DESIGN OF MECHANICAL SERVICE SYSTEM IN HOSPITAL IN HALHUOL

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College of Engineering

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Graduation Project Evaluation

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 fulfillments of the requirements of (B.SC) degree.

Supervisor Signature

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Committee signature

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Department Headmaster Signature

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Dedication

To The Souls Of Our Ancestors

Who Left With Rivers Of Benevolence

To Our Parents Those Who Were Mentors, Teachers and Friends

Who Were Guides With Their Endless Giving

To Our Teachers

Who Were Candles, Lighting Our Path to Excellence

To Our Beloved University

Where Our Hearts Will Remain

To The Entire Islamic Nation

To The Reading Public in General

To All Those

We Promise…

The Promise of the Blood of Martyrs

That We Will Forever Be Loyal Servants To Our Glorious Islam

Abstract

This project deals with the design of mechanical systems for a hospital in Halhoul city which consists of four stories with a total area of 3000 m^2. So that the hospital serves thousands of Palestinian people living in halhoul.

Mechanical systems include heating, ventilation and air conditioning (HVAC systems), water supply, drainage system and firefighting system.

This project is done as an applied for several engineering courses which has been studies in our Specialization.

This project discus briefly theory needed for the design of mechanical systems.

Design output is then displaced on drawing. These drawings will include: piping networks for water distribution, drain and sewage and firefighting system. Also drawing will detail duct systems and different equipment required for the embassy.

يهدف هذا المشروع الى تصميم نظام ميكانيكي متكامل لمستشفى سيتم انشاءه في حلحول، حيث يتواجد الالاف من الفلسطينين يعيشون ويعملون هناك.

النظام الميكانيكي المراد تصميميه يشمل التدفئه، التكييف ، والتهويه، نظام تزويد المياه (الساخنه والبارده)،
نظام صرف صحي متكامل ، نظام تصريف مياه الامطار ، اضافه الى نظام اطفاء الحريق.

نظام التدفئه والتكييف نظا مركب يتكون من ملفات (كويلات) مركبه عليها مراوح لدفع الهواء وتمريره عليها، حيث ان النظام هو نظام مائي كامل يزاود املفات بالمياه الساخنه من البويلر والمياه البارده تصل من الشيلر

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CHAPTER ONE

INTRUDUCTION

1 Introduction

1.1 General Overview of project

The Government hospitals in Palestine had an essential and vital rule, in promoting the general health of the Palestinians people, like Halhol hospital. Halhol hospital have different sections, including internal medicines, Pediatrics, Orthopedic, Surgery, Gynecology, Lab investigation, X-ray and Ultra sound in addition to outpatient clinics.

The different mechanical installation systems including central heating system, air conditioning system, water supply system, drainage supply system, and medical gasses system are not less important for the patients than the medical service itself so, such installations must be in the best manner in addition to the continuous maintenance needed to guarantee best performance.

Halhol hospital as one of these governmental hospitals study, hoping through survey and evaluation of the mechanical systems to race problems and provide solutions for them, to full fill one of the poly technical university aims to help thesociety.

1.2 Project benefits:

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

1.3 Project objectives:

The aim of this project is summarized by the following points:

1- Design domestic water system and design grill of Pipes to sewage and drainage systems.
2- Design HVAC systems for all floors
3- Design fire fighting for all floors
4- Designing gas piping for all floors

1.4 Description of Project Idea.

The hospital named "Halhol Hospital" is located in Halhol in Hebron, which is planned to service thousands of people in Halhol, it contains four floor, each floor area almost (3000) m^2, and it contains the following administration departments.

The hospital also has the following medical departments:-

1. Delivery department.
2. Surgery department.
3. Emergency department.
4. Labs of medical test.
5. Radiology department.
6. Pharmacy

Table 1. 1 area of floors

floor	Area [m^2]
Ground	3009
First	2396
Second	2074
Third	3221
four	568

1.5 Time table.

Time table of the of the first semester.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project selection And proposal																
Information Gathering																
Writing introduction & human comfort																
Load calculation																
HVAC systems																
Printing final copy																

Time table of the second semester

Task\week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Plumping system																
Drainage system																
Gas system																
HVAC System																
Fire fighting system.																
Printing final copy																

1.6 Project layout

- Chapter one: Introduction:

  Include an overview about the project, and the importance of the mechanical systems.

- Chapter two: Human Comfort:

  Include an overview about the appropriate conditions for human life in terms of temperature and humidity.

- Chapter three: Load Calculation:

  Include an overview about the Thermal loads of the building accountinthe summer and winter.

- Chapter Four: Plumbing system:

  Include an overview about the water supply, drainage system, plumbing materials, water distribution in buildings, water service sizing.

- Chapter Five: HVAC System:

  Include an overview about heating and cooling and ventilation system.

- Chapter Six: fire fighting system:

  Include the system that used to fight the fire.

- Chapter seven: medical gas:

  Includes the calculation of the medical gas

CHAPTER TWO

HEAT AND HUMAN COMOFORT

2 Heat and Human Comfort

Extremes temperature (very cold and very hot) can affected on human, so the lack of controlling of the temperature of a hospital can lead to patient and employees dissatisfaction and increased incidence of stress.

The primary job of heating, ventilating and air conditioning system is usually to make people comfortable. The system helps people feel comfort and improves their efficiency. To meet people needs, the HVAC system will effectively manage only the temperature, humidity, air flow and manage the air equality of the exterior environment.

2.1 Human Comfort

People interaction is very complex with their environment; however defining comfort to everyone is difficult for three reasons. First, comfort means subjective feelings and feeling doesn't be measured. Second, comfort is different from one person to other, maybe someone is comfort and the other discomfort or the ideal temperature for each is too worm or too cold. Third, there are many variables that affect human comfort thermal, visual, acoustical and air quality.

2.2 Components of Comfort

1- Physical factors: include sound, light, area-volume, radiation, inspired gas, etc.
2- Reciprocities factors: include clothing, social, incentive and activity.
3- Organism factors: include body type, drive, age, sex, etc.

2.3 Heat and Temperature

Heat is a form of energy that flows from a point at one temperature to another point at a lower temperature and it has two types:

1- Sensible heat: is the heat which causes a change in temperature when it is added or removed.

2- Latent heat: is the heat which causes changes of state or phase in the substance while temperature remains constant. The two most common temperature scales is:

   a. Fahrenheit scale: the most common throughout of united state.

   b. Celsius scale: the most common used scientific thermometer throughout the world.

2.4 Properties of Atmosphere Air

Air is a mixture of nitrogen, oxygen, and small amounts of some other gases. It plays an important role and affected the human comfort because the air all the time surrounds the human body at all times. The study of the physical properties and thermal processes of atmospheric air is called psychometrics, and the properties are:

2.4.1 Dry Bulb (db) Temperature

Dry bulb temperature is usually referred to the air temperature that is measured by thermometer; it is a mixture of several of gases such as nitrogen, oxygen, carbon and other gases. It is called dry bulb because the air temperature doesn't affected by the moisture of the air.

2.4.2 Specific and Relative Humidity

The amount of water vapor in the air can be specified in various ways. Probably the most logical way is to specify directly the mass of water vapor present in a unit mass of dry air. This is called absolute or specific humidity (*humidity ratio*) and is denoted by w:

$$w = \frac{mv}{ma} \quad \text{(kg water vapor/kg dry air)} \qquad (2.1)$$

The amount of moisture in the air has a definite effect on how comfortable we feel in an environment. However, the comfort level depends more on the amount of moisture the air holds (*mv*) relative to the maximum amount of moisture the air can hold at the same temperature (*mg*). The ratio of these two quantities is called the relative humidity (Ø), also its value range from 0 to 1 for saturated air.

$$Ø = \frac{mv}{mg} \qquad (2.2)$$

2.4.3 Wet Bulb Temperature

A wet bulb thermometer measures the extent of cooling as moisture dries from a surface (evaporative cooling). The wet bulb temperature is always lower than the dry bulb temperature except when there is 100% relative humidity, making the wet bulb temperature a more accurate measurement of product temperature.

2.5 Dew-Point Temperature

The dew point temperature is the temperature at which the air must become cooled in order to become completely saturated with water vapor. If the air is cooled to the dew point temperature, it will become saturated and condensation will begin to form.

2.6 ASHRAE Comfort Chart

ASHRAE is an abbreviation for the American Society of Heating Refrigerating and Air conditioning Engineers. Its Standard Thermal Environmental Conditions for Human Occupancy describes the combinations of indoor space conditions and personal factors necessary to provide comfort in the effective way. There are no static rules that indicate the best atmospheric condition for making all the individual comfortable because human comfort is affected by several factors such as health, age, clothing, etc.

Comfort condition is obtained as result of tests for which people are subjected to air at various combinations of temperature and relative humilities. The result of such test indicate that a person will feel just about as cool at 24 ºC and 60% RH as at 26 ºC and 30% RH. Studies conducted by ASHRAE with relative humidity between (30%-70%) indicated that 98% of people feel comfort when the temperature and relative humidity combination fall in comfort zones.

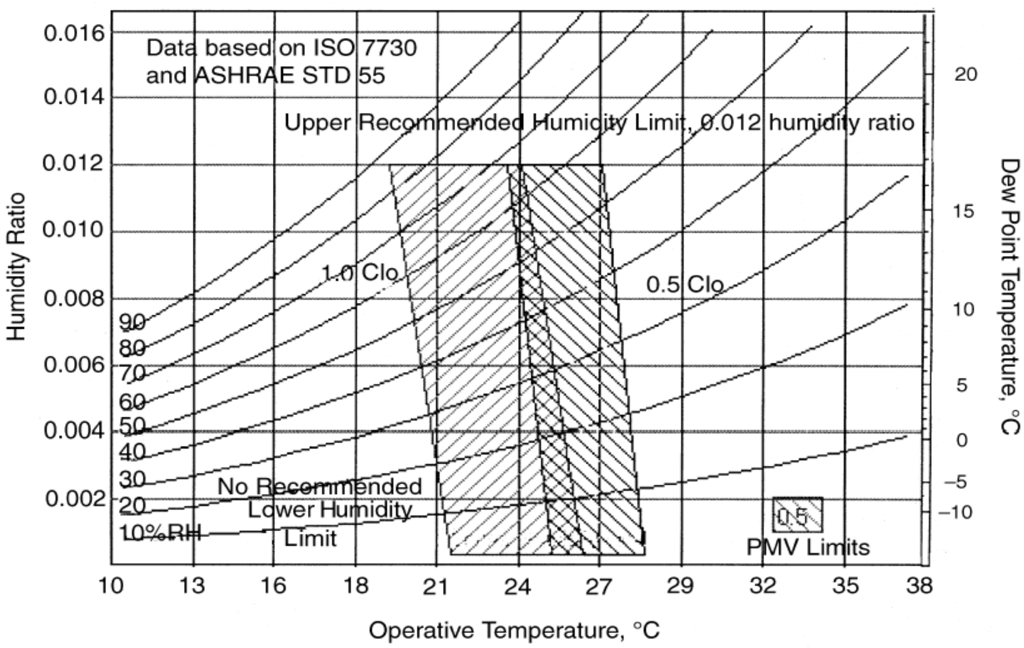


Figure 2. 1 comfort chart

CHAPTER THREE

LOAD CALCULATION

3 Heating System

A heating system is combination of equipment that is used to raise the temperature in any location. This can be accomplished several ways, using energy sources such as: solar, oil, wood, electricity and gas.

Many systems are used for this purpose, such as heating by hot water or heating by warm air, sometime small heaters are used for this purpose, there are many criteria's that will be taken to select the suitable system such as cost, efficiency, flexibility and type of building, So was selected all-water systems as it will be presented in detail in Chapter 5.

3.1 Heating load

The heating load of building consists of the following components:

1) Heat loss through the exposed areas which consist of the walls, the roofs, windows, doors, and walls between the space and unheated spaces.
2) Heat required to warm air infiltrated through cracks of windows and doors, and by opening and closing of doors and windows or to warm mechanical ventilation air to the temperature of the space.
3) Domestic hot water load.
4) Miscellaneous heat load such as emergency heating loads and safety factor heating load

3.2 Air conditioning system

Air-conditioning is stands for heating, ventilating, air-conditioning. it's a process that simultaneously conditions air, distributes it combined with the outdoor air to the conditioned space and controls and maintains the required space’s temperature, humidity, air movement, air cleanliness, sound level, and pressure differential within predetermined limits for the health and comfort of the occupants, for product processing or both.

3.2.1 Cooling Load

Cooling load: it is in summer and it is the rate at which heat must be removed from a space in order to maintain the desired conditions in the space.

3.2.2 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 roof 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:
- Solar radiation transmitted through the glass and absorbed by inside surfaces and furniture.
- 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.

(5) Latent heat produced from cooking, hot baths, or any other moisture producing equipment.

(6) Sensible and latent heat produced by occupants.

3.3 Cooling load calculation:

Table 3. 1 Contains assumption needed for calculation

Table Season location	summer	
	Db Degrees (°C)	RH (%)
Inside design condition	22	50
outside design condition	37	50

3.3.1 Over All Heat Transfer Coefficient (U):

$$U = \frac{1}{R_{th}} = \frac{1}{\frac{1}{h_i}+\frac{\Delta x_1}{k_1}+\frac{\Delta x_2}{k_2}+\cdots+\frac{1}{h_o}}$$

Where:

$U_{ex,wall}$: Is the overall heat transfer coefficient for the external wall.

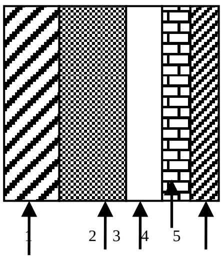
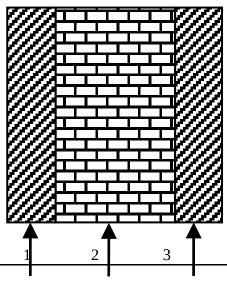
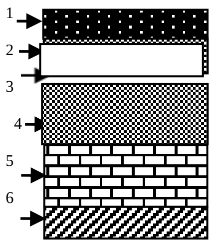
h_i : Is the inside film heat transfer coefficients.

h_o : Is the outside film heat transfer coefficients .

X : Is the thickness of wall layers.

k : Is the thermal conductivity **.**

Table 3. 2 Over all heat transfer coefficient for each section in the building with details

	Construction detail	Construction material	Material thickness [m]	Thermal conduction [W/m.ºC]	Rth [m^2.ºC/W]	U [W/m^2.ºC]
Outside walls		Inside air film 1- stone 2-Concrete 3-Polyurthane 4- Block 5- plaster Outside air film	 0.05 0.1 0.03 0.1 0.02	 2.2 1.75 0.025 0.7 1.2	0.12 0.023 0.057 1.2 0.143 0.016 0.06	0.62
Inside walls		Inside air film 1- plaster 2- Block 3- plaster Outside air film	 0.02 0.2 0.02	 1.2 0.75 1.2	0.12 0.016 0.266 0.016 0.12	1.9
Roof		Inside air film 1- Tiles 2- Mortar 3- Sand 4- Bitumen 5- Concrete 6- Block 7- Plaster Outside air film	 0.005 0.03 0.1 0.01 0.08 0.14 0.02	 0.99 1.4 0.3 0.18 1.75 0.95 1.2	0.12 0.12	1.16

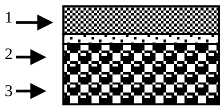
ground		Inside air film 1- Concrete 2- Bitumen 3- Soil and Outside air film	 0.1 0.01 0.65	 1.75 0.18 1.3	0.1 0.06 0.055 0.5 ----	1.39

Table 3.3 Over all heat transfer coefficient for each section in the building

#	Type of section	Over all heat transfer Coefficient $[W/m^2.℃]$
1	Outside wall	0.62
2	Inside wall	1.9
3	Ceiling between tow floor	1.16
4	Ground	1.39
5	Ceiling (roof)	2.4
6	Steel door	5.8
7	Wood door	2.8
8	Glass window	3

3.4 Cooling Load Estimations.

3.4.1 Heat Gain through Sunlit Walls and Roofs:

Direct and diffused solar radiation that is absorbed by walls and roof result in rising the temperature of these surface .amount of radiation absorbed by walls and roofs depends upon time of the day, building orientation, types of wall construction and presence of shading.
The calculation of this type of heat gain can be obtained by using the following relation for heat transmission through walls.

$$Q = U * A * CLTDcorr \tag{3.1}$$

Where:

CLTD: is called cooling load temperature difference for sunlit roofs and walls (Appendix A) Table (2)

$$\left(\mathrm{CLTD}\right)\mathrm{corr} = \left(\mathrm{CLTD} + \mathrm{LM}\right) \mathrm{K} + (25.5 - \mathrm{Ti}) + (\mathrm{To},\ \mathrm{m} - 29.4)\ \mathrm{f} \qquad (3.2)$$

(CLTD) $_{corr}$ for windows

LM: Latitude correction factor for horizontal and vertical surfaces (Appendix A) Table (1)

K: colors adjustment factor such that k=1.0 for dark colored roofs, & k=0. 5 for Permanently Light colored walls.

(25.5-Ti): a correction factor for indoor design temperature where Ti is the room design temperature °C.

(To, m -29.4): a correction factor for outdoor mean temperature (To, m)

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

Table 3 .4 Estimation of Cooling Load for each Region.

NO	Direction	CLTD	LM	(CLTD) $_{corr}$
1	N	1	0.5	2.075
2	E	10	0.0	7.6
3	S	11	-1.6	7.2
4	W	6	-0.5	0
5	Roof	5	0.5	0

CLTD) corr for walls and roof:

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

(CLTD) corr for North walls = (1+0.5)*0.65 + (25.5-22) + (27-29.4)*1= 2.075°C

(CLTD) corr for East walls = (10+0.0)*0.65 + (25.5-22) + (27-29.4)*1=7.6C

(CLTD) corr for South walls = (11+ -1.6)*0. 65+ (25.5-22) + (27-29.4)*1=7.2 °C

3.4.1.1 Heat Transmitted through glass:

$Q_{TOTAL} = Q_{CONV.} + Q_{TR.}$

Q_{CONV}: Heat flow through the windows, by conviction. (Watt)

Q_{TR}: Heat gain due to solar transmission through glass windows (Watt)

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

- 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.
- Absorbed component: this component is absorbed by the glass itself and raises its temperature. About 5 to 50% of solar radiation it absorbed by the glass, depending on the absorptive value of the glass.
- Reflected component: this component is reflected by the glass to the outside of the building. About 8% of the solar energy is reflected back by the glass.

The amount of solar radiation depends upon the following factors:

1- Type of glass (single, double or insulation glass) and availability of inside shading.
2- Hour of the day, day of the month, and month of the year.
3- Orientation of glass area. (North, northeast, east orientation, etc).
4- Solar radiation intensity and solar incident angle.
5- Latitude angle of the location.

Q TOTAL = Q CONV. + Q TR.

Q CONV = U*A*(CLTD) corr

Q CONV: Heat flow through the windows, by convection. (Watt)

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

A: Out windows Area of heat conduction. (m^2).

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

$U = 1 / ((1/ h_{in}) + (\Delta X / K) +(1/ h_{out}))$

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

ΔX: Layer thickness (m).

hi: Indoor convection heat transfer coefficient ($W/m^2.K$).

ho: Outdoor convection heat transfer coefficient ($W/m^2.K$).

(CLTD) corr: is the temperature difference determine by equation :

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

Q TR. = A (SHG)*(SC)*(CLF)

Q TR : Heat gain due to solar transmission through glass windows (Watt)

SHC : Solar heat gain factor : 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 (appendix B) table (10)

SC: Shading coefficient; this factor accounts for different shading effects of the glass wall or window and can be extracted from tables 4 (See Appendix B) for single and double glass without interior shading or from table 5 (See Appendix B) for single and double glass as well as for insulating glass with internal shading

CLF : Cooling load factor : this represent the effects of the internal walls, floor, and furniture on the instantaneous cooling load, and can be extracted from table 9-10 (See Appendix) for glass without interior shading or from table 6 (See Appendix B) for glass with interior shading.

SHG: in July

SHG NORTH = 126 W/ m².

SHG SOUTH = 227 W/ m².

SHG WEST = 678 W/ m².

SHG EAST = 678 W/ m².

