFFP) : is concentrate that uses fluorinated surfactants to produce a fluid aqueous film for suppressing hydrocarbon fuel vapors. FFFP can be more effective than fluoroprotein foams in applications where a film barrier between the foam and fuel is desirable .
4. aqueous film- forming foam (AFFF): is a synthetic foam recommended for the coating of most flammable liquids in storage tanks because of its ability to provide a thin , aqueous film that separates the foam from the fuel enhancing the ability of the foam to smother.

AFFF is the foam of choice for most air craft fire protection , is readily available , and is commonly employed in many flammable and combustible liquid applications.

5. alcohol – resistant foam : is used for protection of alcohol- based flammable liquid fires. Alcohol – resistant concentrates (ARC) form a poly meric membrane between the foam and the fuel that preserves the air bubbles and there fire – fighting capabilities .

3.2.4 Subsurface Injection Low Expansion Foam Systems

A storage tank that contains a flammable or combustible liquid and is covered by a fixed , permanent roof to prevent the collection of rain water either above or below the fuel surface may be amenable to the application of foam through subsurface injection, in which foam is applied below the surface of the liquid , and the foam floats to the surface.

A low –expansion foam is used for this application, and the supply pipe for the injection system may be either tapped into an existing process line at the bottom of the tank , or tapped directly into the tank and dedicated solely to foam injection, with piping and nozzles spaced at the floor of the tank.

Subsurface injection using a dedicated foam line requires high back foam makers.

3.2.4.1 Design Method For Subsurface Injection:

Subsurface injection low- expansion foam systems may be designed successfully by using the following methodology:

1. calculate fuel surface area. The fuel surface area is the circular area of exposed fuel at the upper level of the tank.

$$A = (3.1416) \times r^2 \quad (3.1)$$

Where A= fuel surface area

r=tank radius

2. determine application rate and discharge time . there are special tables that lists application rates and a range of discharge times that vary with respect to the nature of the fuel for subsurface injection. This application rate is distributed over the surface area calculated in step 1 for the duration specified.
3. calculate minimum foam discharge rate and foam concentrate quantity.

Calculate minimum foam discharge rate

$$D = (A) \times (R) \quad (3.2)$$

Where D= foam discharge rate gpm(L/ min)

A=tank surface area(see step 1)in ft^2 . m^2

R = application rate

Calculate the foam concentrate quantity

$$Q= (A) \times (R) \times (T) \times (\%) \quad (3.3)$$

Where Q= primary foam concentrate quantity(gallons)

A= tank surface area (see step 1)

R =application rate

T = discharge time .

% = concentrate percentage for foam selected _ 1%,3%, or 6%

(percentage is represented as a decimal ; i.e ., 0.01 for1%)

4. determine the number of subsurface foam application outlets. there is a convenient table that relates number of outlets to tank diameter and flash point of the fuel.
5. determine supplementary protection requirements. There are tables allow to designer to determine the foam hose allowance that must be added to the minimum subsurface injection quantities calculated previously.
6. calculate supplementary foam quantity.

$$Ds = (N) \times (50\ gpm) \tag{3.4}$$

$$Qs = (N) \times (50\ gpm) \times (Ts) \times (\%) \tag{3.5}$$

Where Ds = supplementary discharge rate (gpm)

Qs = supplementary foam concentrate quantity(gals)

N = number of hose lines , from special table

% = concentrate percentage , expressed as a decimal 50 gpm(189.27 LPM) = minimum flow requirement per hose line.

7. hydraulically calculate the system. A hydraulic calculation of the system must be performed now to ensure that the available water supply is capable of supplying the hazard adequately.

3.2.5 Surface Application Low- Expansion Foam Systems

Surface application discharge devices are designed to roll a thin blanket of foam over the surface area of the fuel.

3.2.5.1 Design Method For Surface Application .

Surface application low expansion foam systems are designed in accordance with the same the last methodology for subsurface injection , but only the table is different than last .

3.2.6 Dike Protection Low Expansion Foam Systems.

A tank farm, an enclosure containing vertical cylindrical tanks , horizontal cylindrical tanks , or spherical tanks, which store flammable or combustible liquids surrounded by a containment dike.

With dike protection systems, the dike area is flooded with foam that will float on top of a flammable liquid that spills within the containment dike.

3.2.6.1 Design Procedure For Dike Protection .

Low expansion foam systems for dike protection are designed using the following methodology.

1. calculate dike area .

$$A = (\text{dike length}) \times (\text{dike width}) \tag{3.6}$$

$$= (33 \times 40) + (30 \times 20) = 1920 \ m^2$$

If a tank is installed with its bottom mounted flush to the floor of the dike , the surface area of the tank may be deducted from the total dike area . if flammable liquid is capabable of flowing beneath a vessel , the entire dike surface area is to be calculated.

2. determine application rate= 4.1 l /min. m^2 and discharge times = 30 second , using table (4-10) p 141
3. calculate minimum foam discharge rate and foam concentrate quantity.

Calculate minimum foam discharge rate

$$D = (A) \times (R) \tag{3.7}$$

$$= 1920 \times 4.1 = 7872 \text{ L / m}$$

Where D= foam discharge rate gpm(L/ min)

A=tank surface area(see step 1)in ft^2 . m^2

R = application rate.

4. Calculate the foam concentrate quantity

Q= (A) × (R) × (T) × (%) (3.8)

Where Q= primary foam concentrate quantity(gallons)

A= tank surface area (see step 1)

R =application rate

T = discharge time .

% = concentrate percentage for foam selected _ 1%,3%, or 6%

(percentage is represented as a decimal ; i.e ., 0.01 for1%)

Q= (A) × (R) × (T) × (%) = (1920) × (4.1) × (30) × (0.03)

= 7085 L 3% AFFF concentrate

1. determine number of foam discharge devices required , this specified that " where fixed discharge outlets installed at a low level are used as the primary protection , they shall be located so that no point in the dike area is more than 9 m (30 ft) from a discharge outlet where the discharge per outlet is 225 L/ min(60 gpm) or less . for outlets having discharge rates higher than 225 L/min (60 gpm), the maximum distance between discharge outlets shall be 18 m (60 ft) ."

$$N = \frac{2L + 2w}{s} \tag{3.9}$$

$$N1 = \frac{2 \times 33 + 2 \times 40}{18} = 8\, devices\, in\, l\arg e\, carage$$

$$N2 = \frac{2 \times 20 + 2 \times 23}{18} = 5\, devices\, in\, small\, carage$$

Where N= number of devices. This quotient is rounded up to the nearest whole device

L = length of dike , ft.(m)

W= width of dike , ft. (m)

S= distance between discharge devices, ft.(m).

Note that the discharge rate per discharge device (7872 l/m ÷ 13 devices) is 606 L/m per device =10.1 L/s so the quantity is 18165 L=18m3 .

3.3. Design sprinkler water system

1. light hazared : maximum one sprinkler in 18 m2 such as hotel ,office.
2. Ordinary hazared: maximum one sprinkler per 12 m2 .
3. Extra hazred : maximum one sprinkler per 9 m2.

Table (3.1) pipe sizing in sprinkler water system

Size of pipe (inch)	Maximum No. of sprinklers allowed
3/4	1
1	2
1 1/4	3
1 1/2	5
2	10
2 1/2	20
3	40
3 1/2	65
4	100
5	160
6	275

Table (3.2) estimate water sprinkler fire fighting system for basement floor section three.

Apartment	11	12	13	14	C1	C2	C3	C4	No. of nozzle
Area of partment(m^2)	46	40	27	14	80	65	70	20	25
No .of sprinkler	3	3	2	1	5	4	4	2	

Table (3.3) estimate water sprinkler fire fighting system for ground floor section three

Apartment	M2	F2	K1	K2	No. of nozzle
Area of partment(m^2)	35	40	100	1200	78
No .of sprinkler	2	3	6	67	

Table (3.4) estimate water sprinkler fire fighting system for first floor section three

apartment	1,2	3	4	5	6	7	8	No. of nozzle
Area of partment(m^2)	49	264	240	112	45	36	105	50
No .of sprinkler	3	15	13	8	3	2	6	

Table (3.5) estimate water sprinkler fire fighting system for second floor section three

apartment	1	2*	3,4	5	6	No. of nozzle
Area of partment(m^2)	310	17	14	90	156	52
No .of sprinkler	26	3	2	8	13	

Table (3.6) estimate water sprinkler fire fighting system for basement floor section two

apartment	1	2	3*	4	5	6	7, 8*	9	10	15	No. of sprinkler
Area of partment(m^2)	24	55	65	44	23	58	32	75	418	56	47
No .of sprinkler	2	3	4	3	2	4	3	5	23	3	

Table (3.7) estimate water sprinkler fire fighting system for ground floor section two

apartment	O1,O2,O3,O4	C1	circle	No. of sprinkler
Area of partment(m^2)	33	28	1200	106
No .of sprinkler	2	2	67	

Table (3.8) estimate water sprinkler fire fighting system for circular department floor p2

Apartment	C First, second floor	C Third, fourth floor	C Fifth, sixth floor	C Seventh floor	D1 in each floor	D2 in each floor	No. of sprinkler
Area of apartment(m^2)	418	267	141	141	96(9)	75 (9)	64
No .of sprinkler	23	15	8	8	5	5	

Section two (suite) = 17 *4*1 + 12 *2*1 =92 nozzle

Section two (bathroom) = 17 *4*1 =68 nozz

floor , sixth floor in a hotel have area equal 30 m^2 and have only two nozzle (2 nozzle)

Each bathroom that situated in any suite or any apartment in any floor in hotel have area equal 4.5 m^2 and have only one nozzle (1 nozzle)

Any suite in first floor , second floor , third floor , & fourth floor in a hotel have area equal 23 m^2 and have only two nozzle (2 nozzle)

Any suite in fifth

3.4 Loading Rack Protection .

A loading rack is the critical point where flammable or combustible liquids are pumped from or to storage tanks , to or from a truck or rail car . the entire manufacturing process of flammable and combustible liquids should be protected by a fixed fire protection systems.

Low –expansion foam protection of the truck loading rack is designed standard for the installation of foam – water sprinkler and foam – water spray systems.

3.4.1 Hazards Associated With Loading Racks .

Considering storage tank protection and dike protection , loading rack protection may be the most sensitive operation involved in the manufacture , storage , and transfer of a flammable or combustible liquid . pumping the liquid to the truck or rail car requires pressurization of the flammable or combustible liquid , creating the possibility of a pressure spray fire if ignited.

The weak links in the process are the pump , which could over heat and fail, and the hose , which could burst or become disengaged from its connector to the truck or rail car .

the number of ignition sources available during this process may be cause for concern , with the possibility of smoking , over heated pumps , electrostatics charges , or ignition sources on the truck or rail car, such as battery.

3.4.2 Fire protection strategy for loading racks .

Foam water sprinklers or nozzles are installed at the roof of the loading rack . if a loading rack does not have a roof , a structure will be needed to support low expansion foam system piping .

Foam water sprinklers usually are spaced no more than 10 feet apart , for a maximum coverage area of 100 square feet per sprinkler.

The object of the roof protection is to provide complete protection of the drainage area . the drainage area is a curbed areadesigned to contain spilled flammable lquid as it flows toward floor drains. The hazardous liquid is directed from the floor drains to aretainage basin for recovery and disposal . the drainage may not directly coincide with the roof area , so care must be taken to ensure coverage of the drainage area from the roof sprinklers .

Additional nozzles are aimed directly at the point of connection of the hose to the truck or rail car , and beneath the truck or rail car to enable the sweeping of liquid away from the truck or rail car.

3.4.3 **Loading Rack System Design Procedure .**

A methodical approach to the design of low – expansion foam protection of loadings racks is presented as follows.

1. define the hazard area. The hazard area is always the drainage area , not the roof area .
2. determine the type of foam to be used (3% AFFF,6% AFFF, etc.) , and determine the primary discharge rate associated with the fuel protected , per special table.
3. determine the discharge time . the discharge time for low expansion foamapplication with truck loading racks is 10 minutes. Where loading racks are protected by monitor nozzles the minimum discharge time is 15 minutes.
4. calculate the primary foam concentrate quantity .

$$Q = A \times D \times T \times \% \quad (3.10)$$

Where Q= primary foam concentrate quantity from roof system , in gallons

A= drainage area , length times width

D= application density rate , where loading racks are Protected by monitor nozzle .

T= discharge time , 10 minutes

%= low – expansion foam percentage , from special table .

5. determine the number of ground sweep nozzles . the number of nozzles is determined by field survey , and is usually two nozzles between each pump.

6. select nozzle and design attributes . the designer must reference a book of manufacturers data to select a specific nozzle . an example of such a nozzle is a wide – angle nozzle , spraying a 120˚ pattern, discharging 29 gpm at 30 psi.

7. determine the ground sweep foam quantity.

$$Qg = N \times D \times T \times \% \quad (3.11)$$

Where Qg= ground sweep foam quantity, in gallons

N = number of ground sweep nozzles on the system

D= gpm discharging from each nozzle (in the example nozzle given In step 6 , 29 gpm is the discharge rate)

T= discharge time , 10 minutes.

% =low expansion foam percentage .

8. determine total foam concentrate quantity.

$$Qt = Q + Qg \quad (3.12)$$

Where Qt= total foam concentrate quantity

Q =primary foam concentrate quantity , from roof system

Qg=foam concentrate quantity from ground sweep nozzles

9. determine the spacing of the roof sprinklers. Divide the length of the drainage

area by 10 feet and around up to the nearest whole number , then do the same for the width of the drainage area . as an example , a drainage area of 128 feet long by 102 feet wide would have 13 sprinklers spaced equidistantly along its length , and 11 sprinklers spaced equidistantly along its width, for a total of 143 sprinklers.

