Palestine Polytechnic University

Hebron-Palestine

College of Engineering & Technology

Mechanical Engineering Department

Project Name

Design and Documentation of the Mechanical System for Palestine Polytechnic University Hospital

Project Team

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According to the project supervisor and according to the agreement of the testing committee members, this project is submitted to the Department of Mechanical Engineering at college of engineering and technology in partial fulfillment of requirement of (B.SC) degree in engineering of refrigeration and air conditioning.

Supervisor signature

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Examine committee signature

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Department Head signature

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Dedication

إلى من أعطاني اسمه ودمه ... إلى المعلم الأول ... وسيد الرجال ... إلى من أضاء لي دروب العلم ... إلى من لا يغفو قلبه إلا بعد أن تغفو جميع القلوب ... إلى من أنا رجلٌ لأني جزء منه ... إلى الجبل الشامخ ... إليك يا أبي. إلى المدرسة الأولى ... وصانعة الرجال ... إلى الحبّ الأبديّ ... إلى من أهدتني صحتها وشبابها ... إلى العين الساهرة ... إلى من تراني طفلها وإن كنتُ كهلا ... إلى القلب الدافئ ... إليك يا أمي إلى الجسد الواحد ... إلى من أشاركهم دمي ... إلى ملاذي عند الشدائد ... إلى من لا تكلّ أيديهم من مدها لي .... إلى الدرع المتين ... إليكم يا نبع العلوم ... وعرين المعلمين ... إلى بيتنا الثاني ... إلى الكنز الثمين ... إليك جامعتي إلى الأرض الطاهرة ... وأرض الأنبياء ....إلى الأرض التي باركها ا ومن حولها ... إلى الصمود والشموخ والكبرياء ... إليكِ فلسطين.

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And, finally, our thanks go to all lecturers & doctors, engineers, and laboratory supervisors in PPU. Their effort and their nice dealing with us improved our characters to become successful engineers in the future.

Abstract

This project deals with the design of mechanical systems for Palestine Polytechnic University hospital , which consists of Nine stories with a total area of 20774 (m^2). So that the hospital serves more than (100) thousand people of Hebron city and villages near.

Mechanical systems include heating, ventilation and air conditioning, Water supply, Drainage system, Fire fighting and Medical Gases.

This project discuses briefly theory needed for the design of mechanical systems. Design output is then displaced on drawings. These drawings will include: piping networks for water distribution, drain and sewage and medical gas system. Also drawing will detail duct systems and different equipment required for the hospital.

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CHAPTER ONE

INTRODUCTION

CHAPTER 1

1.1Introduction

Hospitals in Palestine have an essential and vital rule in enhancing the general health of the Palestinian people. Hospitals are one of the necessities of treatment and therefore we should take in consideration the patient's sense of safety and comfort.

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

The objectives of the project is to study and design the different mechanical systems needed inside hospital, this includes the following main topics:

1. To study the different mechanical systems inside hospitals.
2. Theoretical calculations and design of HVAC system.
3. Theoretical calculations and design of plumping system.
4. Theoretical calculations and design of Central Heating System.
5. Theoretical calculations and design of Fire fighting.
6. Theoretical calculations and design of medical gases system.

Mechanical design should satisfy all requirements inside hospital taking into account the economic states on the level of long range, so in this project effort is made to complete all requirements for designing mechanical systems.

1.2 Hospital Description:

The hospital named (Palestine Polytechnic University Hospital)is located in Hebron city, it is planned to service thousands of habitants living in the city and near Villages. It consists of 9 stories with a total number of (194) bed and a total area of 20774 (m^2). And it contains the following administration departments:-

1. Medical administration.
2. Managerial administration.
3. Financial department and accountancy.

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.

In addition to these departments, the hospital contains other service departments such as maintenance, laundry, stores, and offices. This table to clarify floor Areas

Table (1-1) floor areas:

No	Name of the Floor	The area (m^2)
1	Basement "3" floor	410
2	Basement "2" floor	2965
3	Basement "1" floor	3209
4	Ground floor	3825
5	First floor	2675
6	Second floor	2245
7	Third floor	2245
8	Forth floor	1600
9	Fifth floor	1600

1.3 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 all mechanical calculation and design of system installed in hospital.
3. To be familiar with the different mechanical drawings.

1.4 Project Outline:

Chapter One:-Introduction

It includes an overview about the project, the importance of the mechanical system inside the hospital and the reason to work with it .

Chapter Two: - Heating and Air Conditioning System

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

Chapter Three:-Plumping System

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

Chapter Four:-Firefighting System

Includes overview about Firefighting System, calculation and distribution and drawing system on different facilities.

Chapter five:-Medical Gases

Includes overview about medical gases system, calculation and distribution and drawing system on different facilities.

Chapter Six:-Selection

Includes all calculation which are required for design mechanical system, and include selection of all systems equipment's that are needed to be installed inside the building depending on accurate calculation.

It includes the mechanical system drawing using AutoCAD program.

1.5 The Time Table:

Table (1-2) Time table.

First semester															
Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Choosing the Project idea															
Choosing the building and overview Previous projects															
Overall heat transfer coefficient calculations for walls , ceiling , floor ,doors ,windows and calculations of Heating and cooling load															
Air conditioning															

calculations and design															
Water supply calculations and design															
Drainage system calculations and design															
Second semester															
Week / Task	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Firefighting System calculations and design															
Medical Gases calculations and design															
Mechanical Drawings															
Equipment Selection															
Auditing our work in the project															
Project documentation															

CHAPTER TWO

Heating and Air Conditioning System

CHAPTER 2

2.1 Introduction

Hospitals needs ventilation and air-conditioning (HVAC) systems to provide excellent ventilation effectiveness in order to maintain appropriate indoor air quality, prevent the spread of infection, preserve a sterile and healing environment for patients and staff and to maintain space and comfort conditions.

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

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

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

Thus, air conditioning is independent of time of the day or season of the year and it should function effectively under any outside condition.

The combination of processes in this commonly adopted term is equivalent to the current definition of air conditioning. Because all these individual component processes were developed prior to the more complete concept of air conditioning, the term HVAC (heating, ventilating, air conditioning, and refrigerating& R) is often used by the industry.

2.1.1 Air Conditioning Systems

An air conditioning, or HVAC, system is composed of components and equipment arranged in sequence to condition the air, to transport it to the conditioned space, and to control the indoor environmental parameters of a specific space within required limits.

Parameters such as the size and the occupancy of the conditioned space, the indoor environmental parameters should be controlled; the quality and the effectiveness of control, and the cost involved determine the various types and arrangements of components used to provide appropriate characteristics.

Air conditioning systems can be classified according to their applications as comfort air conditioning systems.

2.1.2 Human Comfort

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

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

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

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

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

2.1.3 Factors Affecting Human Comfort

1. Dry Air:

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

2. Moist Air:

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

3. Humidity:

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

4 .Saturation:

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

5. Partial Pressure:

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

6. Dry Bulb Temperature:

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

7. Wet Bulb Temperature:

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

8. Dew-Point Temperature:

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

9. Humidity:

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

10. Relative Humidity: its defined as the ratio of the partial pressure of water vapor (H_2O) in the mixture to the equilibrium vapor pressure of water at a given temperature.

2.1.4 ASHRAE Comfort Chart:

Research studies have been conducted to show that, with a specific amount of air movement, thermal comfort can be produced with certain combinations of dry-bulb temperature and relative humidity. When plotted on a psychometric chart, these combinations form a range of conditions for delivering acceptable thermal comfort to 80% of the people in a space. This "comfort zone" and the associated assumptions are defined by ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy. Determining the desired condition of the space is the first step in estimating the cooling and heating loads for the space. In this hospital, we will choose 78ºF [25.6ºC] dry-bulb temperature and 50% relative humidity as the desired indoor condition during the cooling season from the **ASHRAE code** [1]**.**

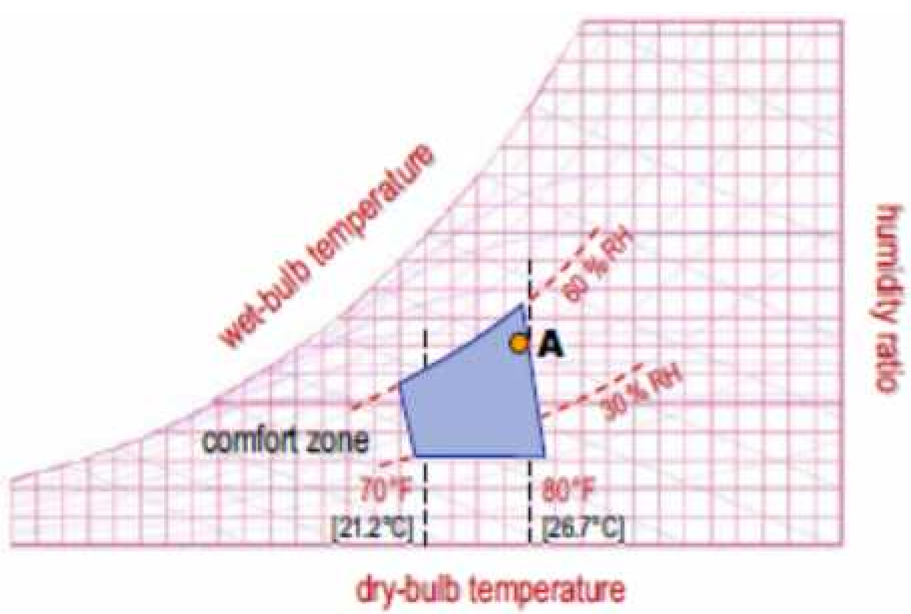


Figure 2-1 comfort zone for operating and temperature and relative humidity

2.1.5 Comfort Condition Inside Hospital

All calculation (heating and cooling loads) will be made according to specified values for inside conditions of hospital design in Table (2-1) below refer to dry bulb temperature and relative humidity in both summer and winter seasons [1].

Table (2-1) Indoor Design Conditions

Room or Area	Summer		Winter	
	Db Degrees C (Degrees F)	**RH Percent**	**Db Degrees C (Degrees F)**	**RH Percent**
Auditoriums	24 (76)	60	22 (72)	--
AIDS Patient Areas	24 (76)	50	25 (78)	30
Autopsy Suites	24 (76)	60	24 (76)	30
Bathrooms & Toilet Rooms	25 (78)	--	22 (72)	--
BMT (Bone Marrow Transplant) Patient Areas	24 (76)	50	25 (78)	30
Computer Rooms	21 (70)	40 (±5)	21 (70)	40 (±5)
CT Scanner	24 (76)	50	25 (78)	30
Dialysis Rooms	25 (78)	50	22 (72)	30
Dining Rooms	25 (78)	50	22 (72)	30
Dry Labs	25 (78)	50	22 (72)	30
Electrical Equipment Rooms	Ventilation Only		10 (50)	--
Elevator Machine Rooms, Electric Drive	36 (94)	--	10 (50)	--
Elevator Machine Rooms, Hydraulic	36 (94)	--	10 (50)	--
Emergency Generator	36 (97)	--	4 (40)	--
Examination Rooms	24 (76)	50	25 (78)	30
ICUs (Coronary, Medical, Surgical)	23–29 (75–85)	30–60	23–29 (75–85)	30-60

Room or Area	Summer		Winter	
	Db Degrees C (Degrees F)	**RH Percent**	**Db Degrees C (Degrees F)**	**RH Percent**
Isolation Suites	24 (76)	50	25 (78)	30
Kitchens	27 (82)	60	21 (70)	--
Laboratories	24 (76)	50	22 (72)	30
Laundries	28 (84)	60	19 (68)	-
Linear Accelerators	24 (76)	50	25 (78)	30
Locker Rooms	25 (78)	50	22 (72)	30
Lounges	25 (78)	50	22 (72)	30
Mechanical Equipment Rooms (MERs)	Ventilation Only		10 (50)	--
Medical Media:				
MRI Units	24 (76)	50	25 (78)	30
Offices, Conference Rooms	25 (78)	50	22 (72)	30
Operating Rooms (O.R.s)	18–27 (62-80)	45-55	18-27 (62-80)	45-55
Patient Rooms	24 (76)	50	25 (78)	30
Pharmacy	22 (72)	50	22 (72)	30
Radiation Therapy	24 (76)	50	25 (78)	30
Recovery Units	23 (75)	50	23 (75)	30
SPECIAL PROCEDURE ROOMS*				
Bronchoscope	24 (76)	50	25 (78)	30
Cardiac Catheterization	17–27 (62-80)	45-55	17-27 (62-80)	45-55
Colonoscopy/EGD	24 (76)	50	25 (78)	30
Cystoscopy	22 (72)	50	25 (78)	50
Endoscopy	24 (76)	50	25 (78)	30
Fluoroscopy	24 (76)	50	25 (78)	30
GI (Gastrointestinal)	24 (76)	50	25 (78)	30
Proctoscopy	24 (76)	50	25 (78)	30

Room or Area	Summer		Winter	
	Db Degrees C (Degrees F)	**RH Percent**	**Db Degrees C (Degrees F)**	**RH Percent**
Sigmoidoscopy	24 (76)	50	25 (78)	30
Spinal Cord Injury Units (SCIUs)	22 (72)	50	27 (82)	30
Supply Processing Distribution (SPD)	24 (76)	50	22 (72)	30
Ethylene Oxide (ETO) MERs	Ventilation only			
Steam Sterilizer MERs	Ventilation only			
Treatment Rooms	24 (76)	50	25 (78)	30
Warehouses	Ventilation Only		15 (60)	--

2.1.6 Outside Design Condition

From the Palestinian code[4].