SC: Shading coefficient for glass windows with interior shading (dark –double glass)

SC = 0.6 W/ m².K

CLF: with interior shading at solar time 14 hours.

CLF NORTH = 0.86

CLF SOUTH = 0.68

CLF WEST = 0.22

CLF EAST = 0.22

3.4.2 Heat Gain Due To Occupants

Q total for occupant = Q sensible + Q latent

Q latent = heat gain latent * No. of people* CLF ;(CLF = 0.5).

Q sensible = heat gain sensible * No. of people* CLF ;(CLF = 0.5).

No. of people : each room taken from number of bed and estimation

3.4.3 Heat Gain Due To Lights

Q_{Lt} = lighting intensity*A*CLF* ballast factor (3.3)

Q Lt. = lighting intensity*A*CLF* Diversity Factor

Lighting intensity= 36 W/ m^2

A: floor area

CLF Lt: the light cooling load factor from (Appendix B) Table (8), Table (9)

3.4.4 Heat gain Due To infiltration

Infiltration airflow = (volume of space*air change rate)/3600

$Q = \dot{m} * \Delta H$ (3.4)

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

V = (number of air change/hour)*volume

$\Delta h = h_i - h_o$

Where:

$\dot{m}_v$: Is the mass flow rate of air due to ventilation.

$\dot{V}_v$: Is the volumetric flow rate of air due to ventilation.

v_o : Is the specific volume at outside condition.

From psychometric chart we get:-

- $V_{outside} = 0.883\ m^3/Kg$
- $h_o = 73.5\ kJ/kg$
- $h_i = 46\ kJ/kg$

3.4.5 Heat Gain Due To Ventilation

$Q_{ven} = m^{\cdot} * C_{pair} * (t_{out} - t_{in})_{air}$ (3.5)

$m^{\cdot}$: total flow rate for fresh air (kg/s) = V_f / v

C_{pa} :Specific heat of air = 1.005 kJ/kg.k.

T_{in}: the inside temperature C^o.

t_{out}: the outside temperature C^o.

V_f : rate of ventilation= no. of people * outdoor air .

outdoor air = (6L/s)/person.

v : specific volume for air @ t max = 32.7 C ^{o} and Φ = 38 % ;v = 0.855 (m^3/kg).

3.5 Heating Load Estimations

3.5.1 Heat Gain through Sunlit Walls and Roofs:

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

$Q = U \times A \times \Delta t$ (3.6)

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

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

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

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

3.5.2 Heat Loss by Infiltration

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

$Q = \dot{m} * \Delta H$ (3.7)

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

V = (number of air change/hour)*volume

$\Delta h = h_i - h_o$

Where:

$\dot{m}_v$: Is the mass flow rate of air due to ventilation.

$\dot{V}_v$: Is the volumetric flow rate of air due to ventilation.

v_o : Is the specific volume at outside condition.

From psychometric chart we get :-

- $V_{outside} = 0.883\ m^3/Kg$
- $h_o = 73.5\ kJ/kg$
- $h_i = 46\ kJ/kg$

3.5.3 Sample Calculations for Cooling & Heating Load

For first floor.

For Patient room 11 .

3.5.3.1 Cooling Load of the sample

1. For outside wall

Q= U*A*(CLTD) corr

$T_{out.m}$ = (T max + T min) / 2

= (37 + 17) / 2 = 27C

Q north wall = 0.62*(4.02*3)*2.075 = 14.22 W

Q= U*A*ΔT

But ΔT= 5 °C

Qwest= U*A* ΔT

Q = 1.9*28.02*5 = 266.19 W.

Q_{south}= U*A*(CLTD) corr

Q = 0.62*17.36*7.21 = 77.602 W.

Q_{east}= U*A*(CLTD) corr

Q = 99.89 W.

2. For Roof

Q= U*A*ΔT

= 1.39*92.08 * (5) = 639.455 W.

3. For ceiling

Q= U*A*ΔT

= 1.16 * 92.08 *(5) = 533.646 W.

4. For glass

Q TOTAL = Q CONV. + Q TR.

Q CONV = U*A*(CLTD) corr

Q TR. = A (SHG)*(SC)*(CLF)

Q TR N. = A (SHG)*(SC)*(CLF)

= (1*1) (126) (0.6) (0.86)

=65.016watt

Q TR S. = A (SHG)*(SC)*(CLF)

= (8.68*1) (227) (0.6) (0.68)

=803.906watt

Q TR S. = A (SHG)*(SC)*(CLF)

= (10.6*1) (678) (0.6) (0.22)

= 943.65watt

Q total= 1817.58

5. For inner door

U=2.8(W/m².K)

$Q_{door} = U_{door}\, A\, (To\text{-}Ti)$

Q_{door} = 2.8 * 1.8*1.8*(5) = 24.3 W

6. Heat gain Due to Ventilation

$Q_{ven} = m^{\cdot} * C_{pair} * (t_{out} - t_{in})air$

$m^{\cdot} = \frac{V_f}{V} = \frac{10*(6\ l/s)}{0.855(1000)}$ = 0.07 kg/sec.

Q_{ven}=0.07*1.005*(32.7 – 24)= 1.634 kW.

7. Heat Gain Due To Infiltration

$Q = \dot{m} * \Delta H$

V = (number of air change/hour)*volume

$= \frac{2}{3600} * 276.024$

= 0.1533

$\dot{m} = \frac{V}{v} = \frac{0.1533}{0.883} = 0.1841089 kg/s.$

$\Delta h = h_i - h_o$

= 73.5-46=27.5

$Q = \dot{m} * \Delta H$

= 0.1841 ∗27.5= 4.217 KW.

8. Heat Gain Due To Lights

Q_{Lt} = lighting intensity*A*CLF* ballast factor

Q Lt = 36 *92.008* 0.99 * 0.4 = 1311.666 W

9. Heat Gain Due To Occupants

Q total for occupant = Q sensible + Q latent

Q latent = heat gain latent * No. of people* Diversity Factor

Q latent = 57*6 * 0.5 =171 W

Q sensible = heat gain sensible * No. of people* CLF* Diversity Factor

Q sensible = 71.5*6 * 0.50 * 0.5 = 214.5 W

Q total for occupant = 385.5 W

Q total= 11.7194KW

3.5.3.2 Heating Load of the Sample

1. For outside wall

Q_{north}= U * A * ΔT

= 0.62 * 12 * (22 – 4) = 123.4296 W

Q_{east}= U * A * ΔT

= 0.62 * 21.2 * (22 – 4) = 236.592 W

Q_{south}= U * A * ΔT

= 0.62 * 17.36* (22 – 4) = 193.737 W

$Q_{ceiling} = Q_{west=} Q_{floor\ =\ 0}$; because we assume that radiators in all room and section are working.

Q total=553.7592 W

2. For Windows Gain Load

Q_n= U * A * ΔT= 3.2 * (1*1) * 18 = 57.6 W

Q_s = U * A * ΔT= 3.2 * 8.68 * 18= 499.9 W

Q_a = U * A * ΔT= 3.2 * 10.6*18 = 610.56 W

Q total=595.728 W.

3. Heat Gain Due To Infiltration.

$Q = \dot{m} * \Delta H$

$V \;\; = \frac{2}{3600} * 276.024$

= 0.1533

$\dot{m} = \frac{V}{v} = \frac{0.1533}{0.883} = 0.1841089 kg/s.$

$\Delta h = h_i - h_o$

= 46-13=33

$Q = \dot{m} * \Delta H$

= 0.1841 ∗33= 5.06 KW.

Q total= 8.7194KW

3.6 Total cooling and heating loads for hospital:

Table 3. 2 Total cooling and heating load for the first Floor.

No	Name	Cooling load(kW)	Heating load(kW)
1	Operating Room1	12.8844	7.1349
2	Operating Room2	12.3845	7.007
3	Operating Room3	14.1278	9.1006
4	Operating Room4	14.0217	9.1204
5	Operating Room5	12.1123	7.966
6	Patients Room 1	11.7194	8.2699
7	Patients Room 2	11.12141	7.2629
8	Patients Room 3	9.645	6.945

9	Patients Room 4	10.119	6.789
10	Patients Room 5	10.123	6.652
11	Patients Room 6	10.231	6.652
12	Patients Room 7	10.119	6.782
13	Patients Room 8,9,16	10.125	7.124
14	Patients Room 10,11	10.1256	7.124
15	Patients Room 12	11.1994	7.749
16	Patients RooM 13,14.15	10.566	7.029
17	Recovery Room1	6.2563	4.328
18	Recovery Room 2	6.322	4.452
19	Recovery Room 3,4	6.425	4.524
20	Recovery Room 5	6.74	4.82
21	Recovery Room 6	11.1214	7.262
22	Doctors Room 1	10.7234	1.0235
23	Doctors Room 2	10.255	8.024
24	Doctors Room 3	8.124	3.726
25	Doctors Room 4	5.235	3.992
26	Doctors Room 5	5.124	3.845
27	Doctors Room 6	2.344	2.854
28	Doctors Room 7	1.66	1.045
29	Doctors Room8	1.824	1.15
30	Doctors Room9	12.112	7.966
31	X Rays Room 1,2,3,4	11.30	11.84
35	WAITING ROOM	11.344	10.844

Table 3. 3total cooling and heating loads for second floor.

No	**Name**	**Cooling load (kW)**	**Heating load (kW)**
1	Patients Room1	11.7194	8.2699
2	Patients Room2	16.234	13.60.3

3	Patients Room 3,4	12.81	11.188
4	Patients Room 5	12.536	9.299
5	Patients Room 6	11.869	8.958
6	Patients Room 7	12.563	11.257
7	Patients Room 8,9,13	10.119	6.7899
8	Patients Room 10,11,12	10.231	6.7268
9	Operating Room1	14.127	9.100
10	Operating Room2	12.1123	7.966
11	Recovery Room 1	6.2563	4.328
12	Recovery Room 2	6.74	4.82
13	X Rays Room 1.2	11.3	10.3
14	waiting room 1,2	9.11	9.11
16	Recovery Room 1	5.5607	3.6314
17	Recovery Room2	5.625	3.614
18	Doctors Room 1	8.234	4.87
19	Doctors Room 2	8.124	3.726
20	Doctors Room 3	11.124	8.726
21	Doctors Room 4	5.235	3.992
22	Doctors Room 4	6.235	5.882
23	Kitchen	5.782	3.15

Table 3. 4Total cooling and heating loads for Third floor

No	**Name**	**Cooling load (kW)**	**Heating load (kW)**
1	Patient Room 1	11.719	8.2699
2	Patients Room2	16.234	13.60.3
3	Patients Room 3,4	12.81	11.188
4	Patient Room 4	3.381	3.293
5	Patients Room 5	12.536	9.299
6	Patients Room 6	11.869	8.958

7	Patients Room 7	16.563	14.257
8	Patients Room 8,9	12.536	9.299
9	Patients Room 10	11.869	8.958
10	Patients Room 11,12	10.125	7.124
11	Patients Room 13,14	10.1256	7.124
12	Patient Room 15	11.1214	7.262
13	Operating Room1	14.1278	9.1006
14	Recovery Room1	6.2563	4.328
15	Doctors Room 1	1.7234	1.0235
16	Doctors Room 2	1.255	1.024
17	Doctors Room 3	8.124	3.726
18	Doctors Room 4,5	5.235	3.992
19	Waiting room 1,2	8.9	7.95

Table 3. 5Total cooling and heating loads for four floor

No	**Name**	**Cooling load (kW)**	**Heating load (kW)**
4	Operating Room4	9.81	8.988
5	Nursery room	6.932	4.665
6	Doctor room1	10.7194	9.2699

Table 3. 6Total cooling and heating loads for Ground floor

No	**Name**	**Cooling load (kW)**	**Heating load (kW)**
1	Doctor room1	11.619	8.2699
2	Doctor room2	11.819	8.2699
3	Doctor Room3	12.656	8.875
4	Doctor Room 4	10.365	9.86
5	Doctor Room 5	11.869	8.958
6	Doctor Room 6	12.563	10.257

7	Doctor room 7	12.536	9.299
8	Doctor room 8	11.869	8.958
9	Doctor room 9	10.125	7.124
10	Doctor room 10	10.1256	7.124
11	Doctor room 11	9.1214	7.262
12	Doctor Room12	11.869	8.958
13	Doctor Room 13	12.563	10.257
14	Doctor room 14	12.536	9.299
15	Doctor room15	11.869	8.958
16	Doctor room 16	10.125	7.124
17	Doctor room 17	10.1256	7.124
18	Doctor room 18	9.1214	7.262
19	Doctor Room 19	11.869	8.958
20	Doctor Room20	12.563	10.257
21	Doctor Room 21	11.589	8.958
22	Doctor Room22	12.763	10.257
23	X Rays Room1	1.9155	1.1154
24	X Rays Room2	2.125	1.21
25	X Rays Room3	1.8555	1.361
26	X Rays Room4	2.225	1.61
27	WaitingRoom1,2	14.9155	10.11
28	Kitchen	11.23	9.25

Table 3. 7Total cooling and heating loads for basement floor

No	**Name**	**Cooling load (kW)**	**Heating load (kW)**
1	Doctor room1,4	11.819	8.2699
2	Doctor Room2,3	12.656	8.875
3	Kitchen 1,2	10.365	9.86
4	Waiting room	11.869	8.958

	Cooling load(kW)	Heating load (kW)
Total load for hospital	468	448

CHAPTER FOUR

PLUMBING SYSTEM

4 Plumbing system

4.1 Introduction

Plumbing systems are one of the most important parts of building design because its prevent transmission of disease, hygiene, remove the dirty water.

Plumbing fixture: it receives water and discharges its waste into a sanitary drainage system.

4.2 Water Supply

4.2.1 Water Supply calculation:

To determine the pipe size for cold and hot water we must calculate the water supply fixture unit (WSFU) for each fixture and fixture unit total on each piping run out and determine the minimum flow pressure required at the most remote outlet.

To calculate the water supply fixture unit (WSFU) in the Bathroom shown. We have three fixtures shower, lavatory, and water closet with flushometer, each have WSFU as follow:

Table 4. 1 WSFU of cold and hot water for the bath room.

Sample of calculation

For first floor .

For bath room in patient room 11 :

Table4. 1 WSFU of cold and hot water for Batroom

Fixture Unit	No. of Units	Load from table (public)	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU For hot & cold water
Water closet	1	(3)	3	-	3
Lavatory	1	3/4 * (1)	0.75	0.75	1
Bath tub	1	3/4 * (2)	1.5	1.5	2
			Σ = 5.25 WSFU	**Σ** = 2.25 WSFU	**Σ** = 6 WSFU

Table 4. 2WSFU of cold and hot water for basement floor

Fixture Unit	No. of Units	Load from table	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU For hot & cold water
Water closet	4	(3)	12	-	12
Lavatory	7	3/4 * (1)	5.25	5.25	7
Sink	10	3/4 * (2)	15	15	20
Bath tub	3	3/4 * (2)	4.5	4.5	6
			Σ = 36.75 WSFU	**Σ** = 24.75 WSFU	**Σ** = 45 WSFU

Table 4. 3WSFU of cold and hot water forground floor

fixture Unit	No. of Units	Load from table (public)	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU For hot & cold water
Water closet	40	(3)	120	-	120
Lavatory	46	3/4 * (1)	34.5	34.5	46
Sink	5	3/4 * (2)	7.5	7.5	10
Bath tub	5	3/4 * (2)	7.5	7.5	10
			Σ = 169.5 WSFU	**Σ** = 49.5 WSFU	**Σ** = 186 WSFU

Table 4. 4WSFU of cold and hot water first floor

Fixture Unit	No. of Units	Load from table (public)	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU For hot & cold water
Water closet	19	(3)	57	-	57
Lavatory	21	3/4 * (1)	15.75	15.75	21
Bath tub	17	3/4 * (2)	25.5	25.5	34
			Σ = 98.25 WSFU	**Σ** = 41.25 WSFU	**Σ** = 112 WSFU

Table 4. 5WSFU of cold and hot water second floor

Fixture Unit	No. of Units	Load from table (public)	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU For hot & cold water
Water closet	16	(3)	48	-	48
Lavatory	18	3/4 * (1)	13.5	13.5	18
Bath tub	12	3/4 * (2)	18	18	24
			Σ = 79.5 WSFU	**Σ** = 31.5 WSFU	**Σ** = 90 WSFU

Table 4. 6WSFU of cold and hot water for third floor

Fixture Unit	No. of Units	Load from table (public)	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU For hot & cold water
Water closet	21	(3)	63	-	63
Lavatory	22	3/4 * (1)	16.5	16.5	22
Bath tub	14	3/4 * (2)	21	21	28
			Σ = 100.5 WSFU	**Σ** = 37.5 WSFU	**Σ** =113 WSFU

Table 4. 7WSFU of cold and hot water for fourth floor

Fixture Unit	No. of Units	Load from table (public)	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU For hot & cold water
Water closet	2	(3)	6	-	6
Lavatory	6	3/4 * (1)	4.5	4.5	6
Bath tub	6	3/4 * (2)	9	9	12
			Σ = 19.5 WSFU	**Σ** = 13.5 WSFU	**Σ** = 24 WSFU

4.2.2 Flow rate calculations:

By using table (A-2 / Appendix B) for supply system predominantly for flush tank for ground floor the estimating demand in gpm for cold water = 106.5 WSFU.

So, by using interpolation = 8.75 gpm. Now we calculate the (gpm) for each floor so, (gpm) for each floor as in the following tables:

Table 4. 8Water supply unit and hot water for roof floor

No. of Floor	Total no. of WSFU For cold water	Total no. of WSFU For hot water	Total no. of WSFU For hot & cold water	Total no. of gpm For cold water	Total no. of gpm For hot water	Total no. of gpm For hot & cold water
Basement	36.75	24.75	45	23.37	16.85	27
Ground	169.5	49.5	186	58.9	28.8	62.2
First	98.25	41.25	112	43.56	25.5	47
Second	79.5	31.5	90	38.85	20.75	41.5
third	100.5	37.5	113	44.125	23.75	47.25
fourth	19.5	13.5	24	13.7	10.1	15.8

4.2.3 Calculations of water pipes' diameters:

The maximum instantaneous water demand on:

1. The amount of total water demand for cold water = 125.72 gpm
2. The amount of total water demand for hot water = 64.6 gpm

So, the total demand for cold and hot water = 137.6 gpm

The available mains pressure at the level outlet is:

Main pressure = static head pressure + friction head pressure + main flow pressure

Static head = [height of floors + height of water tank + height of stairs well – height of fixture unit]

Height of floors = 3 m

Height of stairs well = 3m

Height of water tank as selected = 2m

Height of sink = 1.05m

So we find Conversion meter to ft

1ft = 12 in * 2.54 cm = 30.48 cm

So, the static head = 3 + 2 + 3 – 1.05 = 6.95 m = 22.796 ft

Static pressure = 22.796 * 0.433 = 9.87 psi

Total equivalent length (TEL): the distance from water tanks to the collector in ground floor + distance from collector to fixture unit

TEL = longest run * 1.5

TEL= 39 * 1.5 = 58.5 ft

Main flow pressure of the critical fixture = 8 psi

Friction head = static pressure – main flow pressure = 9.87 – 8 = 1.87 psi

Uniform friction loss = friction head / TEL = 1.87 / 58.5 =1.87 / (0.585 *100)

Uniform friction loss = 3.19 psi/100ft

Selection of water pipes diameters:

By using chart of friction head loss (figure 4.4 / Appendix B) for galvanized steel pipes we select diameters of pipes refer to calculated values of the main pipe that supply cold water from tanks to distribution points on the roof .The diameter is 2.5" refer to calculated values for flow rate (125.72 gpm) , and friction head loss(3.19 psi/100ft) for riser. We have 2 risers in two regions.

The following table shows the diameters of hot and cold water pipes for all floors

Table 4. 9 Diameter of pipe sizing of water supply in inch for each floor.