Table (3.9) estimate wet chemical fire fighting system for apartments in first floor

Apartment / properties	Type of apartment or unclosable opining	Percent between 2 areas	Volume inclosure protected m^3	Flooding Quantity (kg)= V×0.01764	Additional dry Chemical (kg/ m^2)	Total Flooding Quantity (kg)	No. N= V /14.16 m^3
Area of apartment 1(m^2)	Kitchen1=27	34%	88	1.55	11	12.55	7
Area of unclosable Opining(m^2)	Window1=1.5 Door1=1.8 Door2= 5.85 T. areas= 9.15						
Area of apartment 2, 3 (m^2)	K1= 26, 21	19%, 23%	84 68	1.48 1.2	7.32 7.32	8.8 8.5	6 5
Area of unclosable Opining(m^2)	Door1=1.8 Door2= 3.12 T. areas= 4.92						
Area of apartment 4(m^2)	K1= 17.6	91%	57.2	1	40	41	4
Area of unclosable Opining(m^2)	Window1,2=2 Door1= 14 Total areas= 16						
Area of apartment 5(m^2)	K1= 16.7	33%	54.3	1	11	12	4
Area of unclosable	Door1= 1.8 Door1= 3.7						

Opining(m^2)	Total area= 5.5						
Area of apartment 6(m^2)	K1= 30	23%	97	1.7	7.32	9	7
Area of unclosable Opining(m^2)	Door1= 1.8 Door1= 5 Total area= 6.8						

Table (3.10) estimate wet chemical fire fighting system for apartments in 2nd floor

Apartment / properties	Type of apartment or unclosable opining	Percent between 2 areas	Volume inclosure protected m^3	Flooding Quantity (kg)= V×0.01764	Additional dry Chemical (kg/m^2)	Total Flooding Quantity (kg)	No. N= V /14.16 m^3
Area of apartment (m^2)	Kitchen1=27	34%	88	1.55	11	12.55	7
Area of unclosable Opining(m^2)	Window1=1.5 Door1=1.8 Door2= 5.85 T. areas= 9.15						
Area of apartment 2, 3 (m^2)	K1= 26 , 21	19% 23%	84 68	1.48 1.2	7.32 7.32	8.8 8.5	6 5
Area of unclosable Opining(m^2)	Door1=1.8 Door2= 3.12 T. areas= 4.92						
Area of apartment 4(m^2)	K1= 17.6	91%	57.2	1	40	41	4
Area of unclosable Opining(m^2)	Window1,2=2 Door1= 14 Total areas= 16						
Area of apartment 5(m^2)	K1= 16.7	33%	54.3	1	11	12	4

Area of unclosable Opining(m^2)	Door1= 1.8 Door1= 3.7 Total area= 5.5						
Area of apartment 6(m^2)	K1= 30	23%	97	1.7	7.32	9	7
Area of unclosable Opining(m^2)	Door1= 1.8 Door1= 5 Total area= 6.8						

Table (3.11) estimate wet chemical fire fighting system for apartments in 3d floor

Apartment / properties	Type of apartment or unclosable opining	Percent between 2 areas	Volume enclosure protected m^3	Flooding Quantity (kg)= V×0.01764	Additional dry Chemical (kg/m^2)	Total Flooding Quantity (kg)	No. N= V /14.16 m^3
Area of apartment (m^2)	Kitchen1=25	37%	81	1.43	11	12.5	6
Area of unclosable Opining(m^2)	Door1=1.8 Door2= 4.3 T. areas= 6.1						
Area of apartment 2, 3 (m^2)	K1= 21	24%	68.4	1.2	7.32	8.4 For each	5 For each
Area of unclosable Opining(m^2)	Door1=1.8 Door2= 3.12 T. areas= 4.92						
Area of apartment 4(m^2)	K1= 16.5	97%	53.6	1	40	41	4
Area of unclosable Opining(m^2)	Window1,2=2 Door1= 14 Total areas= 16						

Area of apartment 5(m^2)	K1= 15.5	35%	50.4	1	11	12	4
Area of unclosable Opining(m^2)	Door1= 1.8 Door1= 3.7 Total area= 5.5						
Area of apartment 6(m^2)	K1= 27.5	23%	89	1.6	7.32	9	7
Area of unclosable Opining(m^2)	Door1= 1.8 Door1= 5.6 Total area= 6.4						

3.5 Carbon Dioxide System Design.

Carbon dioxide is a gaseous fire protection agent, also known by its chemical designation CO2 , normally the air we breathe contains 21% oxygen , 79% nitrogen , and only a trace amount of carbon dioxide , 0.03% . the presence of significantly higher percentages of carbon dioxide in a room cannot be detected by human senses because it is colorless and odorless.

These properties of carbon dioxide , combined with its property of being in capable of conducting or transmitting electrical charges provided that a proper clearance is maintained between system components and alive uninsulated electrical components , make it useful for protecting many items of equipment . these properties also create a scenario for a potential hazard to human life when high volumes of carbon dioxide are injected into a room.

Carbon dioxide is 1.5 times heavier than air , so it forces oxygen out of a room or significantly reduces the concentration of oxygen at breathing level.

3.5..1 Carbone Dioxide Storage .

To maintain carbon dioxide in its liquid state , it must be kept in pressurized containers at a controlled temperature , the two type of containers for carbon dioxide fire protection system are:

1. High pressure cylinders:

High pressure cylinders contain liquid carbon dioxide at an ambient room temperature of 70˚F (21.5 ˚C), and at pressure above 850 psi (5860.5 kpa).

High pressure cylinders can be as small as 5 pounds (2.267 kg) liquid capacity or up to120 pounds (54.43 kg) liquid capacity. A relief valve must be installed to maintain pressure below the failure pressure of the container , relief valve usually are set at about 2500 to 3000 psi (17236.89 to 20684.27 kpa).

2. low pressure storage containers :

A low pressure storage container contains an insulation refrigeration unit capable of maintaining the carbon dioxide in its liquid state at 0 ˚F and as low pressure of above 300 psi .

Low pressure containers can be ordered in sizes as small as 500 pounds of storage capacity, Low pressure containers can be installed within a building , space permitting , or outside a building , space permitting , or outside a building , either at ground level or on the roof .

3.5..2 Uses For Carbon Dioxide Systems .

Carbon dioxide is an effective extinguishant for

1. ordinary combustibles – class A commodities
2. flammable liquids – class B commodities
3. electrical hazards – class C commodities .

3.5.3 Types of Carbon Dioxide Systems .

four types of carbon dioxide systems are :

1. total flooding carbon dioxide systems: is designed to completely fill a volume with a predetermined percentage of gas discharged by a fixed piping system and supply .
2. local application carbon dioxide systems: a local application system is a fixed system of piping , nozzles , and carbon dioxide storage that provides a discharge of carbon dioxide directly onto an object where combustion is likely, local application is designed for surface fires only.
3. hand hose line carbon dioxide systems :the presence of a hand hose line system assumes that trained personnel are present at all times , are equipped with the necessary life safety equipment , and are willing and capable of using the hand hose line system to approach and extinguish the fire .
4. standpipe systems with mobile supply : hose coupling are provided at locations convenient for attachment to a mobile carbon dioxide tank or truck , an example of such a situation is a chemical plant with a full time fire service brigade located close to the hazard area .

:

3.5 Carbon dioxide System Design Procedure for a computer room

Local application imaginary volume calculation - raised 2 feet (0.6 m) above solid floor.

V imaginary =(length+4ft) ×(width+4ft) ×(height + 4ft) (3.15)

V imaginary =(length+1.2m) ×(width+1.2m) ×(height + 1.2m) (3.16)

V imaginary =(length+1.2m) ×(width+1.2m) ×(height + 1.6m) (3.16)

=(0.6+1.2m) ×(0.8+1.2m) ×(1 + 1.6m) = 9.36 m^3 for each computer

Total V imaginary = 9.36 × 19= 178 m^3

To determine the minimum rate of carbon dioxide required , we use high pressure system:

R=(V imaginary)× (16 kg /min $m3$)×(1.4)

. = (178)× (16 kg /min . $m3$)×(1.4) =3987

Determination of local application carbon dioxide weight

W =(R)× (D) = 3987(kg/min) × 0.5 min = 1993.5 kg is required

The minimum acceptable duration is 30 sec.

Total area for the computer center = 8.5 × 6.5 = 55 m^2 so its need 2 nozzle.

3.6 Wet and dry Chemical Extinguishing System Design

total flooding dry chemical applications

Criteria for the evaluation of compensation for unclosable openings are as follows:

1. when the area of unclosable opining is within 1% to 5% of the total enclosure interior surface area , an additional 0.5 ib (2.44 kg/ m^2) of dry chemical per square foot of opening is required.
2. when the area of unclosable opining is within 5% to 15% of the total enclosure interior surface area , an additional 1 ib (4.88 kg/ m^2) of dry chemical per square foot of opening is required.

Total flooding quantity calculation

Qb = (V hazard) × (0.0385 Ib / ft^3)

Qb(metric) = (V hazard) × (0.01764 kg/ m^3) (3.17)

Where :
Qb = basic minimum dry chemical required , in pounds (kg)
V= volume of enclosure protected , in cubic feet (ft^3)
Additional agent is added to the total above to account for unclosable openings.

Nozzle spacing and location for total flooding systems:

The minimum nozzles required for a total flooding system can be estimated by specifying one nozzle for each 500 ft^3 . (14.16 m^3) of enclosure volume:

N= (V)/ (500 ft^3)

N=(V)/ (14.16 m^3) (3.18)

Where N: minimum estimated number of nozzles (whole number)

V : volume of hazard (m3)

In most cases , nozzles may be spaced 2.286 m apart and 1.524 from a wall or obstruction , assuming 6.096 m maximum ceiling height.

After these estimates are performed , more detailed design , involving flow calculations , nozzle and cylinder selection , and pipe size determination , can be performed in accordance with the manufacturers recommendations .

Note : see AutoCAD drawing in Appendix .

CHAPTER FOUR

PLUMBING SYSTEM

4.1 Introduction:

Since the late 19^{th} century water has been used inside structures for drinking ,cooking ,washing , bathing , and fire fighting.

Now we takes about kinds of water:

1.Potable water: water which is tested and corrected to be suitable for human drinking , cooking , and bathing .

2. Non potable water: surface water ,ground water , or collected rain water which contains some degree of impurity .this water can be used for any purpose except human drinking , cooking ,and bathing.

3. Gray water : water discharged from dish washers , washing machines , bathtubs ,sinks , and other fixtures , except waste water from toilets or urinals.

4. Black water : Water containing toilets and urinals wastes.

4.2 Design of Water System .

The first step in planning and designing any project is to determine the availability of water that will serve the project .

there are two types of water systems:

1. community or municipality water system
2. private water system

4.2.1 Design of Well

Because there are proplems in water sources in west bank &the annual rainfall in Palestine it’s range is (450 -550) mm . so we have a well for each building .

4.2.2 Hot Water System .

Hot water is needed within a building for bathing ,dishwashing ,laundry, and other related services.

4.2.3 Water Measurement :

One gallon of water weighs 8.33 pounds . by volume 1 gallon of water is 231 cu . in .,or 0.134cu .ft

4.2.4 Water Pressure:

The pressure of water in the system is measured in pounds per square inch (psi). Eight psi of pressure is considered sufficient for all fixture in a system, except when a flush valve is used , requiring approximately 15 psi . the maximum permissible pressure for fixtures in a system is 50 psi . pressure tanks(pneumatic) for a residence operate at approximately 35 psi . pressure of a municipality water supply . for a residence it is about 35 psi , and approximately 50 psi for other structures . the architect should contact the department of water supply to obtain the amount of pressure available to supply the structure . water pressure above 80 psi will damage the fixtures.

4.2.5 Static Pressure:

The pressure of the water at the bottom of a pipe is directly related to the weight of water and is height .

One cubic foot of water weighs 62.352 pounds at 60 ˚ F at the bottom of 1 cubic foot . we have :

12 in × 12 in = 144 in

62.352 Ib 144 in / ft^2 =0.433 psi / ft of height

Therefore :

Static pressure = 0.433 psi / ft of height .

In other wards : 1 psi = 2.3 ft of height .

4.2.6 Pneumatic Tank (Pressurized Tank)

A pneumatic tank is normally located below the fixtures to be supplied . when water is used , the air pressure on the top portion of the tank forces the water into the system . when a portion of water is used , the air pressure in the tank will drop , actuating the starting switch and causing the pump to start delivering water to the tank and increasing the air pressure . this system is generally favored for small structures .

4.2.7 Reservoir(Gravity Tank):

A reservoir is supported on the top of a structures in a multistory building and when used to supply water to a community , is located on the top of a tower (water tower) or, if the community is on the hilly side , it may be economical to locate it on the top of the hill.

4.3 Cold Water Distribution.

There are two basic type of water distribution systems for buildings:

A. upfeed distribution system:

there are two methods commonly used for upfeed distribution system :

1. the supply of water for the building is received from a public street main (usually 35 psi for residential structures , and about 50 psi for other buildings).
2. Private water supply enters into a pneumatic tank and is pressurized from approximately (35 to 60 psi).