2.1.6.1 Outside Design Condition For Summer:

$T_{dry\ bulb\ max}$ =35.8 [°C]

Relative humidity = 57 %

T_{wet} = 25 [°C]

Max wind speed = 1.4 [m/s]

Design month = July

2.1.6.2 Outside Design Condition For Winter :

$T_{dry\ bulb\ average}$ =5 [°C]

Relative humidity = 72%

T_{wet} = 2 [°C]

Max wind speed = 3 [m/s]

Design month = January

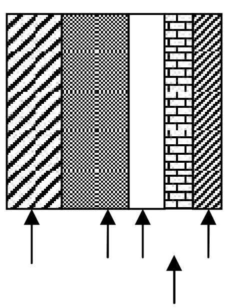
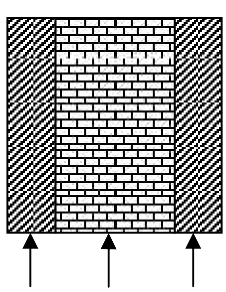
2.1.7 Over All Heat Transfer Coefficient “U” :

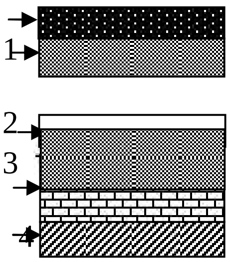
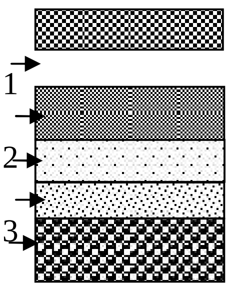
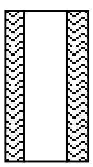
$$U = \frac{1}{R_{th}} = \frac{1}{\frac{1}{h_i} + \frac{\Delta x_1}{k_1} + \frac{\Delta x_2}{k_2} + \cdots + 1/h_0} \qquad \textbf{[2.1]}$$

h_i : Convection coefficient (surface conductance) of inside wall, floor, or ceiling ($h_i =$ 9.37 $W/m^2.C^0$) from the Palestinian code[4].

h_0 : Convection coefficient (surface conductance) of outside wall, floor, or roof ($h_0 =$ 22.7 $W/m^2.C^0$) from the Palestinian code[4].

Table (2-2) : Overall Heat Transfer Coefficients.

	Construction detail	Construction material	Material thickness [m]	Thermal conduction [W/m.°C]	U [W/m^2.°C]
Outside walls	 1 2 3 4 5	1- stone 2-Concrete 3-Insulation 4- Block 5- plaster	0.07 0.2 0.03 0.01 0.03	1.7 1.75 0.04 0.95 1.2	0.81
Inside walls	 1 2	1- plaster 2- Block 3- plaster	0.02 0.01 0.02	1.2 0.95 1.2	2.95

	3				
Roof	 1 2 3 4 5 6	1- Asphalt 2- Concrete 3- Insulation 4- Concrete 5- Block 6- plaster	0.02 0.05 0.02 0.06 0.18 0.02	0.81 1.75 0.04 1.75 0.95 1.2	1.08
ground	 1 2 3 4 5	1-Tiles 2- Concrete 3- Mortar 4- Sand 5- rocks	0.02 0.12 0.02 0.1 0.5	1.1 1.75 1.2 0.7 1.05	1.03
Windows		Double	-	-	5
Doors	 1	1-wood	0.04	0.17	3.6

2.2 CoolingLoad

2.2.1 Heat Gain Through Sunlit Walls And Roofs

$Q=U.A.(CLTD)_{corrected}$. **[2-2]**

Q : cooling load [kw].

U: over all heat transfer coefficient [$W/m^2.°C$].

A : surface area [m^2].

CLTD corr: corrected cooling load temperature deference .

$(CLTD)_{corr}$= (CLTD+LM)k+(25.5-Ti)+(To,m-29.4)f **[2-3]**

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

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

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

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

Ti : inside design wall temp .

$T_{o,m}$: out design door main temperature .

Note:CLTD value for roofs, walls, are taken depending on U values and time of day from CLTD table on appendix.

2.2.2 Heat Gain Through Inside Walls and Ground

$Q=U.A.\Delta T$ **[2-4]**

Q: loading load gain inside walls.

A: inside walls area.

U: overall heat transfer coefficient.

ΔT: temperature deference between inside air conditioning space and beside air temp space .

2.2.3 Heat Gain Due To Glass Windows

$$Q_{tr}=A\ (SHG)\ (SC)\ (CLF) \qquad [2\text{-}5]$$

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

(a) solar heat gain factor (SHG):

This factor represents the amount of solar energy they would be received by floor, furniture and the inside walls of the room and can be extracted;(from appendix A) Table(3).

(b) Shading coefficient (SC):

It accounts from for different shading effects of the glass wall or window and can be extracted (from appendix A) Table (4). For single and double glass, as well as, for insulation glass with internal shading (venetian blinds, curtains, drapes, roller shades, etc.).The shading coefficient, SC is defined as the ratio of solar heat gain of glass window of the space to the solar heat gain of double strength glass.

(c) Cooling load factor (CLF):

This represents the effect of the internal walls, floor, and furniture on the instantaneous cooling load, and can be extracted (from appendix A) Table(5). For glass with interior shading. It accounts for the variation of shag factor with time, mass capacity of the structure and the internal shading.

2.2.4 Heat Gain Due To Occupants

Q total for occupant = Q sensible + Q latent ;(from appendix A) Table(6). **[2-6]**

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

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

2.2.5 Heat Gain Due To Lights

Q_{Lt} = lighting intensity*A*CLF* ballast factor **[2-7]**

Lighting intensity: 10-30 w/m^2 for apartment so we will take $10W/m^2$.

A : floor area.

CLF = cooling load factor, dimensionless. (From appendix A) Table (7).

Similar to the sensible heat gain from people, a cooling load factor (CLF) can be used to account for the capacity of the space to absorb and store the heat generated by the lights. If the lights are left on 24 hours a day, or if the air conditioning system is shut off or set back at night, the CLF is assumed to be equal to 1.

Ballast factor = 1.2 for fluorescent lights, 1.0 for incandescent lights.

2.2.6 Heat gain Due To infiltration

$$\mathbf{Q_{inf} = \frac{V_f}{V_{outside}} * \; h_o - h_i} \qquad \textbf{[2-8]}$$

From psychometric chart we get :-

- $V_{outside} = 0.95\ m^3$
- $h_o = 90\ kJ/kg$
- $h_i = 45\ kJ/kg$
- $V_f \rightarrow 7\ L/sec\ \ per\ person$.

2.2.7 Heat gain Due To people

Q_{people} (total) = n * total heat gain per person; (from appendix A) Table(8). **[2-9]**

2.2.8 Heat Gain Due To Ventilation

$$Q\ ven = m^{\cdot} * C_{pair} * (T_{out} - T_{in})air \quad [2\text{-}10]$$

$m^{\cdot}$: 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 = (7L/s)/person.

v : specific volume for air @ t max = 35.8 C^o and Φ = 57 % ;v = 0.95 (m^3/kg dry air)

From the Palestinian code[4].

2.3 Heating System

The space heating load is the rate at which heat must be added to a space in order to maintain the desired conditions in the space, generally a dry-bulb temperature.

In general, the estimation of heating loads assumes worst conditions for the space. The winter design outdoor temperature is used for determining the conduction heat loss through exterior surfaces. No credit is given for heat gain from solar radiation through glass or from the sun's rays warming the outside surfaces of the building. Additionally, no credit is given for internal heat gains due to people, lighting, and equipment in the space.

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.

The heating load for a space can be made up of many components, including:

1- Conduction heat loss to the outdoors through the roof, exterior walls, skylights, and windows
2- Conduction heat loss to adjoining spaces through the ceiling, interior partition walls, and floor
3- Heat loss due to cold air infiltrating into the space from outdoors through doors, windows, and small cracks in the building envelope.

When calculating heating loss by conduction through the roof, the exterior walls, and the windows, no credit is given for the effect of the sun shining on the outside surfaces. With this assumption, the amount of heat transferred through the surface is a direct result of the temperature difference between the outdoor and indoor surfaces (Δ T is used instead of CLTD).

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

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

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

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

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

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

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

2.3.1 Heat Loss By Infiltration

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

$$\mathbf{Q_{inf} = \frac{V_{inf}}{V_{outside}} * \quad h_o - h_i} \qquad \textbf{[2-12]}$$

$$\mathbf{V_{inf} = K*L*(0.613(s1 * s2 * v)^{\wedge}2)^{2/3}} \qquad \textbf{[2-13]}$$

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

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

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

h_o ,h_i: $are\ the\ outside\ and\ inside\ enthapies\ of\ infiltrated\ air,\ \ respectively$ [KJ/Kg].

K: the coefficient of infiltration air for windows, (from appendix A) Table(9).

L: the crack length [m].

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

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

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

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

To obtain these values from psychometric chart (from appendix A) figure (1).

Values for outdoor design conditions

Season	T_{out} (℃)	$_{out}$%	v_{out} ($m^3/Kg\ \ dry\, air$)	h_{out} (KJ/Kg)
Heating	5	72	0.854	41

Table (2-3)

Values for indoor design conditions

Season	T_{in} (℃)	$_{in}$%	h_{in} (KJ/Kg)
Heating	22	50	5

Table (2-4)

2.4 Sample Of Heating And Cooling Load

For ground floor.

For room #A1 from clinic room .

2.4.1 Cooling Load Calculation

1-For Roof and Ground, from equation [2-4].

$Q=U*A*\Delta T$

-Roof

Q_R=1.08*(6.45*7.45)*(35.8-22)=716.2 W.

-Ground

Q_G=1.03*(6.45*7.45)*(22-15)=346 W.

2-Heat Gain Through Sunlit Walls, from equation[2-2] & [2-3].

Q=U.A.(CLTD)corrected

$(CLTD)_{corr}$=(CLTD+LM)k+(25.5-Ti)+(To,m-29.4)f

- East

25.5 – 22 =3.5 C^o.

35.8 – 29.4 =6.4 C^o.

$(CLTD)_{corr}$=(2 + 0.5)*0.83 +(3.5) + (6.4)=12C^o.

Q_{NE}=0.81*(45)*12=437.4 W.

- North

$(CLTD)_{corr}$=(0+.5)*.83 + (3.5) +(6.4)=10.4 C^o.

Q_{NW}=0.81*(4*7.45) *10.4=248.6 W.

3-Heat Gain Due To Glass Windows, from equation [2-5].

Q_{tr}=A (SHG) (SC) (CLF)

A=3*(1.2)=3.6 m^2.

SHG=126 W/m^2, (from appendix A) Table(3).

SC =0.83 ,(from appendix A) Table(4).

CLF =0.69 ,(from appendix A) Table(5).

Q_{tr}=3.6*(126)*(0.83)*(0.69)=260 W.

4-Heat Gain Due To Occupants, from equation [2-6].

Q total for occupant = Q sensible + Q latent

Q latent = 56*4*0.5 =112 W.

Q sensible = 0*15*4*0.5 =0 W.

Q_{oc}=112 W.

5-Heat Gain Due To Lights,from equation [2-7].

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

Q_{Lt}=10*(48)*.75*1.2 =432 W.

6-Heat Gain Due ToInfiltration, from equation [2-8].

$$Q_{inf} = \frac{V_f}{V_{outside}} * \; h_o - h_i$$

$$Q_{inf} = \frac{4\ person*7}{0.95(1000)} * \; 90 - 45 \; =1326\ W$$

7- Heat Gain Due ToPeople, from equation [2-9].

Q_{people} (total) = n * total heat gain per person

Q_{people} (total) =4 * (114) =456 W

8-Heat Gain Due To Ventilation, from equation [2-10].

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

$m^{\cdot} = \frac{V_f}{V} = \frac{4*(7\ l/s)}{0.95(1000)}$ = 0.03 kg/sec.

Q_{ven}=0.03*1.005*(35.8 – 22)=416 W.

$Q_{total\ Cooling\ Load} = \sum Q$ = 4.75 Kw .

2.4.2 Heating Load Calculation

1-ForOutside Wall ,from equation [2-11].

$Q_{wall} = U \times A \times \Delta t$

Q_{wall}=0.81 * [(6.45*4)-(3*1)+(7.45*4)] *(22-5) =724.3 W

a-For Inside Wall.

Q_{wall}=2.95 * [(7.45*4)-(2*0.9)+(6.45*4)] *(6 **)** =952 W

b- For Roof

Q_{roof}. = 1 * (48) * (22-5) **=** 816 W

c- For Floor

Q_{floor}=1.03 * (48) * (22-5 =840.4 W

d-For Window

Q_{window}=3.2*(3*1))*(22-5) =163.2 W.

e-For Door

Q_{door}=3.1* (2.1*.9) (22 - 5) = 99.6W.

2- For Infiltration Due Windows, from equation [2-12] &[2-13].

$Q_{inf} = \frac{V_{inf}}{V_{outside}} * \ h_o - h_i$

V_{inf} = K*L*$(0.613(s1 * s2 * v)^2)^{2/3}$

V_{inf}=0.45*[2*3+1*3] * $[0.613*(1*0.65*3)^2]^{2/3}$ =6.04 W.

$Q_{inf} = \frac{6.04}{0.854} * \ 90 - 45$ =246 W.

$Q_{total\ heating\ Load}$ =∑ Q =2690.49 =3.8 Kw.

2.5 Total Cooling And Heating Loads For Hospital

Table (2-5) Total cooling and heating loads for basement 2floor.

No of room	Name of room	Cooling load (Kw)	Heating load(Kw)	Area (m^2)
R1	Treatment room	12.2	8.13	150
R2	Treatment room	19.5	13	110
R3	Doctor room	3.4	3	22.7
R4	Resuscitation room	2.7	1.97	31
R5	Resuscitation room	2.9	2	32
R6	Office room	27.9	16.6	214
R7	Plaster room	1.47	0.98	12.6
a	Corridor a	27.6	18.4	271
Total		93.27	63.25	843.3

Table (2-6) Total cooling and heating loads for basement 1floor.

No of room	Name of room	Cooling load (Kw)	Heating load(Kw)	Area (m^2)
F1	X-Ray room	13.6	9.1	116.8
F2	Processing room	0.91	0.6	7.8
F3	X-Ray room	3.3	2.7	22.2
F4	X-Ray room	6.14	5.4	40.7
F5	Fluoroscopy room	0.9	0.6	8
F6	Processing room	0.5	0.3	6
F7	Store	0.47	0.28	5.5
F8	Class room	5.75	3.8	49.3
F9	Physiotherapy room	6.2	4.2	53.2
F10	Worker resting room	5.3	4.5	36.5
F11	Worker room	2.05	1.3	17.6
F12	Physiotherapy +Reception room	2.8	1.8	24
F13	Office	1.2	0.7	17.2
F14	Office	1.2	0.7	17.2
F15	Pathology room	1.9	1.35	28.3
F16	Registration	1.7	1	21
F17	Lapatory	4.2	2.7	35.7
F18	Microplogy room	13.67	9.115	117.5
F19	Lapatory	4.46	2.97	38.5
F20	Kitchen head	3.5	2.3	30.8
F21	Kitchen	20.8	13.9	179
B	Corridor	5.8	3.8	57
C	Corridor	4	2.6	40
D	Corridor	8.6	5.7	84
Total		118.92	81.32	1053.8

Table (2-7)Total cooling and heating loads for ground floor.