No. of floor	No. of collector	Total load of cold water (gpm)	Total load of hot water (gpm)	Friction of head loss	Diameter of cold water pipe	Diameter of hot water pipe
Basement	1	9.65	5.56	2.72	1"	3/4"
	2	8.6	7.25	2.19	1 "	3/4"
	3	8.6	7.25	2.19	1 "	3/4"
Ground	1	17.3	6.125	2.14	1 1/4"	3/4"
	2	11	5	3.62	1"	3/4"
	3	6.1	1.5	4.2	3/4"	3/4"
	4	6.12	5	4	3/4"	3/4"
	5	22.62	6.68	3.52	1 1/4"	1"
	6	8.6	5	2.3	1"	3/4"
	7	11.9	4	3.62	1"	3/4"
	8	13.7	6.75	2.67	1 1/4"	3/4"
	9	12.65	3	4.69	1"	3/4"
	10	12.65	3	4.69	1"	3/4"
First	1	11	5	3.62	1"	3/4"
	2	11	5	3.62	1"	3/4"
	3	8.25	4.6	2.13	1"	3/4"
	4	6.1	4	4.2	3/4"	3/4"
	5	11	5	2.55	1"	3/4"
	6	5	3.5	2.8	3/4"	3/4"
	7	8.75	5	2.37	1"	3/4"
	8	12.65	8.56	4.69	1"	3/4"

Second	1	6.1	4	4.2	3/4"	3/4"
	2	11	5	2.55	1"	3/4"
	3	11	5	3.62	1"	3/4"
	4	8.25	4.6	2.13	1"	3/4"
	5	5	3.5	2.8	3/4"	3/4"
	6	8.25	5	2.13	1"	3/4"
	7	8.75	5	2.37	1"	3/4"
Third	1	11	5	3.62	1"	3/4"
	2	13.65	5	5.4	1"	3/4"
	3	11	5	3.62	1"	3/4"
	4	11	5	3.62	1"	3/4"
	5	5	3	2.8	3/4"	3/4"
	6	6	2.7	3.92	3/4"	3/4"
	7	8.75	5	2.37	1"	3/4"
	8	8.25	5	2.13	1"	3/4"
Fourth	1	5	5	2.8	3/4"	3/4"
	2	5.56	5.56	3.41	3/4"	3/4"
	3	6.125	5	4.07	3/4"	3/4"

COLD WATER PUMP: we select two-pump standby WB200/185D from NINGBO YINZHOU H.T. INDUSTRY COMPANY.

4.3 Drainage piping sizing.

The required pipe sizing are calculated by using a concept of fixture unit instead of using gpm of drainage water, we use drainage fixture units (dfu). This unit takes into account not only the fixtures water use but also its frequency of use, which is the (dfu) has a built–in diversity factor.

This enable us, exactly as for water supply, to add the dfu of fixtures to obtain the maximum expected drainage flow. Drainage pipes are then sized for particular number of drainage fixtures units, according to Tables. (See appendix (B)) Table (3) &Table (4).

Built into these tables are the fill factors that are:

- Branches (Horizontal Pipes) to run maximum of (50%) fill.
- Stacks (Vertical Pipes) are designed to run at maximum of (25%-33%) fill.
- Building drain and swear drains may run somewhat higher (Over 50%) fill.

Tables will show the drainage fixture unit (dfu) for the roof.

Table 4. 10dfu for basement floor.

Fixture unit	No. of Fixture	Drainage Fixture Unit value, dfu	dfu value (Horizontal Branch)	Diameter of Pipe, in.
WC. Stack(c)	1	6	6	2
Lavatory. Stack(c)	2	1	2	1 1/2
Bathtub. Stack(c)	1	6	6	2
Kitchen Sink. Stack(C)	4	2	8	2 1/2
Kitchen Sink. Stack(D)	2	2	4	2
WC. Stack(A5)	1	6	6	2
Lavatory. Stack(A5)	2	1	2	1 1/2
Bathtub. Stack(A5)	1	6	6	2
Kitchen Sink. Stack(H)	4	6	24	4
WC. Stack(H)	1	6	6	2
Lavatory. Stack(H)	2	1	2	1 1/2
Bathtub. Stack(H)	1	6	6	2
WC. Stack(K)	1	6	6	2
Lavatory. Stack(K)	1	1	2	1 1/2

Table 4. 11dfu for vertical stack.

Stack	dfu value (Stack)	Diameter of Pipe, in.
A	55	4
B	26	4
C	75	4
D	11	4
E	26	4
F	32	4
G	26	4
H	40	4
I	40	4
J	40	4
K	27	4
L	47	4
M	89	4
N	41	4
O	47	4
P	26	4
Q	46	4
R	42	4
S	42	4
T	29	4
U	39	4
V	9	4
W	7	4
X	7	4
Y	9	4
Z	9	4
A1	12	4
A2	28	4
A3	22	4
A4	42	4
A5	53	4
A6	42	4

A7	41	4

4.4 Sanitary Drainage System

4.4.1 Manhole Design.

We design the manhole around the building so as that the sewage comes from the stacks flows in, then the sewage flows from one manhole to another so as reaching the septic tank .
The design of the manholes depend on the ground and its nature around the building, and so as the first manhole height should not be less than 50 cm. and then we calculate the height of the other manhole depending on the spacing between manholes and the slope of drainage pipes between manhole to be1.5%.

As a result of these calculations we estimate the invert level of the manhole that is the depth of the pipe entering the manhole and we choose the diameter of the manhole depending on the depth of the manhole as below.

Θ 60 cm for manhole depth (50-100) cm.

Θ 80 cm for manhole depth (100-150) cm

Θ 100 cm for manhole depth (150-250) cm.

Θ 120 cm for manhole depth >250 cm.

4.4.2 Manholes Calculations

We assume the depth of the first manhole to be (60 cm) and we calculate the second manhole according to it and so on.

For MAN.1:

Top level = 0.0 m

Depth = 0.6

Outlet level=Top level-Depth = 0.0- 0.6 = -0.6 m

For MAN.2:

The distance between MAN.1 &MAN.2 is 8 m.

Depth of MAN.2 is:

Depth = ((distance*Slope) + depth MAN.1 +5 cm) = 77 cm

Outlet level MAN.2 =Top level-Depth MAN.2= 0.0- 0.77 = -0.77m

Slope is 1.5%

Invert level of MAN.2 = Outlet Level of MAN.2 + 5 cm= -0.72 m

The following table shows calculations and dimensions of all manholes that used in our project:

Table 4. 12Manholes Calculations.

MAN.NO	Top Level (m)	Invert Level (m)	Outlet Level (m)	Depth (cm)	Diameter (cm)	Cover	Type
$M.H_1$	0.0	- 0.55	- 0.6	60	60	Medium	8 Ton
$M.H_2$	0.0	- 0.72	- 0.77	77	.60	Medium	8 Ton
$M.H_3$	0.0	-0. 85	-0.9	90	60	Medium	8 Ton
$M.H_4$	0.0	-0.98	-1.03	103	80	Medium	8 Ton
$M.H_5$	0.0	- 1.08	-1.13	113	80	Medium	8 Ton
$M.H_6$	0.0	- 1.2	- 1.25	125	80	Medium	8 Ton
$M.H_7$	-0.3	-1.35	-1.4	110	80	Medium	8 Ton
$M.H_8$	-0.3	-1.55	-1.6	130	80	Medium	8 Ton
$M.H_9$	-0.3	-1.72	-1.77	147	80	Medium	8 Ton

$M.H_{10}$	-0.3	-1.8	-1.85	155	100	Medium	8 Ton
$M.H_{11}$	-0.3	-1.91	-1.96	166	100	Medium	8 Ton
$M.H_{12}$	-0.3	-2.03	-2.08	178	100	Medium	8 Ton
$M.H_{13}$	-0.3	-2.13	-2.18	188	100	Medium	8 Ton
$M.H_{14}$	-1.0	-2.28	-2.33	133	80	Medium	8 Ton
$M.H_{15}$	-1.0	-2.39	-2.44	144	80	Medium	8 Ton
$M.H_{16}$	-1.5	-2.5	-2.55	105	80	Medium	8 Ton
$M.H_{17}$	-1.5	-2.56	-2.61	111	80	Medium	8 Ton
$M.H_{18}$	-1.7	-2.25	-2.3	60	60	Medium	8 Ton
$M.H_{19}$	-1.7	-2.35	-2.4	70	60	Medium	8 Ton
$M.H_{20}$	-1.7	-2.48	-2.53	83	60	Medium	8 Ton
$M.H_{21}$	-1.7	-2.66	-2.71	101	80	Medium	8 Ton
$M.H_{22}$	-1.7	-2.74	-2.79	109	80	Medium	8 Ton
$M.H_{23}$	-1.7	-2.95	-3.0	130	80	Medium	8 Ton
$M.H_{24}$	-2.0	-2.84	-2.89	119	80	Medium	8 Ton
$M.H_{25}$	-2.0	-3.04	-3.09	139	80	Medium	8 Ton

$M.H_{26}$	-3.0	-3.57	-3.62	62	60	Medium	8 Ton
$M.H_{27}$	-3.0	-3.76	-3.81	81	60	Medium	8 Ton
$M.H_{28}$	-3.0	-3.95	-4.0	100	80	Medium	8 Ton
$M.H_{29}$	-3.0	-4.13	-4.18	118	8	Medium	8 Ton
$M.H_{30}$	-3.0	-4.33	-4.38	138	80	Medium	8 Ton
$M.H_{31}$	-3.0	-4.52	-4.57	157	100	Medium	8 Ton
$M.H_{32}$	-3.0	-4.7	-4.75	175	100	Medium	8 Ton
$M.H_{33}$	-3.0	-4.81	-4.86	186	100	Medium	8 Ton
$M.H_{34}$	-3.0	-5.04	-5.09	209	100	Medium	8 Ton
$M.H_{35}$	0.0	-0.55	-0.60	60	60	Medium	8 Ton
$M.H_{36}$	0.0	-0.75	-0.80	80	60	Medium	8 Ton
$M.H_{37}$	0.0	-0.93	-0.98	98	60	Medium	8 Ton
$M.H_{38}$	-1.0	-1.55	-1.6	60	60	Heavy	25 Ton
$M.H_{39}$	-1.0	-1.72	-1.77	77	60	Heavy	25 Ton
$M.H_{40}$	-1.0	-1.89	-1.94	94	60	Medium	8 Ton
$M.H_{41}$	-3.0	-5.23	-5.28	228	100	Medium	8 Ton

Selection The Diameter And The Slope Of The Drainage Pipe System.

Here we will talk about the choice of diameter and slope of the drainage pipe system and we will take the following Bathroom as an example of how we will choose the diameter and the slope of the drainage pipe system.

1. We will use pipes (Branches) from fixture unit to the floor drainage (F.D.) with diameter (2") for lavatory and shower and with slope(1%).
2. We will use pipes (Building Drains) from fixture unit to the manhole with diameter (4") for water closet with flush valve and with slope (1% - 2%).
3. We will use pipes (Sewage Pipes) between manholes with diameter (6") and with slope (1.5%), and the waste water will transfer between manholes until it reach the main Manhole.
4. We will use floor trap (F.T.) at the end of the branches as a collection box for this pipes and in order to provide a water seal to prevent odors, sewage gases and vermin's from entering building.
5. We will use clean out (C.O) at the end of the branches in order to clean the pipes from any things that can blockage and close the pipes.
6. We will use a stack with diameter (4") in order to drain the waste water to the manholes.

The design procedure following

1. Draw an isometric of the entire system to show all the fixtures.
2. Assign drainage unit to each fixture, if a fixture not listed specifically base DFU requirement on its trap size. Drainage requirements not due to fixtures, such as non-recalculated of cooling water or process water, use conversion of 1gpm=2DFU.
3. Find the total of DFU in each drainage pipe and mark them on the drawing.
4. Determined the required size of horizontal fixture branches and stacks.
5. Determined the size and slop of the building drain and its branches and the building sewer.
6. Determined that the size and slop that found in step5 meet the requirement of the code

CHAPTER FIVE

HVAC SYSTEMS

5 HVAC SYSTEM

5.1 HVAC systems classifications

HVAC systems are classified into two basic categories: all-water systems table (5-1) listed HVAC systems types are used in this project.

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

Air handling units (AHUs) are used to supply and circulate air around a building, or to extract stale air as part of a building's heating, ventilating and air conditioning (HVAC) system.

Table 5. 1 HVAC systems classifications

NO	HVAC systems category	HVAC system
1	**All-Water**	**Fan coils , ducted fan coils**
2	**Central Systems**	**air handling units (AHU)**

5.2 Fan coils Systems

A fan coil unit (FCU) is a simple device consisting of a heating or cooling coil and fan. It is part of an HVAC system found in residential, commercial, and industrial buildings. Typically a fan coil unit is not connected to ductwork, and is used to control the temperature in the space where it is installed, or serve multiple spaces. It is controlled either by a manual on/off switch or by thermostat.

Due to their simplicity, fan coil units are more economical to install than ducted or central heating systems with air handling units. However, they can be noisy because the fan is within the same space. Unit configurations are numerous including horizontal (ceiling mounted) or vertical (floor mounted).

The use of this type is in all patient rooms in the hospital rooms and administrative departments, clinics and emergency departments and doctors offices and reception rooms and nursing.

5.2.1 Sample of calculations for fan coils:

For Patients Room 11 at ground floor:

Q = 10.12 kW

Q = $\dot{m}$ * C.p* ΔT

Q: total heat losses [kW]

$\dot{m}$: mass flow rate[kg/s]

C.p: specific heat capacity at constant pressure

C.p water = 4.18 [kJ/kg C]

ΔT : water temperature difference = 7 C.

Q = 10.12 K w, ΔT = 7 C

So, $\dot{m}$= 0.345 kg/s

$A = \frac{\dot{m}}{p*v}$

Where:

A: cross – sectional area of pipe

$\dot{m}$: Mass flow rate[kg/s]

p :Water mass density 1000 [kg/m^3]

$A = \frac{\dot{m}}{p*v} = \frac{0.345}{1000*2}$ = 1.72E-04m^2

$d = \sqrt[2]{\frac{4*1.72E-05}{\pi}}$ = 0.014 m = 0.58 inch, so d selected =1 [inch]

Where d = pipe cross – sectional diameter (m).

Data of calculations for all fan coils units in rooms:

Calculations for all fan coils in ground floor rooms

Table 5. 2calculated data for (FCU)'s for ground floor due to cooling load

No	Room Name	Cooling load, kw	Flow kg/s	Diameter m	Diameter inch	selected Diameter inch	Air Flow cfm
1	Doctor room1	**11.619**	0.397	0.0015	0.625	1	731.1
2	Doctor room2	**11.819**	0.403	0.0016	0.630	1	743.8
3	Doctor room3	**12.656**	0.432	0.0015	0.625	1	757.4
4	Doctor room4	**10.365**	0.353	0.0014	0.627	1	652.6
5	Doctor room5	**11.869**	0.405	0.0016	0.630	1	743.6
6	Doctor room6	**12.563**	0.429	0.0016	0.650	1	755.3
7	Doctor room7	**12.536**	0.428	0.0016	0.650	1	755.3
8	Doctor room8	**11.869**	0.405	0.0016	0.625	1	743.6
9	Doctor room9	**10.125**	0.349	0.0014	0.627	1	652.6
10	Doctor room10	**10.1256**	0.349	0.0014	0.627	1	652.6
11	Doctor room11	**9.1214**	0.311	0.0014	0.554	1	603.2
12	Doctor room12	**11.314**	0.406	0.0016	0.630	1	603.2

13	Doctor room13	**12.563**	0.428	0.0016	0.650	1	755.3
14	Doctor room14	**12.536**	0.428	0.0016	0.650	1	655.3
15	Doctor room15	**11.869**	0.405	0.0016	0.650	1	643.2
16	Doctor room16	**10.125**	0.349	0.0014	0.627	1	652.6
17	Doctor room17	**10.1256**	0.349	0.008	0.3131	1	652.3
18	Doctor room18	**9.1214**	0.311	0.0014	0.554	1	603.2
19	Doctor room19	**11.869**	0.405	0.0016	0.650	1	603.2
20	Doctor room20	**12.563**	0.428	0.0016	0.650	1	705.3
21	Doctor room21	**11.589**	0.403	0.0016	0.650	1	703.2
22	Doctor room22	**12.763**	0.430	0.0016	0.650	1	560.2
23	Waiting Room 1,2	**14.9155**	0.480	0.0018	0.708	1	1127.2
24	Kitchen	**11.23**	0.384	0.0016	0.650	1	740.2

Table 5. 3calculated data for (FCU)'s for ground floor due to heating load

No	Room Name	Heating load, kw	Flow kg/s	Diameter m	Diameter inch	selected Diameter inch	Air Flow cfm
1	Doctor room1	8.2699	0.28	0.013	0.53	1	500.7
2	Doctor room2	8.2699	0.28	0.013	0.53	1	500.7
3	Doctor room3	8.875	0.30	0.014	0.55	1	537.3
4	Doctor room4	9.86	0.34	0.015	0.58	1	596.9
5	Doctor room5	8.958	0.31	0.014	0.55	1	542.3
6	Doctor room6	10.257	0.35	0.015	0.59	1	621.0
7	Doctor room7	9.299	0.32	0.014	0.56	1	563.0
8	Doctor room8	8.958	0.31	0.014	0.55	1	542.3
9	Doctor room9	7.124	0.24	0.012	0.49	1	431.3
10	Doctor room10	7.124	0.24	0.012	0.49	1	431.3
11	Doctor room11	7.262	0.25	0.013	0.50	1	439.6
12	Doctor room12	8.958	0.31	0.014	0.55	1	542.3
13	Doctor room13	10.257	0.35	0.015	0.59	1	621.0
14	Doctor room14	9.299	0.32	0.014	0.56	1	563.0

15	Doctor room15	8.958	0.31	0.014	0.55	1	542.3
16	Doctor room16	7.124	0.24	0.012	0.49	1	431.3
17	Doctor room17	7.124	0.24	0.012	0.49	1	431.3
18	Doctor room18	7.262	0.25	0.013	0.50	1	439.6
19	Doctor room19	8.958	0.31	0.014	0.55	1	542.3
20	Doctor room20	10.257	0.35	0.015	0.59	1	621.0
21	Doctor room21	8.958	0.31	0.014	0.55	1	542.3
22	Doctor room22	10.257	0.35	0.015	0.59	1	621.0
23	Waiting Room 1,2	10.11	0.35	0.015	0.58	1	612.1
24	Kitchen	9.25	0.32	0.014	0.56	1	560.0

Table 5. 4selection data for fan coils units and grills in ground floor

No	**Room Name**	**Air Flow cfm**	**Fan coil type**	**Grill Size mm*mm**
1	Doctor room1	731.1	42CED008	14*20
2	Doctor room2	743.8	42CED008	14*20
3	Doctor room3	757.4	42CED008	14*20
4	Doctor room4	652.6	42CED008	14*20
5	Doctor room5	743.6	42CED008	14*20
6	Doctor room6	755.3	42CED008	14*20
7	Doctor room7	755.3	42CED008	14*20

8	Doctor room8	743.6	42CED008	14*20
9	Doctor room9	652.6	42CED008	14*20
10	Doctor room10	652.6	42CED007	14*20
11	Doctor room11	603.2	42CED006	12*20
12	Doctor room12	603.2	42CED008	14*20
13	Doctor room13	755.3	42CED008	14*20
14	Doctor room14	655.3	42CED007	14*20
15	Doctor room15	643.2	42CED007	14*20
16	Doctor room16	652.6	42CED007	14*20
17	Doctor room17	652.3	42CED007	14*20
18	Doctor room18	603.2	42CED006	12*20
19	Doctor room19	603.2	42CED006	12*20
20	Doctor room20	705.3	42CED007	14*20
21	Doctor room21	703.2	42CED007	14*20
22	Doctor room22	560.2	42CED006	14*20
23	Waiting Room 1,2	1127.2	42CED014	16*20
24	Kitchen	740.2	42CED008	14*20

Table 5. 5calculated data for (FCU)'s for First floor due to cooling load

No	**Room Name**	**Cooling load, kw**	**Flow kg/s**	**Diameter m**	**Diameter inch**	**selected Diameter inch**	**Air Flow cfm**
1	Patients Room 1	11.7194	0.397	0.0015	0.625	1	740.1