B. down feed distribution system :

1. water pressure of 60 psi can serve a building of up 10 stories . for structures with more stories in height , in this system , water from a street main or from suction tank (which is located in the basement of a building and is filled with water from the street main or private water supply) is pumped to a reservoir on the top of a building . the water from the

reservoir serves the floors below by down feed distribution(gravity) system .

2. minimum pressure required on the top floor of the building is usually 15 psi (for flush valve) , and maximum pressure on the lowest floor of the building should not exceed 50 psi (pressure above 80 psi will damage the fixtures).
3. If the pressure on lowers floors exceeds 50 psi , pressure reducing valves are used to reduce the pressure .

4.4 Hot Water Distribution .

1. the most practical system of distribution is to locate the hot water heater as close as possible to the area which it is serving .
2. the longer the hot water supply , the less efficient the system will be .
3.a hot water pipe losses its heat to the surrounding air very quickly , even if it is insulated .
4.it is a good practice to use two or more water heaters in a structure instead of running a long hot water supply line or to design a hot water circulation system .

4.5 Hot Water Circulating System:

1. in this system hot water continues to the farthest fixture and returns to the hot water heater .
2.in this system only the hot water in the branch piping may cool off .
3.the hot water circulating system can be used in up feed , down feed , or combination of up feed or down feed on a horizontal feeding system .
4.a check valve is used in this system to cause the flow of the water in the proper direction .

4.6 Forced Circulation of Hot Water:

1.forced circulating hot water system may be used in long structures of a few stories in height .
2. the lack of high pressure in a cold water system and friction lossin the long pipe create low pressure in a hot water system
3. this system employs a storage tank with no air gap, and circulating pump on return pipe of a hot water supply.

4.7 Sewage Disposal Systems .

4.7.1 Sewage Or Waste :

1. Gray water: waste water with minor pollution discharged from bathtubs ,sinks ,lavatories ,dishwashers ,and washing machines is called gray water.
2.Black water: waste water with major pollution from toilets and urinals is referred to as black water.
3.Sewage or waste: a compination of gray water and black water .

4.7.2 Sewer Systems .

In general there are two types of sewer systems :

1. municipal (public) sewer systems
2. private sewer systems

4.7.3 Municipal (Public) Sewer Systems:

There are three systems in use :

1. compined sewer system: Carries away both sewage from the buildings and water polluted as it drains off buildings ,streets , or land during a storm .
2. sewer (sanitary) system : Carries only sewage from buildings .

3. storm drainage system : Used to carry storm water only .

4.7.4 Design Procedure For Municipal Sewer System :

Step1. Contact the owner for the sewer system and obtain confirmation in witing stating that your project may discharge the required gallons of sewer into the sewer main .Step 2. Obtain information as to the location , elevation , and requirements for connecting the building sewer to the main sewer line , and the cost required .

Step 3. If there is no public sewer or the puplic sewer does not have adequate capacity to serve your building ,then a private sewer system for the building ha to be designed .

Step 4 . in this project we separate between the sewer (sanitary) system that carries only sewage from buildings and the storm drainage system that used to carry storm water .

4.8 Storm Drainage System.

Rainfall(also known as storm water) on the roof and balconies of the building , paved area around the structure , and parking areas serving the project has to be collected and discharged to one of the folowing :

1.municipality storm drainage systems :

there are two systems in use :

A. combined sewer system , which carries away both sewage and storm water
B. storm drainage system , which carries only storm water, and this system that we used in project.

2. private storm drainage system .

4.8 water and drainage system calculation.

Table (4.1) Estimating demand and drainage fixture unit for Basement floor

properties / Type Of department	fixture	use	Type of supply control	Fixture unit	Cold water f.u*3/4	Hot water f.u*3/4	d.f.u for each fix.	diam (in)
Security room	2 lavatory 1water closet	private	Faucet Flush tank	2×1=2 1×3=3	1.5 2.25	1.5	2 4	2 4
Laundery	3 Clot.wsh 3laundry trays	general general	Faucet	3×4=12 3×3=9	9 6.75	9 6.75	3 2	2 2
Bakery	2 lavatory 2 kitchen sink	Private general	faucet	2×1=2 2×4=8	1.5 6	1.5 6	2 3	2 2
Hot production area	1 kitchen sink 1 lavatory	General private	faucet	1×4=4 1×1=1	3 3/4	3 3/4	3 2	2 2
Fruit and vegetable area prep.	2 kit. sink 1 lavatory	General private	faucet	2×4=8 1×1=1	6 3/4	6 3/4	3 2	2 2
Male senior staff showers and toilets	3lavatories 3 shower head 3 urinals 3 w.c	General	Faucet mixi. valve Flush tank Flushometer	3×2=6 3×4=12 3×3=9 3×10=30	4.5 9 6.75 22.5	4.5 9	2 2 4 6	2 2 2 4
female senior staff showers and toilets	3lavatories 3 shower head 3 water closets	General	Faucet Mix. valve Flushometer	3×2=6 3×4=12 3×10=30	4.5 9 22.5	4.5 9	2 2 6	2 2 4
Room service	1 kitchen sink	General	Faucet	1×4=4	3	3	3	2
w.c for administrator	lavatory 1wat.closet 1bidet	private	Faucet Flushometer Flush tank	1×1=1 1×6=6 1×1=1	3/4 4.5 0.75	3/4 0.75	2 4 2	2 4 2
			Total WSFU		125	67		
			Demand gpm		75	58		

Table (4.2) Estimating demand and drainage fixture unit for ground floor

properties / Type Of department	fixture	use	Type of supply control	Fixture unit	Cold water = f.u*(3/4)	Hot water = f.u*(3/4)	d.f.u for each fix.	dim (in)
(1) Male senior staff showers and toilets	4 lavatory 4 urinals 6 water closets	General	Faucet	4×2=8	6	6	2	2
			Flush tank Flushometer	4×3=12 6×10=60	9 45		4 6	2 4
(1) female senior staff showers and toilets	3 lavatory 6water closets	General	Faucet	3×2=6	4.5	4.5	2	2
			Flushometer	6×10=60	45		6	4
(2) Male senior staff showers and toilets	3 lavatory 4 urinals 5 water closets	General	Faucet	3×2=6	4.5	4.5	2	2
			Flush tank Flushometer	4×3=12 5×10=50	9 37.5		4 6	2 4
(2) female senior staff showers and toilets	3 lavatory 4water closets	General	Faucet	3×2=6	4.5	4.5	2	2
			Flushometer	4×10=40	30		6	4
			Total WSFU		195	18		
			Dmand gpm		90	33		

Table (4.3) Estimating demand and drainage fixture unit for first floor

properties / Type Of department	fixture	use	Type of supply control	Fixture unit	Cold water = f.u*(3/4)	Hot water = f.u*(3/4)	d.f.u for each fix.	Di in
Male senior staff showers and toilets	3 lavatories 4 showers head 3 water closet	General	Faucet Mixing valve	3×2=6 4×4=16	4.5 12	4.5 12	2 4	2 2
			flushometer	3×10=30	22.5		6	4
female senior staff showers and toilets	3 lavatories 4 showers head 3 water closet	General	Faucet Mixing valve	3×2=6 4×4=16	4.5 12	4.5 12	2 4	2 2
			flushometer	3×10=30	22.5		6	4
Partment (1,2,3,4,5,6)	1 lavatory 1 bath tub 1 water closet 1 bidet (first w.c)	private	Faucet Faucet	1×1=1 1×2=2	0.75 1.5	0.75 1.5	2 2	2 2
			Flushometer Flush tank	1×6=6 1×1=1	4.5 0.75	 0.75	4 2	4 2
	1 lavatory 1 bath tub 1 water closet 1 bidet (second w.c)	private	Faucet Faucet	1×1=1 1×2=2	0.75 1.5	0.75 1.5	2 2	2 2
			Flushometer Flush tank	1×6=6 1×1=1	4.5 0.75	 0.75	4 2	4 2
	Kitchen sink	private	faucet	1×2=2	1.5	1.5	3	2
Suite 1 (1×17 suite)	1 lavatory 1 buth tub 1 water closet 1 bidet	private	Faucet Faucet	1×1=1 1×2=2	0.75 1.5	0.75 1.5	2 2	2 2
			Flushometer Flush tank	1×6=6 1×1=1	4.5 0.75	 0.75	4 2	4 2
Massage room	7 lavatories 4 shower head 1 water closet	general	Faucet Mixing valve	7×2=14 4×4=16	10.5 12	10.5 12	2 2	2 2
			flushometer	1×10=10	7.5		4	4
Spa&sawna	spa	general	faucet	10	7.5	7.5	2	2
			Total WSFU		342	159		
			Dmand gpm		116	81		

Table (4.4) Estimating demand and drainage fixture unit for second floor

properties / Type Of department	fixture	use	Type of supply control	Fixture unit	Cold water = f.u*(3/4)	Hot water = f.u*(3/4)	d.f.u for each fix.	Di in
Male senior staff show& toilets	3 lavatories 3 water closet	General	`Faucet	3×2=6	4.5	4.5	2	2
			flushometer	3×10=30	22.5		6	4
Partment (1,2,3,4,5,6)	1 lavatory 1 bath tub 1 water closet 1 bidet (first w.c)	private	Faucet Faucet	1×1=1 1×2=2	0.75 1.5	0.75 1.5	2 2	2 2
			Flushometer Flush tank	1×6=6 1×1=1	4.5 0.75	 0.75	4 2	4 2
	1 lavatory 1 bath tub 1 water closet 1 bidet (second w.c)	private	Faucet Faucet	1×1=1 1×2=2	0.75 1.5	0.75 1.5	2 2	2 2
			Flushometer Flush tank	1×6=6 1×1=1	4.5 0.75	 0.75	4 2	4 2
	Kitchen sink	private	faucet	1×2=2	1.5	1.5	3	2
Suite 1 (1×17 suite)	1 lavatory 1 buth tub 1 water closet 1 bidet	private	Faucet Faucet	1×1=1 1×2=2	0.75 1.5	0.75 1.5	2 2	2 2
			Flushometer Flush tank	1×6=6 1×1=1	4.5 0.75	 0.75	4 2	4 2
Staff dining bath	1 lavatories 1 water closet	private	Faucet	1×1=1	0.75	0.75	2	2
			flushometer	1×6=6	4.5		2	2
			Total WSFU		259	101		
			Dmand gpm		112	68		

Table (4.5) Estimating demand and drainage fixture unit for third floor

properties / Type Of department	fixture	use	Type of supply control	Fixture unit	Cold water = f.u*(3/4)	Hot water = f.u*(3/4)	d.f.u for each fix.	Di in
Partment (1,2,3,4,5,6)	1 lavatory 1 bath tub	private	Faucet Faucet	1×1=1 1×2=2	0.75 1.5	0.75 1.5	2 2	2 2
	1 water closet 1 bidet (first w.c)		Flushometer Flush tank	1×6=6 1×1=1	4.5 0.75	 0.75	4 2	4 2
	1 lavatory 1 bath tub	private	Faucet Faucet	1×1=1 1×2=2	0.75 1.5	0.75 1.5	2 2	2 2
	1 water closet 1 bidet (second w.c)		Flushometer Flush tank	1×6=6 1×1=1	4.5 0.75	 0.75	4 2	4 2
	Kitchen sink	private	faucet	1×2=2	1.5	1.5	3	2
Suite 1 (1×17 suite)	1 lavatory 1 buth tub	private	Faucet Faucet	1×1=1 1×2=2	0.75 1.5	0.75 1.5	2 2	2 2
	1 water closet 1 bidet		Flushometer Flush tank	1×6=6 1×1=1	4.5 0.75	 0.75	4 2	4 2
general bath	1 lavatories 1 water closet	general	Faucet	1×2=2	1.5	1.5	2	2
			flushometer	1×10=10	7.5		6	4
			Total WSFU		236	98		
			Dmand gpm		96	67		

Table (4.6) Estimating demand and drainage fixture unit for fourth floor

properties / Type Of department	fixture	use	Type of supply control	Fixture unit	Cold water = f.u*(3/4)	Hot water = f.u*(3/4)	d.f.u for each fix.	Di in
Suite 1 (1×17 suite)	1 lavatory 1 buth tub 1 water closet 1 bidet	private	Faucet Faucet	1×1=1 1×2=2	0.75 1.5	0.75 1.5	2 2	2 2
			Flushometer Flush tank	1×6=6 1×1=1	4.5 0.75	 0.75	4 2	4 2
general bath	1 lavatories 1 water closet	general	Faucet	1×2=2	1.5	1.5	2	2
			flushometer	1×10=10	7.5		6	4
			Total WSFU		137	53		
			Dmand gpm		78	52		

Table (4.7) Estimating demand and drainage fixture unit for fifth floor

properties / Type Of department	fixture	use	Type of supply control	Fixture unit	Cold water = f.u*(3/4)	Hot water = f.u*(3/4)	d.f.u for each fix.	Di in
Suite 1 (1×12 suite)	1 lavatory 1 buth tub 1 water closet 1 bidet	private	Faucet Faucet	1×1=1 1×2=2	0.75 1.5	0.75 1.5	2 2	2 2
			Flushometer Flush tank	1×6=6 1×1=1	4.5 0.75	 0.75	4 2	4 2
			Total WSFU		90	36		
			Dmand gpm		65	44		

Table (4.8) Estimating demand and drainage fixture unit for sixth floor

properties / Type Of department	fixture	use	Type of supply control	Fixture unit	Cold water = f.u*(3/4)	Hot water = f.u*(3/4)	d.f.u for each fix.	Di in
Suite 1 (1×12 suite)	1 lavatory	private	Faucet	1×1=1	0.75	0.75	2	2
	1 buth tub		Faucet	1×2=2	1.5	1.5	2	2
	1 water closet		Flushometer	1×6=6	4.5		4	4
	1 bidet		Flush tank	1×1=1	0.75	0.75	2	2
			Total WSFU		90	36		
			Dmand gpm		65	44		

NOTE: 1. The last calculations depends the tables (5.9 , 5.10 , 5.11 , 5.12, 5.13, 5.14 Appendix A)

2. see AUTOCAD drawing in Appendix A

4.6 Solar system design:

We use collectors have type compouned parabolic concentration (CPC) , 7700 kcal / day / one collectors , area = 2.2 m^2 , 1 L = 3.78 gallon

4.19 × 7700 = 32263 kj / day = 32263 / (3600) = 9 kwh.