No of room	Name of room	Cooling load (Kw)	Heating load(Kw)	Area (m^2)
A1	Hart clinic	4.75	3.8	48
A2	Venereal clinic	4.5	3	38.65
A3	store	1.1	0.94	13.93
A4	Class room	4.75	3.8	48.7
A5	clinic	4.5	3	38.3
A6	store	0.99	0.8	12
A7	Plaster clinic	4.7	4.2	31.5
A8	secretary	3.6	3.2	23.8
A9	Men clinic	4.5	4	30
A10	Women clinic	4.4	3.9	29.8
A11	secretary	3.8	3.4	25.5
A12	Women clinic	4.5	4	29.89
A13	Chest clinic	3.6	2.4	41.6
A14	Skin clinic	5.12	3.4	50.22
A15	Children clinic	3.6	2.4	41.34
A16	Children clinic	3.7	2.5	42.4
A17	pharmacy	15.2	10.2	131
A22	Meeting room	4.6	3.13	45.9
A23	Admin room	5.2	4.7	35.9
A24	Vice admin room	3.8	3.3	25.4
e-f-g-h-i	Corridor	75.6	50	
A26	Office room	5	3.3	49.4
A27	Office room	5.2	3.4	53.7
A28+29	Office room	6.2	4.3	63.2
A30	Office room	5.3	3.4	54.5
A31	Office room	6.3	4.4	64.1
A32	Office of public relations	2.9	1.9	27.3
A33	Wait room	1.9	1.3	18.9
A34	Archive	3.1	2.8	20.8
A35	Reception	2.4	2.1	16.3
A36	Security room	3.2	2.9	22.2
A37	Gift shop	1.6	1.0	15.16
A38	Barber	1.7	1.1	17.6
A39	Cafeteria	3.2	21.3	250.7
A40	Store	0.7	0.5	8.3
Total		247	176.77	2298.75

Table (2-8) Total cooling and heating loads for first floor.

No of room	Name of room	Cooling load (Kw)	Heating load(Kw)	Area (m^2)
B1	Surgery room	3.5	2.3	30.5
B2	Medicine room	0.5	0.35	4.4
B3	Reception room	1.4	0.9	10.7
B4	Recovery room	3.9	2.7	33.3
B5	Surgery room	5.8	3.8	57.2
B6	Nurse room	0.7	0.54	11
B7	Store room	0.6	0.48	7.3
B8	Recovery room	2	1.3	17.6
B9	Reception	2.1	1.4	18.3
B10	Archive	1.8	1.2	16
B11	Recovery room	3.7	2.6	31.7
B12	Surgery room	5.8	3.8	50
B13	Medicine room	0.82	0.6	7.3
B14	Medicine room	0.82	0.6	7.3
B15	Doctors Changing room	0.82	0.6	7.3
B16	Doctors Changing room	0.82	0.6	7.3
B17	Surgery room	7	4.6	60
B18	ICU	17.3	11.5	148.6
B19	CCU	17.3	11.5	148.6
B20	Class room	5.2	4.4	36.3
B21	Archive	2.4	2.1	16
B22	Reception	1.5	1.2	10
B23	Staff resting room	3.5	3	23
B24	Reception room	1.5	1	16
B25	Dialysis room	13	8.7	112
B26	Cafeteria	16.8	11.2	144
y-j	Corridor	29.8	19.8	294
Total		119.76	79.84	1325.7

Table (2-9) Total cooling and heating loads for second floor.

No of room	Name of room	Cooling load (Kw)	Heating load(Kw)	Area (m^2)
C1	Medical store room	0.6	0.4	9.22
C2	Surgery room	7.8	5.2	67.29
C3	Dressing room of preparing	2.8	1.7	22.91
C4	Patient recovery room	13.2	8.8	113.26
C5	Nurse room	1.4	0.86	11.47
C6	Surgery room	10.47	7	89.98
C7	Archive room	1.1	0.8	16.40
C8	Reception	1	0.6	15.98
C9	Patient room	2.7	1.9	35.45
C10	Patient room	3	2.1	35.45
C11	Patient room	2.6	1.8	35.45
C12	Patient room	2.7	1.9	35.45
C13	Patient room	3	2.1	35.45
C14	Patient room	2.6	1.8	35.45
C15	Archive room	0.9	0.6	10.11
C16	Patient room	1.1	0.7	12.52
C17	Patient room	1.2	0.8	13.47
C18	Patient room	1.4	0.9	13.47
C19	Class room	4.7	2.8	36.68
C20	Archive room	2.4	2.1	16.18
C21	Reception	1.5	1.2	10.15
C22	Staff resting room	3.5	3	22.9
C23	Patent room	1.2	0.8	12.52
C24	Patient room	1.1	0.7	11.75
C25	Patient room	1	0.65	11.75
C26	Reception room	0.7	0.5	10.13
C27	Surgery room	5.2	3.7	47.95
C28	New Births room	5.9	3.9	51.38
C29	New birth room	2.8	2.2	41.90
C30	Surgery room	5.2	3.7	47.95
K	Corridor	7	4.6	70
L	Corridor	7.3	4.8	74
Z	Corridor	22.6	15	222
Total		129.6	86.2	930.47

Table (2-10) Total cooling and heating loads for third floor.

No of room	Name of room	Cooling load (Kw)	Heating load(Kw)	Area (m^2)
D1	Store	15.7	10.4	134.2
D2	Manager room	0.77	0.5	23.3
D3	Meeting room	4	2.7	35.64
D4	Secretary room	1.26	0.8	12
D5	Reception	1.03	0.6	9
D6	Secretary room	1.5	1.02	22.3
D7	Office	1.2	0.8	17.7
D8	Office	1.2	0.8	17.7
D9	Secretary	1	0.6	14.7
D10	Men changing room	1.5	1.02	22.6
D11	Women changing room	1.26	0.8	12
D12	Resting room	3.4	2.7	50
D13	Patient room	4.1	2.7	35.45
D14	Patient room	4.1	2.7	35.45
D15	Patient room	4.1	2.7	35.45
D16	Patient room	4.1	2.7	35.45
D17	Patient room	4.1	2.7	35.45
D18	Patient room	4.1	2.7	35.45
D19	Patient room	1.2	0.8	13.4
D20	Patient room	1.4	0.9	13.47
D21	Patient room	1.1	0.7	12.5
D22	Class room	5.2	4.4	36.3
D23	Archive	2.4	2.1	16
D24	Reception	1.5	1.2	10
D25	Resting room	3.5	3	23
D26	Patient room	1.1	0.7	11.9
D27	Patient room	1.2	0.8	12.5
D28	Patient room	1	0.65	11.9
D29	Patient room	4.1	2.7	35.5
D30	Patient room	4.1	2.7	35.5
D31	Patient room	4.1	2.7	35.5
D32	Patient room	4.1	2.7	35.5
D33	Patient room	4.7	3.15	40.6
D34	Patient room	4.7	3.15	40.6
m-o-p-q	Corridor	46.6	31.3	464
Total		156.3	102.59	932.51

Table (2-11) Total cooling and heating loads for fourth floor.

No of room	Name of room	Cooling load (Kw)	Heating load(Kw)	Area (m^2)
E1	Patient room	4.1	2.7	35.3
E2	Patient room	4.1	2.7	35.3
E3	Patient room	4.1	2.7	35.3
E4	Patient room	4.1	2.7	35.3
E5	Patient room	4.1	2.7	35.3
E6	Patient room	4.1	2.7	35.3
E7	Patient room	1.1	0.7	12.5
E8	Patient room	1.2	0.8	13.4
E9	Patient room	1.4	0.9	12.9
E10	Class room	4.3	2.8	36.3
E11	Archive	2.1	2	16
E12	Reception	1.5	1.2	10
E13	Staff resting room	2.9	1.9	23
E14	Patient room	1.2	0.8	12.5
E15	Patient room	1.1	0.7	11.9
E16	Patient room	1.1	0.7	11.9
E17	Patient room	4.1	2.7	35.5
E18	Patient room	4.1	2.7	35.5
E19	Patient room	4.1	2.7	35.5
E20	Patient room	4.1	2.7	35.5
E21	Patient room	4.7	3.1	40.6
E22	Patient room	4.7	3.1	40.6
R	Corridor	7.2	4.8	72
S	Corridor	22.6	15	222
T	Corridor	7.3	4.8	74
Total		105.4	107.2	963.4

Table (2-12) Total cooling and heating loads for fifth floor.

No of room	Name of room	Cooling load (Kw)	Heating load(Kw)	Area (m^2)
E1	Patient room	4.1	2.7	35.3
E2	Patient room	4.1	2.7	35.3
E3	Patient room	4.1	2.7	35.3
E4	Patient room	4.1	2.7	35.3
E5	Patient room	4.1	2.7	35.3
E6	Patient room	4.1	2.7	35.3
E7	Patient room	1.1	0.7	12.5
E8	Patient room	1.2	0.8	13.4
E9	Patient room	1.4	0.9	12.9
E10	Class room	4.3	2.8	36.3
E11	Archive	2.1	2	16
E12	Reception	1.5	1.2	10
E13	Staff resting room	2.9	1.9	23
E14	Patient room	1.2	0.8	12.5
E15	Patient room	1.1	0.7	11.9
E16	Patient room	1.1	0.7	11.9
E17	Patient room	4.1	2.7	35.5
E18	Patient room	4.1	2.7	35.5
E19	Patient room	4.1	2.7	35.5
E20	Patient room	4.1	2.7	35.5
E21	Patient room	4.7	3.1	40.6
E22	Patient room	4.7	3.1	40.6
V	Corridor	7.2	4.8	72
W	Corridor	22.6	15	222
X	Corridor	7.3	4.8	74
Total		105.4	107.2	963.4

2.6 Central air conditioning system

2.6.1 Introduction

Includes all calculation which are required for design mechanical system, and include selection of all systems equipment's that are needed to be installed inside the building depending on accurate calculation.

Includes calculation of fan coils unit (FCU), ducted fan coils design, air handling units (AHU) design ,ventilation system design ,water system design and distribution of all system in planning ,and drawing the planes of it by using AutoCAD program.

Air and water systems condition spaces by distributing air and water supplies to terminal units installed in the spaces. The air and water are cooled or heated by equipment in a central mechanical room. These systems typically involve air-and-water induction units and fan-coil units(FCU).There is a variety of installation possibilities for air-water systems, which means that, for almost every building, variants that meet the most demanding architectural requirements are available.

We will use this project the two systems for heating and cooling are, fan coils (FCU) in patient rooms and corridors, and air handling units (AHU) in operation and recovery rooms.

2.6.2Fan Coils With Duct

The terminal units regulate the volume of air and often heat the air with hot water, steam, or electric resistance coils in response to space temperature conditions. The terminal units are equipped with fans (fan-powered) to recalculate room air for energy conservation and temperature control. The fan-powered boxes may be either constant volume discharge or variable volume.

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 (CFM).

2.6.3Fan Coils Systems

Fan-coil system units have a finned-tube coil, filter, and fan section. The fan recalculates air continuously from the space through the coil, which contains either hot or chilled water. Some units have electric resistance heaters or steam coils, It is controlled either by a manual on/off switch or by thermostat.

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

2.6.3.1Sample of fan coil :-

For the room (R1) in basement 2 the total load 17.5 kw (5ton)

$Q_{total} = m_s*Cp*(Twater\ out – Twater\ in)$ [4-1]

$17.5 = m_{water}*4.18*(7)$

$m_{water} = 0.6$ kg/s

$m_{water} = \rho * \dot{v}$ [4-2]

$0.6 = 1000 * \dot{v}$

$\dot{v} = 6*10^{-4}$

$\dot{v} = A * V$ [4-3]

$6*10^{-4} = A * 0.7$

$A = 8.57*10^{-4}$

$d = \sqrt[2]{\frac{A}{\pi/4}}$ [4-3]

$d = \sqrt[2]{\frac{8.57*10^{-4}}{\pi/4}} = 0.03$ m = 1.25

the diameter of the water pipe in and out is the same in the FCU and equal 1.25

Table (2-13)diameter of the water pips of fan coils in basement 2 floor

Room	Q (kw)	Q (Ton)	$\dot{m}$ (kg/s)	Diameter (in)
R_1	12.20	3.48	0.42	1.25
R_2	19.5	5.5	0.6	1.25
R_3	3.5	1	0.116	0.75
R_4	2.7	0.77	0.09	0.50
R_5	2.9	0.82	0.09	0.50
R_6	27.9	7.97	0.95	1.50
R_7	1.47	0.42	0.05	0.50
Corridor a	27.6	7.9	0.95	1.50

The total load of room (R1) in bacement 2 =12.20 kw

= 3.48ton

from catalogue of fan coil (PETRA) we are selected the (DC18)

DC 18	H	1870	76	45058	36947	9.01	2.82	54855	36643	10.97	4.10	65205	36254	13.04	5.69
			78	45752	40490	9.15	2.91	55497	40125	11.10	4.19	65998	39797	13.20	5.82
			80	45752	43739	9.15	2.91	55794	43463	11.16	4.23	66313	43170	13.26	5.87
			85	52308	52308	10.46	3.74	56371	51862	11.27	4.31	66960	51559	13.39	5.98
	M	1535	76	40373	31935	8.08	2.29	48687	31647	9.74	3.27	57314	31351	11.46	4.45
			78	40761	34769	8.15	2.34	49196	34584	9.84	3.33	57991	34331	11.60	4.55
			80	41097	37603	8.22	2.37	49578	37432	9.92	3.38	58394	37197	11.68	4.61
			85	44768	44768	8.95	2.79	50242	44464	10.05	3.47	59218	44295	11.84	4.74
	L	1168	76	34248	25857	6.85	1.68	40477	25622	8.10	2.31	47318	25457	9.46	3.10
			78	34727	28129	6.95	1.73	41206	27979	8.24	2.38	47920	27746	9.58	3.17
			80	35152	30406	7.03	1.77	41650	30238	8.33	2.43	48329	30012	9.67	3.22
			85	36144	36035	7.23	1.86	42651	35869	8.53	2.54	49457	35708	9.89	3.37

Figer

(2-2) From Petra catalogue

Table (2-14) The summary of ducts and its fan coil types in the room at basement 2floor .

No	**Name**	**Load KW**	**Flow** **kg/s**	**Diameter Selection. inch**	**Flow** **cfm**	**Fan Coil Type**
1	F1	19.5	0.60	1.25	1224	42CED004
2	F2	19.5	0.60	1.25	1224	42CED004

3	F3	12.5	0.42	1.25	1224	42CED006
4	F6	27.9	0.95	1.5	1645	42CED004
5	F7	27.9	0.95	1.5	1645	42CED006

Table (2-15) F1 duct and grills specifications.