2	Patients Room 2	11.12141	0.397	0.0015	0.625	1	739.1
3	Patients Room 3	9.645	0.311	0.0014	0.554	1	610.2
4	Patients Room 4	10.119	0.349	0.0014	0.627	1	652.1
5	Patients Room 5	10.123	0.349	0.0014	0.627	1	652.3
6	Patients Room 6	10.231	0.349	0.0014	0.627	1	655.1
7	Patients Room 7	10.119	0.349	0.0014	0.627	1	652.1
8	Patients Room 8,9,16	10.125	0.349	0.0014	0.627	1	652.3
9	Patients Room 10,11	10.1256	0.349	0.0014	0.627	1	652.4
10	Patients Room 12	11.1994	0.397	0.0015	0.625	1	738.2
11	Patients Room 13,14,15	10.566	0.349	0.0014	0.627	1	655.2

12	Doctors Room 1	10.125	0.349	0.0014	0.627	1	652.3
13	Doctors Room 2	10.255	0.349	0.0014	0.627	1	317.8
14	Doctors Room 3	6.124	0.291	0.0012	0.490	0.5	315.3
15	Doctors Room4	10.125	0.349	0.0014	0.627	1	652.3
16	Doctors Room9	8.124	0.291	0.0012	0.490	0.5	515.3
17	X rays 1,2,3,4	11.344	0.058	0.0005	0.300	0.5	700.8
18	Waiting room	11.344	0.398	0.0015	0.60	1	700.8

Table 5. 6calculated data for (FCU)'s for First floor due to Heating load

No	**Room Name**	**Heating load, kw**	**Flow kg/s**	**Diameter m**	**Diameter inch**	**selected Diameter inch**	**Air Flow cfm**
1	Patients Room 1	8.2699	0.28	0.013	0.53	1	500.7
2	Patients Room 2	7.2629	0.25	0.013	0.50	1	439.7
3	Patients Room 3	6.945	0.24	0.012	0.48	1	420.4
4	Patients Room 4	6.789	0.23	0.012	0.48	1	411.0
5	Patients Room 5	6.652	0.23	0.012	0.47	1	402.7
6	Patients Room 6	6.652	0.23	0.012	0.47	1	402.7
7	Patients Room 7	6.782	0.23	0.012	0.48	1	410.6

8	Patients Room 8,9	7.124	0.24	0.012	0.49	1	431.3
9	Patients Room 10,11	7.124	0.24	0.012	0.49	1	431.3
10	Patients Room 12	7.749	0.26	0.013	0.51	1	469.1
11	Patients Room 13,14	7.029	0.24	0.012	0.49	1	425.5
12	Doctors Room 1	10.125	0.349	0.0014	0.627	1	652.3
13	Doctors Room 2	10.255	0.349	0.0014	0.627	1	317.8
14	Doctors Room 3	6.124	0.291	0.0012	0.490	0.5	315.3
15	Doctors Room4	10.125	0.349	0.0014	0.627	1	652.3
16	Doctors Room9	8.124	0.291	0.0012	0.490	0.5	515.3
17	X rays 1,2,3,4	11.344	0.058	0.0005	0.300	0.5	700.8
18	Waiting room	11.344	0.398	0.0015	0.60	1	700.8

Table 5. 7selection data for fan coils units and grills in First floor

No	**Room Name**	**Air Flow cfm**	**Fan coil type**	**Grill Size mm*mm**
1	Patients Room1	740.1	42CED008	14*20
2	Patients Room 2	739.1	42CED008	14*12
3	Patients Room 3	610.2	42CED007	14*12

4	Patients Room 4	652.1	42CED007	14*12
5	Patients Room 5	652.3	42CED007	14*12
6	Patients Room 6	655.1	42CED007	14*12
7	Patients Room 7	652.1	42CED007	14*12
8	Patients Room 8,9,16	652.3	42CED007	14*12
9	Patients Room 10,11	652.4	42CED007	14*12
10	Patients Room 12	738.2	42CED007	14*12
11	Patients Room 13,14,15	655.2	42CED007	14*12
12	Doctors Room 1	655.2	42CED007	14*12
13	Doctors Room 2	317.8	42CED003	12*8
14	Doctors Room 3	515.3	42CED005	10*12
15	Doctors Room4	600	42CED006	10*12
16	Doctors Room9	500.2	42CED005	10*12
17	X rays 1,2,3	700.8	42CED007	14*20
18	Waiting room	700.8	42CED007	14*20

Table 5. 8calculated data for (FCU)'s for Second floor due to cooling load

No	**Room Name**	**Cooling load, kw**	**Flow kg/s**	**Diameter m**	**Diameter inch**	**selected Diameter inch**	**Air Flow cfm**
1	Patients Room1	11.7194	0.397	0.0015	0.625	1	740.1
2	Patients Room2	16.234	0.397	0.0018	0.739	1	1023.1
3	Patients Room 3,4	12.81	0.311	0.0015	0.625	1	759.4

4	Patients Room 5	12.536	0.428	0.0016	0.650	1	755.3
5	Patients Room 6	11.869	0.405	0.0016	0.650	1	743.2
6	Patients Room 7	12.563	0.428	0.0016	0.650	1	755.3
7	Patients Room 8,9,13	10.119	0.349	0.0014	0.627	1	652.3
8	Patients Room 10,11,12	10.231	0.352	0.0014	0.637	1	658.3
9	Doctors Room 1	8.234	0.291	0.0012	0.490	0.5	510.8
10	Doctors Room 2	8.124	0.291	0.0012	0.490	0.5	509.7
11	Doctors Room 3	11.124	0.349	0.0014	0.627	1	655.2
12	Doctors Room 4	5.235	0.177	0.0010	0.417	0.5	510.8
13	Waiting Room 1	10.119	0.349	0.0014	0.627	1	652.3
14	Waiting Room 2*2	10.119	0.349	0.0014	0.627	1	652.3
15	X rays 1,2	11.344	0.058	0.0005	0.300	0.5	700.8

Table 5. 9calculated data for (FCU)'s for Second floor due to Heating load selection data for fan coils units and grills in Second floor

No	**Room Name**	**Air Flow cfm**	**Fan coil type**	**Grill Size mm*mm**
1	Patients Room1	740.1	42CED008	14*20
2	Patients Room2	1023.1	42CED014	16*20

3	Patients Room 3,4	759.4	42CED008	14*20
4	Patients Room 5	755.3	42CED008	14*20
5	Patients Room 6	743.2	42CED008	14*20
6	Patients Room 7	755.3	42CED008	14*20
7	Patients Room 8,9,13	652.3	42CED007	12*20
8	Patients Room 10,11,12	658.3	42CED007	14*20
9	Doctors Room 1	510.8	42CED006	12*20
10	Doctors Room 2	509.7	42CED006	12*20
11	Doctors Room 3	655.2	42CED007	14*20
12	Doctors Room 4	510.8	42CED006	12*20
13	Waiting Room 1	655.2	42CED007	14*20
13	Waiting Room 2*2	655.2	42CED007	14*20
13	X rays 1,2	655.2	42CED007	14*20

Table 5. 10 calculated data for (FCU)'s for Third floor due to cooling load

No	Room Name	Cooling load, kw	Flow kg/s	Diameter m	Diameter inch	selected Diameter inch	Air Flow cfm
1	Patient Room 1	11.719	0.397	0.0015	0.625	1	740.1
2	Patients Room2	16.234	0.397	0.0018	0.739	1	1023.1
3	Patients Room 3,4	12.81	0.311	0.0015	0.625	1	759.4
4	Patient Room 4	3381	0.113	0.0085	0.334	0.5	210.8
5	Patients	12.536	0.428	0.0016	0.650	1	755.3

	Room 5						
6	Patients Room 6	11.869	0.405	0.0016	0.650	1	743.2
7	Patients Room 7	16.563	0.497	0.0018	0.739	1	1053.1
8	Patients Room 8,9	12.536	0.428	0.0016	0.650	1	755.3
9	Patients Room 10	11.869	0.405	0.0016	0.650	1	743.2
10	Patients Room 11,12	10.125	0.349	0.0014	0.627	1	652.4
11	Patients Room 13,14	10.1256	0.349	0.0014	0.627	1	652.4
12	Patient Room 15	8.29	0.31	0.014	0.55	1	542.3
13	Doctors Room 1,2	9.7234	0.058	0.0057	0.225	0.5	510.8
14	Doctors Room 3,4	9.299	0.32	0.014	0.56	1	563.0
13	Waiting room 1	8.124	0.291	0.0012	0.490	0.5	670.8
13	Waiting room 2 *2	8.958	0.31	0.014	0.55	1	542.3

Table 5. 11calculated data for (FCU)'s for Third floor due to Heating load

No	**Room Name**	**heating load, kw**	**Flow kg/s**	**Diameter m**	**Diameter inch**	**selected Diameter inch**	**Air Flow cfm**
1	Patient Room 1	8.2699	0.28	0.013	0.53	1	500.7
2	Patients		0.46	0.017	0.68	1	823.3

	Room2	13.60					
3	Patients Room 3,4	11.188	0.38	0.016	0.61	1	677.3
4	Patient Room 4	3.293	0.13	0.268	0.35	0.5	199.4
5	Patients Room 5	9.299	0.32	0.014	0.56	1	563.0
6	Patients Room 6	8.958	0.31	0.014	0.55	1	542.3
7	Patients Room 7	14.257	0.49	0.018	0.69	1	863.1
8	Patients Room 8,9	9.299	0.32	0.014	0.56	1	563.0
9	Patients Room 10	8.958	0.31	0.014	0.55	1	542.3
10	Patients Room 11,12	7.124	0.24	0.012	0.49	1	431.3
11	Patients Room 13,14	7.124	0.24	0.012	0.49	1	431.3
12	Patient Room 15	7.262	0.25	0.013	0.50	1	439.6
13	Doctors Room 1,2	9.7234	0.058	0.0057	0.225	0.5	510.8
14	Doctors Room 3,4	9.299	0.32	0.014	0.56	1	563.0
13	Waiting room 1	8.124	0.291	0.0012	0.490	0.5	670.8
13	Waiting room 2 *2	8.958	0.31	0.014	0.55	1	542.3

Table 5. 12selection data for fan coils units and grills in Third floor

No	Room Name	Air Flow cfm	Fan coil type	Grill Size mm*mm
1	Patient Room 1	740.1	42CED008	14*20
2	Patients Room2	1023.1	42CED014	16*20
3	Patients Room 3,4	559.4	42CED006	12*20
5	Patients Room 5	569.2	42CED006	12*20
6	Patients Room 6	549.4	42CED006	12*20
7	Patients Room 7	1053.1	42CED014	16*20
8	Patients Room 8,9	755.3	42CED008	14*20
9	Patients Room 10	1023.1	42CED014	16*20
10	Patients Room 11,12	652.4	42CED007	14*12
11	Patients Room 13,14	652.4	42CED007	14*12
12	Patient Room 15	655.2	42CED007	14*12
13	Doctors Room 1,2	569.2	42CED006	12*20
14	Doctors Room 3,4	510.8	42CED005	10*12
15	Waiting room 1	660.8	42CED007	14*20
16	Waiting room 2 *2	670.8	42CED007	14*20

Table 5. 13calculated data for (FCU)'s for Four floor due to cooling load

No	Room Name	Cooling load, kw	Flow kg/s	Diameter m	Diameter inch	selected Diameter inch	Air Flow cfm
1	Nursery room	6.932	0.212	0.0011	0.457	0.5	655.8

2	Doctor room1	10.7194	0.359	0.0014	0.637	1	665.2
3	Doctor room1	10.7194	0.359	0.0014	0.637	1	665.2

Table 5. 14calculated data for (FCU)'s for Four floor due to Heating load

No	**Room Name**	**Heating load, kw**	**Flow kg/s**	**Diameter m**	**Diameter inch**	**selected Diameter inch**	**Air Flow cfm**
1	Nursery room	4.665	0.16	0.010	0.40	0.5	282.4
2	Doctor room1	9.2699	0.32	0.014	0.56	1	561.2
3	Doctor room1	10.7194	0.359	0.0014	0.637	1	665.2

Table 5. 15selection data for fan coils units and grills in Four floor

No	**Room Name**	**Air Flow cfm**	**Fan coil type**	**Grill Size mm*mm**
1	Nursery room	655.8	42CED007	14*20
2	Doctor room1	665.2	42CED007	14*20
3	Patient Room 1-4	740.1	42CED008	14*20

Table 5. 16calculated data for (FCU)'s for Basement floor due to cooling load

No	Room Name	Cooling load, kw	Flow kg/s	Diameter m	Diameter inch	selected Diameter inch	Air Flow cfm
1	Doctor room1,4	11.819	0.406	0.0016	0.630	1	743.2
2	Doctor Room2,3	12.656	0.311	0.0014	0.554	1	610.2
3	Kitchen 1,2	10.365	0.352	0.0014	0.637	1	658.3
4	Waiting room	11.869	0.406	0.0016	0.630	1	743.2

Table 5. 17calculated data for (FCU)'s for Basement floor due to Heating load

No	Room Name	Heating load, kw	Flow kg/s	Diameter m	Diameter inch	selected Diameter inch	Air Flow cfm
1	Doctor room1,4	8.2699	0.28	0.013	0.53	1	500.7
2	Doctor Room2,3	8.875	0.30	0.014	0.55	1	537.3
3	Kitchen1,2	9.86	0.34	0.015	0.58	1	596.9
4	Waiting room	8.958	0.31	0.014	0.55	1	542.3

Table (5-19) selection data for fan coils units and grills in Basement floor

No	Room Name	Air Flow cfm	Fan coil type	Grill Size mm*mm
1	Doctor Room1,4	743.2	42CED008	14*20
2	Doctor Room2,3	610.2	42CED006	14*20
3	Kitchen 1,2	658.3	42CED007	14*20
4	Waiting room	743.2	42CED008	14*20

5.3 Fan coils with duct.

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

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

5.3.1 Sample of Calculations

For Fan oils With Duct In First Floor.

Using of equal pressure drop method for B1 at First floor with Q_{Total} = 10 kW, and $V_{(required\ air\ velocity)}$= 5 m/s, from relative friction losses chart at $\dot{m}_{(air\ flow\ rate)}$ = 0.21 m^3/s, we will divided main duct into two equal ducts.

$$\dot{m} = \frac{\pi}{4} * d^2 * v$$

$$d = \sqrt[2]{\frac{4*0.2}{5*\pi}} = 0.21 \text{ m.}$$

$$\frac{\Delta p}{El} = 1.3 \text{ Pa/m.}$$

For F1 ducted area the specifications of duct and grills shown below in the Table.

Table 5. 18F1 at First floor with duct and grills specifications

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity *m*/s	Diameter m	Duct Size mm
1	A-B	0.21	444	12*20	4.9	0.24	250W * 200H
2	B-C	0.12	254	8*10	4.3	0.20	250W * 150H
3	C-D	0.06	127	8*10	3.7	0.18	200W * 150 H

Table 5. 19Summary of Ducts and its Fan Coil Types at First Floor.

No	Name	Load kW	Flow kg/s	Diameter inch	Diameter Selection. inch	Flow cfm	Fan Coil Type
1	F1	10	0.34	0.580	0.5	825	42CED008

Table 5. 20f2 Summary of Ducts and its Fan Coil Types at First Floor.

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity *m*/s	Diameter m	Duct Size mm
1	A-B	0.12	254	8*10	4.3	0.20	250W * 150H
2	B-C	0.06	127	8*10	3.7	0.18	200W * 150 H

Table 5. 21F3 at First floor with duct and grills specifications

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity *m*/s	Diameter m	Duct Size mm
1	A-B	0.21	444	12*20	4.9	0.24	250W * 200H
2	B-C	0.12	254	8*10	4.3	0.20	250W * 150H
3	C-D	0.06	127	8*10	3.7	0.18	200W * 150 H

Table 5. 22F4 at First floor with duct and grills specifications.

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.23	487	12*20	4.9	0.24	250W * 200H
2	B-C	0.12	254	8*10	4.3	0.20	250W * 150H
3	C-D	0.06	127	8*10	3.7	0.18	200W * 150 H

Table 5. 23F5 at First floor with duct and grills specifications.

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.21	444	12*20	4.9	0.24	250W * 200H
2	B-C	0.12	254	8*10	4.3	0.20	250W * 150H
3	C-D	0.06	127	8*10	3.7	0.18	200W * 150 H

Table 5. 24F4 at First floor with duct and grills specifications.

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.12	254	8*10	4.3	0.20	250W * 150H
2	B-C	0.06	127	8*10	3.7	0.18	200W * 150 H

Table 5. 25 Summary of Ducts and its Fan Coil Types at First Floor.

No	Name	Load KW	Flow kg/s	Diameter inch	Diameter Selection. inch	Flow cfm	Fan Coil Type
1	F1	10	0.34	0.580	0.5	825	42CED008
2	F2	8	0.27	0.51	0.5	381	42CED004

3	F3	10	0.34	0.580	0.5	825	42CED008
4	F4	11	0.36	0.609	1	868	42CED009
5	F5	10	0.34	0.580	0.5	825	42CED008
6	F6	8	0.27	0.51	0.5	381	42CED004

Table 5. 26 G1&2&G5 at Ground floor with duct and grills specifications.

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.12	254	8*10	4.3	0.20	250W * 150H
2	B-C	0.06	127	8*10	3.7	0.18	200W * 150 H

Table 5. 27G3 at Ground floor with duct and grills specifications

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.21	444	12*20	4.9	0.24	250W * 200H
2	B-C	0.12	254	8*10	4.3	0.20	250W * 150H
3	C-D	0.06	127	8*10	3.7	0.18	200W * 150 H

Table 5. 28G4 at Ground floor with duct and grills specifications

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.27	572	12*20	5	0.27	250W * 250H
2	B-C	0.21	444	10*12	4.9	0.24	250W * 200H
3	C-D	0.15	317	10*12	4.5	0.2	250W * 150H
4	D-E	0.09	190	8*10	3.8	0.19	200W * 150 H

Table 5. 29Summary of Ducts and its Fan Coil Types at Ground Floor.

No	Name	Load KW	Flow kg/s	Diameter inch	Diameter Selection. inch	Flow cfm	Fan Coil Type
1	G1	8	0.27	0.51	0.5	381	42CED004
2	G2	8	0.27	0.51	0.5	381	42CED004
3	G3	10	0.34	0.580	0.5	825	42CED008
4	G4	13	0.44	0.662	1	1523	42CED014
5	G5	8	0.27	0.51	0.5	381	42CED004

Table 5. 30S1 at Second floor with duct and grills specifications

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.21	444	12*20	4.9	0.24	250W * 200H
2	B-C	0.12	254	8*10	4.3	0.20	250W * 150H
3	C-D	0.06	127	8*10	3.7	0.18	200W * 150 H

Table 5. 31S2 at Second floor with duct and grills specifications.

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.27	572	12*20	5	0.27	250W * 250H
2	B-C	0.21	444	10*12	4.9	0.24	250W * 200H
3	C-D	0.15	317	10*12	4.5	0.2	250W * 150H
4	D-E	0.09	190	8*10	3.8	0.19	200W * 150 H

Table 5. 32S3&S4 at Second floor with duct and grills specifications.

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.12	254	8*10	4.3	0.20	250W * 150H
2	B-C	0.06	127	8*10	3.7	0.18	200W * 150 H

Table 5. 33Summary of Ducts and its Fan Coil Types at Ground Floor

No	Name	Load kW	Flow kg/s	Diameter inch	Diameter Selection. inch	Flow cfm	Fan Coil Type
1	S3	10	0.34	0.580	0.5	825	42CED008
2	S2	13	0.44	0.662	1	1523	42CED014
3	S3	8	0.27	0.51	0.5	381	42CED004
4	S4	8	0.27	0.51	0.5	381	42CED004

Table 5. 34T1&T2 at Third floor with duct and grills specifications.

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.27	572	12*20	5	0.27	250W * 250H
2	B-C	0.21	444	10*12	4.9	0.24	250W * 200H
3	C-D	0.15	317	10*12	4.5	0.2	250W * 150H
4	D-E	0.09	190	8*10	3.8	0.19	200W * 150 H

Table 5. 35T3 at Third floor with duct and grills specifications.

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.12	254	8*10	4.3	0.20	250W * 150H
2	B-C	0.06	127	8*10	3.7	0.18	200W * 150 H

Table 5. 36Summary of Ducts and its Fan Coil Types at Third Floor.