The total WSFU for hot water for a hotel = 67+18+159+101+98+53+36+36=568

So from table we required quantity of hot water Qr= 146 gpm

$\dot{m}$ = (146 × 16 h × 60 m / 3.78*1000) = 37 m^3/day (by American code)

$\dot{m}$ = 37 × 0.70= 26 m^3 / day = 26000 kg / day (by Palestinian code)

Q= m cp (To –Ti) = 26000 × 4.18× (60- 20) = 4347200 kj/day

Q= 4347200 / 3600 = 1207 kwh

No .of units = 1207 / 9 = 134 solar collectors

No.of storage tank = 0.5 × $\dot{m}$ = 0.5 × 26= 13 m^3 ,

Note : see AutoCAD drawing in Appendix .

CHAPTER FIVE

LOCALIZED IRRIGATION

Part one : Sprinkler Irrigation

The surrounding of a hotel contains many of green lands that need to continuously irrigation to protect general overview for a hotel so we use sprinkler irrigation system to irrigate this green lands.

Consists of irrigation system :

1. pumping unit
2. mainline and submain
3. laterals
4. sprinklers.

Type of sprinkler:

1. impact sprinkler : doing under pressure (5-30) m
2. geer sprinkler : doing under pressure (20 -40)m
3. rocker arm sprinkler : doing under pressure (50 – 100)m
4. spray – type sprinkler : doing under pressure (5-20) m .

5.1 Flow From Sprinkler Opening :

The flow from sprinkler opining can be calculated by equation:

$$Q = Kd \times (HP)^{0.5} \tag{5.1}$$

Where:

Q: flow from sprinkler opining .

Kd: factor depend the type of sprinkler .

HP: pressure head .

The type of sprinkler is spray type sprinkler and doing under pressure (5-20) m and flow from sprinkler is 0.5 liter / second .

5.2 Deep of Irrigation:

We calculate the depth of water that should be reached in the soil under the glasswort by equation:

$$Dx = AD \times (Fc - PWP) \times D \qquad (5.2)$$

$$= 0.70 \times (0.36 - 0.16) \times 150 = 21mm$$

Where:

Dx: depth of irrigation

AD: humidity depletion .

D : the depth of roots.

Fc: the amount of moisture of soil at wilt(blasting) point.

PWP : the amount of moisture of soil at refreshment(exhilaration) point.

Daily evapotranapiration (daily consumptive use):

Blany – criddle method :

$$ET = Kc \times C [P (0.46 T + 8)]$$

$$= \{ 0.2 \times 0.95 [31 (0.46 \times 30+ 8)]\} / 30 = 4.28 \text{ mm / day.}$$

Annual consumptive use = 4.28 × 300 = 1284 mm / seedling / year

Where:

ET : daily consumptive use .

Kc: crop factor .

C: factor depend on humidity ratio and solar radiation and wind speed .

P: factor depend the ratio between annual solar radiation and month solar radiation depend on the latitude line

T: average temperature degrees for one month.

5.3 Number of Irrigations :

The number of days between irrigation and other can be calculated by using the equation

$I = Dx / ETM$ (5.3)

$= 21 / 4.28 = 5$ days

Where :

I : the number of days between irrigation and other.

ETM: the daily evapotranspiration for glasswort.

Dx : depth of irrigation.

5.4 Total Deep of Irrigation:

The total deep of irrigation can be found by the equation:

$Dg = Dx / Ea$ (5.4)

Where :

Dg: The total deep of irrigation

Dx : depth of irrigation

Ea : the efficiency of localized irrigation and depends on many factors such as the type of sprinkler and the speed of wend etc.

5.5 Efficiency of Localized Irrigation (Ea) :

The Efficiency of localized irrigation (Ea) can be calculated by equation:

$Ea = Es \times Eu$ (5.5)

$= 0.96 \times 0.70 = 0.67$ %

So the efficiency of localized irrigation depend on two pats :

1. storage efficiency (Es): depend on how much the soil storage water. Its about (0.87 – 0.100) (depends on the type a soil).
2. uniformity of application (Eu) : depends on the distributed the water in the farm and accuracy of manufacturing and design .

so $Dg = Dx / Ea = 21 / 0.67 = 31$ mm

There is some trees in the surrounding of a hotel that need for irrigate by using drip irrigation system as in part two .

Part Two: Trickle Irrigation (Drip Irrigation).

5.7 Introduction:

Trickle irrigation , also referred to as drip irrigation , consists of an extensive network of pipes usually of small diameter that deliver filtered water directly to the soil near the plant . the water outlet device in the pipe is called an "emitter " discharging only a few liters per hour (2 – 10 liter / hour) . from the emitter , water spreads laterally and vertically by soil capillary forces augmented in the vertical movement by gravity . the area wetted by an emitter depends upon the flow rate , soil type , soil moisture , and the vertical and horizontal permeabilities of the soil .

The "control head " usually located at the source of the water , consists of flow control valves , measuring devices , pressure controls , and filters . usually a fertilizer injection system is located also at the control head . the filter system must remove essentially all debris , sand , and clay to reduce clogging of the emitters .

Flow may be controlled manually or may be set to automatically deliver :

1.desired volume of water

2.water for a predetermined time

3.water whenever soil moisture decreases to a predetermined amount .

lateral lines are generally flexible PVC or polyethylene pipe 12 to 32 millimeters in diameter . emitters are inserted into lateral lines at a predetermined spacing chosen to fit crop and soil conditions . twin bore pipe , porous pipe , and pipe with small perforations is used in some installations to function both as a lateral conveyance pipe and as an emitter system .

emitters must produce a relatively small flow and yield a nearly constant discharge . the flow cross section needs to be relatively large to reduce clogging of the emitters .

5.12 Distributers :

the distributers in irrigation system is a heart of localized irrigation .
type of distributers :

1. drippers : the flow of water about (2 – 10 L / h).
2. bubbler : the flow of water about (200 L/ h). and we can control the opining of bubbler.
3. sprayer: the flow of water about (150 L / h).
4. emission point : the water line under the surface of soil .

5.13Flow From Distributers :

the flow from distributers can be calculated by equation:

$$Q = Kd \times H^x \quad (5.14)$$

Where:

Q: flow of distributers (L/ s)

Kd: factor depend on the type of distributers .

H : the high of pressure (m).

X : factor depend on the flow of distributers .

5.14 Amount of Water In One Irrigation :

The amount of water that we needed in once irrigation can be calculated by equation:

$$Q = (Dg \times A)/ T \quad (5.15)$$

Where:

Q: The amount of water that we needed in once irrigation (litre).

Dg: the total deep of irrigation (m).(calculated in part one)

A: total area covered by tree(m^2).

T: time of working in one day (hours).

So Q = (0.31 × 1426)/ 1 = 442 Liter in once irrigation

But we irrigate area about 1426 m2 by drip irrigation so Q = 1.426 × 1284 =

1831 m^3 /year ,

the quantity of water required in one day = 1831 /300 = 6 m3/day , but we need once irrigation for plant in week so we required 42 m3/ week .

number of dripper = 42 / 0.048 =875 dripper ,

so the area for any dripper equal 1426 / 875 = 1.63 m2 /dripper

where the flow from one distributer equal 2 L/h= 0.042 m3/day

5.15 Design the Line of Irrigation:

The flow of water in irrigation line can be calculated by the equation :

$$Qi = Q \times ne \quad (5.16)$$

Where:

Qi: flow of water in irrigation line.

Q: The amount of water that we needed in once irrigation (liter).

ne: number of distributers .

the total flow in drip irrigation can be calculated by equation:

$$Qt = Qi \times n \quad (5.17)$$

Where:

Qt: total flow of water.

Qi: flow of water in irrigation line.

n: number of lines.

5.16 Design of Water Pump :

The power of water pump can be calculated by equation:

$$W.P = Qt \times Ht \times sp \ (w) \quad (5.18)$$

Where;

W.P: power a pump;

Qt: total flow of water.

Ht: total dynamics head..

Table (5.1) number of sprinkler depending on area

section	**Area (m2)**	**No. of sprinkler**
2	288	4
3	238	4
4	416	6
5	168	3
6	140	2
7	88	1
8	24	1
9	140	2
10	156	2
11	125	2
12	304	5
13	130	2
Total	**2218**	

Table (5.2) number of dripper according to area

section	Areas(m2)	No. of dripper
1	43.5	27
14	36	26
15	75	46
16	100	61
17	46	28
18	68	42
19	25	15
20	10	7
21	58	36
22	44	27
23	86	53
24	120	73

25	168	103
26	40	25
27	15	9
28	40	25
29	160	100
30	117	72
31	110	69
32	64	39
Total	**1426**	

Note : see AutoCAD drawing in Appendix .

CHAPTER SIX

GAS PIPING DESIGN

6.1 System Configurations And Sizing

System configurations :

There are several piping system options available to the installer using gas piping material , see table (6.2 Appendix A) showes some gas requirement for buildings.

Low pressure system :

1. series : A series layout is the most common arrangement utilized for black iron pipe . this consists of a main run with tees branching off to each appliance .

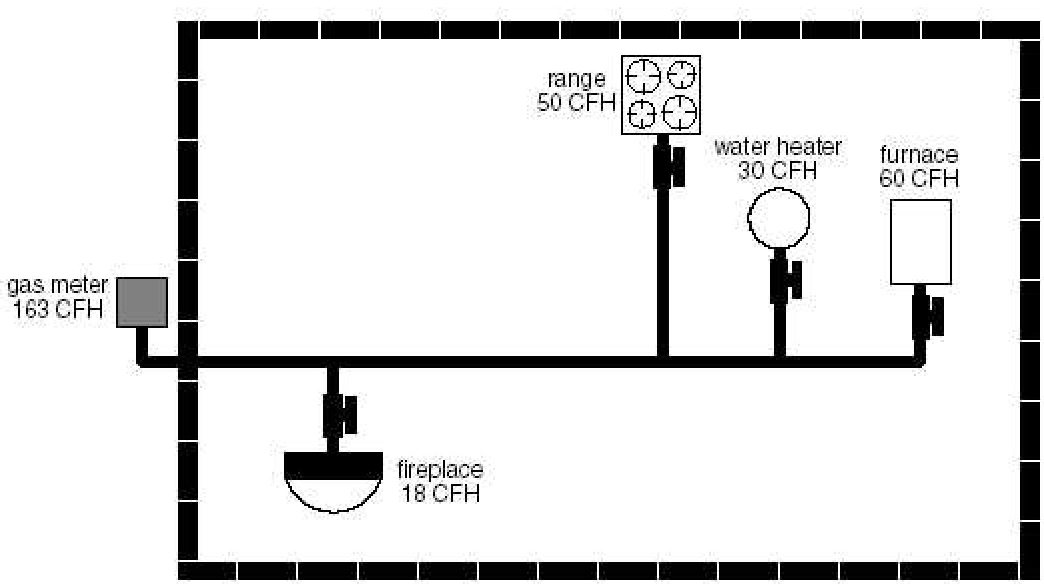


Figure (6.1): a series layout

2. parallel : a parallel system consists of a central distribution manifold with branch runs to the appliances .this is usually accomplished by providing a main supply line to a manifold and installing “ home runs “ to each appliance location . in the

parallel system shown below the pressure is not elevated above 0.5 pound and no regulator is required .

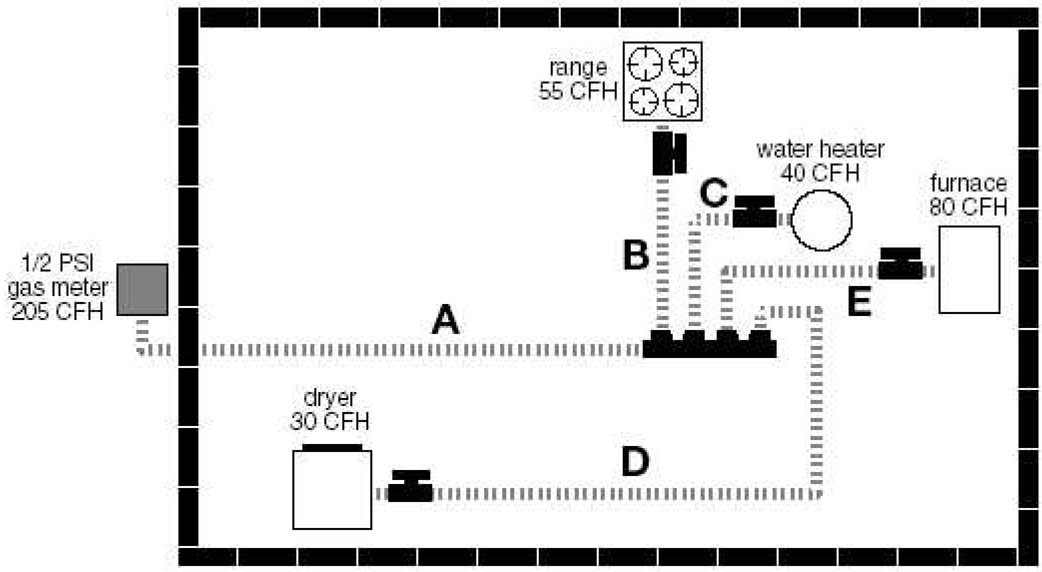


Figure (6.2): a parallel layout

3.dual pressure systems :

elevated pressure systems (2psi for residential and up to 5 psi for commercial installations) are usually piped with one or more house line regulators (pounds to inches) followed by a manifold and runs to each of the appliances . it is possible that these runs to appliances may contain tees branching off to an additional appliance where gas loads permit .