NO	Branch Name	Flow m^3/s	Velocity /s	Grill size Inch	Duct Size Inch
1	A-B	2.62	5	12*12	20W * 10H
2	B-C	1.71	5	12*12	16W * 10H
3	C-D	0.87	5	12*12	10W * 10H

Note (the other fan coils and details shows in the drawing)

Table (2.16) summary of ducts and its fan coil types in the corridors at fifth floor.

No	Name	Load KW	Flow kg/s	Diameter Selection. inch	Flow cfm	Fan Coil Type
1	F1	7	0.21	1	1224	42CED004
2	F2	10.6	0.32	1.25	1535	42CED004
3	F3	12.1	0.37	1.25	1535	42CED006
4	F4	14.9	0.46	1.25	1645	42CED004

Table (2.17) F1 duct and grills specifications

NO	Branch Name	Flow m^3/s	Velocity /s	Grill size Inch	Duct Size Inch
1	A-B	2.6	5	6*6	18W *10 H
2	B-C	2.2	5	6*6	16W * 10H
3	C-D	1.8	5	6*6	14W * 10H

4	D-F	1.5	5	6*6	12W * 10H
5	F-G	1.1	5	6*6	10W * 10H
6	G-H	0.7	5	6*6	8W * 10H
7	H-I	0.3	5	6*6	6W *10 H

Note (the other fan coils and details of the corridors shows in the drawing)

2.6.4 Air Handling Units (AHU)

Air Handling Units (AHU), it's a plenum centrifugal fan. Intervention in the chilled water cooling coil cooling occurs inside (AHU) centrifugal fan absorbs the air and after piece through the duct and distributed to the desired location.

An air handling unit system (AHU) comprises a large insulated metal box that contains a fan, heating and/or cooling elements, filters, sound attenuators and dampers. In most cases, the (AHU) is connected to air distribution ductwork; alternatively, the (AHU) can be open to the space it serves.

The use of this type is in Operating Rooms, Intensive Care Unit (ICU) , recovery room and Critical Care Unit (CCU) . Environmental conditions are mostly determined by the operations mission done inside the hygienic spaces:

1- Comfort: Temperature, fresh air amount, filtration, pressure difference of septic-aseptic environments, relative humidity and sound level.
2- Installation cost and the running of cost: Operation expenses (OPEX) and maintenance costs should be taken into consideration during the economic lifetime.

3- Service performance and maintenance: Is service and maintenance methods and facility for the continuous operation

2.6.4 .1 Sample of Air handling units (AHU)

For air handling unit that bransh surgery room B17 at First floor. temperature and relative humidity of 50%. The supply air temperature is 38 C^0. The inside design conditions is 16 C^0 dbtemperature.

for the surgery room (B17) in the first floor

$Q_{total} = Q_{latent} + Q_{senseble}$ [4-5]

$Q_{total} = 7Kw$

$Q_l = \frac{Heat\ from\ person * No.of\ person}{1000}$ [4-6]

$Heat\ from\ person$:- 30w

$number\ of\ person$:- 4 person for each room

$Q_l = \frac{30*14}{1000}$ = 0.12 kw

$Q_{senseble} = Q_{total} - Q_{latent}$

$Q_{senseble}$ = 7 _ 0.12 = 6.88 kw

$Q_{senseble} = \dot{m}_s * Cp * (Tsupply - Tcoil)$

$Q_{senseble} = \rho * \dot{v} * Cp * (Tsupply - Tcoil)$

ρ:- density of air =1.25 kg/m³

v:- flow rate

Cp:- 1.0 kJ/kg.K

Tsupply:- 38 c˚

Tcoil:- *16* c˚

6.88 = 1.25 ∗ v *1*(38– 16)

$\dot{v}$= 0.250 m³/s

by velocity method , recommended velocities at **AHU** as following from table(1-4) in appendix[b] .

-the velocity of air in the supply velocity (main duct) = 8m/s

-the velocity of air in the bransh = 4 m/s

from duct sizer :-

by adding the values of the flow rate (L/m) and velocity (m/s)

This figure shows how to fined the duct size of the branch by duct sizer program :-

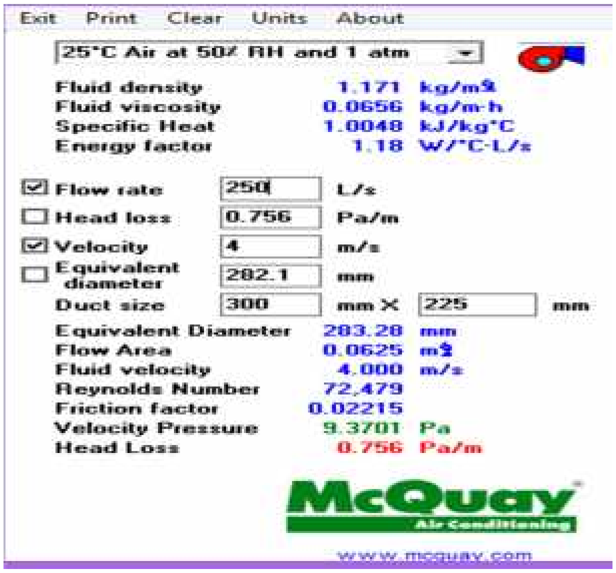


Figure (2-3)

For the room (B1,B4,B5,B8,B11,B12,B17)

$Q_{\text{Total senseble}}$ = 3.38 +3.78 +5.68+1.88+3.58+5.68+6.88

= 30.86 kw

the total flow rate ($\dot{v}$)= 1.122 m³/s

from duct sizer the main duct size is (500×300) as shows :-

This figure shows how to fined the duct size of the main duct of AHU by duct sizer program :-

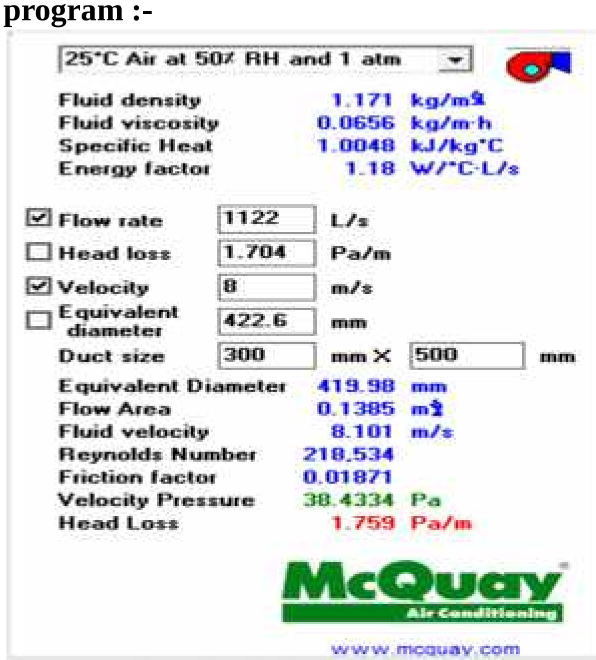


Figure (2-4)

(all air handling unit models were selected from york air system company) from the catalogue of

AHU (YMA) , we are selected(YMA 970/950).

Table (2.18) The summary of AHU data

NO	Room name	location	Total load kW	Unit Name	Flow L/s	Unit selected
B1	Surgery room	First floor	3.38	AHU1	122	YMA 970/950
B4	Recovery room	First floor	3.78	AHU1	137	YMA 970/950
B5	Surgery room	First floor	5.68	AHU1	206	YMA 970/950
B8	Recovery room	First floor	1.88	AHU1	68	YMA 970/950
B11	Recovery room	First floor	3.58	AHU1	130	YMA 970/950
B12	Surgery room	First floor	5.68	AHU1	206	YMA 970/950
B17	Surgery room	First floor	6.88	AHU1	250	YMA 970/950
B18	ICU	First floor	17.18	AHU2	624	YMA 970/950
B19	CCU	First floor	17.18	AHU2	624	YMA 970/950
C2	Surgery room	Second floor	7.68	AHU3	279	YMA 970/950
C4	Patient recovery room	Second floor	12.96	AHU3	471	YMA 970/950
C6	Surgery room	Second floor	10.35	AHU3	376	YMA 970/950
C27	Surgery room	Second	5.08	AHU4	184	YMA

		floor				610/750
C30	Surgery room	Second floor	5.08	AHU4	184	YMA 610750

Note :- (The location and details of all AHU shown in the drawing)

Table (2.19) selection and data of grills in first floor

NO of room	The sensible loade (kw)	TR	CFM	Grill size mm
B1	3.38	0.96	384	6*12
B4	3.78	1.08	432	10*12
B5	5.68	1.62	648	6*12
B8	1.88	0.53	212	8*12
B11	3.58	1.02	408	10*12
B12	5.68	1.62	648	12*24
B17	6.88	1.96	784	12*24
B18	17.18	4.90	1960	18*24
B19	17.18	4.90	1960	18*24

Note (Each of grill have a value of CFM as shown in table(1-5) in appendix B)

Table (2-20) selection and data of grills in second floor

NO of room	The sensible loade (kw)	TR	CFM	Grill size mm
C2	7.68	0.96	384	6*12
C4	12.96	1.08	432	10*12
C6	10.35	1.62	648	6*12
C27	5.08	0.53	212	8*12
C30	5.08	1.02	408	10*12

2.7 Ventilation:

Ventilation is the process of supplying and removing air by natural or mechanical means to and from a building. The design of a building's ventilation system should meet the minimum requirements of the Building (Ventilating Systems) Regulations.

Mechanical or forced ventilation is provided by air movers or fans in the wall, roof or Air-conditioning system of a building. It promotes the supply or exhaust air flow in a controllable manner.

2.7.1 Purposes of Ventilation:

Ventilation in a building serves to provide fresh and clean air, to maintain a thermally comfortable work environment, and to remove or dilute airborne contaminants in order to prevent their accumulation in the air. Air-conditioning is a common type of ventilation system in modern office buildings. It draws in outside air and after filtration, heating or cooling and humidification, circulates it throughout the building. A small portion of the return air is expelled to the outside environment to control the level of indoor air Contaminants.

2.7.2 Sample of ventilation system used:

$$total\ number\ of\ air\ change(CFM) = \frac{V(M^3)*n}{1.7} \qquad [4\text{-}7]$$

n: from ASHRE ventilation for acceptable air quality (CFM/m² room)
V: volume of the space

TABLE 2
OUTDOOR AIR REQUIREMENTS FOR VENTILATION* (*Continued*)
2.1 COMMERCIAL FACILITIES (offices, stores, shops, hotels, sports facilities)

Application	Estimated Maximum** Occupancy P/1000 ft² or 100 m²	Outdoor Air Requirements cfm/person	L/s person	cfm/ft²	L/s m²	Comments
Retail Stores, Sales Floors, and Show Room Floors						
Basement and street	30			0.30	1.50	
Upper floors	20			0.20	1.00	
Storage rooms	15			0.15	0.75	
Dressing rooms				0.20	1.00	
Malls and arcades	20			0.20	1.00	
Shipping and receiving	10			0.15	0.75	
Warehouses	5			0.05	0.25	
Smoking lounge	70	60	30			Normally supplied by transfer air, local mechanical exhaust; exhaust with no recirculation recommended
Hotels, Motels, Resorts, Dormitories				cfm/room	L/s room	Independent of room size.
Bedrooms				30	15	
Living rooms				30	15	
Baths				35	18	Installed capacity for intermittent use.
Lobbies	30	15	8			
Conference rooms	50	20	10			
Assembly rooms	120	15	8			
Dormitory sleeping areas	20	15	8			See also food and beverage services, merchandising, barber and beauty shops, garages.
Gambling casinos	120	30	15			Supplementary smoke-removal equipment may be required.

Table (2-5) from ASHRAE

Example : For mechanical store in Basement 3 :-

$$total\ number\ of\ air\ change\ (CFM) = \frac{V(M3)*n}{1.7}$$

$$total\ number\ of\ air\ change\ (CFM) = \frac{778\ M^3*1}{1.7} = 457.6\ CFM$$

from (fast fan – vortice fan selection) program

This figure(2.6) shows the fan data from the program :-

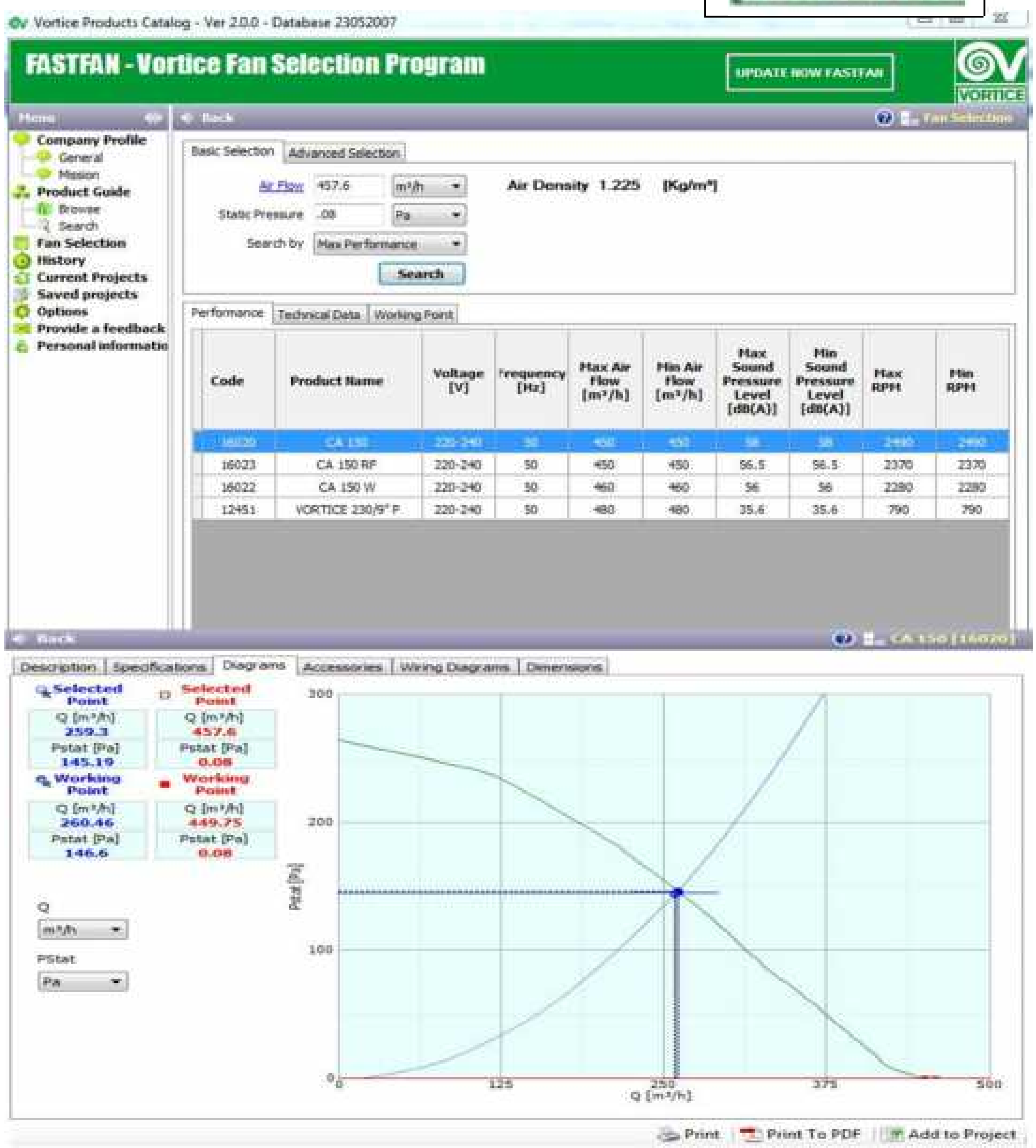


Table (2-21) Data of the fans selected in basement 2:

#No	Room name	CFM	Fan type
1	Lundary arrange	1200	CA250W
2	washing	2216	E302T
3	Ironing	1115	MPC254M
4	Store	112	MICRO160I
5	Bath room	865	CA160W
6	Store	743	CA200Q
7	Store	303	C1012M5MO
8	Bath room	564	CA160Q
9	Bath room	865	CA160W
10	Bath room	71	ARIETLI
11	Bath room	71	ARIETLI
12	Bath room	113	MICRO100T

Note (all other fans selection type are shown on drawings)

2.8 selection of other HVAC system component :-

2.8.1 chiller :

chiller 1 in zone 1

$Q_{cooling}$ =98.35 ton (the cooling load of AHU & Fan coil in connected to chiller 1)

by multiply of safety factor 1.5

$Q_{cooling}$ = 98.35 * 1.5=147.5 ton

= 516.25 KW

So, the chiller selected from career company is model no. **30XW/30XWH552**.

- Chiller (2) selected from career company is model no. **30XW/30XWH802**.
- Chiller (3) selected from career company is model no. **30XWP/30XWHP562**.

Note (The expansion tank of chiller 400L from table in appendix [A])

2.8.2 Boiler :

Boiler (1) connected to the AHU & Fan coil in zone 1 .

$Q_{heating}$ = 64 ton (the heating load of AHU & Fan coil in zone 1)

by multiply of safety factor 1.5

$Q_{heating}$ = 64*1.5 = 96 ton

= 336 KW

So, the boiler selected from ideal company, model no **ideal 350V-600H**.

Table (2-22) The summary of boiler selection

Boiler No.	Location	$Q_{heating}$	Model no.
1	Mechanical store In basement 3	344 KW	**ideal 350V-600H**.
2	Mechanical store In basement 2	739.2 KW	**ideal 400V-600H**
3	Mechanical store In basement 2	390.6KW	**ideal 400V-600H**.

2.8.3 Pump:

Pump (2) that connected to chiller (2), which have a Characteristics of flow rate of 507.24gpm and a head of 40.2 m

So, the Pump selected from GRANDFOS company , model no. **NB 65-160/177 60 Hz.**

Table (2-23) The summary of chiller pump selection

Pump No.	Location	Flow rate Q=[gpm]	Head[m]	Model no.
1	Roof plan	354gpm	40.2 m	**NB 65-200/219 50 Hz**
2	Roof plan	507.24gpm	40.2 m	**NB 65-160/177 60 Hz.**
3	Roof plan	402gpm	24. 45m	**NB 65-142/115 50 Hz**

Note: Each chiller have another stand by pump having the same Characteristics .

Table (2-24) The summary of Poiler pump selection

Pump No.	Location	Flow rate Q=[gpm]	Head[m]	Model no.
1	Mechanical store In basement 3	236gpm	40.2 m	**CR 45-3-3 ,3400V-50 Hz.**
2	Mechanical store In basement 2	507gpm	40.2 m	**NB 65-160/177 ,3 400V-50 Hz.**
3	store In basement 2	268gpm	24. 45m	**CR 45-3-2,3 400V-50 Hz.**

CHAPTER THREE

Plumbing System

CHAPTER 3

3.1 Introduction

Plumping system consist of two things which are water supply system and drainage distribution system.

Plumbing design is the system of pipes drains fittings, valves, valve assemblies, and devices installed in a building for the distribution of water for drinking and washing, and the removal of waterborne wastes, and the skilled trade of working with pipes, tubing and plumbing fixtures in such systems.

Plumbing fixtures are exchangeable devices using water that can be connected to a building's plumbing system, Some examples of fixtures include water closets (also known as toilets), urinals, bidets, showers, bathtubs, utility and kitchen sinks, lavatory.

3.1.1water supply system

Enough water to meet the needs of occupants must be available for all building further water needs for fire protection; air conditioning, heating and possibly process use must also be met.

There are two basic types of water distribution systems for building:

1. Up feed distribution system.
2. Down feed distribution system.

In this project we have choose the up feed distribution system for cold water and up feed distribution system for hot water, the supply of water for the hospital is received from the municipal then to a water well and to be pumped up to the fixture units, Usually the water pressure at the supply point of the municipality be between (35-50) psi, this water enters the well of the hospital and then by using pumps which pumping the water to the fixtures in the building.

Minimum flow pressure required in the top floor is usually (8) psi from Appendix B Table -(9.3)for flush tank and maximum pressure on the lowest floor should not exceed (80) psi otherwise pressure reducing valves should be used to reduce the pressure.

3.1.2 Up feed water distribution system

There are two methods commonly used for up feed distribution system.

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

3.1.2 Drainage system

The drainage or waste system is the most complex member of a well designed plumping system .its composed of two parts: the pipes which covey solid and liquid wastes to the house sewer, and the venting system.

Parts of drainage system

1 - Building sewer: That section of pipe which runs between the house drainage system and the connection to the public sewer or septic tank.

2-Building drain: The lowest piping in a house drainage system, this pipe receives the discharge from soil, waste, and other drainage pipes, and then carries such discharge to the house sewer.

3-Soil stack and pipe: Any line of pipe which carries the discharge of water closets. The term "stack" refers to the vertical runs of such piping.

4-Waste stack and pipe: All pipe receiving the discharge of fixtures other than water closets.

5-Trap: Refers to a fitting or device constructed to prevent the passage of air or gas back through a pipe or fixture, without materially affecting the flow of sewage or waste water.

6-Vent piping: Provides ventilation to the drainage system and prevents trap siphonage and back pressure from clogging or contaminating the drainage system.

7-**Fixture**: Any receptacle intended to receive or discharge water or water-carried waste into the drainage system.

8-Branch: That part of the plumbing system which extends from the stack to a fixture.

9-Leader: Any vertical line of piping which receives and carries rain water.

10-Fitting: Any one of a number of devices used to connect pieces of pipe or change the direction of pipe.

11-Manhole:manholes are considered as clean -outs ,they are recommended to be installed around buildings.

3.1.3 Calculation for the water well volume needed for the hospital (used for esrimation):

(500L/bed/day) is the amount of water needed taken from **ASHRAEcode** [1]**.**

We have **194 bed** in our hospital

So (500L/1000)m^3*194=97 ber day

For 3 days

We need 291 m^3

3.2 Calculations for hot and cold water system

3.2.1 Water service sizing for each floor in the hospital:

To determine the water service water size in building, a technique called water supply fixture unit (WSFU) is used; WSFU = Water Supply Fixture Unit.

The following Tables shows the water supply fixture unit for the each floor (see next bage):

Using Table (1) for estimating demand: (See appendix (B))

Table (3.1)Water supply fixture unit for the hospital:

Fixture Type	Demand per fixture (FU)	No of fixtures	Total demand for cold water	Total demand for hot water
Lavatory (General)	2*3/4	20	30	30
Shower head(General)	4*3/4	3	9	9
Separate Shower(private)	2*3/4	2	3	3
WC (General) flush tank	5	12	60	0
kitchen sink (General)	4*3/4	4	12	12
Total for basment 2			114	54
			54 (gpm)	35 (gpm)
Fixture Type	**Demand per fixture (FU)**	**No of fixtures**	**Total demand for cold water**	**Total demand for hot water**
Lavatory (General)	2*3/4	13	19.5	19.5
Shower head(General)	4*3/4	2	6	6
WC (General) flush tank	5	9	45	0
Total for basment 1			70.5	25.5
			36.15 (gpm)	17.3(gpm)
Fixture Type	**Demand per fixture (FU)**	**No of fixtures**	**Total demand for cold water**	**Total demand for hot water**
Lavatory (General)	2*3/4	20	45	45
Shower head(General)	4*3/4	1	3	3
Urinal (general)	2*3/4	4	6	0
WC (General) flush tank	5	19	95	0
Total for ground floor			149	48
			56 (gpm)	28 (gpm)

Fixture Type	Demand per fixture (FU)	No of fixtures	Total demand for cold water	Total demand for hot water
Lavatory (General)	2*3/4	28	42	42
Shower head(General)	4*3/4	14	42	42
WC (General) flush tank	5	11	55	0
Total for 1st floor			139	84
			52 (gpm)	40 (gpm)

Fixture Type	Demand per fixture (FU)	No of fixtures	Total demand for cold water	Total demand for hot water
Lavatory (General)	2*3/4	20	30	30
Shower head(General)	4*3/4	12	36	36
WC (General) flush tank	5	14	70	0
Total 2nd floor			136	66
			52.2 (gpm)	35 (gpm)

Fixture Type	Demand per fixture (FU)	No of fixtures	Total demand for cold water	Total demand for hot water
Lavatory (General)	2*3/4	20	30	30
Shower head(General)	4*3/4	16	48	48
Separate Shower(private)	2*3/4	2	3	3
WC (General) flush tank	5	20	100	0
Total for both 3rd 4th and 5th floors			181	81
			67 (gpm)	40 gpm)

3.2.2Water pipe sizing :

By friction head loss method:

1-calculate the head for the fifth floor.(1m = 3.28 ft).

floor to floor height is 4 m.
Static head = floor to floor height
Static head = (no.of floors*floor to floor hight)*3.28

Static head = (9*4)*3.28=118 ft.
So then the static pressure = static head * 0.433 psi/ft = 118 * 0.433 = 51.1 psi.

2-Total equivalent length.

we will calculate the equivalent length from the well to the farthest outlet (Sink faucet) at the fifth floor at farthest collector.

Since both hot and cold water are using up feed system we will need the follwing equation:

Pump pressure =Friction head + static pressure + minimum flow pressure

The recommended velocity for all fixture units should not exceed 8fps ,except for water closet

With flush valve of 4fps.

a- For cold water system:

Total length from pump to riser2 =3.4m .

Total length from floor to floor = 32m.

Total length from riser to collector =7m

Total length form collector to fixture unit =8.7m.

Total length =51.1m.

Total equivalent length=51.1*1.5*3.28=**251 ft.**

b- For hot water system:

Total length from boiler to riser1 =8m .

Total length floor to floor =36m.

Total length from riser to collector =6m

Total length form collector to fixture unit =8m.

Total length =58m.

Total equivalent length=58*1.5*3.28=**285.36 ft**.

3-Minimum flow pressure and friction head.

The minimum required flow pressure at the most remote outlet on the fifth floor (Sink faucet) is 8 psi. **From table [3] Appendix B**

a- For cold water system:

Pump pressure =Friction head + static pressure + minimum flow pressure

Friction head = 74.1–(51.1+8)= 15psi.

Uniform friction loss = friction/100ft = available friction head/ total equivalent length.

Friction/100ft =15 psi/(251/100 ft) = 6 (psi/100ft).

b- For hot water system:

Pump pressure =Friction head + static pressure + minimum flow pressure

Friction head = 82.6 **–** (57.6+8) = 17psi.

Uniform friction loss = friction/100ft = available friction head/ total equivalent length.

Friction/100ft =17psi/(285.36/100 ft) = 6 (psi/100ft).

3.2.3 Calculation for cold water

As an example the following table (3.2) shows load of fixture unit in which Riser 2 is located (back to drawings):

Type of FU	Demand per FU	Number of FU	cold water
Lavatory	2* ¾	10	16.5
Water closet	5	4	20
Shower	2* ¾	11	15
Total 1st floor			51.5 Fu
			30 gpm
Type of FU	**Demand per FU**	**Number of FU**	**Cold water**
Lavatory	2* 3/4	12	18
Water closet	5	6	30
Shower	2* 3/4	6	9
Total 2nd floor			57Fu
			32 gpm
Type of FU	**Demand per FU**	**Number of FU**	**cold water**
Lavatory	2* 3/4	6	9
Water closet	5	6	30
Shower	2* 3/4	6	9
Total 3rd ,4th and 5th floor			48Fu
			28 gpm

Calculation of Branch connected to riser 2:-

Table (3.3) The sizing pip of branch for cold water .

Branch's of riser 2	Flow rate (gpm)	Total equivalent length (ft)	Friction (psi/100ft)	Pipe size (inch)
1st floor	30	190.2	7.8	1 ¼
2nd floor	32	228.8	6.5	1 ¼
3rd floor	28	211.5	7	1 ¼
4th floor	28	231.2	6.4	1 ¼
fifth floor	28	251	6	1 ¼

For the branch 1st floor:-

EL = 16 +3+19.66 = 38.6 m

Total equivalent length = EL * 1.5 * 3.28 = 190.2 ft.

friction pipe = 15 psi.so Friction/100ft = 15 psi/190.2 *100 ft =7.8 (psi/100ft).
From chart (9.5) steel pipe :- For (7.8 psi)&(30 gpm) size pipe is 1 ¼ inch.

Pipe sizing of riser2:
Table (3.4) The sizing pipe of riser2 for cold water .