No	Name	Load KW	Flow kg/s	Diameter inch	Diameter Selection. inch	Flow cfm	Fan Coil Type
1	T1	13	0.44	0.662	1	1523	42CED014
2	T2	13	0.44	0.662	1	1523	42CED014
3	T3	8	0.27	0.51	0.5	381	42CED004

Table 5. 37H1 at Four floor with duct and grills specifications

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.27	572	12*20	5	0.27	250W * 250H
2	B-C	0.21	444	10*12	4.9	0.24	250W * 200H
3	C-D	0.15	317	10*12	4.5	0.2	250W * 150H
4	D-E	0.09	190	8*10	3.8	0.19	200W * 150 H

Table 5. 38Summary of Ducts and its Fan Coil Types at Ground Floor.

No	Name	Load KW	Flow kg/s	Diameter inch	Diameter Selection. inch	Flow cfm	Fan Coil Type
1	H1	13	0.44	0.662	1	1523	42CED014

Table 5. 39B1,B2 at basment floor woth duct and grills specifiatin

NO	Branch Name	Flow m^3/s	Flow cfm	Grill size inch	Velocity m/s	Diameter m	Duct Size mm
1	A-B	0.21	444	12*20	4.9	0.24	250W * 200H
2	B-C	0.12	254	8*10	4.3	0.20	250W * 150H
3	C-D	0.06	127	8*10	3.7	0.18	200W * 150 H

Table 5. 40 H at Summary of Ducts and its Fan Coil Types atforth table

No	Name	Load kW	Flow kg/s	Diameter inch	Diameter Selection. inch	Flow cfm	Fan Coil Type
1	H1	13	0.44	0.662	1	1523	42CED014

5.4 Air Handling Units

Air handling unit and often abbreviated to AHU, is a device used as part of a heating, ventilating, and air-conditioning (HVAC) system. Usually, an air handler is a large metal box containing a blower, heating and cooling elements filter racks or chambers, sound attenuators, and dampers. Air handlers usually connect to ductwork that distributes the conditioned air through the building, and returns it to the AHU. Sometimes AHUs discharge (supply) and admit (return) air directly to and from the space served, without ductwork. Small air handlers, for local use, are called terminal units, and may only include an air filter, coil, and blower; these simple terminal units are called blower coils or fan coil units. Larger air handlers that condition 100% outside air, and no recalculated air, are known as makeup air units (MAUs). Air handlers commonly also provide provisions to allow the introduction of outside air into, and the exhausting of air from, the building.

5.4.1 Sample of calculations of (AHU's)

For air handling unit that supply operations room 1 at First floor. The out side condition is 5 C db temperature and relative humidity of 50%.the supply air temperature is 40 C . the inside design conditions is 20 C db temperature.

$Q_{space} = \dot{m}_s * Cp * (Ts - Ti)$

$m_s = \frac{\text{Q space}}{\text{Cp} * (\text{Ts} - \text{Ti})} = \frac{9.71}{1 * (40 - 20)} = 0.485$ kg/s

Where:

Q is the heat rate kW.

w is the humidity ratio kJ/kj.

ws is the humidity at surrounding conditions ratio kJ/kJ.

wi is the humidity at inside conditions ratio kJ/kJ.

And Ts: the outside design conditions

Ti: the inside design conditions

With ws = wi =0.007Kg/Kg.a at Ts = 40 C

kg/From psychometric chart Vs = 0.89 m/kg d.a

And h_s = 57 kJ/kg.d.a

Vs = vs. * $\dot{m}_s$ = 0.89 * 0.485 = 431.6 l/s = 0.4316 m^3/s=1553.7m^3/hr

After using thecatalogCarrier Selection39FD/X-220

All used air handling units (AHU's) data were emptied in the table below.

Air handling units (AHU's) data41 .Table 5

NO	Room name	location	Total load kW	Unit Name	Flow L/s	Unit selected
1	Operations room 1-2	first floor	9.7	AHU1	431	**39FD/X-220**
2	Operations room 3-4	first floor	11.12	AHU3	494	**39FD/X-220**
3	Operations room 5	first floor	9.7	AHU4	431	**39FD/X-220**
4	Recovery Room1-5	first floor	3.3	AHU5	146	**39S00**
5	Recovery Room6	first floor	9.7	AHU6	431	**39FD/X-220**
6	Operations room1	Second floor	11.12	AHU7	494	**39FD/X-220**
7	Operations room 2	Second floor	9.7	AHU8	431	**39FD/X-220**
8	Recovery room 1-4	Second floor	3.3	AHU9	146	**39S00**
9	Operations room1	Third floor	11.12	AHU10	494	**39FD/X-220**
10	Recovery room 1	Third floor	3.3	AHU11	146	**39S00**

5.5 Ventilation System

All Buildings need ventilation to remove stale interior air and excessive moisture and to provide oxygen for the inhabitants. There has been considerable concern recently about how much ventilation is required to maintain the quality of air in homes.

While it is difficult to gauge the severity of indoor air quality problems, building science experts and most indoor air quality specialists agree that the solution is not to build an inefficient, “leaky” home.

Research studies show that standard houses are as likely to have indoor air quality problems as energy efficient ones.

While opening and closing windows offers one way to control outside air for ventilation, this strategy is rarely useful on a regular, year-round basis. Most building researchers believe that no house is so leaky that the occupants can be relieved of concerns about indoor air quality. The researchers recommend mechanical ventilation systems for all houses.

Air leaks are unpredictable, and leakage rates for all houses vary. For example, air leakage is greater during cold, windy periods and can be quite low during hot weather. Thus, pollutants may accumulate during periods of calm weather even in drafty houses. These homes will also have many days when excessive infiltration provides too much ventilation, causing discomfort, high energy bills, and possible deterioration of the building envelope.

Construction are ineffective—a prime contributor to interior moisture problems in homes. Bath and kitchen exhaust fans should vent to the outside, not just into an attic or crawl space. General guidelines call for providing a minimum of 50 cubic feet per minute (cfm) of air flow for baths and 100 cfmfor kitchens. Manufacturers should supply a cubic feet per minute (cfm) rating for any exhaust fan.

This places in General or medium-use housing , But in project, "the hospital" will be more than normal use, we hitaccountsfor1.5safetyfactor
then ; for the baths of 75 cubic feet per minute (cfm) of air flow and 150 cfm for
kitchens

5.6 Selections of other HVAC system components.

1-Boiler:

Boiler capacity = Total heating load * corrections factor

= 406.8*1.1

= 447.48 kW

Boiler model: **Super Series** 450kW **General data 450V** (seeAppendix).

2. Expansion tank:

Expansion tank volume has been determent according to boiler capacity. An expansion tank with volume of 1800 (see appendix).

475Gallons= 1800Liters

Expansion tank**:** 3010 model from Steptrutnov Company (see appendix).

4. Chiller

Chiller model: 30HXC155AH packaged screw worked by R-134a.

From carrier company(see appendix).

5. Pumps

Standard Pumps and Trim Based on Chiller Capacities according to American slandered have been selected using pump tables in appendix.

CHAPTER SIX

FIRE FIGHTING SYSTEM

6 Fire fighting system.

6.1 The Fire Triangle

There are three (3) components required for combustion to occur:

Fuel – to vaporize and burn

Oxygen – to combine with fuel vapor

Heat – to raise the temperature of the fuel vapor to its ignition temperature

The following is the typical “fire triangle”, which illustrates the relationship between these three components:

Classifications of Fire

Fires are classified into five groups as follows:

Class A: Class A fires involve common combustibles such as wood, paper, cloth, rubber, trash and plastics. They are common in typical commercial and home settings, but can occur anywhere these types of materials are found.

Class B: Class B fires involve flammable liquids' gases, solvents, oil, gasoline, paint, lacquers, tars and other synthetic or oil-based products. Class B fires often spread rapidly and, unless properly secured, can reflash after the flames are extinguished.

Class C: Class C fires involve energized electrical equipment, such as wiring, controls, motors, data processing panels or appliances. They can be caused by a spark, power surge or short circuit and typically occur in locations that are difficult to reach and see.

Class D: Class D fires involve combustible metals such as magnesium and sodium. Combustible metal fires are unique industrial hazards which require special dry powder agents.

Class K: Class K fires involve combustible cooking media such as oils and grease commonly found in commercial kitchens. The new cooking media formulations used form commercial food preparation require a special wet chemical extinguishing agent that is especially suited for extinguishing and suppressing these extremely hot fires that have the ability to reflash..

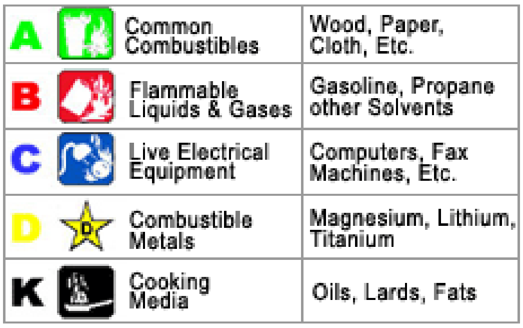


Figure 6. 1 fire clasification.

Fire Signatures

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

6.2 Types of Firefighting Systems

Fire systems are classified as follows:

6.2.1 Portable Fire Extinguishers

Portable fire extinguishers can contain a wide variety of extinguishing agents; the portable 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.

- **Types of Portable Firefighting Extinguishers**:

1) Foam: fire extinguishers extinguish the fire by taking away the heat element of the fire triangle. Foam agents also separate the oxygen element from the other elements.
   Water extinguishers are for Class A fires only - they should not be used on Class B or C fires. The discharge stream could spread the flammable liquid in a Class B fire or could create a shock hazard on a class C fire.
   Foam extinguishers can be used on Class A & B fires only. They are not for use on Class C fires due to the shock hazard.
2) Carbon Dioxide: Carbon dioxide fire extinguishers extinguish the fire by taking away the oxygen element of the fire triangle and also by removing the heatwith a very cold discharge. Carbon dioxide can be used on Class B & C fires. They are usually ineffective on Class A fires.
3) Clean agent extinguishers: Halogenated or Clean Agent extinguishers include the halon agents as well as the newer and less ozone depleting halocarbon agents. They extinguish the fire by interrupting the chemical reaction of the fire triangle.
4) Dry chemical extinguishers, hand and wheeled: fire extinguishers extinguish the fire primarily by interrupting the chemical reaction of the fire triangle
5) Wet chemical extinguishers: Wet Chemical is a new agent that extinguishes the fire by removing the heat of the fire triangle and prevents reigniting by creating a barrier between the oxygen and fuel elements and use in kitchen.
6) Dry Powder: extinguishers are similar to dry chemical except that they extinguish the fire by separating the fuel from the oxygen element or by removing the heat element of the fire triangle. .

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

6.2.2 Calculating the A-Rated extinguishers required

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

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

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

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

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

6.2.3 Fire hose cabinet.

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

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

Consist of tow type:

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

Figure 6. 2 fire hose

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

Fire hose calculation and pump selection.

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

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

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

Flow rate **($\boldsymbol{Q}_{\mathbf{efectiv}}$)**=100gpmwhich equal 0.00639 m^3

The velocity in the pipe defined in the equation:

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

Reynolds number (Re):

μ_{water}@25℃=0.001

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

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

from mody chart the friction factor (f)=0.03

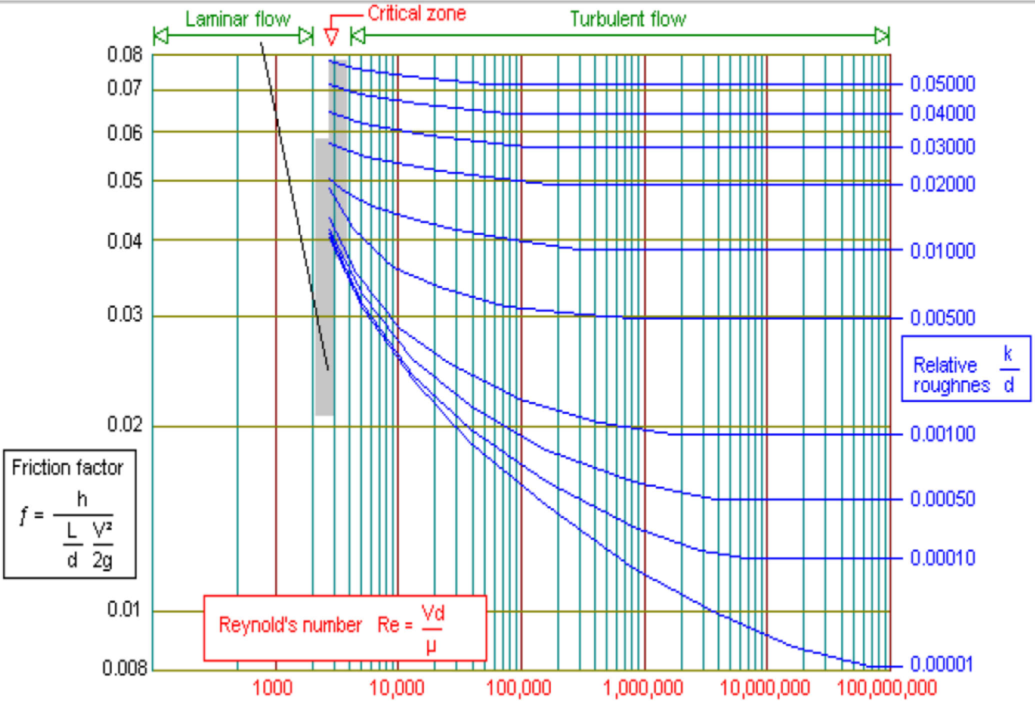


Figure 6.3 moody chart

Head loss:

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

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

Major h_f =0.113 +0.102= 0.215 m.

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

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

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

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

Factor of safety = 8.115*1.15= 9.33

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

P loss =0.915bar

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

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

6.3 Selections of other firefighting system components

1. Fire hose :

   We need a hose length of 30 meter.

   Selection : kiddeModel 31A.
2. Pump:

   Xylem Model 2.5X2.5X7F electric pumps.

   Xylem Model 3X2X11F-S diesel pump.

   Peerless Model J - J65F jockey pump.
3. Fire Extinguishers:

   Wet Chemical Extinguishers.

   HCFC Extinguishers.

   Carbone dioxide.

CHAPTER SEVEN

MEDICAL GASES

7 Medical gases

7.1 Introduction.

Hospital and healthcare facilities are the most complex building type to design because they have critical plumbing systems. they also require special equipment for life support systems, which include medical gas systems and plumbing connections to other medical equipment. Which forces the plumping engineers to keep up with the new technologies to provide innovative approaches to the design of medical-gas system? Designing, building, operating a medical-gas and vacuum systems can be complicated, it also need for good planning for the system with good budget because the oversights of anything could have serious implications for your addition to the dangers it could present to patients, so The goal of designing medical-gas and vacuum system is to provide safe and sufficient flow at required pressures to the medical gas-outlet or inlet terminals served. System design and layout should be allowing convenient access by the medical staff to outlet and inlet terminals, values and equipment during patient care.

Medical-gas is any gas that used in medical application, medical gases are used everyday by a lot of people in different location, these gases such oxygen, nitrous oxide, medical air, medical vacuum perform a critical role in healthcare in such location as hospitals, ambulances, dental offices and more.

There are essential steps to design medical-gas piped system in perfect way , which are recommended to the plumping engineer:

1- Analyze each specific area of the healthcare facility to determine the following items:

a. Which piped medical-gas systems are required?

b. How many of each different type of medical-gas outlet/inlet terminal are required?

c. Where should the outlet/inlet terminals be located for maximum efficiency and convenience?

d. Which type and style of outlet/inlet terminal best meet the needs of the medical staff.

2- Anticipate any building expansion and plan in which direction the expansion will take place (vertically or horizontally).Determine how the medical-gas system should be sized and valued in order to accommodate the future expansion.

3- Determine locations for the various medical-gas supply sources.

a. Bulk oxygen (O_2).

b. High-pressure cylinder manifolds (O_2, N_2O or N_2).

c. Vacuum pumps (VAC).

d. Medical-air compressors (MA).

4- Prepare the schematic piping layout locating the following:

a. Zone valves.

b. Isolation valves.

c. Master alarms.

d. Area alarms.

5- Calculate the anticipated peak demands for each medical-gas system. Appropriately size each particular section so as to avoid exceeding the maximum pressure drops allowed.

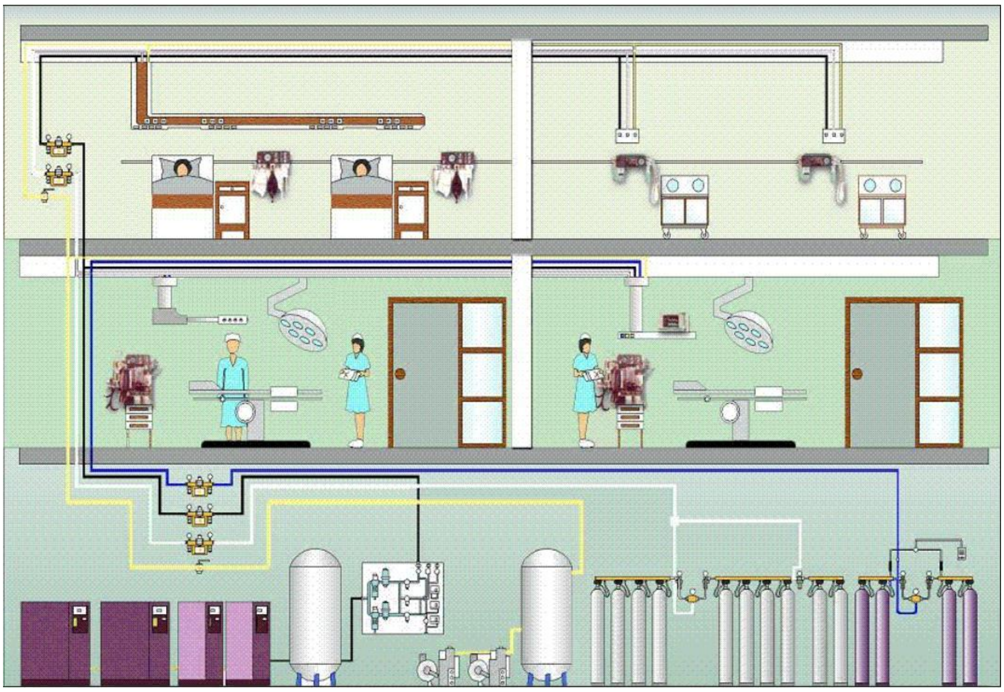


Figure 7.1 midocal gas sample

7.2 Medical Gases Flow Rate:

Each station must provide a minimum flow rate for the proper functioning of connected equipment under design and emergency conditions. The flow rates and diversity factors vary for individual stations in each system depending on the total number of outlets and the type of care provided.

The flow rate from the total number of outlets, without regard for any diversity, is called the “total connected load. If the total connected load were used for sizing purposes, the result would be a vastly oversized system, since not all of the stations in the facility will be used at the same time. A diversity, or simultaneous- use factor, is used to allow for the fact that not all of the stations will be used at once. It is used to reduce the system flow rate in conjunction with the total connected load for sizing mains and branch piping to all parts of the distribution system. This factor varies for different areas throughout any facility.

7.3 Provision Of Terminal Unit:

Terminal unit provision is given in Table 7.1. Medical treatment policy is evolutionary, although , the project team should review requirements for individual schemes.

Mounting heights for terminal units should be between 900 mm and 1400 mm above finished floor level (FFL) when installed on walls or similar vertical surfaces. When terminal units are incorporated within a horizontal bedhead service trucking system, which also provides integrated linear lighting for general room and/or patient reading illumination, it should be of a design that does not compromise the convenience of the medical gas facility.

Terminal units should be mounted in positions thatresult in the shortest practicable routes for flexible connecting assemblies, between the terminal unit and apparatus. Terminal units may be surface- or flush-mounted. They may also be incorporated with electrical services, nurse call systems, televisions, radio and audio services, in proprietary fittings such as medical supply units, wall panel systems and pendant fittings etc.

When planning the installation of operating-roompendant fittings, the location of the operating luminaire and other ceiling-mounted devices should be taken into consideration. When the operating room is provided with an ultra-clean ventilation (UCV) system, it may be more practicable (and cost-effective) to have the services (both medical gas and electrical) incorporated as part of the UCV system partial walls.