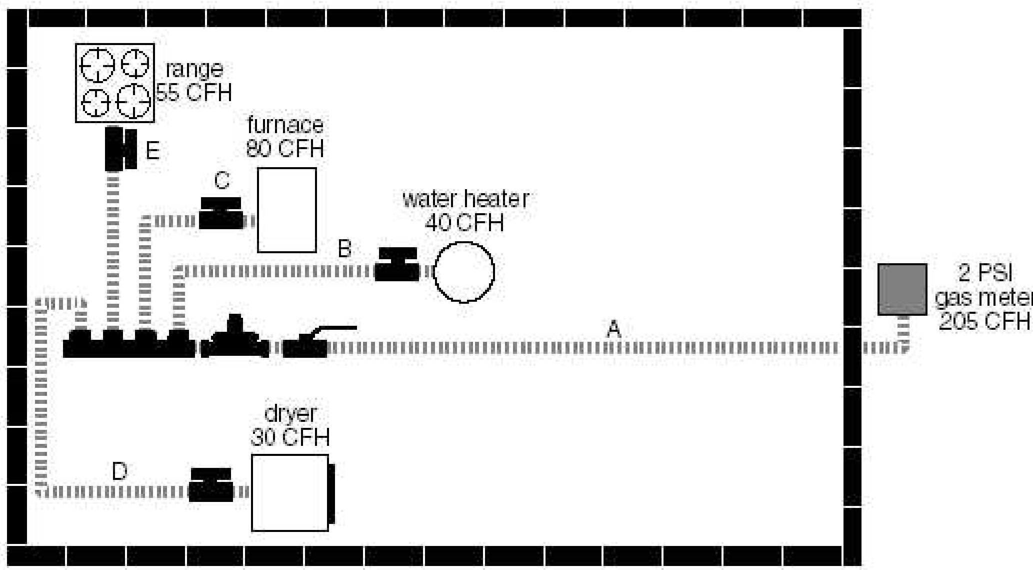


Figure (6.3): a dual layout

6.2 System Pressure Choices :

1. natural gas : determine the delivery pressure provided by the local distribution utility where the piping will be installed .

   a . low pressure : 6 to 7 inches water column – equivalent to 4 ounces or 0.25 pound is the standard pressure supplied by natural gas utilities in the USA and Canada .

   b . medium pressure : 0.5 pound – 12 to 14 inches water column – is available from many natural gas utilities as an enhanced pressure supply . the increase in pressure is provides for reductions in pipe size and does not require a pressure regulator . most natural gas appliances manufactured for use in the US and Canada are designed to operate up to maximum of 14 inches water column .

   c . elevated pressure – 2 psi – is the highest natural gas pressure usually supplied within residential buildings in north America . this pressure always requires the installation of a pounds to inches house line regulator between the utility meter set and the appliances .

2. propane : (LP gas) : is typically supplied within residential buildings at 11 inches water column , set at the second stage regulator mounted outside the building .

propane can also be utilized at medium pressure , with the use of a 13- 14 inch setting . a second stage regulator which reduces 10 psi from the tank to 2 psi must be used .

6.3 Sizing Method of A gas Piping :

6.3.1 Use of Sizing Method :

Every piping system introduces pressure loss to the fluid flowing within . the amount of loss depends on the piping size and the gas flow , expressed in cubic feet per hour (and converted to BTUs) . the object of the sizing exercise is to determine the smallest size piping which will introduce the allowed pressure loss or drop with in the length of piping required . sizing tables (capacity charts) provide the maximum flow capacity for a given length of run for each pipe size . a different sizing table is used for each system pressure and pressure drop combination .

6.3.2 Branch Length Method :

To size each of the gas piping systems , determine the required size for each section and outlet . to size each section of the system determine both the total gas load for all appliances and the maximum distance (longest length) in which a particular section delivers gas .

example: low pressure system series arrangement :

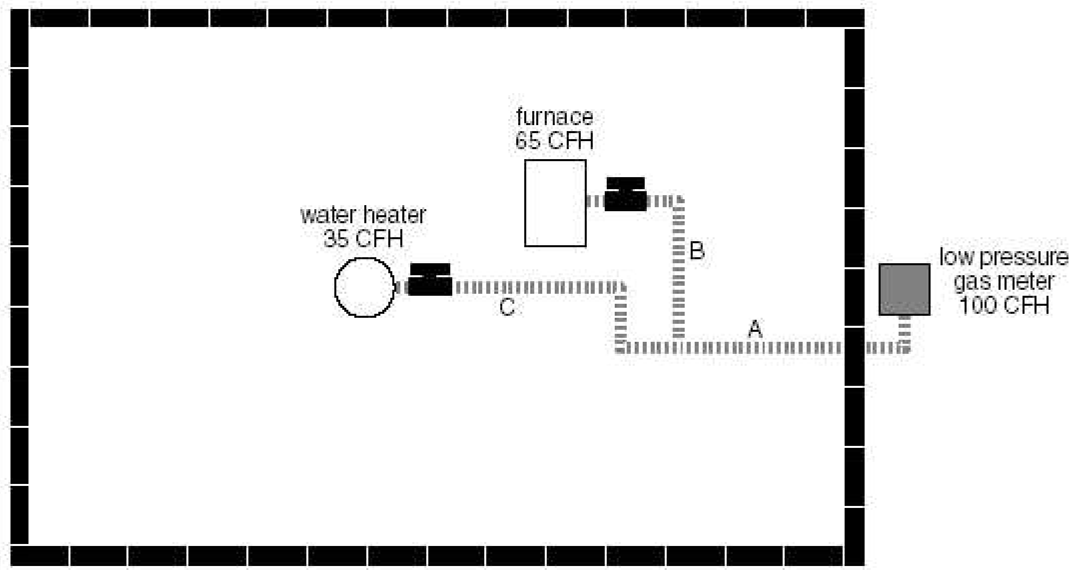


Figure (6.4): ex. branch length method

length of runs : A=10 feet

B= 10 feet

C =15 feet.

Supply pressure 6 inches w.c.

Allowable drop 0.5 inches w.c .

1.The system presented in figure is typical of a single family installation in which there are a limited number of appliances located in one general area . the supply pressure is 6 inches water column and allowable drop is 0.5 inch.

2.to size section A , determine the longest run from the meter that includes section A and the total gas load it must deliver :

A . meter to furnace is 20 ft .(A+B)

B . meter to water heater is 25 ft .(A+C). this is longest run .

C. determine the maximum load transported by section A .

D. furnace plus water heater = 100 cfh (100,000 btu)

E. select from special table (7-1) “ low pressure 6 inches – 0.5 inch w.c drop”

F. using the longest run method , select the column showing the measured length , or the next longest length if the the table does not give the exact length . referring to table (7-1) the column for 25 feet of piping shows that sizes

3 8 and 0.5 are too small and the next available size is 3/ 4 supplying 157 cfh.

G . the correct size is 3 4 inch.

3. to size section B , determine the length of run from the meter to the furnace and the load delivered :

A. length is 20 ft (A+B) and load is 65 cfh (65,000 btu)

B. table (7-1) shows that size 0.5 inch supplies 70 cfh

C. the correct size is 0.5 inch .

4. to size section C , determine the length of run from the meter to the water heater and the load delivered :

A. length is 25 ft (A+C) and load is 35 cfh (35,000 btu)

B. table (7-1) shows that size 0.5 inch is required , because size 3 / 8 inch only supplies 29 cfh (29,000 btu)

C. the correct size is 0.5 inch .

Table (6.1): Estimate cooking gas piping diameter for first and second floor

Properties / section	*Length(m,ft)	flow rate(CFH)	Dimention(inch)	type of gas unit connect.
A	55,180	162	1 1/4	combination
B	14.5,48	147	1	combination
C	18.8,62	135	1	combination
D	20.8,68	120	1	combination
E	25.8,85	108	1	combination
F	27.5,90	93	1	combination
G	33.4,110	81	1	combination
H	35.4,116	66	3/4	combination
I	47,154	54	3/4	combination
J	51.3,168	27	1/2	combination
K	51.2,168	27	1/2	combination
1	12.5,41	15	3/8	furnace
2	15.5,51	12	3/8	range
3	21.3,106	15	3/8	furnace
4	21.7,71	12	3/8	range
5	27.8,91	15	3/8	furnace
6	28.8,94.5	12	3/8	range
7	32.3,106	15	3/8	furnace
8	32.9,108	12	3/8	range
9	50,163	15	1/2	furnace
10	50.4,165	12	1/2	range
11	51.8,170	15	1/2	furnace
12	53,174	12	1/2	range

Table (6.2): Estimate cooking gas piping diameter for first and second floor

Prop. / section	*Length(m, ft)	flow rate(CFH)	Dimension(inch)	type of gas unit connect.
A	14,46	54	3/4	combination
B	20.5,67	27	1/5	combination
C	21,68	27	1/5	combination
1	24.4,80	15	3/8	Furnace
2	22.4,73.5	12	3/8	range
3	22.4,73	15	3/8	furnace
4	21.5,70.5	12	3/8	range

*Length of gas pipe from the gas meter until the end of that section

6.3.3 Sizing Hybrid Method Systems :

(black iron and tracpipe combination)

to size a commercial or a residential system with a rigid black iron truck line and flexible tracpipe branches feeding the appliances , we will need both the standard gas piping capacity tables for black iron printed in many plumbing and mechanical codes (and contained in both national and international fuel gas code) and the tracpipe capacity tables discussed in second semester .

Example: low pressure hybrid system (black iron and tracpipe combination) series arrangement :

length of run :

A=15 feet , C= 20 feet

A1=45 feet , C1= 5 feet

B= 15 feet , D1 = 20 feet

B1 = 10 feet .

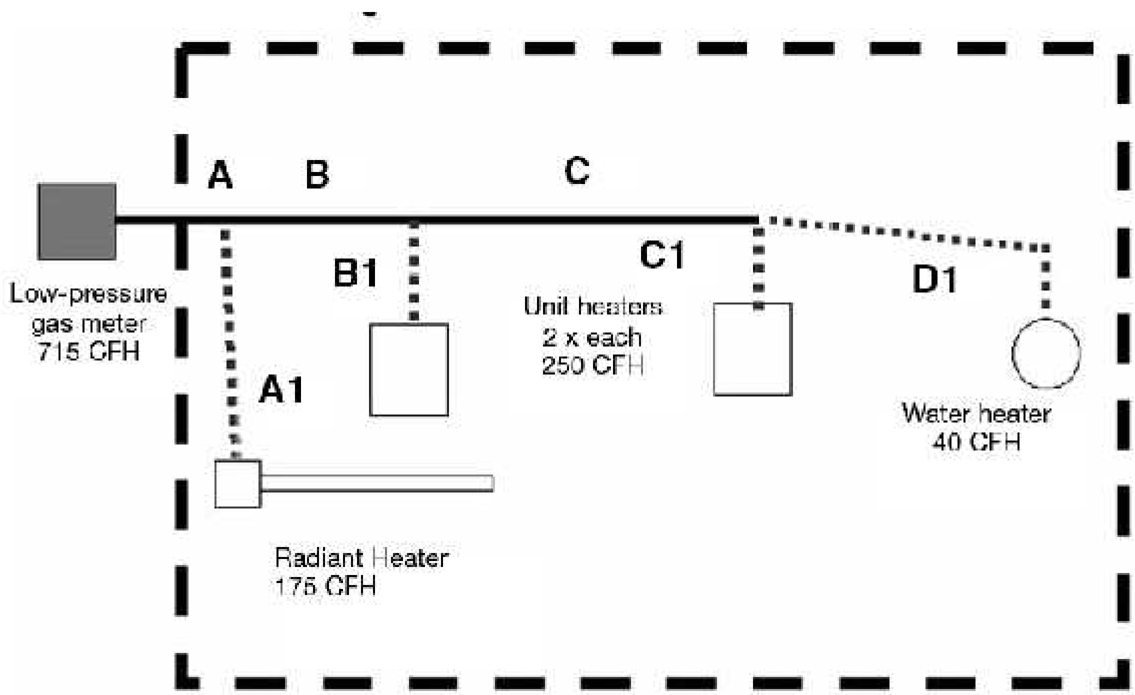


Figure (6.5): ex. sizing hybrid method

1. the system shown in figure is atypical commercial building with 4 appliances . the gas pressure for this example is standard low pressure with 6 inch supply pressure and 0.5 inch pressure drop .
2. to determine rigid pipe size (section A) determine the longest run from the meter to the furthest appliance :
   meter to water heater add A+B+C+D1 = 70 ft.
   total load is 715 cfh (715,000 btu) section A correct size is 11 2 inch black pipe .