Size of riser 2	Flow rate (gpm)	Total equivalent length (ft)	Friction (psi/100ft)	Pipe size (inch)
1st floor	76	190	7.8	2
2nd floor	65	228.8	6.5	2
3rd floor	55.5	211.5	7	2
4th floor	43	231.2	6.4	1½
fifth floor	28	251	6	1 ¼

3.2.4 Calculation for hot water :

As an example The following table table (3.5) shows load of fixture unit in which Riser1 is located (back to drawings):

Type of FU	**Demand per FU**	**Number of FU**	**Hot water**
Lavatory	2* 3/4	1	1.5
laundry	3* 3/4	7	15.5
Shower	2* 3/4	2	6
Total for basment 2			23 Fu
			15.5 gpm
Type of FU	**Demand per FU**	**Number of FU**	**Hot water**
Lavatory	2* 3/4	4	6
laundry	3* 3/4	4	12
Shower	2* 3/4	2	6
Total for basment 1			24Fu
			16 gpm
Type of FU	**Demand per FU**	**Number of FU**	**Hot water**
Lavatory	2* 3/4	5	7.5
Total for ground and 1st floor			7.5Fu
			6.5 gpm
Type of FU	**Demand per FU**	**Number of FU**	**Hot water**
Lavatory	2* 3/4	5	7.5
Shower	2* 3/4	3	9
Total 2nd floor			16.5Fu
			12 gpm

Type of FU	Demand per FU	Number of FU	Hot water
Lavatory	2* 3/4	9	13.5
Bathtub	3* 3/4	2	3
Shower	2* 3/4	7	21
Total 3rd ,4th and 5th floor			37.5Fu
			24 gpm

Calculation of Branch connected to riser 1:-

Table (3.6) The sizing pip of branch for hot water .

Branch's of riser 1	Flow rate (gpm)	Total equivalent length (ft)	Friction (psi/100ft)	Pipe size (inch)
basement 2 floor	15.5	155	10.9	1
basement 1 floor	16	174.6	9.7	1
ground floor	6.5	177.6	9.6	¾
first floor	6.5	202.2	8.4	1
second floor	12	222.3	7.6	1 ¼
third floor	24	246	7	1 ¼
forth floor	24	265.6	6.4	1 ¼
fifth floor	24	285.3	6	1 ¼

Table (3.7)Pipe sizing of riser1:

Size of riser 1	Flow rate (gpm)	Total equivalent length (ft)	Friction (psi/100ft)	Pipe size (inch)
basement 2 floor	65	155	10.9	2
basement 1 floor	59	174.6	9.7	2
ground floor	54	177.6	9.6	1½
first floor	52	202.2	8.4	1½
second floor	51	222.3	7.6	1½
third floor	47	246	7	1½
forth floor	36	265.6	6.4	1 ¼
Fifthfloor	24	285.3	6	1 ¼

For riser 1 fifth floor :
EL = 14 +36+8 = 58 m
Total equivalent length = EL * 1.5 = 58 * 1.5 = 87 m = 285.3 ft.
friction pipe = 17 psi.
Friction/100ft = 17 psi/285.3 *100 ft = 10.9 (psi/100ft).

From chart (9.5) steel pipe :-

For (10.9 psi)&(24 gpm) size pipe is 2 inch.

3.3 Drainage Piping sizing

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

This enable us, exactly as for water supply, to add the dfu of varies 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.

Table (3.8)the drainage fixture unit (dfu) for basement 2 stacks:

Fixture unit	No. of Fixture	Drainage Fixture Unit value, dfu Table (4)	dfu value (Horizontal Branch)	Diameter of Pipe, in. Table (3)
Lavatory. Stack(D)	5	1	5	1 ½
WC. Stack(D)	3	6	18	2 ½
Lavatory. Stack(E)	1	1	1	1 ½
WC. Stack(E)	1	6	6	2

Shower. Stack(E)	1	2	2	1 ½
Lavatory. Stack(F)	5	1	5	1 ½
WC. Stack(F)	2	6	12	2 ½
Lavatory. Stack(G)	5	1	5	1 ½
WC. Stack(G)	2	6	12	2 ½
Lavatory. Stack(H)	3	1	3	1 ½
WC. Stack(H)	1	6	6	2
Shower. Stack(H)	1	2	2	1 ½
Lavatory. Stack(I)	1	1	1	1 ½
WC. Stack(I)	1	6	6	2
Shower. Stack(I)	1	2	2	1 ½
Laundry. Stack(V)	2	2	4	2
Laundry. Stack(W)	5	2	10	2 ½
Lavatory. Stack(12)	1	1	1	1 ½
WC. Stack(12)	2	6	12	2 ½
Shower. Stack(12)	2	2	4	1 ½

Table (3.9) Example for how to calculate the diameter for stuck 12:

Stack 4	dfu value (Stack)	Diameter of Pipe, in. Table (3)
From floor 5	9	2
From floor 4	18	2
From floor 3	27	2 ½
From floor 2	36	2 ½
From floor B1	40	2 ½
From floor B2	57	2 ½
To M.H59	57	2 ½

Table (3.10) For vertical stack in hospital:

Stack	dfu value (Stack)	Diameter of Pipe, in. Table (3)
A	13	2 ½
B	22	3
C	16	2 ½
D	22	3
E	9	2
F	17	2 ½
G	17	2 ½
H	11	2 ½
I	21	3
J	32	3
K	38	3
L	13	2 ½
M	13	2 ½
N	13	2 ½
O	12	2 ½
P	13	2 ½
Q	9	2
R	36	2 ½
S	36	2 ½
T	36	2 ½
U	36	2 ½
V	69	3
W	37	2 ½
X	27	2 ½
Y	36	2 ½
X	13	2 ½
1	15	2 ½
2	9	2
3	36	2 ½
4	36	2 ½
5	36	2 ½
6	64	3

7	65	3
8	36	2 ½
9	78	4
10	9	2
11	58	3
12	53	3
13	34	2 ½
14	33	2 ½
15	33	2 ½

3.4 Sanitary Drainage System

3.4.1 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 main manhole

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.

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

ϕ 80 cm for manhole depth (100-150) cm.

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

ϕ 120 cm for manhole depth > 250 cm.

3.4.2 Manholes Calculations

We assume the depth of the first manhole to be (80 cm) and we calculate the second manhole according to it and so on.

For manhole #.1 :

Top level = +0.00

Depth = 0.60 m

Invert level=Top level-Depth = 0.00 - 0.60 = -0.60 m

For manhole #. 2 :

The distance between manhole 1 & manhole 2 is 4.00 m.

Invert level for manhole 2 is:

Y = ((S*Slope) + 5) / 100

Where: S is the distance between manhole 1 & manhole 2.

Slope is 1.5%

5 cm, is the point in manhole 2 where the pipe will be connected.

So:

Y = ((4.00 * Slope) + 5) / 100

= ((4.00 * 1.5) + 5) / 100

= 0.11 m

Top level = +0.00

Invert level of manhole 2 = Invert level of M1 – Y= -0.60 – 0.11= -0.71 m.

Depth = $T.L_{M2}$ - I.LM2 = 0.00 – (-0.71) = 0.71 m.

The following table(3.11) shows calculations and dimensions of all manholes that used in our project:

Manhole #	Top level (m)	Invert level (m)	Depth (m)	Diameter (m)	Cover type
M_1	+0.00	-0.60	0.60	0.60	Medium duty

M_2	+0.00	-0.71	0.71	0.60	Medium duty
M_3	+0.00	-0.84	0.84	0.60	Medium duty
M_4	+0.00	-1.00	1.00	0.60	Medium duty
M_5	+0.00	-1.16	1.16	0.80	Medium duty
M_6	+0.00	-1.35	1.35	0.80	Medium duty
M_7	+0.00	-1.43	1.43	0.80	Medium duty
M_8	+0.00	-1.52	1.52	1.00	Medium duty
M_9	+0.00	-1.65	1.65	1.00	Medium duty
M_{10}	+0.00	-1.75	1.75	1.00	Medium duty
M_{11}	+0.00	-1.83	1.83	1.00	Medium duty
M_{12}	+0.00	-1.92	1.92	1.00	Medium duty
M_{13}	+0.00	-2.00	2.00	1.00	Medium duty
M_{14}	+0.00	-2.16	2.16	1.00	Medium duty
M_{15}	+0.00	-2.34	2.34	1.00	Medium duty
M_{16}	+0.00	-2.45	2.45	1.00	Medium duty
M_{17}	+0.00	-2.61	2.61	1.20	Medium duty
M_{18}	+0.00	-2.80	2.80	1.20	Medium duty
M_{19}	+0.00	-2.93	2.93	1.20	Medium duty
M_{20}	+8.00	+7.40	0.60	0.60	Medium duty
M_{21}	+8.00	+7.40	0.60	0.60	Medium duty
M_{22}	+8.00	+7.30	0.70	0.60	Medium duty
D M_{23}	+8.00	+7.15	0.85	0.60	Medium duty
D.M_{24}	+7.50	+6.90	0.60	0.60	Medium duty
M_{25}	+7.50	+6.80	0.70	0.60	Medium duty
D.M_{26}	+7.00	+6.20	0.60	0.60	Medium duty
D.M_{27}	+5.50	+4.90	0.60	0.60	Medium duty
D.M_{28}	+5.00	+4.40	0.60	0.60	Medium duty

$D.M_{29}$	+4.45	+3.85	0.60	0.60	Medium duty
$D.M_{30}$	+0.00	-0.60	0.60	0.60	Medium duty
M_{31}	+0.00	-0.83	0.83	0.60	Medium duty
M_{32}	+0.00	-0.89	0.89	0.60	Medium duty
M_{33}	+0.00	-1. 05	1.05	0.80	Medium duty
M_{34}	+0.00	-1.21	1.21	0.80	Medium duty
M_{35}	+0.00	-1.37	1.37	0.80	Medium duty
$D.M_{36}$	+0.00	-1.53	1.53	1.00	Medium duty
M_{37}	+8.00	+7.40	0.60	0.60	Medium duty
M_{38}	+8.00	+7.32	0.68	0.60	Medium duty
M_{39}	+8.00	+7.14	0.86	0.60	Medium duty
M_{40}	+8.00	+7.06	0.94	0.60	Medium duty
M_{41}	+8.00	+6.91	1.09	0.80	Medium duty
M_{42}	+8.00	+6.83	1.17	0.80	Medium duty
M_{43}	+8.00	+6.73	1.27	0.80	Medium duty
M_{44}	+8.00	+6.62	1.38	0.80	Medium duty
M_{45}	+8.00	+6.56	1.44	0.80	Medium duty
M_{46}	+8.00	+7.40	0.60	0.60	Medium duty
M_{47}	+8.00	+6.40	1.60	1.00	Medium duty
M_{48}	+8.00	+6.29	1.71	1.00	Medium duty
M_{49}	+8.00	+6.22	1.78	1.00	Medium duty
M_{50}	+8.00	+6.08	1.92	1.00	Medium duty
$D.M_{51}$	+7.00	+6.40	0.60	0.60	Medium duty
$D.M_{52}$	+5.00	+4.40	0.60	0.60	Medium duty
M_{53}	+5.00	+4.33	0.67	0.60	Medium duty
M_{54}	+3.50	+2.90	0.60	0.60	Medium duty
$D.M_{55}$	+3.50	+2.83	0.67	0.60	Medium duty

M_{56}	+3.00	+2.40	0.60	0.60	Medium duty
$D.M_{57}$	+3.00	2.32	0.68	0.60	Medium duty
$D.M_{58}$	+2.00	+1.40	0.60	0.60	Medium duty
$D.M_{59}$	+2.00	+1.34	0.66	0.60	Medium duty
M_{60}	+1.00	+0.40	0.60	0.60	Medium duty
$D.M_{61}$	+1.00	+0.30	0.70	0.60	Medium duty
$D.M_{62}$	-0.50	-1.10	0.60	0.60	Medium duty
$D.M_{63}$	-0.50	-1.22	0.72	0.60	Medium duty
M_{64}	-2.00	-2.60	0.60	0.60	Medium duty

3.4.3 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(2%).
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 the4"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 4"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.

3.4.4 Drainage Piping Fill

1. Branches are designed to run maximum of 50% fill.
2. Stacks are designed to flow between 25 – 30 % maximum.

3. Building drains and sewer drains may be designed over 50% fill.

3.4.5 Drainage Piping Velocity

1. For branches the recommended velocity is 2 ft/s.
2. For building the recommended velocity is 3 ft/s.
3. For greasy the recommended velocity is 4 ft/s.

Velocity of water flow through drainage piping depends on:

1. Pipe diameter.
2. Slope.

For the same diameter large pipe diameter required lower slope

For pipes of diameter $\leq$ 3" the minimum slope is 1/4 in/ ft.

For pipes of diameter $\geq$ 4" the minimum slope is 1/8 in/ ft.

3.5 Selection of cold &hot water system pump :

Table (3.12)selection of cold water pump :-

GRUNDFOS

Pump No.	Location	Flow rate Q=[gpm]	Head[m]	Model no.
1	Mechanical store In basement 3	125gpm	40.2 m	**HYDRO MULTI-E 2 CR 32-3 50 Hz**
2	Mechanical store In basement 2	76gpm	40.2 m	**HYDRO MULTI-E 2 CME10-03 50 Hz**
3	store In basement 2	105gpm	24. 45m	**HYDRO MULTI-E 2 CR 32-3 50 Hz**

Table(3.13)selection of Hor water pump:

Pump No.	Location	Flow rate Q=[gpm]	Head[m]	Model no.
1	Mechanical store In basement 3	91gpm	40.2 m	**CR 20-6 A-A-A-E-HQQE**
2	Mechanical store In basement 2	65gpm	40.2 m	**CR 18-8 A-F-G-E-HQQE**
3	store In basement 2	73gpm	40.2 m	**CR 15-8 A-F-A-E-HQQE**

CHAPTER FOUR

FIRE FIGHTING SYSTEM

CHAPTER 4

4.1 The Fire Triangle :

Fire: is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat, light, and various reaction products. Slower oxidative processes like rusting or digestion are not included by this definition.

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:

Figure (4.1) The fire triangle

4.2 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.