Terminal units that are wall mounted should be located as follows:

a. distance between centre's of adjacent horizontal terminal units:

1- 135 ± 2.5 mm for three or more terminal units.

2- 150 ± 2.5 mm for two terminal units only.

b. the distance between the centre of the terminal unit and a potential obstruction on either side(for example when installed in a corner) should be a minimum of 200 mm on either side.

c. care should be taken to ensure that connected medical gas equipment and hoses do not foul other nearby equipment and services during use.

Table 7. 1The distribution of gases in departmant

Department	**O_2**	**N_2O**	**N_2O/O_2**	**MA4**	**SA7**	**VAC**	**AGSS**
Accident and emergency department							
Resuscitation room, per trolley space	1	1	-	1	-	1	1
Major treatment/plaster room per trolley space	1	1	1p	1	1p	1	1
Post-anesthesia recovery per trolley space	1	-	-	1p	-	1	-
Treatment room/cubicle	1	-	-	-	-	1	-
Operating department							
Anaesthetic rooms (all)	1	1	-	1	-	1	1
Operating theatre anesthetist	1	1	-	1	1p	2	1
surgeon	1	1	-	1	1p	2	1
Post-anesthesia recovery, per bed space	1	-	-	1	-	1	-

Equipment service room per work space	1	1	-	1	1p	1	1
Maternity department							
Delivery mother	1	-	1	-	-	1	-
Baby	1	-	-	1	-	1	-
Abnormal delivery room mother	1	1	1	1	-	2	1
Baby	1	-	-	1	-	1	-
Operating suite Anesthetist room	1	1	-	1	-	1	1
Operating theatre Anesthetist	1	1	-	-	-	1	-
In-patient accommodation							
Department	**O_2**	**N_2O**	**N_2O/O_2**	**MA_4**	**SA_7**	**VAC**	**AGSS**
Single-bed room	1	-	-	-	-	1	-
Multi-bed room	1	-	-	-	-	1	-
p=Project Team Option							

7.4 Type of Medical Gases:

- **Oxygen**

Oxygen is one of the most extensively used at atmospheric temperatures and pressures exists and its a colorless, odorless, non-flammable and tasteless gas. Primarily used by patients with respiratory or airway obstruction and to relieve.

symptoms and signs associated with respiratory distress, therapy, anesthesia, used for face mask and ventilator. Oxygen should be avoided as a power source because of fire risk and cost, and should not be used where medical air is available, Oxygen supplied to hospitals by multiple standard cylinders. Pressures are usually around 55 psi.

Oxygen is generally supplied from:

• a liquid source such as a large vacuum-insulated evaporator (VIE).
• liquid cylinders or compressed gas cylinders.
• a combination of these to provide the necessary stand-by/back-up capacity.

- Oxygen can also be supplied from an oxygen concentrator (pressure-swing adsorbed). Such systems are usually installed where liquid or cylinders are expensive, unavailable or impracticable.

To calculate the amount of hospital oxygen gas there is a table (6.2) where n number of beds, Q the flow of oxygen and L/M space you need to know which is the diameter of the pipe.

Table 7. 2flow of oxygen.

Department	**Design flow for each terminal unit (L/min)**	**n**	**Diversified flow *Q* (L/min)**	
In-patient accommodation (ward units):				
Single 4-bed rooms and treatment room	10	0	$Qw = 10 + [(n - 1)6/4] =$	0
Ward block/department	10	0	$Qd = Qw[1 + (nW - 1)/2] =$	0
Accident & emergency:				
Resuscitation room, per trolley space	100	0	$Q = 100 + [(n - 1)6/4] =$	0
Major treatment/plaster	10	0	$Q = 10 + [(n - 1)6/4] =$	0
room, per trolley space Post-anesthesia recovery, per trolley space	10	0	$Q = 10 + [(n - 1)6/8] =$	0
Treatment room/cubicle	10	0	$Q = 10 + [(n - 1)6/10] =$	0

Operating:				
Anaesthetic rooms	100	0	Q = no addition made	
Operating rooms	100	0	$Q = 100 + (nT - 1)10 =$	0
Post-anesthesia recovery	10	0	$Q = 10 + (n - 1)6 =$	0
Maternity:				
LDRP rooms:				
Mother	10	0	$Q = 10 + [(n - 1)6/4] =$	0
Baby	10	0	$Q = 10 + [(n - 1)3/2] =$	0
Operating suites:				
Anesthetist	100	0	$Q = 100 + (nS - 1)6 =$	0
Pediatrician	10	0	$Q = 10 + (n - 1)3 =$	0
Post-anesthesia recovery	10	0	$Q = 10 + [(n - 1)3/4] =$	0
In-patient accommodation:				
Single/multi-bed wards	10	0	$Q = 10 + [(n - 1)6/6] =$	0
Nursery, per cot space	10	0	$Q = 10 + [(n - 1)3/2] =$	0
Special care baby unit	10	0	$Q = 10 + (n - 1)6 =$	0
Radiological:				
All anesthetic and procedures rooms	100	0	$Q = 10 + [(n - 1)6/3] =$	0
Critical care areas	10	0	$Q = 10 + [(n - 1)6]3/4 =$	0
Coronary care unit	10	0	$Q = 10 + [(n - 1)6]3/4 =$	0
High-dependency unit (HDU)	10	0	$Q = 10 + [(n - 1)6]3/4 =$	0
Renal	10	0	$Q = 10 + [(n - 1)6/4] =$	0
CPAP ventilation	75	0	$Q = 75n \times 75\%$	0
Adult mental illness accommodation:				
Electro-convulsive therapy (ECT) room	10	0	$Q = 10 + [(n - 1)6/4] =$	0
Post-anesthesia, per bed space	10	0	$Q = 10 + [(n - 1)6/4] =$	0
Adult acute day care				

accommodation:				
Treatment rooms	10	0	$Q = 10 + [(n - 1)6/4] =$	0
Post-anesthesia recovery per bed space	10	0	$Q = 10 + [(n - 1)6/4] =$	0
Oral surgery/orthodontic:				
Consulting rooms, type 1	10	0	$Q = 10 + [(n - 1)6/2] =$	0
Consulting rooms, types 2 & 3	10	0	$Q = 10 + [(n - 1)6/3] =$	0
Recovery room, per bed space	10	3	$Q = 10 + [(n - 1)6/6] =$	12
Out-patient:				
Treatment rooms	10	0	$Q = 10 + [(n - 1)6/4] =$	0
Equipment service rooms, sterile services etc	100		Residual capacity will be adequate without an additional allowance	

- **Nitrous Oxide (NO2):**

Nitrous Oxides a medical gas that used for anesthetic and analgesic purposes, being mixed with air, oxygen, and nebulizer agents. It delivered to the hospitals in standard tanks. System pressures around 50 psi.

Nitrous calculation are the same as the oxygen calculation but here there is a difference in flow rate equation and the table 6.3 show that.

Table 7. 3Flow of Nitrous Oxide

Department	**Design flow for each terminal unit (L/min)**	**n**	**Diversified flow *Q* (L/min)**	
Accident & emergency: resuscitation room, per trolley space	10	0	$Q = 10 + [(n - 1)6/4]$ =	0
Operating	15	0	$Q = 15 + (nT - 1)6$ =	0
Maternity: operating suites	15	0	$Q = 15 + (nS - 1)6$ =	0
Radiological: all anesthetic and procedures rooms	15	0	$Q = 10 + [(n - 1)6/4]$ =	0
Critical care areas	15	0	$Q = 10 + [(n - 1)6/4]$ =	0
Oral surgery/orthodontic: consulting rooms, type 1	10	0	$Q = 10 + [(n - 1)6/4]$ =	0
Other departments	10	0	No additional flow included =	0
Equipment service rooms	15	0	No additional flow included =	0

- **Medical Air MA4:**

Medical Air is primarily used for respiratory therapy. it supplied by a special air compressor to patient care areas using clean outside air. Pressure are maintained around 55 psi. Medical Air gas calculations are the same as the previous gas but the difference between them is the flow rate equations and it is in table 6.4

Table 7. 4Flow Of Medical Air

Department	Design flow for each terminal unit (L/min)	n	Diversified flow Q (L/min)	
In-patient accommodation (ward units):				
Single 4-bed rooms and treatment room	20	0	Qw = 20 + [(n – 1)10/4] =	0
Ward block/department	20	0	Qd = Qw[1 + (nW– 1)/2] =	0
Accident & emergency:				
Resuscitation room, per trolley space	40	0	Q = 40 + [(n – 1)20/4] =	0
Major treatment/plaster room, per trolley space	40	0	Q = 40 + [(n – 1)20/4] =	0
Post-anesthesia recovery, per trolley space	40	0	Q = 40 + [(n – 1)40/4] =	0
Operating:				
Anaesthetic rooms	40	0	Q = no addition made	
Operating rooms	40	0	Q = 40 + [(nT– 1)40/4] =	0
Post-anesthesia recovery	40	0	Q = 40 + [(n – 1)10/4] =	0
Maternity:				
LDRP rooms:	40	0	Q = 40 + [(n – 1)40/4] =	0
Baby	40	0	Q = 40 + [(n – 1)40/4] =	0
Operating suites:				
Anesthetist	40	0	Q = 40 + [(nS– 1)10/4] =	0
Post-anesthesia recovery	40	0	Q = 40 + [(n – 1)40/4] =	
Neonatal unit (SCBU)	40	0	Q = 40n	
Radiological:				
All anesthetics and procedures rooms	40	0	Q = 40 + [(n – 1)40/4] =	0
Critical care areas	80	0	Q = 80 + [(n – 1)80/2] =	0

High-dependency unit (HDU)	80	0	$Q = 80 + [(n – 1)80/2] =$	0
Renal	20	0	$Q = 20 + [(n – 1)10/4] =$	0
Oral surgery/orthodontic:				
Major dental/oral surgery	40	0	$Q = 40 + [(n – 1)40/2] =$	0
All other departments	40	0	No additional flow allowance to be made	0
Equipment service rooms	40		No additional flow included	0

- **Medical Vacuum**

Medical Vacuum Primarily used for patient treatment in surgery, recovery, and ICU to remove fluids and aid in drainage, but it doesn't used in Infectious Diseases Unit (IDU). Medical vacuum systems operate low flow rates at the terminal units (~40 L/min), it usually supplied to hospitals by vacuum pump systems. Continuous vacuum is maintained around 22 inches of mercury.
Medical vacuum gas calculation similar to the previous gas but there is a deference in flow rate and it is in table 6.5.

Table 7. 5Flow Of Medical Vacuum

Department	**Design flow for each terminal unit (L/min)**	**n**	**Diversified flow *Q* (L/min)**	
In-patient accommodation (ward units):				
Ward unit Multiple ward units	40 40	0 0	$Q = 40$ $Qd = 40 + [(n – 1)40/4] =$	0 0
Accident & emergency:				

Resuscitation room, per trolley space	40	0	$Q = 40 + [(n - 1)40/4] =$	0
Major treatment/plaster	40	0	$Q = 40 + [(n - 1)40/4] =$	0
Post-anesthesia recovery, per trolley space	40	0	$Q = 40 + [(n - 1)40/4] =$	0
Treatment room/cubicle	40	0	$Q = 40 + [(n - 1)40/8] =$	0
Operating:				
Anaesthetic rooms	40	0	No additional flow included	0
Operating rooms:				
Anesthetist	40	0	$Q = 40$	
Surgeon	40	0	$Q = 40$	
Operating suites	40	0	$Qs = 80 + [(nS-1)80/2] =$	0
Post-anesthesia recovery	40	0	$Q = 40 + [(n - 1)40/4]$	
Maternity:				
LDRP rooms:				
Mother	40	0	$Q = 40 + [(n - 1)40]/4 =$	0
Baby	40	0	No additional flow included	0
Operating suites:				
Anesthetist	40	0	$Q = 40$	0
Obstetrician	40	0	$Q = 40$	0
Operating suites	80	0	$Qs = 80 + [(nS-1)80/2] =$	0
Post-anesthesia recovery	40	0	$Q = 40 + [(n - 1)40/4] =$	0

In-patient accommodation:				
Ward unit comprising	40	0	$Q = 40$	0
Multi-ward units	40	0	$Q = 40 + [(n - 1)40/2] =$	0
Nursery, per cot space	40	0	No additional to be included	0
SCBU	40		$Q = 40 + [(n - 1)40/4] =$	
Radiological:				
All anesthetic and procedures rooms	40	0	$Q = 40 + [(n - 1)40/8] =$	0
Critical care areas	40	0	$Q = 40 + [(n - 1)40/4] =$	0
High-dependency unit (HDU)	40	0	$Q = 40 + [(n - 1)40/4] =$	0
Renal	40	0	$Qd = 40 + [(n - 1)40/4] =$	0
Adult mental illness accommodation:				
Electro-convulsive therapy (ECT) room	40	0	$Q = 40 + [(n - 1)40/4]=$	0
Post-anesthesia, per bed space	40	0	$Q = 40 + [(n - 1)40/4] =$	0
Oral surgery/orthodontic:				
Consulting rooms, type 1	40	0	Dental vacuum only	0
Consulting rooms, types 2 & 3	40	0	Dental vacuum only	0
Recovery room, per bed space	40	0	$Q = 40 + [(n - 1)40/8] =$	0

Out-patient:				
Treatment rooms	40	0	$Q = 40 + [(n - 1)40/8] =$	0
Equipment service rooms, sterile services etc	40		Residual capacity will be adequate without an additional allowance	

- **Anesthetic Gas Scavenging System:**

Anaesthetic Gas Scavenging System (AGSS) used for example in anesthetic and operating room. Used to capture and carry away gasesvented from the patient breathingcircuit during the normal operation ofgas anesthesia or analgesiaequipment. AGSS incorporate a mechanical pump to assist with the disposal of the waste gas.

AGSS gas calculation are the same as the previous gas but there is a difference in flow rate equation and the Table (5.6). Show that.

Table7.6:Flow of AGSS

Department	**Design flow for each terminal unit (L/min)**	**n**	**Diversified flow Q (L/min)**	
Accident & emergency resuscitation room (per trolley space)	130	0	$Q = V + [(n - 1)V/4] =$	0
Operating departments	130	0	$Q = V + (nT - 1)V =$	0
Maternity operating suites	130	0	$Q = V + (nS - 1)V =$	0
Radio diagnostic (all an aesthetic and procedures room)	130	0	$Q = V + [(n - 1)V/4] =$	0

Oral surgery/orthodontic consulting rooms (type 1)	130	0	$Q = V + [(n - 1)V/4] =$	0
Other departments	130	0	$Q = V + [(n - 1)V/8] =$	0

7.5 Calculation Of Medical Gases

7.5.1 Sample calculation of first floor.

- **Oxygen.**

1- Operating rooms

Q=100+(n-1)10 from table 6.2.

Q: The flow of oxygen gases(L/m).

n: Number of beds.

Q=100+(1-1)10

Q=100 L/m

There are five operating rooms on the first floor.

2- Recovery rooms

Q=10+[(n-1)6/6] from table 6.2

Q=10+[(2-1)6/6]

Q= 16L/m

There are five recovery rooms on the first floor.

3- ICU rooms

Q=10+[(n-1)6]3/4 from table 6.2

Q=10+[(1-1)6]3/4

Q= 10 L/m

There are one ICU rooms on the first floor.

4- patient rooms

Q=40+[(n-1)40/4] from table 6.4.

N: Number of beds.

Q=40+[(4-1)40/4]

Q=70 L/m

There are 7 patient rooms on the first floor

Q=40+[(n-1)40/4] from table 6.4.

N: Number of beds.

Q=40+[(2-1)40/4]

Q=50 L/m

There are 8 patient rooms on the first floor.

- **Nitrous Oxide**

1- Operating rooms

Q=15+(n-1)6 from table 6.3.

Q: The flow of nitrous oxide gases(L/m).

N: Number of beds.

Q=15+(1-1)6

Q=15 L/m

There are five operating rooms on the first floor.

- **Medical Air**

1- Operating rooms

Q=40+[(n-1)40/4] from table 6.4.

Q: The flow of medical air gases(L/m).

N: Number of beds.

Q=40+[(1-1)40/4]

Q=40 L/m

There are five operating rooms on the first floor.

2- Recovery rooms

Q=40+[(n-1)10/4] from table 6.4

Q=40+[(2-1)10/4]

Q=42.5 L/m

There are Five recovery rooms on the first floor.

3- ICU rooms

Q=80+[(1-1)80/2] from table 6.5

Q=80+[(4-1)80/2]

Q=80 L/m

There are one ICU rooms on the first floor.

- **Medical Vacuum**

1- Operating rooms

We need flow of medical vacuum gases in operating room always 80L/M from table (6.5) .

There are two operating rooms on the first floor.

2- Recovery rooms

Q=40+[(n-1)40/8]

Q=40+[(1-1)40/8]

Q= 40 L/m

There are one recovery rooms on the first floor.

3- ICU rooms

Q=40+[(n-1)40/4]

Q=40+[(1-1)40/4]

Q= 40 L/m

There are five ICU rooms on the first floor.

4- Patient rooms

Q=40+[(n-1)40/4] from table 6.4.

N: Number of beds.

Q=40+[4-1)40/4]

Q=70 L/m

There are 7 patient rooms on the first floor

Q=40+[(2-1)40/4] from table 6.4.

N: Number of beds.

Q=40+[(2-1)40/4]

Q=50 L/m

There are 8 patient rooms on the first floor

- **Anesthetic gas scavenging system (AGSS)**

1- Operating rooms

Q=130+[(n-1)130/4] from table 6.6

Q: The flow of (AGSS) gases(L/m).

N: Number of beds.

Q=130+[(1-1)130/4]

Q=130 L/m

There are two operating rooms on the first floor

Table 7. 6the flow of medical gas in the all of the floors of the hospital:

Floor	**Oxygen**	**Nitrous Oxide**	**Medical Air**	**Medical Vacuum**	**AGSS**
first floor	1480 L/m	75L/m	429.5L/m	1530L/m	650L/m
second floor	912 L/m	30 L/m	325 L/m	870 L/m	260L/m
Third floor	846 L/m	15L/m	82.5L/m	785 L/m	130L/m
Fourth floor	_ _	_ _	_ _	260L/m	_ _
Basment	_ _	_ _	_ _	70L/m	_ _
Grund	250 L/m	15 L/m	82.5 L/m	265 L/m	130 L/m
TOTAL	3494 L/m	135 L/m	982.5 L/m	3780 L/m	1170 L/m

7.5.2 Mechanical Equipment

- **Cylinder Oxygen**

The amount of oxygen gas m^3/h= Fx60 min/1000 lit, where F the amount of oxygen gas following in all hospital L/m.

The amount of oxygen gas m^3/h= 3494x60/1000

= 209.64/h

The number of cylinder oxygen gases= the amount of oxygen gas m^3/h capacities of oxygen gas cylinders m3. The capacities of oxygen gas cylinders = 6540 liters.

Number of cylinder oxygen gases= 209.64/6.54

= 32 cylinders

- **Cylinder Nitrous Oxide**

The amount of Nitrous Oxide m3/h= Fx60 min/1000 lit, where F the amount of Nitrous Oxide gas following in all hospital L/m.

The amount of Nitrous Oxide gas m^3/h= 135x60/1000

= 8.1 m^3/h.

The number of cylinder Nitrous Oxide gases= the amount of Nitrous Oxide gas m^3/h capacities of Nitrous Oxide gas cylinders m^3. The capacities of Nitrous Oxide gas cylinders= 4740 liters.

Number of cylinder Nitrous Oxide gases= 8.1/4.74

=1.7= 2 cylinders

- **Compressor of Medical Air**

The amount of Medical Air m^3/h= Fx60 min/1000 lit, where F the amount of Medical Air gas following in all hospital L/m

The amount of Medical Air gas m^3/h= 982.5x60/1000

= 58.9 m^3/h

We need a compressor can compress 60 m^3/h of the medical air gases.

- **Pump of Medical Vacuum**

The amount of Medical Vacuum m^3/h= Fx60 min/1000 lit, where F the amount of Medical Vacuum gas following in all hospital L/m

The amount of Medical Vacuum gas m^3/h=3780x60/1000

= 226.8m^3/h

We need to be able suction pump 230 m^3/h of the gas to the outside air.