3. to determine rigid pipe size (section B) reduce load by the load carried in section A1 to radiant heater (175 cfh) . use same number for length : 70 ft . is longest run . load for this section is 540 cfh section B correct size is 1.5 inch black pipe
4. to determine rigid pipe size (section c) reduce load further by the load carried in section B1 to first unit heater (250 cfh). Use same number for length : 70 ft . is longest run . load for this section is 290 cfh . section C correct size is 1 1/ 4 inch black pipe .

5. to determine tracpipe sizing for the branch runs the length to be used is the Total length of black pipe plus tracpipe from the meter to that appliance . the load used is the load of the individual piece of equipment .

6.to determine the size of tracpipe (section D1) the length is 70 ft and the load is 40 cfh . using table(7-1) : section D correct size is 3 4 inch

7. to determine the size of tracpipe (section C1)the length is 55 ft and the load is 250cfh . using table (7-1) :

Section C1 correct size is 1 1/ 4 inch .

8. to determine the size of tracpipe (section A1)the length is 60 ft and the load is 175 cfh . using table (7-1) .

Section A1 correct size is 1 1/4 inch.

6.4 Supporting Tracpipe

Piping shall be supported in a workmanlike manner with pipe straps, bands, brackets or hangers suitable for the size and weight of the piping. TracPipe which passes over or through a structural member is considered to be supported by that member.

6.4.1 Vertical Runs

Spacing of supports is not to exceed 10 feet, requiring hangers only where the height of each floor is greater than 10 feet.

6.4.2 Horizontal Runs

Spacing of supports Hangers, supports and anchors-Piping shall be supported at intervals not to exceed those shown in Table 7.1. It is acceptable to use standard pipe straps or tubing clips available in metal or plastic materials,

Table (6.3). supporting in pipes

PIPING SIZE	SPACING OF SUPPORTS
3/8 inch	4 FEET
1/2 inch	6 FEET
3/4 inch	8 FT. (USA) 6 FT. (CANADA)
1 inch	8 FT. (USA) 6 FT. (CANADA)
1-1/4 inch	8 FT. (USA) 6 FT. (CANADA)
1-1/2 inch	8 FT. (USA) 6 FT. (CANADA)
2 inch	8 FT. (USA) 6 FT. (CANADA)

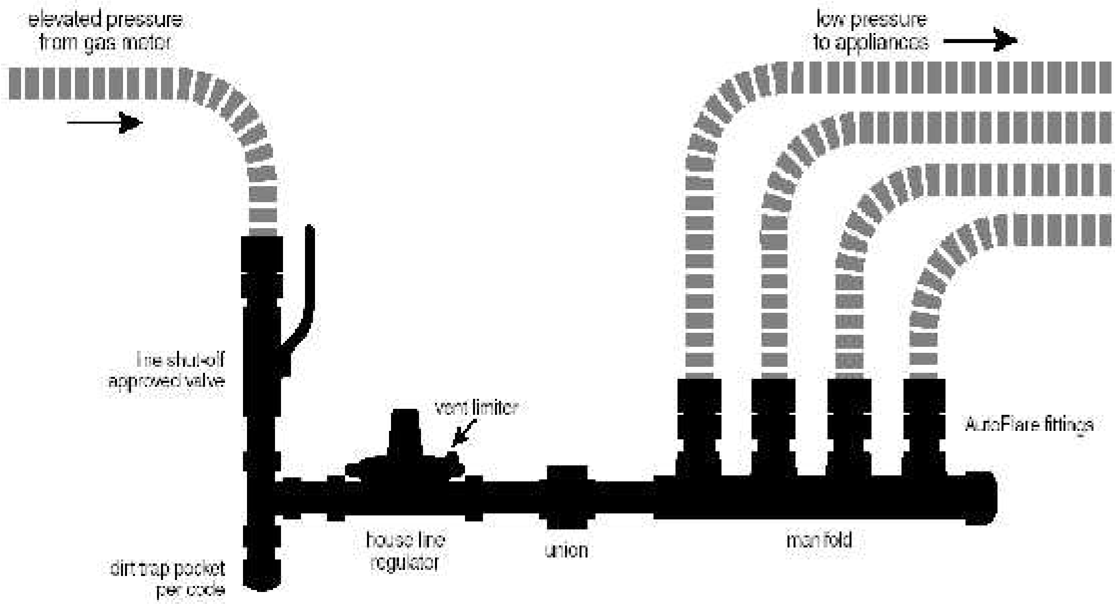


Figure (6.6): mechanical component for gas pipe

Note : see AutoCAD drawing in Appendix .

References

A. Books

1.Mohammed A.Alsaad, and Mahmud A.Hammad, Heating And Air Conditioning For Residential Building . Fourth Edition, 2007.

2. John A Duffie, and William A Beckman. Solar Engineering of Thermal processes, Second Edition, John Wiley And Sons.

3.McGRAW-HILL.2000, building design and construction hand book, six edition , Fredrick s .Merritt and Jonathan T, Ricketts , New York

4. ASHRAE.1999.HVAC application .USA.

5.design of special hazard and fire alarm systems , 2^{nd} editions ,Robert M .Gagnon , America.

6.the design and layout of fire sprinkler systems , 2^{nd} edition , MARK BROMANN, NEW HOLLAND.

7. principle of irrigation and practice , dr. Mohammed Bany Hani ,Quds open university , Amman.

B. Internet

http://www.gas piping design .com

APPENDIX A

TABLE A-1 :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
40	December	−3.3	−4.4	−5.5	−7.2	−5.5	−3.8	0.0	3.8	5.5	−11.6

TABLE A-2 : Performance data for selecting return air diffusers

TABLE 10–12 Performance data for selecting return air diffusers. [a]

Face Velocity m/s	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75
ΔP, Pa	2.0	4.0	7.5	12.5	17.4	22.4	29.9	39.8	49.8	69.7
Size, cm	Volumetric Flow Rate, L/s									
15 × 15	18	23	30	36	45	47	54	65	74	77
15 × 23	23	32	43	54	63	74	85	97	108	117
15 × 30	27	40	54	68	83	97	110	124	137	150
23 × 23	32	45	60	77	92	108	125	140	155	170
23 × 30	38	60	77	97	117	135	155	173	195	212
23 × 38	47	70	92	115	140	162	185	207	230	254
30 × 30	50	72	97	122	145	170	195	218	243	268
30 × 46	70	105	137	173	207	240	276	310	345	378
30 × 53	80	120	160	198	240	280	320	358	395	437
38 × 53	97	145	195	243	293	340	390	435	485	535
38 × 61	110	165	220	275	330	387	440	495	550	603
46 × 61	120	170	230	288	347	403	465	522	567	637
53 × 61	150	225	304	378	456	530	603	684	765	837
61 × 61	170	260	350	437	518	612	702	783	873	954

TABLE A-3 : recommended and maximum air velocities used in warm air heating systems

Description	Recommended Velocity, m/s			Maximum Velocity, m/s		
	Residence Buildings	Public Buildings	Industrial Buildings	Residence Buildings	Public Buildings	Industrial Buildings
Outside air intake	2.5	2.5	2.5	4.0	4.5	6.0
Heating coils	2.3	2.5	3.0	2.5	3.0	3.8
Cooling coils	2.3	2.5	3.0	2.5	3.0	3.5
Fan suction	3.5	4.0	5.0	4.5	5.0	7.0
Fan outlet	5.0-8.0	6.5-10.0	8.0-12.0	8.5	7.5-11.0	8.5-14.0
Main duct	4.0-4.5	5.0-6.5	6.0-9.0	4.0-6.0	5.5-8.0	6.5-11.0
Branch ducts	3.0	3.0-4.5	4.0-5.0	3.5-5.0	4.0-6.5	5.0-9.0
Branch risers	2.5	3.0-3.5	4.0	3.5-4.0	4.0-6.0	5.0-8.0

TABLE A-4 : instantaneous heat gain room occupants in units of watt

Type of Activity	Typical Application	Total Heat Dissipation Adult Male	Total Adjusted[a] 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

TABLE A-5 : Design inside dry bulb temperature usually specified for sensible

Type of Space	T_{di} °C	Type of Space	T_{di} °C
Schools:		*Theaters:*	
Classrooms	22-24	Seating space	20-22
Assembly rooms	20-22	Lounge rooms	20-22
Gymnasiums	16-21	Auditorium	23-24
Toilets and bathes	21	*Hotels:*	
Locker rooms	18-20	Bedrooms and bathes	22-24
Kitchens	19	Dining rooms	22
Dining and lunch rooms	22-24	Kitchen and laundries	19
Play rooms	16-18	Ballrooms	18-20
Hospitals:		Toilets and service rooms	20
Private rooms	22-23	*Public rooms*	22-23
Patient rooms	23-24	*Steam bathes*	43
Operation rooms	21-25	*Foundries and boiler rooms*	10-16
Wards	22-23	*Paint shops*	27
Kitchens and laundries	19	*Factories:*	
Toilets	20	Light work	16-21
Bathrooms in general	23-27	Heavy work	14-20
Stores	21-23	*Swimming pools*	24

TABLE A-6 : Minimum outside air requirements for mechanical ventilation

Application	Maximum Occupancy Per 100 m²	Ventilation Air Requirements	
		L/s/Person	L/s/m²
Game rooms	70	3.5-17.5	—
Ice arenas	—	—	2.50
Swimming pools	—	—	2.50
Gymnasium floors	30	10.0	
Ballrooms and discos	100	3.5-17.5	—
Bowling alleys	70	3.5-17.5	
Theaters:			
Ticket booths	60	10.0	—
Lobbies	150	10.0	—
Auditorium	150	8.0	—
Stages, studios	70	8.0	—
Transportation:			
Waiting rooms	100	8.0	—
Platforms	100	8.0	—
Vehicles	150	8.0	—
Workrooms:			
Meat processing	10	8.0	—
Photo studios	10	8.0	—
Darkrooms	10	—	2.50
Pharmacy	20	8.0	—
Bank vaults	5	8.0	—
Printing, duplicating rooms	—	—	2.50
Correctional facilities:			
Cells	20	10.0	—
Dining halls	100	8.0	—
Guard stations	40	8.0	—
Education :			
Classrooms	50	2.5-12.5	—
Laboratories	30	10.0	—
Training shops	30	3.5-17.5	—
Music rooms	50	3.5-17.5	—
Libraries	20	2.5	—
Locker rooms	—		2.50
Corridors	—	—	0.50
Auditorium	150	8.0	—
Smoking areas	70	30.0	—
Hospitals:			

TABLE A-7 : Number of air change per hour in residences and our commercial

Type of Room or Building	No. of Air Change per Hour
Rooms with no windows or exterior doors	0.5
Rooms with windows or exterior doors on one side only	1.0
Rooms with windows or exterior doors on two sides	1.5
Rooms with windows or exteriors doors on three sides	2.0
Entrance halls	2.0-3.0
Factories, machine shops	1.0-1.5
Recreation rooms, assembly rooms, gymnasium	1.5
Homes, apartments, offices	1.0-2.0
Classrooms, dining rooms, lounges, hospital rooms, kitchens, laundries, ballrooms, bathrooms	2.0
Stores, public buildings	2.0-3.0
Toilets, auditorium	3.0

TABLE A-8 : Cooling load temperature differences (CLTD) for sunlit roofs.

No.	Roof Description of Construction	U_{o}, $W/m^2 \cdot °C$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
			Solar Time, h																							
			Without Suspended Ceiling																							
1	Steel sheet with 25.4 mm (or 50.8 mm) insulation	1.209 (0.704)	0	−1	−2	−2	−3	−2	3	11	19	27	34	40	43	44	43	39	33	25	17	10	7	5	3	1
2	25 mm wood with 25.4 mm insulation	0.963	3	2	0	−1	−2	−2	−1	2	8	15	22	29	35	39	41	41	39	35	29	21	15	11	8	5
3	101.6 mm L.W. concrete	1.209	5	3	1	0	−1	−2	−2	1	5	11	18	25	31	36	39	40	40	37	32	25	19	14	10	7
4	50.8 mm H.W. concrete 25.4 mm (or 50.8 mm) insulation	1.170 (0.693)	7	5	3	2	0	−1	0	2	6	11	17	23	28	33	36	37	37	34	30	25	20	16	12	10
5	25.4 mm wood with 50.8 insulation	0.619	2	0	−2	−3	−4	−4	−4	−2	3	9	15	22	27	32	35	36	35	32	27	20	14	10	6	3
6	152.4 mm L.W. concrete	0.897	12	10	7	5	3	2	1	0	2	4	8	13	18	24	29	33	35	36	35	32	28	24	19	16
7	63.5 mm wood with 25.4 mm insulation	0.738	16	13	11	9	7	6	4	3	4	5	8	11	15	19	23	27	29	31	31	30	27	25	22	19
8	203.4 mm L.W. concrete	0.715	20	17	14	12	10	8	6	5	4	4	5	7	11	14	18	22	25	28	30	30	29	27	25	22
9	101.6 mm H.W. concrete with 25.4 mm (or 50.8 mm) insulation	1.136 (0.681)	14	12	10	8	7	5	4	4	6	8	11	15	18	22	25	28	29	30	29	27	24	21	19	16
10	63.5 mm wood with insulation	0.528	18	15	13	11	9	8	6	5	5	5	7	10	13	17	21	24	27	28	29	29	27	25	23	20
11	Roof terrace system	0.602	19	17	15	14	12	11	9	8	7	8	8	10	12	15	18	20	22	24	25	26	25	24	22	21