This figure shows the types of fires as classified **:-**

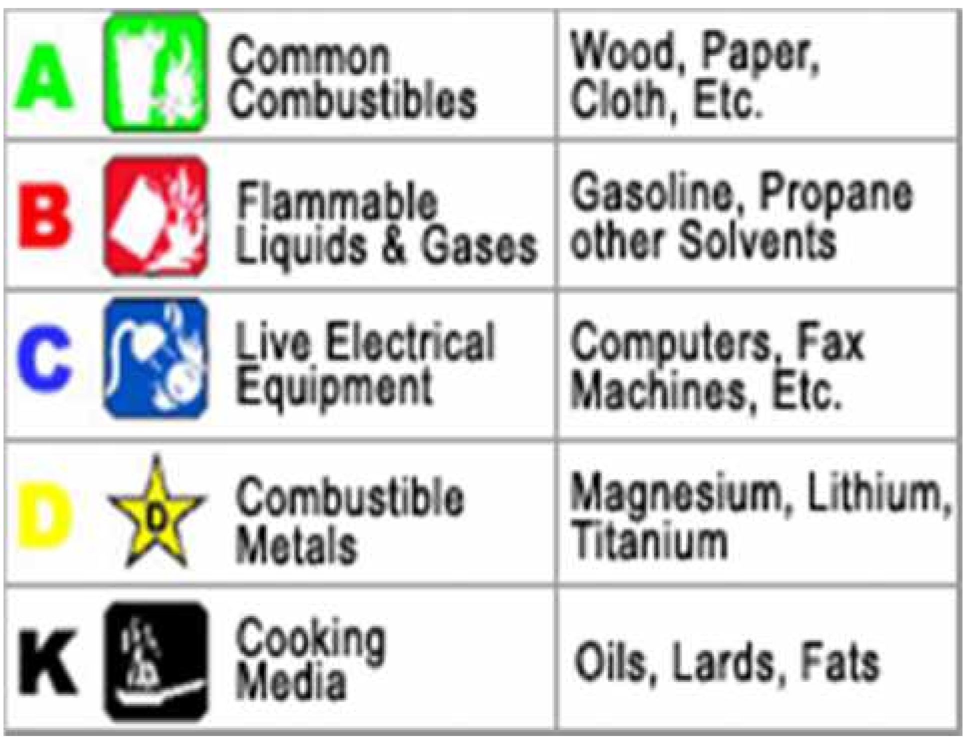


Figure (4.2) Types of fires as classified

4.2.1 Classifications of Hazard:

Light: Class A & little of Class B

Ordinary: Class A & B

Extra: Class A & B but with large quantity.

4.3 The main Fire Fighting systems:

1)water system

a)Automatic

Sprinkler System which includes

- Dry system
- Wet system
- Deluge system
- Pre -action system

b)Manual

which includes [FHC ,FH, Siamese connection]

2)Gas system

a) Automatic

- CO2
- FM200

b)Manual

- Extinguisher

3)foam system

a)Automatic

- High pressure(Foam nozzle)
- Low pressure (Foam generator)

b)Manual - Extinguisher

4.4 Fire extinguisher :-

1-Fire extinguisher classification &UL rating :

-Class A

-Class B

-Class C

-Class D

The UL rating is broken down into class A and class B&C, for example the rating A is a water equivalency rating (each A=1.25 GPM), the rating B is related to the coverage area for example (20B:C=20ft^2) and the rating C means that its suitable for electrically energized equipment, All according to NPF10.

Note: the UL rating is found on the extinguisher label

The following table (4.1) shows the type of the extinguisher and where should it used:

Extinguisher Type	Agent	Class	Sample Applications
Multi-Purpose Dry Chemical	Monoammonium Phosphate	ABC	Offices, Hotels, Schools and Warehouses
Regular Dry Chemical	Sodium Bicarbonate	BC	Vehicles, Training and Laboratories
Purple K Dry Chemical	Potassium Bicarbonate	BC	Oil Industry, Airport Ramps, Military and Fuel Services
CO2	Carbon Dioxide	BC	Factories and Food Processing Plants
Halotron	Halotron I	ABC & BC	Military, Computer Rooms, Aircraft and Museums
Water	H2O	A	Storerooms, Barns and Attics
Foam	AFFF / FFFP	AB	Fueling Areas, Manufacturing and Construction Sites

2-Hazard classification:

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

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

3) Extra (high) hazard occupancy:
   Defined as a room, space, or enclosure where the combustibility of contents of the storage, handling, or manufacturing of class A combustible material in which the quantity of class A material is high, or where large amount of class B flammables (more than 5 gallons) are present, and where rapidly developing fires with high rates of heat release are expected.
   Extra (high) hazard occupancies could consist of wood working, vehicle repair, air craft and boat servicing, cooking areas, individual product displays and storage and manufacturing processes such as painting, dipping, coating, and flammable liquid handling.

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

5) Specialized occupancies:
   Aircraft hangar.

3-Extinguisher size & replacement:

There are three things important in determining the extinguisher size and place

-Hazard and hazard area.

-Rating &coverage area .

- Distributing the extinguisher per the allowable reveal distance for each type according to NPFA10.

The following table (4.2) shows the fire extinguisher size and placement for class A hazard:

Criteria	Light (Low) Hazard Occupancy	Ordinary (Moderate) Hazard Occupancy	Extra (High) Hazard Occupancy
Minimum Rated single extinguisher	2-A	2-A	4-A
Maximum floor area per unit of A	3,000 ft2	1,500 ft2	1,000 ft2
Maximum floor area for extinguisher	11,250 ft2	11,250 ft2	11, 250 ft2
Maximum travel distance to extinguisher	75 ft.	75 ft.	75 ft.

The following table(4.3) shows the fire extinguisher size and placement for class B hazard:

Type of Hazard	Basic Minimum Extinguisher Rating	Maximum Travel Distance to Extinguisher
Light (Low)	5-B	30 ft.
	10-B	50 ft.
Ordinary (Moderate)	10-B	30 ft.
	20-B	50 ft.
Extra (High)	40-B	30 ft.
	80-B	50 ft.

• **Class C extinguishers** are required where energized electrical equipment is potentially directly involved in or surrounds electrical equipment. Normally Class C fires are in direct location of Class A and/or B fires, the extinguisher shall be sized per the Class A or B hazard.

Class D Locations

• Fire extinguishers for Class D locations shall not be located more than 75 ft. from the hazard. Size determination for Class D locations is based on the specific combustible metal, particle size, area to be covered, and manufacturer recommendations.

Class K Locations

• Class K hazards shall have a fire extinguisher located where there is a Potential for a fire involving combustible cooking media (vegetable or Animal oils and fats). The extinguisher shall be located no more than 30 ft. from the hazard.

Travel Distance for "A" Rating NFPA 10 .

4.4.1 Fire Extinguisher color code:

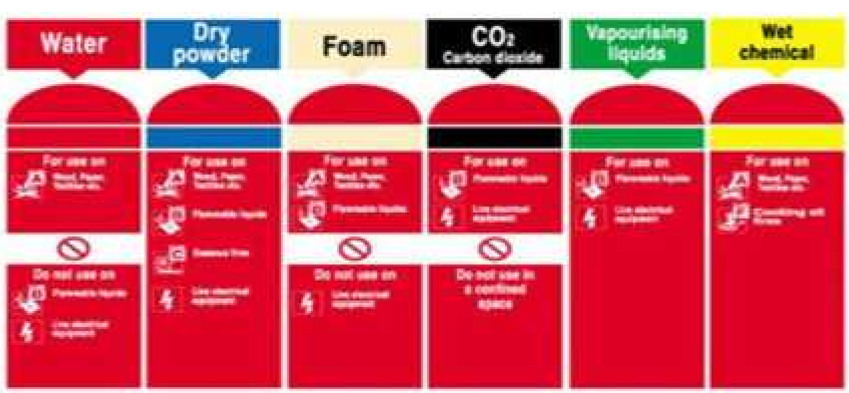


Figure (4.4) Extinguisher color code

4.4.2 Sample on Fire extinguisher:

This table (4.4)shows the extinguisher size and location for basement floor :-

Type of hazard	Type of Fire extinguisher	Type of room	No .of fire extinguisher	Wight (kg)	Coverage area
Ordinary	Co2	Service store	3	6kg	$129m^2$
Ordinary	Co2	Mechanical store	5	6kg	$316m^2$
light	Dry powder	Emergency	7	6kg	$471m^2$
Ordinary	Co2	laundry	5	6kg	$1058m^2$

4.5 Fire Hose cabinet:

Fire house cabinet categorized into of three classes:

A) Class I Systems:

1) At each intermediate landing between floor levels in every required exit stairway

2) On each side of the wall adjacent to the exit openings of horizontal exits.

3) At the entrance to each exit passageway or exit corridor, and at exterior public entrances to the mall.

4) Travel distance =46 m (with throw) – general design at 35 m.

B) Class II Systems:

1) Travel distance =36 m (with throw) – general design at 30 m.

C) Class III Systems: combined of class I and class II.

Fire house cabinet includes two types:

a) House Reel :

Figure (4.5) House Reel

b) House Rack:

Figure(4.6) House Rack

Fire Hose cabinet should be installed according to NPFA 14 and shown in drawings:

1-Near escape stairs

2- 30 m(100ft) length of the pipe which is the distance traveled by the pipeline passing barriers and walls until it reaches the fire place .

3- Next to the main door of the building.

4- Fire house cabinet height above the ground (90-150)cm.

5- The Pipe that enters the cabinet diameter is 1’’or 1.25’’ and the flow should be 100gpm at pressure 4.5 bar.

Note: all Fire Hose cabinet distribution is shown on drawings.

4.6 Fire hydrant:

Located in the street and it is used in case that we couldn’t overcome the fire from inside the building

Fire Hydrant should be installed according to NPFA 14:

-A pipe with 4’’ diameter branched into two pipes each with 2.5’’diameter with a flow of 250gpm

Figure (4.7) Fire hydrant

3) Siamese connection:

Installed at the outside wall of the building connected to the water tank to fill it in case it's empty

4.7 PUMP ROOM

4.7.1 Component and equipment used:

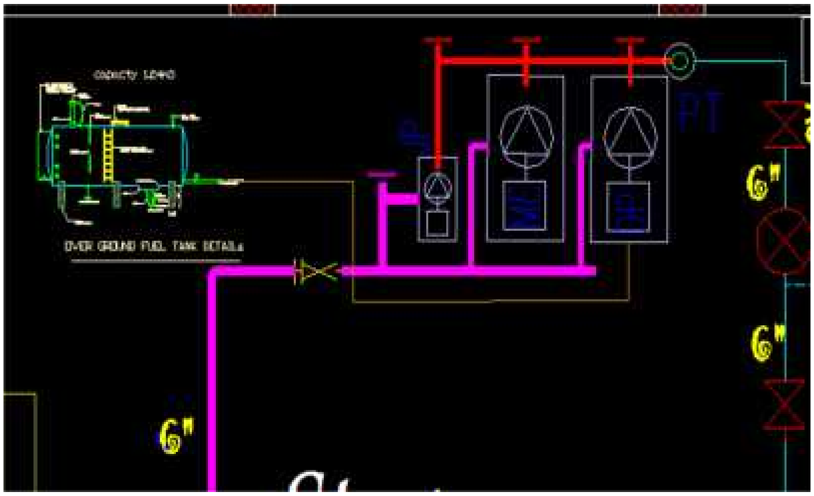


Figure (4.8) Pump room located in basement 2 floor

In any fire fighting system we need water to be pumped until it reaches the desired fire place

1- Gate valve

2- check valve : It prevents back flow, and allows only flow in on direction, and is installed in pump discharge line directly to prevent pumps from starting at a load or at the system pressure.

3- Suction header: It prevents vortex
4- Discharge header

5- Diesel pump: It's a 100% stand-by pump, operates in case of power failure with the failure of pressure make up process by the electric pump, or to even with the present of power if failure of pressure make up
process.

6- Jockey pump

It's the first pump to start in case of fire, It operates as a pressure maintenance pump so in case of a leakage in the system pressure it will makes the system pressure as recommended, and A jockey pump should be sized to make up the allowable leakage rate within10 minutes or 1GPM (3.8 L/min), whichever is larger, and is used for this job instead-off starting the electric pump to protect it from starting until a serious problem occurs.

7- Electric pumps

It's the second pump to start in case of fire;it's the 100% duty pump.

8- Pressure relief valve

A valve being set at a pressure higher than the system pressure or shut off pressure of the diesel pump to protect the system from the very high pressure generated by the diesel pump in case of sudden acceleration.

The relief valve shall be located between the pump and the pump discharge check valve and shall be so attached that it can be readily removed for repairs without disturbing the piping.

Note: - locations of all gate valves in the pump room are mainly for make ease maintenance for each component in the room and without loss water in pipes as possible as we can and for make maintenance which stops the system 100 % is very not possible as we can.

9- Flow switch

It gives signal when a flow happened in a pipe.

10- Fuel tank

Which is used in diesel pump

4.7.2 Shut off of the pumps:

1- The Jockey pumps stops automatically when the pressure in pipes reached its rated pressure.

2- The Electric pump stops after reached the rated pressure by 10 minutes.

3- The Diesel pump stops after 30minutes after reaching its rated pressure.

4.8 Selections of pump room Components:

NFPA20 puts some conditions on fire pump selection and they should take into account at any selection of the pumps :

1-The pump must verify required flow and the desired head .

2- when the flow increase to 150% the head must not be less than 65%.

3-The shut of head ranges from 101% to 140%.