7.5.2.5 Pump (AGSS)

the amount of AGSS m^3/h= Fx60 min/1000 lit, where F the amount of AGSS gas following in all hospital L/m.

the amount of AGSS gas m^3/h=1170x60/1000

$= 70.2\ m^3/h$

We need to be able suction pump 75 m^3/h of the gas to the outside air.

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APPENDIX A

BILL OF QUANTITIES

Item No.	Description	Unit	Qty.	Unit Rate
	Preamble			
	In the list of recommended makes, out of two or three makes mentioned in the list, only 1st. Make shall be preferred for use, unless otherwise specified in BOQ. However if non-availability or any other technical reason, the alternative make is allowed.			
	This section shall be read in conjunction with general and particular mechanical technical specifications, mechanical drawings, addendums and invitation to bid conditions except where otherwise indicated.			
	The unit price for all items in this section shall include supplying, installing, testing, and commissioning of mechanical works and materials, unless otherwise specifically mentioned or instructed by engineer.			
	All civil and finishing works related to the concerned items shall be included in the unit price.			
	Preparing of coordinated shop drawing and submitting to the approval of the supervision engineer, coordination with other activities, material storage, removing away from site the remnant of mechanical works and handling over the mechanical works to local mechanical auth.			
	Flexible PVC suitable size conduits and adaptors to be used for connecting motors to power supply.			
	Electrical cables up to mechanical equipment, to be supplied, installed connecting to mains side, testing and to be commissioned by electrical contractor, just cables termination to mechanical equipment to be carried on by mechanical contractor.			

Total Page Carried Forward			
Item No.	Description	Unit	Qty.
1.1	Waste and drainage system		
1.1.1	Vertical and horizontal UPVC pipe Supply, install UPVC pipes and fittings similar to (Royal) or E.A. The rate shall include all needed connections and all types of fittings caps, all done according to drawings, specifications and the approval of the supervision engineer.		
A.	Dia 2"	ML	370
B.	Dia 4"	ML	620
1.1.2	Floor trap and clean out Supply, installation, and commissioning of floor trap melding threaded (15*15) cm chrome plated cover UPVC red siphon (including junction box). And connected it with vertical pipes the price including rings fittings and whatever needed the complete the job as located on drawing specifications and approval of supervision engineer.		
A.	Floor trap size 4" diameter	No.	67
B.	Floor drain size 4/2" diameter	No.	55
C.	Clean outs 4" but with closed type cover, size (11*11) cm.	No.	118
D.	Clean outs 6" but with closed type cover.	No.	2
1.1.3	Supply, installation, and commissioning all pipes and fittings to and overflow storage tank in basement the price includes manhole inside boiler room and whatever needed to complete the job as located on drawing specifications and approval of supervision engineer.	Job	1

Item No.	Description	Unit	Qty.	Unit
	Carreid Before			
1.1.4	Supply install and test UPC (UPA) or E.A. external drainage All rain pipes and fittings including connection excavation covering with layer 20 cm sand around the pipe and back filling as shown in drawings and specifications approval of supervisor engineer.			
B.	Size 6 inch diameter	ML	90	
C.	Size 8 inch diameter	ML	0	
1.1.5	Supply and install PRE-CAST concrete manholes of 15 cm thick walls and base with heavy duty cast iron covers and frames of 25 tons load strength with all necessary excavation back filling as specified to the required depth with steps of galvanized pipe of 1/2" benching and connecting it to main city manholes as shown in drawing and in accordance to specifications and approval engineers.			
A.	Size 60 cm (inside diameter)	No.	2	
1.1.5	Supply and install concrete manholes of 15 cm thick walls and base with Medium duty concrete and frames of 8 tons load strength with all necessary excavation back filling as specified to the required depth with steps of galvanized pipe of 1/2" benching and connecting it to main city manholes as shown in drawing and in accordance to specifications and approval engineers.			
A.	Size 60 cm (inside diameter)	No.	12	
B.	Size 80 cm (inside diameter)	No.	18	
C.	Size 100 cm (inside diameter)	No.	9	

1.1.6	Supply, install and test drain water and rain concrete channel with low carbon steel frame and mesh cover as shown in drawing and in accordance to specifications and approval engineers.			
B.	Width = 25 cm, h = 30 cm	No.	2	
C.	Ditto but with stainless steel frame and mesh cover (kitchen)	No.	3	

Item No.	Description	Unit	Qty.	Unit Rate €
Carreid Before				Euro
1.2	Domestic hot and cold water system			
1.2.1	Main water supply Supply and install galvanized steel main water pipes 2" with asphalt protection (factory covered) which will take from the main line of the city 2", with all necessary fitting e.g. elbow tee union stop valves non return valve and whatever needed to complete the job and all are of approved quality pipes are to be piped and laid underground through 4" PVC pipe from main supply to water storage tank, price shall include piping with all fitting, water meter, steel box excavation insulation with sand back filling disposal of remained excavated soil and charges for connection with main water supply all are according to PWA and approval of supervisor engineer.	L.S	1	
1.2.2	Supply and install galvanized pipes medium class for domestic cold water, hot water and hot water return, the work includes all fittings, valves, required flow direction signs, TOLGO type hangers, all required fittings, the prices includes vidoflex 13 mm for hot water pipes and hot water return.			
A.	Dia 3/4"	ML	250	
B.	Dia 1"	ML	150	
C.	Dia 11/4"	ML	120	
D.	Dia 11/2"	ML	60	
E.	Dia 2"	ML	85	

Item No.	Description	Unit	Qty.	Unit Rate €
	Carreid Before			
1.2.3	Supply and install hot and water collectors type GIACOMINI or E.A. price include all the supplying and installing 16 mm PEX plastic pipes with its 22 mm plastic conduits to be connected from the copper collectors openings up to location of sanitary fixtures outlets according to plans and engineers instructions, with all required hangers (type GIACOMINI) and support, air vent, shut-off valves on the collectors outlets, shut- off valve each collector must have main valve at the entrance of the collector the price include metallic painted steel cabinet of approved quality, including cover with double doors for domestic water collectors. Job as located on drawing specification and approval of supervisor engineer.			
A.	Dia 3/4"	EYE	40	

Item No.	Description	Unit	Qty.	Unit Rate €
	Carreid Before			
2.0	HVAC System:			
2.1	Fan coils units: Supply and instill fan coil unit with forward curved fans as made Carrier (France) ,The unit price shall include flexible connection on fan discharge, vibration isolators and hangers, two gates, thermostats, one strainer, automatic air Vent, three-way on/off valve, digital push button thermostats and flexible Connections on pipes drain connection.			
A.	Cooling Load =4 kw	No	2	
B.	Cooling Load =5 kw	No	1	
C.	Cooling Load =6 kw	No	8	
D.	Cooling Load =8 kw	No	7	
E.	Cooling Load =9 kw	No	7	
F.	Cooling Load =10 kw	No	23	
G.	Cooling Load =11 kw	No	24	
H.	Cooling Load =12kw	No	13	
I.	Cooling Load =14 kw	No	3	
2.2	Aluminum Grills: Supply and instill exhaust air aluminum grills made by Cooling Industries, fixed 45-degree blades, double deflection, 1" thick frame ,3/4" spacing. The unit price shall include connection to duct, and all accessories and works required to complete the work, all done according to drawings specifications and approval of the engineer.			
A.	8"X12"	No	1	
B.	10"X12"	No	4	
C.	12"X20"	No	8	
D.	14"X20"	No	40	

Item No.	Description	Unit	Qty.	Unit Rate €
	Carreid Before			
2.3	<u>Air handling units (AHU):</u> Supply ,instillations and setting to work including all required field wiring in rigid metal conduit from AHU panel to local isolator, condenser anti corrosion coating , spring vibration isolator, electrical isolators temperature controls , testing and commissioning etc .complete (modeling 3 way valve temperature controls). The unit price shall include vibration isolators and hangers, two gate valves, thermostats, one strainer, automatic air vent, double regulating valve, three-way modulating valve, digital push button thermostats and Flexible connections on pipes, drain connection with U trap, fire damper The price should include the rubber pads underneath the AHU. Each chilling unit has tow pumps working in an alternating sequence according to the Cooling load demand. The chilling system operation is interlocked with the operation of the pumps and is Protected against no-flow by means of water flow switch. Water side of the HVAC system, as well as fresh air intake and exhaust system, are energized from the remote control panel on the ground floor; ON mode onset of the Day and OFF mode end of the day.			
A.	AHU – 1 capacity 3.3 kW	No	3	
B.	AHU – 2 capacity 9.7 kW	No	5	
C.	AHU – 3 capacity 11.12 kW	No	3	

Item No.	Description	Unit	Qty.	Unit Rate €
	Carreid Before			
2.4	Air Cooled Water Chillers Supply And Install : Air Cooled Chillers with capacity of 552KW each as per technical specification & technical requirements in the tender documents with vibration isolators to include flexible connections,pressuregauges, thermometers, flow switches, motorized control valves, gate valves, ball valves, double regulating valves, drain pipe, connection supports, control wiring and electrical wiring to the nearest point (not more than 3 meters).The unit capacities are to be achieved at 115 DEG, F , The unit is ready to be connected to bms , ,easy maintenance, friendly refrigerant and availability of spare parts			
A.	Chiller capacity = 552kW	No	1	
2.5	Chilled water pump Supply, instillation and setting to work including all required field wiring, galvanized rigid metal conduit from pump panel to local isolator and from pump top pump panel, electrical isolator, pump control panel, control , spring type vibrations isolators testing and commission etc. The unit price shall include two isolating valves, check valves, strainers, pressure gauges, air release valves, flexible connections, vibration isolators, concrete base, anti vibration pad, and suction and discharge Headers as shown on the drawings and as called for in the specifications.			
A.	Q=1500L/min , H=45m primary pump	No	2	
B.	Q=400L/min , H=51m secondary	No	2	

Item No.	Description	Unit	Qty.	Unit Rate €
	Carreid Before			
2.6	<u>Heating Water Boilers:</u> The unit price shall include the expansion tank, all accessories, control panel, thermostats and thermometers on the supply and return pipes, gate valves, safety valves, oil filter, mechanical fire valve, flexible connections on fuel pipes, and ball valve, supply & return collectors and sand tray Underneath the burner and where needed. Boiler 448KW has three circulating pumps; maximum two working at one time and one stand-by with an alternating sequence programmed			
A.	Hot water pumps	No	1	
B.	Boiler capacity = 448 kW	No	1	
2.7	<u>Expansion Tank (closed type):</u> The unit price shall include gate valve, double check valve, safety valve, Drain valve. Expansion Tank volume :475 Gallons			
A.	Expansion Tank volume :475 Gallons	No	1	

Item No.	Description	Unit	Qty.	Unit Rate €
	Carreid Before			
2.8	<u>Extract air fans :</u> The unit price shall include vibration isolators, resilient mountings, skids and hangers, flexible connections on fan inlet and outlet, filters where required, insect screen, back draft dampers or automatic shutter, maintenance isolating switch (IP protection as needed), one set of spare belt drives per each fan (if belt driven), and all other accessories as shown on drawing and as called in specifications			
A.	$\dot{m}$=75CFM	No	8	
B.	$\dot{m}$=150CFM	No	55	
2.9	<u>Duct Works</u> Supply, installations and setting to work duct including full sealing of all joints, rectangular volume control dampers , galvanized hangers and supports, leak testing, air balancing and testing and commissioning etc. complete for air conditioned air and Exhaust. Supply and instillation aluminum cladding 0.6 mm thickness to exposed supply and return ducts including full sealing of all joints. The unit price shall include pre-insulated panels ducting with all joints, sealant compound, fire retardant sealants for all ductwork passing through fire rated structures, hangers and supports and brackets Acoustic liners, reinforcing angles, flexible connections, volume access doors and panels. all vanes, volume damper, splitter damper, volume control and regulating damper, fire dampers, smoke dampers, screws, coating, painting all joints plenum boxes volume damper adapter and coupling and all accessories as specified and as shown on drawings.			

	Duct shall be measured in m2 for the installed duct work.			
A.	200*150mm	m^2	200	
B.	250*200mm	m^2	200	
B.	250*250mm	m^2	150	
2.10	<u>Supply Diffusers:</u> The unit price shall include making holes in fals eceiling, adapters, flexible connection, fixing properly as per manufacturer Recommendations.			
A.	8*10"	No	19	
B.	8*12"	No	30	
C.	12*10"	No	62	
D.	12*20"	No	19	
2.11	<u>Fuel Oil Tank:</u> The unit price shall include: the tank, air vents, overflow line, filling lines and valves, dislodge drain line and valve, main feeding suction line with isolating valves, return lines from served equipment with isolating valves, return line to main tank with isolating valves, oil content gages, one access opening with covers, two oil storage low level sensors, two high level sensors, all painting, and corrosion resist coating, earthling, anchoring and Steel base frame and support.			
A.	V=500L	No	1	

Item No.	Description	Unit	Qty.	Unit Rate €
	Carreid Before			
3.0	Fire Fighting System			
3.1	<u>Sch.40 pipes :</u> Supply and install black steel Sch. 40 pipes jointed by welding for diameters above 2" and by threads for 2" pipes and below, all as made by MODGAL or E.A. The work also includes all valves, strainer, unions, nipples, fittings, hangers and all needed other accessories including painting with the final red color paint according to specifications and the approval of the Engineer.			
A.	Insulated 4" Sch-40 black steel pipe as exist.	No	360	
B.	Insulated 3.5 Sch-40 black steel pipe as exist.	No	360	
C.	3"Sch-40 black steel pipe as exist	No	360	
D.	Butterfly valve 4" as exist.	No	1	
E.	Butterfly valve 3" as exist	No	1	
F.	Butterfly valve 2" as exist	No	1	
G.	4" flange as existing.	No	1	
H.	3" flange as existing.	No	1	
I.	21/2" flange as existing.	No	1	
J.	3" strainer as existing.	No	1	
K.	Temperature gauge as existing. Pressure gauge as existing.	No	1	
L.	4" flexible connection as existing	No	1	
M.	3" flexible connection as existing	No	1	
N.	4" non-return valve as existing	No	1	
O.	3" non-return valve as existing.	No	1	
2.10	<u>fire extinguisher cylinder:</u> Supply and install the CO2 " 3kg" , HCFC "3kg",and Wet chemical "3kg"			
A.	CO2 fire extinguisher cylinder	No	10	
B.	HCFC fire extinguisher cylinder	No	35	
C.	Wet fire extinguisher cylinder	No	3	

Item No.	Description	Unit	Qty.	Unit
	Carreid Before			
4.1	Medical gas system:			
4.2	Air compressor 60 m3/hr	No	1	
4.3	Compressed air tank 500 liter	No	1	
4.4	Compressed air filtration unit	No	1	
	Medical gas copper piping as per ASTM / HTM02.01 Supply, install, connect, and testing of the following degreased medical oxygen compatible seam-less copper pipes type L. The pipes must be cleaned and treated for medical gas usage including capping the ends of each pipe to ensure that no foreign bodies or dusts or vapors affect the pipes. The copper pipes must meet the international standard of ASTM B-819 and to be cleaned for medical usage (degreased) in accordance with CE 0473. Each pipe must be pro-factory marked continuously with:_ OXY/MED ASTM B-819 Pipeline network must be welded and hanged according to the latest welding and hanging methods of healthcare technical memorandum HTM 02.01, ASTM B819 and G-01 Price includes proper isolation for piping under plastering and penetrations , hangers, brackets, fasteners, etc.., as well as various fittings and accessories needed to complete the works as shown on drawings and as per specifications. Price also includes proper flushing of the entire piping network using purified Nitrogen or Medical Compressed Air.			
A	15mm O.D	No	620	
B	35mm O.D	No	450	
C	42mm O.D	No	150	

Item No.	Description	Unit	Qty.	Unit
	Carreid Before			
4.5	Area Valves Control Boxes Supply: install, connect, and testing of the following recessed area valve control box for medical oxygen and vacuum, including 2 full-port 3-parts NIBCO shut off valves which controls the supply of gases or vacuum through the pipelines, and line pressure and vacuum gauges. The valves diameter varies between 15 up to 35 mm			
A	No. Area Valves Control Boxes	No	20	
4.6	Isolation Valves: From NEW HTM2022 ZSU DESIGN-with stub pipes			
A	O2	No	5	
B	N2O	No	4	
C	A4	No	4	
D	AGSS	No	3	
E	VAC	No	5	
4.7	Terminal Units: STANDARD GEM 10's(Vertical or Horizontal) with fascia			
A	O2	No	245	
B	N2O	No	9	
C	A4	No	48	
D	AGSS	No	245	
E	VAC	No	9	

APPENDIX B

Tables, Charts, catalogs

Table (1)

TABLE A(3.10) 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
	Jan./Nov.	−2.7	−3.8	−5.5	−6.6	−5.0	−3.3	0.5	4.4	6.1	−10.5
	Feb./Oct.	−2.7	−3.8	−4.4	−5.0	−3.3	−1.6	1.6	4.4	6.6	−7.7
	Mar/Sept.	−2.2	−2.7	−2.7	−3.3	−1.6	0.5	2.2	3.8	5.5	−4.4
	Apr./Aug.	−1.1	−1.6	−1.6	−1.1	0.0	0.0	1.1	1.6	2.2	1.6
	May/July	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5
	June	0.5	0.5	0.5	0.5	0.0	0.5	0.0	0.0	−0.5	1.1
48	December	−3.3	−4.4	−6.1	−7.7	−7.2	−5.5	−1.6	1.1	3.3	−13.8
	Jan./Nov.	−3.3	−4.4	−6.1	−7.2	−6.1	−4.4	−0.5	2.7	4.4	−13.3
	Feb./Oct.	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	0.5	4.4	6.1	−10.0
	Mar/Sept.	−2.2	−3.3	−3.3	−3.8	−2.2	−0.5	2.2	4.4	6.1	−6.1
	Apr./Aug.	−1.6	−1.6	−1.6	−1.6	−0.5	0.0	2.2	3.3	3.8	−2.7
	May/July	0.0	−0.5	0.0	0.0	0.5	0.5	1.6	1.6	2.2	0.0
	June	0.5	0.5	1.1	0.5	1.1	0.5	1.1	1.1	1.6	1.1

Table (2)

TABLE A(3.11) Approximate CLTD values for light, medium, and heavy weight construction walls, °C.

Solar Time	Wall construction											
	Light				Medium				Heavy			
	N	E	S	W	N	E	S	W	N	E	S	W
8:00	—	16	—	—	—	—	—	—	—	—	—	—
9:00	—	20	—	—	—	6	—	—	—	—	—	—
10:00	—	21	2	—	—	11	—	—	—	—	—	—
11:00	—	18	7	—	—	14	—	—	—	3	—	—
12:00	—	12	12	—	—	15	—	—	—	5	—	—
13:00	2	9	15	5	—	14	5	—	—	7	—	—
14:00	3	7	16	13	—	12	9	1	—	8	—	—
15:00	3	7	14	21	1	10	11	6	—	8	1	—
16:00	4	6	11	27	2	9	12	12	—	8	3	—
17:00	4	5	7	30	2	8	11	17	—	8	5	3
18:00	5	3	4	27	3	7	9	22	—	8	6	7
19:00	2	1	1	17	3	5	7	23	—	7	6	10
20:00	—	—	—	6	3	3	5	20	1	7	6	12

Table (3)

TABLE A(3.16) Cooling Load factors (CLF) for glass windows with interior shading, North latitude.

Fenestration Facing	Solar Time, *h*																
	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 (4)

TABLE A(3.14) Shading coefficient (SC) for glass windows with interior shading.

Type of Glass	Nominal Thickness, mm	Type of Interior Shading				
		Venetian Blinds		Roller Shade		
				Opaque		Translucent
		Medium	Light	Dark	White	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	0.20-0.40	—	—	—	—

Table (6)

TABLE A(3.15) Cooling load factors (CLF) for glass windows without interior shading, north latitudes.