TABLE A-9 :Solar heat gain factor (SHG) for sunlit glass (W/m2) for a latitude

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
N	76	85	101	114	120	139	126	117	104	88	76	69
NNE/NNW	76	85	117	252	350	385	350	249	110	88	76	69
NE/NW	91	205	338	461	536	555	527	445	325	199	91	69
ENE/WNW	331	470	577	631	656	656	643	615	546	451	325	265
E/W	552	647	716	716	694	675	678	691	678	615	546	511
ESE/WSW	722	764	748	691	628	596	612	663	716	738	710	688
SE/SW	786	782	716	590	489	439	473	571	688	754	773	776
SSE/SSW	789	732	615	445	213	262	303	429	596	710	776	795
S	776	697	555	363	233	189	227	350	540	678	767	795
Horizontal	555	685	795	855	874	871	861	836	770	672	552	498

TABLE A-10 : Shading coefficient (SC) for glass windows with interior shading

Type of Glass	Nominal Thickness, mm	Type of Interior Shading: Venetian Blinds: Medium	Venetian Blinds: Light	Roller Shade: Opaque: Dark	Roller Shade: Opaque: White	Roller Shade: Translucent: Light
Single Glass						
Clear, regular	2.5-6.0	—	—	—	—	—
Clear, plate	6.0-12.0	—	—	—	—	—
Clear Pattern	3.0-12.0	0.64	0.55	0.59	0.25	0.39
Heat Absorbing	3	—	—	—	—	—
Pattern or Tinted(gray sheet)	5.0-5.5	—	—	—	—	—
Heat Absorbing, plate	5.0-6.0	0.57	0.53	0.45	0.30	0.36
Pattern or Tinted, gray sheet	3.0-5.5	—	—	—	—	—
Heat Absorbing Plate or Pattern Heat Absorbing	10	0.54	0.52	0.40	0.82	0.32
Heat Absorbing or Pattern	—	0.42	0.40	0.36	0.28	0.31
Reflective Coated Glass	—	0.30	0.25	0.23	—	—
	—	0.40	0.33	0.29	—	—
	—	0.50	0.42	0.38	—	—
	—	0.60	0.50	0.44	—	—
Double Glass						
Regular	3	0.57	0.51	0.60	0.25	—
Plate	6	0.57	0.51	0.60	0.25	—
Reflective	6	0.20-	—	—	—	—

TABLE A-11 : Shading coefficient (SC) for glass windows without interior shading

Type of Glass	Nominal Thickness, mm	Solar Trans.	Shading Coefficient, W/m²·K	
			$h_o = 22.7$	$h_o = 17.0$
Single Glass				
Clear	3	0.84	1.00	1.00
	6	0.78	0.94	0.95
	10	0.72	0.90	0.92
	12	0.67	0.87	0.88
Heat absorbing	3	0.64	0.83	0.85
	6	0.46	0.69	0.73
	10	0.33	0.60	0.64
	12	0.42	0.53	0.58
Double Glass				
Regular	3	—	0.90	—
Plate	6	—	0.83	—
Reflective	6	—	0.20-0.40	—
Insulating Glass				
Clear	3	0.71	0.88	0.88
	6	0.61	0.81	0.82
Heat absorbing*	6	0.36	0.55	0.58

TABLE A-12 : Circular equivalent diameters of rectangular ducts for equal pressure drop and

Lgth. Adj.	Length of One Side of Rectangular Duct, mm																			
	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700	750	800	900
100	109																			
150	133	150	164																	
200	152	172	189	204	219															
250	169	190	210	228	244	259	273													
300	183	207	229	248	266	283	299	314	328											
400	207	235	260	283	305	325	343	361	378	409	437									
500	227	258	287	313	337	360	381	401	420	455	488	518	547							
600	245	279	310	339	365	390	414	436	457	496	533	567	598	628	656					
700	261	298	331	362	391	418	443	467	490	533	572	610	644	677	708	737	765			
800	275	314	350	383	414	442	470	496	520	563	609	649	683	722	755	787	818	847	875	
900	289	330	367	402	435	465	494	522	548	597	643	686	726	763	799	833	866	897	927	984
1000	301	344	384	420	454	486	517	546	574	626	674	719	762	802	840	876	911	944	976	1037
1200	324	370	413	453	490	525	558	590	620	677	731	780	827	872	914	954	993	1030	1066	1133
1400	344	394	439	482	522	559	595	629	662	724	781	835	886	934	980	1024	1066	1107	1146	1220
1600	362	415	463	508	551	591	629	665	700	766	827	885	939	991	1041	1088	1133	1177	1219	1298
1800	379	434	485	533	577	619	660	698	735	804	869	930	988	1043	1096	1146	1195	1241	1286	1371
2000	395	453	506	555	602	646	688	728	767	840	908	973	1034	1092	1147	1200	1252	1301	1348	1438
2200	410	470	525	577	625	671	715	757	797	874	945	1013	1076	1137	1195	1251	1305	1356	1406	1501
2400	424	486	543	597	647	695	740	784	826	905	980	1050	1116	1180	1241	1299	1355	1409	1461	1561
2600	437	501	560	616	668	717	764	810	853	935	1012	1085	1154	1220	1283	1344	1402	1459	1513	1617
2800	450	516	577	634	688	738	787	834	879	964	1043	1119	1190	1259	1324	1387	1447	1506	1562	1670

TABLE A-13 : Cooling load temperature differences (CLTD) for convection heat gain for glass windows

Solar Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
CLTD °C	1	0	-1	-1	-1	-1	-1	0	1	2	4	5	7	7	8	8	7	7	6	4	3	2	2	1

TABLE A-14 : Diversity factor for selected application

Application	Diversity Factor	
	Lights	People
Peripheral aras of offices with glazing area of 20%-50%	0.70-0.85	0.7-0.8
Core areas of offices and peripheral areas with less than 20% glazing	0.90-1.00	0.7-0.8
Apartments and hotel bedrooms	0.30-0.50	0.4-0.6
Public rooms in hotels	0.90-1.00	0.4-0.6
Department stores and supermarkets	0.90-1.00	0.8-1.0

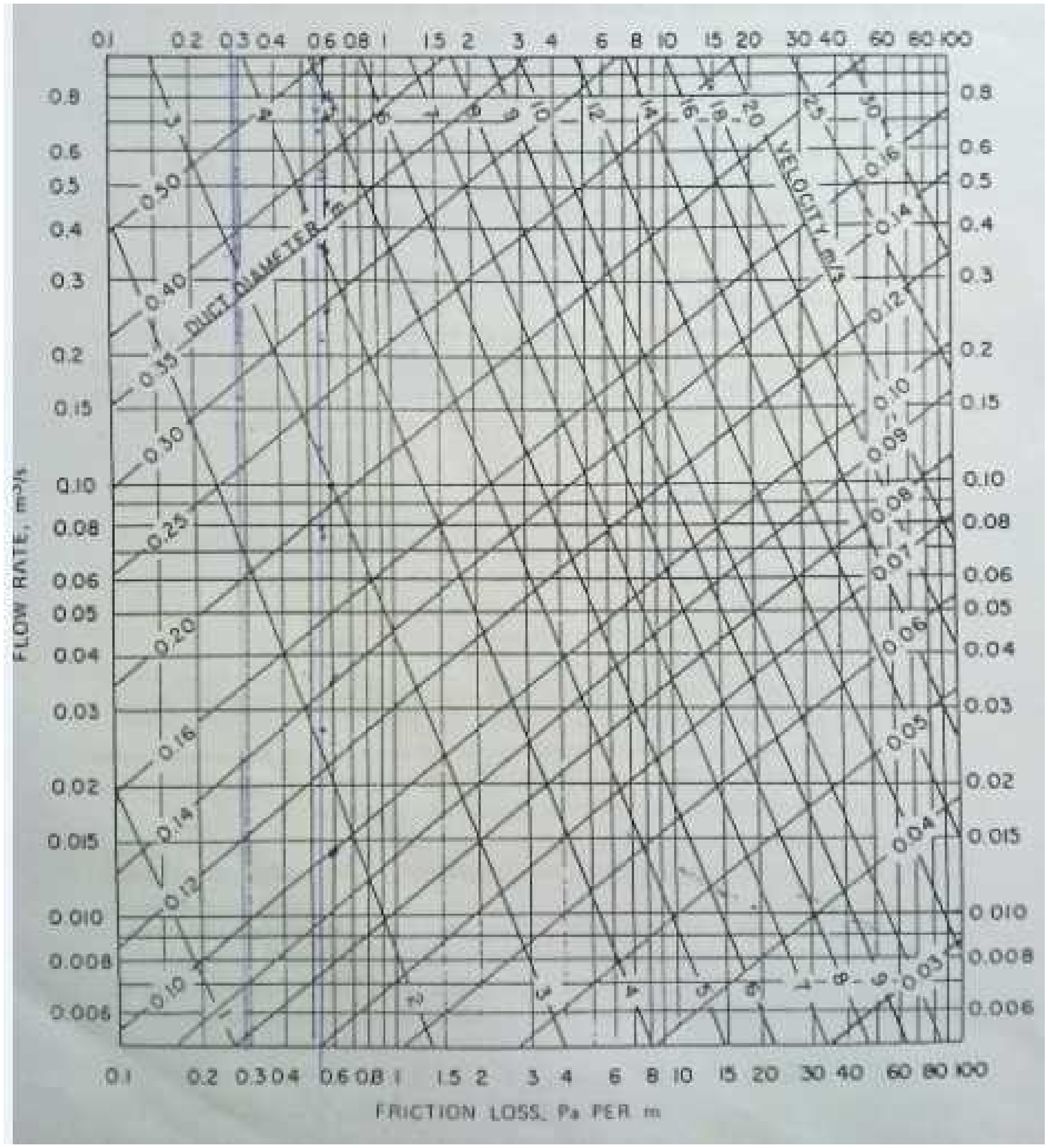


FIGURE A-1: Pressure drop (ΔP/EL) for low flow rates of air in galvanized steel ducts, based on round duct diameter.

TABLE A-15 : Approximate values of equivalent length Le ,for commonly used fittings.

Fitting	L_e m
45° Round elbow	1.5
90° Four pieces elbow	3.0
Gradual reduction	6.0
45° Round Tee:	
Main run	1.5
Branch	11.0
90° Round Tee:	
Main run	1.5
Branch	15.0
90° Rectangular elbow	5.0
Abrupt round contraction or expansion	11.0

TABLE A-16 : Performance data for selecting return air diffusers

Face Velocity m/s	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75
ΔP, Pa	2.0	4.0	7.5	12.5	17.4	22.4	29.9	39.8	49.8	69.7
Size, cm	Volumetric Flow Rate, L/s									
15 × 15	18	23	30	36	45	47	54	65	74	77
15 × 23	23	32	43	54	63	74	85	97	108	117
15 × 30	27	40	54	68	83	97	110	124	137	150
23 × 23	32	45	60	77	92	108	125	140	155	170
23 × 30	38	60	77	97	117	135	155	173	195	212
23 × 38	47	70	92	115	140	162	185	207	230	254
30 × 30	50	72	97	122	145	170	195	218	243	268
30 × 46	70	105	137	173	207	240	276	310	345	378
30 × 53	80	120	160	198	240	280	320	358	395	437
38 × 53	97	145	195	243	293	340	390	435	485	535
38 × 61	110	165	220	275	330	387	440	495	550	603
46 × 61	120	170	230	288	347	403	465	522	567	637
53 × 61	150	225	304	378	456	530	603	684	765	837
61 × 61	170	260	350	437	518	612	702	783	873	954

TABLE A-17 : thermal conductivity of some construction materials.

Material Number	Material	Density kg/m³	Thermal Conductivity W/m·°C
1	*Building Stone*		
	Marble	2,600	2.90
	Hard stone	2,500	2.20
	Firm stone	2,250	1.70
	Semi-firm stone	2,000	1.40
	Soft stone	1,750	1.05
	Granite	2,800	3.50 - 4.1
	Basalt and stones	2,800	3.50
	Lime stone	2500	1.3
2	*Sand*	1,800	0.70
	Soil	-	1.0 – 1.15
3	*Building brick*		
	Cement brick, solid	1,900	1.20
	Cement brick, with air gaps	1,600	1.00
	Common brick (low density)	1,400	0.72
	Face brick (high density)	1,200	1.27
	Glass brick	1,000	0.65
	Fire-clay brick	2,000	1.00
		1,800	0.80
		1,600	0.70
		1,400	0.60
		1,200	0.52
		1,000	0.47
	Clay	-	1.4
4	*Concrete, regular and reinforced*		
	Light concrete	2,300	1.75
		2,000	1.20
		1,800	1.00
		1,600	0.87
		1,400	0.72
		1,200	0.60
		1,000	0.47
	Foam concrete	1,600	0.68
		1,400	0.61
		1,200	0.52

Material Number	Material	Density kg/m³	Thermal Conductivity W/m °C
		1,000	0.43
		900	0.36
		800	0.30
		700	0.22
		600	0.19
		500	0.16
	Mortar	1800	0.72 – 1.05
5	*Titles*		
	Terrazzo tiles	2,000	1.40
	Ceramic tiles	2,100	1.10
	PVC tiles	2,000	1.20
	Rubber tiles	1,500	0.23
	Rubber flooring	-	0.4
	Plastic tiles	-	0.2 – 0.5
6	*Cement Plaster*	2,000	1.20
		1,800	0.85
		1,400	0.70
		1,200	0.40
	Gypsum plaster	720	0.8
7	*Wood, natural*		
	Oak	800	0.21
	Pine	600	0.14
	Beech	800	0.17
	Mahogany	700	0.16
	Teak	700	0.17
	Red wood	-	0.11
8	*Wood boards*		
	Hard fiber boards	1,000	0.14
	Soft fiber boards	300	0.06
	Plywood boards	545	0.12
	Chip boards	800	0.15
	parquet	-	0.23
9	*Gypsum boards*	-	0.17
	Cork boards	800	0.95
10	*Window glass*		
	Regular	2,500	1.05
	Thermal resisting	2,250	1.10
11	*Metals*		

Material Number	Material	Density kg/m³	Thermal Conductivity W/m·°C
	Aluminum	2,300	200
	Copper	8,900	250
	Brass	8,400	130
	Cast iron	7,000	40
	Mild steel	7,800	45
	Stainless steel	7,800	15
12	*Insulating material*		
	Polystyrene boards	30	0.030
		25	0.034
		15	0.037
	Polyurethane boards	30	0.027 – 0.035
		37	0.030
	Rock wool	140	0.040
		130	0.036
		80	0.038
		50	0.039
	Glass wool	180	0.042
		130	0.045
		80	0.035
		65	0.032
		50	0.033
		25	0.040
	Cork boards	160	0.045
		145	0.042
		130	0.040
		110	0.039
	Cork particles	45 - 120	0.045
13	*Asphalt mix*	2,300	1.10
	Asphalt	2100	0.80
	Roll roofing	1,100	0.18

TABLE A-18 : Approximate CLTD values for sunlit roofs C.

Solar Time	Roof Construction		
	Light	Medium	Heavy
10:00	5	—	—
11:00	12	—	—
12:00	19	3	0
13:00	25	8	2
14:00	29	14	5
15:00	31	19	8
16:00	31	23	10
17:00	29	25	12
18:00	24	26	14
19:00	19	25	15
20:00	11	22	16

TABLE A-19 : cooling load factors(CLF) for glass windows without interior shading

Glass Facing	Building Construction	Solar Time, h																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
N	L	0.17	0.14	0.11	0.09	0.08	0.33	0.24	0.48	0.56	0.61	0.71	0.76	0.80	0.82	0.82	0.79	0.75
	M	0.23	0.20	0.18	0.16	0.14	0.34	0.14	0.46	0.53	0.59	0.65	0.70	0.73	0.75	0.76	0.74	0.75
Shaded	H	0.25	0.23	0.21	0.20	0.19	0.38	0.45	0.49	0.55	0.60	0.65	0.69	0.72	0.72	0.72	0.70	0.70
NNE	L	0.06	0.05	0.04	0.03	0.03	0.26	0.43	0.47	0.44	0.41	0.40	0.39	0.39	0.38	0.36	0.33	0.30
	M	0.09	0.08	0.07	0.06	0.06	0.24	0.38	0.42	0.39	0.37	0.37	0.36	0.36	0.36	0.34	0.33	0.30
	H	0.11	0.10	0.09	0.09	0.08	0.26	0.39	0.42	0.39	0.36	0.35	0.34	0.34	0.33	0.32	0.31	0.28
NE	L	0.04	0.04	0.03	0.02	0.02	0.23	0.41	0.51	0.51	0.45	0.39	0.36	0.33	0.31	0.28	0.26	0.23
	M	0.07	0.06	0.06	0.05	0.04	0.21	0.36	0.44	0.45	0.40	0.36	0.33	0.31	0.30	0.28	0.26	0.24
	H	0.09	0.08	0.08	0.07	0.07	0.23	0.37	0.44	0.44	0.39	0.34	0.31	0.29	0.27	0.26	0.24	0.22
ENE	L	0.04	0.03	0.03	0.02	0.02	0.21	0.40	0.52	0.57	0.53	0.45	0.39	0.34	0.31	0.28	0.25	0.22
	M	0.07	0.06	0.05	0.05	0.04	0.20	0.35	0.45	0.49	0.47	0.41	0.36	0.33	0.30	0.28	0.26	0.23
	H	0.09	0.09	0.08	0.07	0.07	0.22	0.36	0.46	0.49	0.45	0.38	0.31	0.30	0.27	0.25	0.23	0.21
E	L	0.04	0.03	0.03	0.02	0.02	0.19	0.37	0.51	0.57	0.57	0.50	0.42	0.37	0.32	0.29	0.25	0.22
	M	0.07	0.06	0.06	0.05	0.05	0.18	0.33	0.44	0.50	0.51	0.46	0.39	0.35	0.31	0.29	0.26	0.23
	H	0.09	0.09	0.08	0.08	0.07	0.20	0.34	0.45	0.49	0.49	0.43	0.39	0.32	0.29	0.26	0.24	0.22
ESE	L	0.05	0.04	0.03	0.03	0.02	0.17	0.34	0.49	0.58	0.61	0.57	0.48	0.41	0.36	0.32	0.28	0.24
	M	0.08	0.07	0.06	0.05	0.05	0.16	0.31	0.43	0.51	0.54	0.51	0.44	0.39	0.35	0.32	0.29	0.26
	H	0.10	0.09	0.09	0.08	0.08	0.19	0.32	0.43	0.50	0.52	0.48	0.41	0.36	0.32	0.29	0.26	0.24
SE	L	0.05	0.04	0.04	0.03	0.03	0.13	0.28	0.43	0.55	0.62	0.63	0.57	0.48	0.42	0.37	0.33	0.28
	M	0.09	0.08	0.07	0.06	0.05	0.14	0.26	0.38	0.48	0.54	0.56	0.51	0.45	0.40	0.36	0.33	0.29
	H	0.11	0.10	0.10	0.09	0.08	0.17	0.28	0.40	0.49	0.53	0.53	0.48	0.41	0.36	0.33	0.30	0.27
SSE	L	0.07	0.05	0.04	0.04	0.03	0.06	0.15	0.29	0.43	0.55	0.63	0.64	0.60	0.25	0.45	0.40	0.35
	M	0.11	0.09	0.08	0.07	0.06	0.08	0.16	0.26	0.38	0.58	0.55	0.57	0.54	0.48	0.43	0.39	0.35
	H	0.12	0.11	0.11	0.10	0.09	0.12	0.19	0.29	0.40	0.49	0.54	0.55	0.51	0.44	0.39	0.35	0.31
S	L	0.08	0.07	0.05	0.04	0.04	0.06	0.09	0.14	0.22	0.34	0.48	0.59	0.65	0.65	0.59	0.50	0.43
	M	0.12	0.11	0.09	0.08	0.07	0.08	0.11	0.14	0.21	0.31	0.42	0.52	0.57	0.58	0.53	0.47	0.41
	H	0.13	0.12	0.12	0.11	0.10	0.11	0.14	0.17	0.24	0.33	0.43	0.51	0.56	0.55	0.50	0.43	0.37
SSW	L	0.10	0.08	0.07	0.06	0.05	0.06	0.09	0.11	0.15	0.19	0.27	0.39	0.52	0.62	0.67	0.65	0.58
	M	0.14	0.12	0.11	0.09	0.08	0.09	0.11	0.13	0.15	0.18	0.25	0.35	0.46	0.55	0.59	0.59	0.53
	H	0.15	0.14	0.13	0.12	0.11	0.12	0.14	0.16	0.18	0.21	0.27	0.37	0.46	0.53	0.57	0.55	0.49
SW	L	0.12	0.10	0.08	0.06	0.05	0.06	0.08	0.10	0.12	0.14	0.16	0.24	0.36	0.49	0.60	0.66	0.66
	M	0.15	0.14	0.12	0.10	0.09	0.09	0.10	0.12	0.13	0.15	0.17	0.23	0.33	0.44	0.53	0.58	0.59
	H	0.15	0.14	0.13	0.12	0.11	0.12	0.13	0.14	0.16	0.17	0.19	0.25	0.34	0.44	0.53	0.56	0.56
WSW	L	0.12	0.10	0.08	0.07	0.05	0.06	0.07	0.09	0.10	0.12	0.13	0.17	0.28	0.40	0.52	0.62	0.66
	M	0.15	0.13	0.12	0.10	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.17	0.24	0.35	0.46	0.54	0.58
	H	0.15	0.14	0.13	0.12	0.11	0.11	0.12	0.13	0.14	0.15	0.16	0.19	0.26	0.36	0.46	0.53	0.56

TABLE A-20 : cooling load factors(CLF) for glass windows with interior shading

Fenestration	Solar Time, h																
Facing	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
N	0.08	0.07	0.06	0.06	0.07	0.73	0.66	0.65	0.73	0.80	0.86	0.89	0.89	0.86	0.82	0.75	0.78
NNE	0.03	0.03	0.02	0.02	0.03	0.64	0.77	0.62	0.42	0.37	0.37	0.37	0.36	0.35	0.32	0.28	0.23
NE	0.03	0.02	0.02	0.02	0.02	0.56	0.76	0.74	0.58	0.37	0.29	0.27	0.26	0.24	0.22	0.20	0.16
ENE	0.03	0.02	0.02	0.02	0.02	0.52	0.76	0.80	0.71	0.52	0.31	0.26	0.24	0.22	0.20	0.18	0.15
E	0.03	0.02	0.02	0.02	0.02	0.47	0.72	0.80	0.76	0.62	0.41	0.27	0.24	0.22	0.20	0.17	0.14
ESE	0.03	0.03	0.02	0.02	0.02	0.41	0.67	0.79	0.80	0.72	0.54	0.34	0.27	0.24	0.21	0.19	0.15
SE	0.03	0.03	0.02	0.02	0.02	0.30	0.57	0.74	0.81	0.79	0.68	0.49	0.33	0.28	0.25	0.22	0.18
SSE	0.04	0.03	0.03	0.03	0.02	0.12	0.31	0.54	0.72	0.81	0.81	0.71	0.54	0.38	0.32	0.27	0.22
S	0.04	0.04	0.03	0.03	0.03	0.09	0.16	0.23	0.38	0.58	0.75	0.83	0.80	0.68	0.50	0.35	0.27
SSW	0.05	0.04	0.04	0.03	0.03	0.09	0.14	0.18	0.22	0.27	0.43	0.63	0.78	0.84	0.80	0.66	0.46
SW	0.05	0.05	0.04	0.04	0.03	0.07	0.11	0.14	0.16	0.19	0.22	0.38	0.59	0.75	0.83	0.81	0.69
WSW	0.05	0.05	0.04	0.04	0.03	0.07	0.10	0.12	0.14	0.16	0.17	0.23	0.44	0.64	0.78	0.84	0.78
W	0.05	0.05	0.04	0.04	0.03	0.06	0.09	0.11	0.13	0.15	0.16	0.17	0.31	0.53	0.72	0.82	0.81
WNW	0.05	0.05	0.04	0.03	0.03	0.07	0.10	0.12	0.14	0.16	0.17	0.18	0.22	0.43	0.65	0.80	0.84
NW	0.05	0.04	0.04	0.03	0.03	0.07	0.11	0.14	0.17	0.19	0.20	0.21	0.22	0.30	0.52	0.73	0.82
NNW	0.05	0.05	0.04	0.03	0.03	0.11	0.17	0.22	0.26	0.30	0.32	0.33	0.34	0.34	0.39	0.61	0.82
HORIZ.	0.06	0.05	0.04	0.04	0.03	0.12	0.27	0.44	0.59	0.72	0.81	0.85	0.85	0.81	0.71	0.58	0.42

Table(7-1) : low pressure standard

Maximum Capacity of OmegaFlex TracPipe CSST in Cubic Feet per Hour (CFH) of Natural Gas (1000 BTU per cubic foot approx)
Min. Gas Pressure: 6-7 in w.c.
Pressure Drop: 0.5 in w.c.
(Based on a 0.60 Specific Gravity Gas)

Size	EHD	5	10	15	20	25	30	40	50	60	70	75	80	90	100	125	150	200	250	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
		Tubing Length (feet)																														
3/8"	15	63	45	37	32	29	27	23	21	19	18	17	17	16	15	14	12	11	10	9	8	7	6	6	5	5	5	5	4	4	4	4
1/2"	19	138	95	81	70	63	58	50	45	41	38	37	36	34	32	29	26	23	20	19	16	14	13	12	11	11	10	10	9	9	9	8
3/4"	25	344	245	201	175	157	143	125	112	102	95	92	88	84	80	71	65	57	51	46	40	36	33	31	29	27	26	24	23	22	22	21
1"	31	650	470	348	295	267	244	212	190	174	161	156	151	142	135	121	111	96	86	79	68	61	55	52	48	45	42	41	40	38	37	36
1 1/4"	37	1103	789	646	561	503	460	399	358	327	303	293	284	268	254	228	208	181	162	148	128	115	105	97	91	85	82	78	75	72	69	67
1 1/2"	46	1790	1261	1027	888	793	723	625	558	509	471	456	440	416	393	351	322	277	247	226	196	174	159	147	137	129	123	117	112	107	103	100
2"	62	4142	2924	2388	2068	1850	1690	1462	1307	1190	1114	1078	1047	983	931	835	762	661	591	540	468	419	383	354	331	312	296	283	271	260	251	242

see notes below*
EHD (Equivalent Hydraulic Diameter) A theoretical size which reflects the hydraulic performance of the tubing. It is not a true physical measure. This number is used to compare individual sizes between different manufactures.
The higher the EHD number the greater the flow capacity of the piping.

Table(7-2) : approximate gas requirement

Activity	Volume of Gas
Cooking for a family of 5 or 6 persons	$2m^3$ per day
Heating water in a 100-liter tank	$3m^3$ per day
Lighting one lamp	$0.1-0.15m^3$ per hour
Operating a two-horsepower stationary engine	$0.9m^3$ per hour