Glass Facing	Building Construction	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Solar Time, h																
N Shaded	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
	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	0.49	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

Table (7)

TABLE 9-12 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 (8)

TABLE A(3.17) Cooling load factor $(CLF)_{Lt}$, for lights.[3]

Number of hours after lights are turned On	Fixture X[c] hours of operation		Fixture Y[c] hours of operation	
	10	16	10	16
0	0.08	0.19	0.01	0.05
1	0.62	0.72	0.76	0.79
2	0.66	0.75	0.81	0.83
3	0.69	0.77	0.84	0.87
4	0.73	0.80	0.88	0.89
5	0.75	0.82	0.90	0.91
6	0.78	0.84	0.92	0.93
7	0.80	0.85	0.93	0.94
8	0.82	0.87	0.95	0.95
9	0.84	0.88	0.96	0.96
10	0.85	0.89	0.97	0.97
11	0.32	0.90	0.22	0.98
12	0.29	0.91	0.18	0.98
13	0.26	0.92	0.14	0.98
14	0.23	0.93	0.12	0.99
15	0.21	0.94	0.09	0.99
16	0.19	0.94	0.08	0.99
17	0.17	0.40	0.06	0.24
18	0.15	0.36	0.05	0.20

Table (9)

TABLE 9—15 Diversity factor for selected applications.[4]

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

Table (10)

TABLE A(3.12) Solar heat gain factor (SHG) for sunlit glass, W/m², for a latitude angle of 32 °N.

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

Carrier

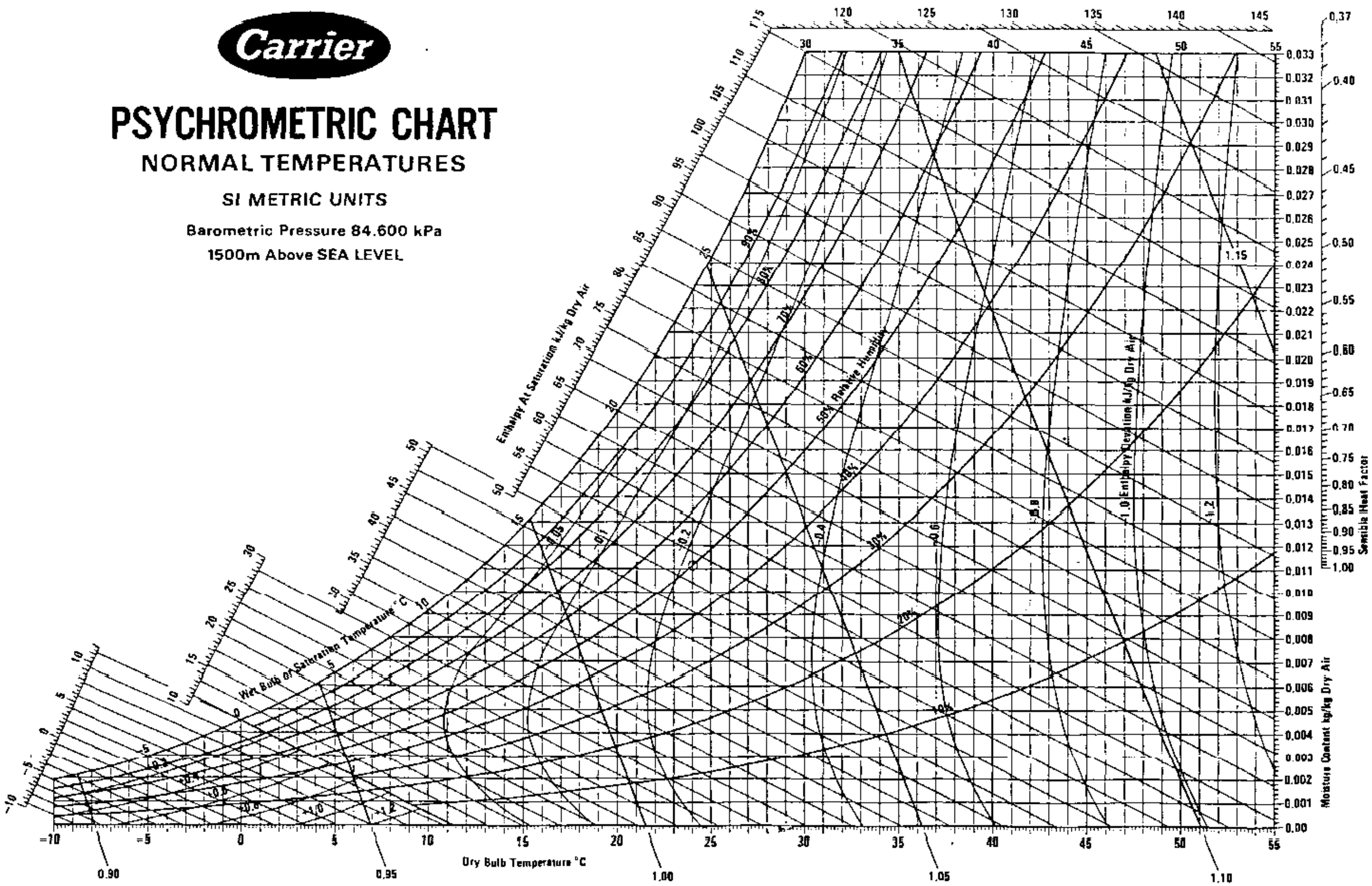
PSYCHROMETRIC CHART

NORMAL TEMPERATURES

SI METRIC UNITS

Barometric Pressure 84.600 kPa

1500m Above SEA LEVEL



Below 0°C Properties and Enthalpy Deviation Lines Are For Ice

Table 9.3 Water Supply Fixture Units and Fixture Branch Sizes

Fixture[a]	*Use*	*Type of Supply Control*	*Fixture Units*[b]	*Min. Size of Fixture Branch*[d] *in.*
Bathroom group[c]	Private	Flushometer	8	—
Bathroom group[c]	Private	Flush tank for closet	6	—
Bathtub	Private	Faucet	2	1/2
Bathtub	General	Faucet	4	1/2
Clothes washer	Private	Faucet	2	1/2
Clothes washer	General	Faucet	4	1/2
Combination fixture	Private	Faucet	3	1/2
Dishwasher[f]	Private	Automatic	1	1/2
Drinking fountain	Offices, etc.	Faucet 3/8 in.	0.25	1/2
Kitchen sink	Private	Faucet	2	1/2
Kitchen sink	General	Faucet	4	1/2
Laundry trays (1–3)	Private	Faucet	3	1/2
Lavatory	Private	Faucet	1	3/8
Lavatory	General	Faucet	2	1/2
Separate shower	Private	Mixing valve	2	1/2
Service sink	General	Faucet	3	1/2
Shower head	Private	Mixing valve	2	1/2
Shower head	General	Mixing valve	4	1/2
Urinal	General	Flushometer	5	3/4[e]
Urinal	General	Flush tank	3	1/2
Water closet	Private	Flushometer	6	1
Water closet	Private	Flushometer/tank	3	1/2
Water closet	Private	Flush tank	3	1/2
Water closet	General	Flushometer	10	1
Water closet	General	Flushometer/tank	5	1/2
Water closet	General	Flush tank	5	1/2

Water supply outlets not listed above shall be computed at their maximum demand, but in no case less than the following values:

Table 9.4 Table for Estimating Demand

Supply Systems Predominantly for Flush Tanks		*Supply Systems Predominantly for Flushometers*	
*Load, WSFU**	*Demand, gpm*	*Load, WSFU**	*Demand, gpm*
6	5	—	—
10	8	10	27
15	11	15	31
20	14	20	35
25	17	25	38
30	20	30	41
40	25	40	47
50	29	50	51
60	33	60	55
80	39	80	62
100	44	100	68
120	49	120	74
140	53	140	78
160	57	160	83
180	61	180	87
200	65	200	91
225	70	225	95
250	75	250	100
300	85	300	110
400	105	400	125
500	125	500	140
750	170	750	175
1000	210	1000	218
1250	240	1250	240
1500	270	1500	270
1750	300	1750	300
2000	325	2000	325
2500	380	2500	380
3000	435	3000	435
4000	525	4000	525
5000	600	5000	600
6000	650	6000	650
7000	700	7000	700
8000	730	8000	730
9000	760	9000	760
10,000	790	10,000	790

Table 10.4 Horizontal Fixture Branches and Stacks

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

Table (4.9)

TABLE 4.1 Required Minimum Flow Rates and Pressures during Flow for Fixtures

Fixture	Pressure, psi*	Flow, gpm
Basin faucet	8	3
Basin faucet, self-closing	12	2.5
Sink faucet, ⅜-in	10	4.5
Sink faucet, ½-in	5	4.5
Dishwasher	15–25	†
Bathtub faucet	5	6
Laundry tub cock, ¼-in	5	5
Shower	12	3–10
Water closet ball cock	15	3
Water closet flush valve	15–20	15–40
Urinal flush valve	15–20	15
Garden hose, 50 ft, and sill cock	30	5

*Residual pressure in pipe at entrance to fixture. 20 psi minimum required at water conserving type fixture. Verify minimum pressure reqirements with fixture manufacturer.

†As specified by fixture manufacturer.

FIGURE 4.3

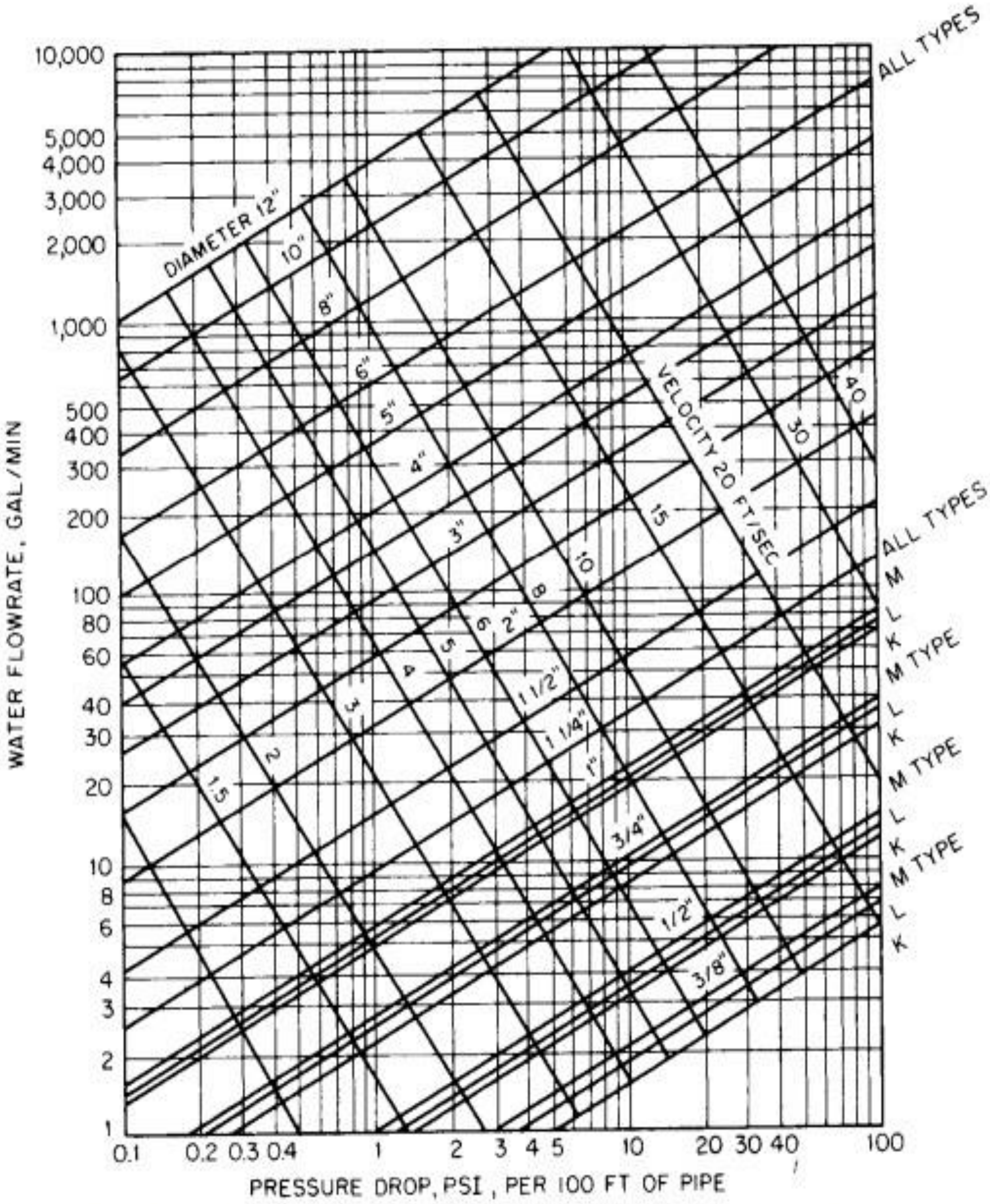


FIGURE 4.3 Chart for determination of flow in copper tubing and other pipes that will be smooth after 15 to 20 years of use.

Table (4.10)

Table 4.10 Fixture Units and Trap and Connection Sizes for Plumbing Fixtures

Fixture type	Domestic water: Fixture-unit value as load factors, Private	Public	Domestic water: Min size of connections, in, Cold water	Hot water	Drainage: Fixture-unit value as load factors	Min size of trap, in
Bathtub† (with or without overhead shower	2	4	½	½	2	1½
Bidet	2	4	½	½	2	Nominal 1½
Combination sink and tray	3		½	½	2	1½
Combination sink and tray with food-disposal unit	4				3	1½
Dental unit or cuspidor		1	⅜		1	1¼
Dental lavatory	1	2	½	½	2	1¼
Dishwasher, domestic	2				2	1½
Drinking fountain	1	2	⅜		1	1¼
Floor drains‡	1				2	2
Kitchen sink	2	4	½	½	2 or 3	1½
Kitchen sink, domestic, with food-waste grinder	3				2	1½
Lavatory¶	1		⅜	⅜	1	Small P.O. 1¼
Lavatory¶		2	½	½	2	Large P.O. 1½
Lavatory, barber, beauty parlor		2			2	1½
Lavatory, surgeon's	2				2	1½
Laundry tray (1 or 2 compartments)	2	4	½	½	2	1½
Shower, per head	2	4	½	½	2	2
Sinks:						
Surgeon's	3		½	½	3	1½
Flushing rim (with valve)		2	¾	¾	6	3
Service (trap standard)	3		½	½	3	3
Service (P trap)	2	4	½	½	3	2
Pot, scullery, etc.		4			3	1½
Urinal, pedestal, siphon jet, blowout		10	1		6	Nominal 3
Urinal, wall lip		5	½		2	1½
Urinal stall		5	¾	2	2	2
Urinal with flush tank		3			2	1½
Wash sink (circular or multiple) each set of faucets		2	½	½	3	Nominal 1½
Water closet, tank-operated	3	5	⅜		4	Nominal 3
Water closet, valve-operated	6	10	1		6	3

FIGURE 4.4

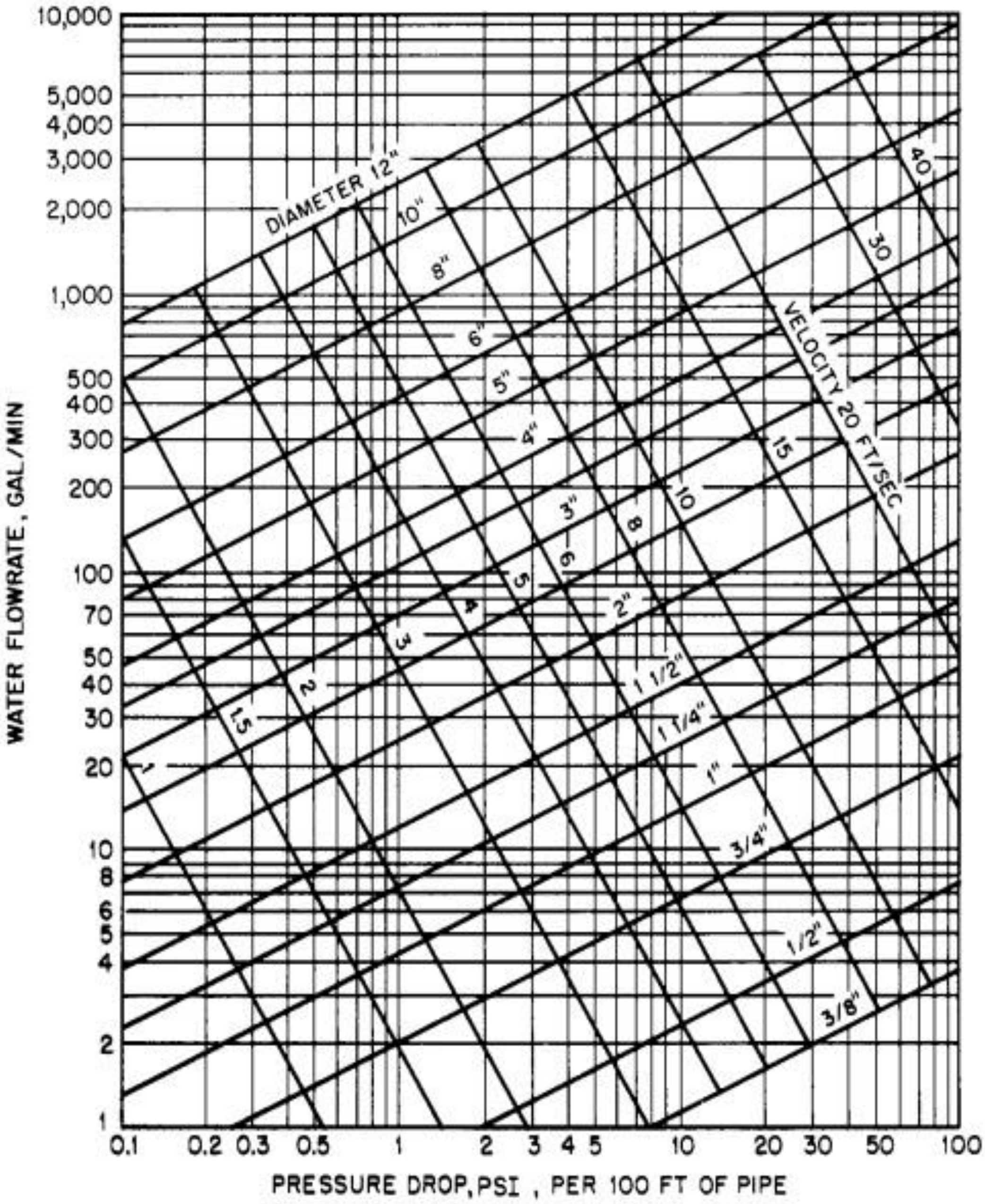


FIGURE 4.4 Chart for determination of flow in pipes such as galvanized steel and wrought iron that will be fairly rough after 15 to 20 years of use.

Table 6. 1 Equivalent Length.

Equivalent Length of Straight Pipe for Valves and Fittings (meter)														
Flanged Fittings		Pipe Size												
		1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	6	8	10
Elbows	Regular 90 deg	0.3	0.4	0.5	0.6	0.7	0.9	1.1	1.3	1.8	2.2	2.7	3.7	4.3
	Long radius 90 deg	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.3	1.5	1.7	2.1	2.4
	Regular 45 deg	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.1	1.4	1.7	2.3	2.7
Tees	Line flow	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.9	1.0	1.2	1.4	1.6
	Branch flow	0.6	0.8	1.0	1.3	1.6	2.0	2.3	2.9	3.7	4.6	5.5	7.3	9.2
Return Bends	Regular 180 deg	0.3	0.4	0.5	0.6	0.7	0.9	1.1	1.3	1.8	2.2	2.7	3.7	4.3
	Long radius 180 deg	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.3	1.5	1.7	2.1	2.4
Valves	Globe	11.6	12.2	13.7	16.5	18.0	21.4	23.5	28.7	36.6	45.8	58.0	79.3	94.6
	Gate	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.0
	Angle	4.6	4.6	5.2	5.5	5.5	6.4	6.7	8.5	11.6	15.3	19.2	27.5	36.6

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Table of A rating 1

Type	Size	A-Rating
Water	3ltr	13A
Water	6ltr	13-21A
Water	9ltr	13A
AFF Foam	3ltr	13A
AFF Foam	6ltr	21A
ABC Powder	2kg	13A
ABC Powder	4kg	21A
ABC Powder	6kg	34A
Wet Chemical	6ltr	13A

Typical examples of A-Ratings

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