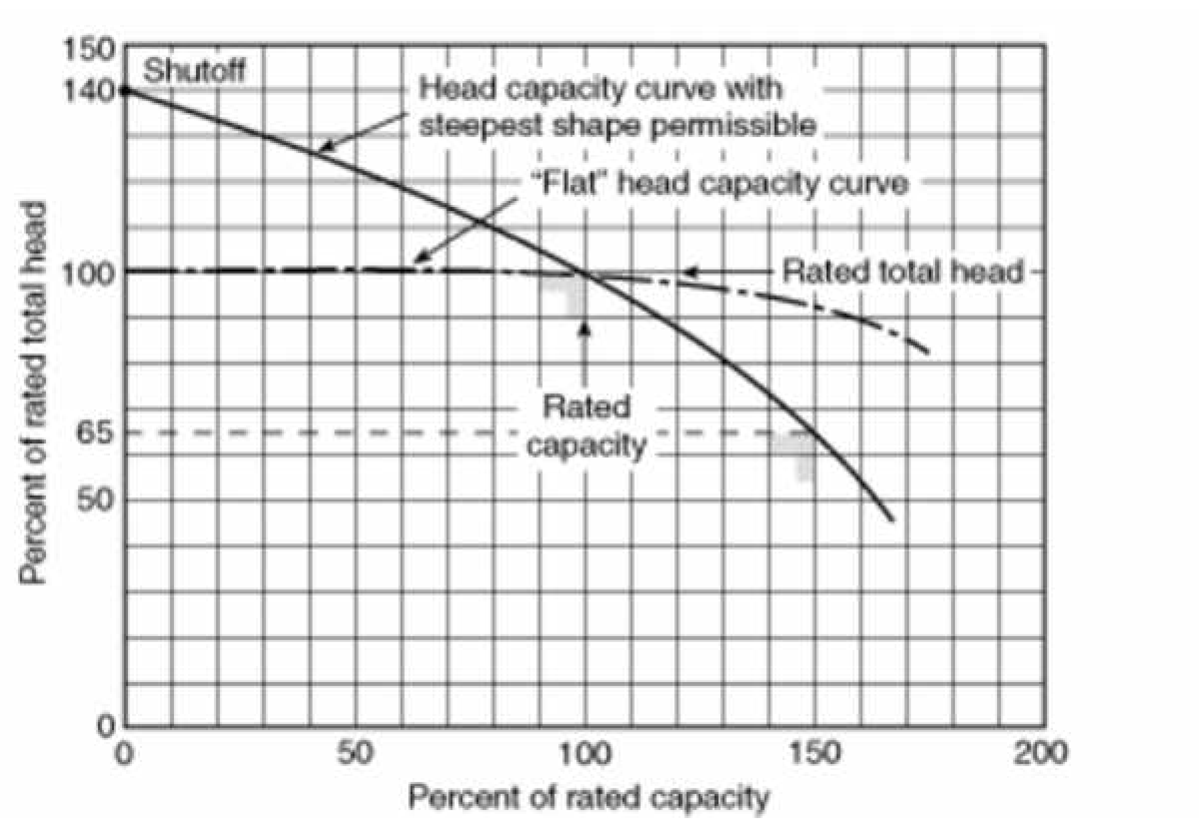


Figure (4.9) Fire fighting characteristic curve

4.8.1 Fire fighting pump Selection:

We have two pump room the first one is in basement 3 mechanical store and the second one is in basement 2

Q total=Q pump=Q sprinkler +Q FHC+QFH ,we have used only FHC [4-1]

So,

Q total=Q pump= QFHC

Qt=Q pump =Q elec= Q diesel

Qj= (5-10) % Q p , elec ,diesel

Qj always taken (25-50)gpm from NPFA 20 ,we will take Q= 50 gpm for jokey pump

Calculating the flow rate needed the 1st pump room connected with riser 1

which gives (15)FHC each one of them needs 100 gpm

So, The total flow rate= (15*100gpm) =1500gpm.

Calculating the flow rate needed the 2nd pump room connected with risers 2,3and 4

The total flow rate for riser2= (10*100gpm) +250gpm (as factor of safety for each riser add to the first riser "from code NPFA=1500gpm.

The following table(4.5) shows the flow rate for each riser connected to the pump room:

No. of pump	Name of risers	l load (gpm)
1	1	1500
	Total load	1500 gpm
No of pump	**Name of risers**	**load (gpm)**
2	2	1250
	3	950
	4	750
	Total load	2950 gpm

The following table shows the pump flow rate and head and type:

Note: Type of pipes used seamless black Steel schedule 40 .

Selecting pump for riser 1:

At 1500 gpm and 6 inch pipe diameter (seamless black steel schedule 40).

The head loses =15ft/100ft (6psi/100ft=0.413bar) from figuer (1) in appendix[B] **.**

The static head=118ft (51psi=3.5bar).

The FHC Residual pressure 4.5 bar from NPAF10.

So, we need 1500gpm and 8.413 bar

Table (4.6) selection of pump

No of pump	Q total (gpm)and head(m)	Selection of pump type
1	1500 gpm&32m	**Seffco pump100/24**
2	2950gpm&32m	**Seffco pump100/24**

See the catalog,

Figure (4.10) SFFECO Fire pump

4.9 Selections of fire extinguisher and fire house cabinet:

We will use 6kg of Dry powder Heba fire extinguisher with cabinet for different rooms and offices (see the catalog) :

Fig (4.11) Fire extinguisher

And 6 kg of CO_2 Heba fire extinguisher with cabinet for mechanical stores (see the catalog) :

Fig (4.12) Fire extinguisher

And Rubber house reel cabinet at the escaping stairs and kitchen (see the catalog):

Figure (4.13) Fire extinguisher

4.10 calculation of water tank volume:

Q=500 gpm

Time = 60 m (from NPFA13 ordinary hazard)

Tank volume=QX Time [4-2]

Tank volume =500X60=30000 Gallon

Tank volume =114 m^3

4.11 calculation of the Fuel tank volume needed for the Desial pump:

Q=[(Diesel engine (HP) rating *1(Gal/HP)+10% (factor of safety)] [4-3]

From catalog the Jokey pump rating is 270HP

Q=[270*1Gal/HP+10%]=270*3.785/1000L+10%=1.24m^3 total fuel tank volume .

CHAPTER FIVE

MEDICAL GASES

CHAPTER 5

5.1 Introduction

Health care is in a constant state of change, which forces the plumbing engineer to keep up with new technology to provide innovative approaches to the design of medical-gas systems. In designing medical-gas and vacuum systems, the goal is to provide a safe and sufficient flow at required pressures to the medical-gas outlet or inlet terminals served. System design and layout should allow convenient access by the medical staff to outlet/inlet terminals, valves, and equipment during patient care Or emergencies.

The plumbing engineer must determine the needs of the health-care staff. As any hospital facility must be specially designed to meet the applicable local code requirements and the health-care needs of the community it serves, the medical-gas and vacuum piping systems must also be designed to meet the specific requirements of each hospital.

Medical-gas is any gas that used in medical application, medical gases are used every day 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 health-care facility to determine the following items.
   A. piped medical-gas systems are required.
   B. Number of each different type of medical-gas outlet/inlet terminal is required.
   C. The outlet/inlet terminals be located for maximum efficiency and convenience.
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.
4. Prepare the schematic piping layout locating the following :
   A. Zone valves.
   B. Isolation valves.
   C. Master 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 5-1 Medical gas Distribution in Hospital

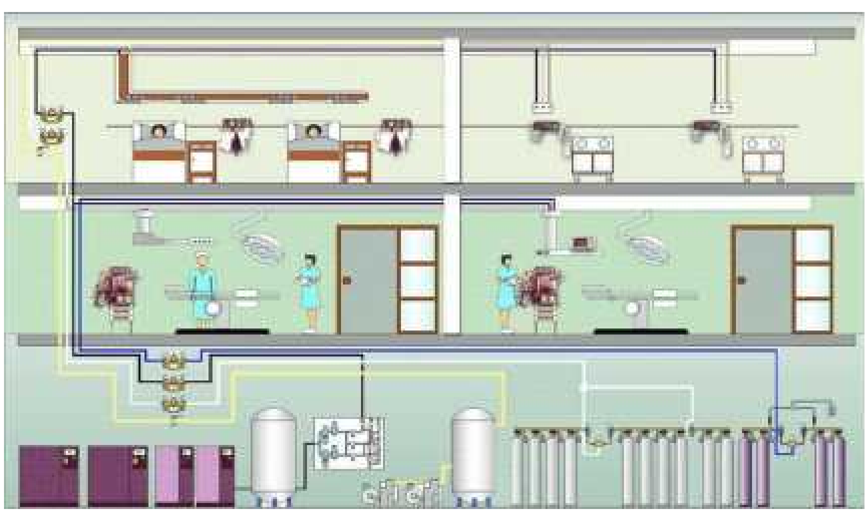


Figure 5-2 Medical gas Distribution in Hospital

5.2 Medical Gases Flow Rate

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 out lets, 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.

There are three aspects of gas flow to consider when designing the pipeline distribution system:

a. the flow which may be required at each terminal unit.

b. the flow required in each branch of the distribution system (see the schematic, which shows a system with several main branches).

c. the total flow, i.e. the sum of the flows in each branch.

The total flow for the system is the sum of the diversified flows to each department all flows are in normal liters per minute (l/min) unless otherwise stated.

5.3 Provision Of Terminal Unit

A typical schedule of provision of terminal units is given in Table (5.1). Medical treatment policy is evolutionary, and therefore the project team should review the 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 that result 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-room pendant 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 as recommended in **HTM 0201 code** :

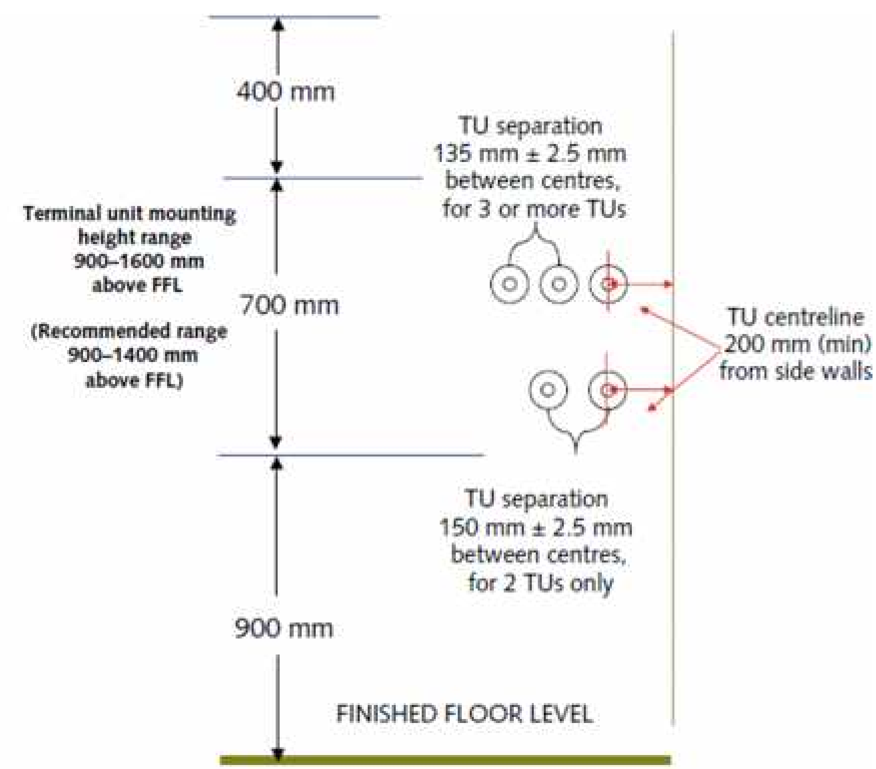


Figure (5-3) shows the location as recommended for terminal unit.

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 center 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.

A sample of the table in the **HTM 0201 Code:**
Note: to determine the No. of terminal unit u need to know the type of room in hospital

Department	O_2	N_2O	N_2O/O_2	MA4	SA7	VAC	AGSS	He/O_2	AVSU	Alarm
Accident and Emergency									1 set (7)	1 set hp/lp (9)
Resuscitation room, per trolley space	2	2	–	2	–	2	2	–	2 sets*	
Note: One set either side of the trolley space, if installed in fixed location, eg trunking; or both sets in an articulated supply pendant that can be positioned either side of the bed space.										
Major treatment/plaster room per trolley space	1	1	1p	1	1p	1	1	–	1 set/8 TUs	
Post-anaesthesia recovery per trolley space	2	–	–	2	–	2	–	–	2 sets*	
Note: One set either side of the trolley space, if installed in fixed location, eg trunking; or both sets in an articulated supply pendant that can be positioned either side of the bed space.										
Treatment room/cubicle	1	–	–	–	–	1	–	–	1 set/8 TUs	
Operating department									1 set (7)	
Anaesthetic rooms (all)	1	1	–	1	–	1	1	–		
Operating room, orthopaedic:										
For anaesthetist	2	1	–	2	–	2	1	–	1 set per suite (2)(3)	1 set per suite hp/lp (10)
For surgeon	–	–	–	–	4	2	–	–	–	–
Note: Orthopaedic surgery is normally performed in operating rooms provided with ultra-clean systems. Such systems are much more effective in terms of airflow when provided with partial walls. These walls may be effectively used to include terminal units that can be supplied by rigid pipework. Such installations do not suffer from excessive pressure loss when surgical air is required at high flows.										
Operating room, neurosurgery										
Anaesthetist	2	1	–	2	–	2	1	–	1 set per suite (2)(3)	1 set per suite hp/lp (10)
Surgeon	–	–	–	–	2	2	–	–		
Note: If multi-purpose pendants are used, there may be some loss of performance of surgical tools because of bore restrictions and convolution of the flexible connecting assemblies at the articulated joints.										

Figure (5.4) from HTM 0201 Code

5.4 Type Of Medical Gases

5.4.1 Oxygen (O_2)

Oxygen may be used for patients requiring supplemental oxygen via a mask. Usually accomplished by a large storage system of liquid oxygen at the hospital which is evaporated into a concentrated oxygen supply, pressures are usually around 55 psi. In small medical centers with a low patient capacity, oxygen is usually supplied by multiple standard cylinders.

Oxygen is generally supplied from:

1. A liquid source such as a large vacuum-insulated evaporator (VIE).
2. Liquid cylinders or compressed gas cylinders.
3. 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 (5.2) from **HTM 0201 Code**. Where n number of beds, Q the flow of oxygen and L/M space you need to know which the diameter of the pipe is.

This table(5.1) shows the flow of oxygen (O_2)in HTM0201 code

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 room, per trolley space	10	0	$Q = 10 + [(n - 1)6/4] =$	0
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

5.4.2 Nitrous Oxide (NO_2)

Nitrous Oxide is 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.

Table (5.2) Nitrous Oxide calculation are the same as the oxygen calculation but here there is a difference in flow rate equation as shown

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

5.4.3 Medical Air

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.

Table(5.3)Medical Air gas calculations are the same as the previous gas but the difference between them is the flow rate equations as shown:

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 rooms	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

5.4.4 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.

Table (5.4)Medical vacuum gas calculation similar to the previous gas but there is a deference in flow rate as shown

Department	**Design flow for each terminal unit (L/min)**	**n**	**Diversified flow *Q* (L/min)**	
In-patient accommodation (ward units):				
Ward unit	40	0	*Q* = 40	0
Multiple ward units	40	0	*Q*d = 40 + [(*n* – 1)40/4] =	0
Accident & emergency:				
Resuscitation room, per trolley space	40	0	*Q* = 40 + [(*n* – 1)40/4] =	0
Major treatment/plaster room, per trolley space	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	*Q*s = 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 single, multi-bed and treatment room	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	

5.4.5 Anesthetic Gas Scavenging Systems

Anesthetic Gas Scavenging System (AGSS) used for example in anesthetic and operating room. Used to capture and carry away gases vented from the patient breathing circuit during the normal operation of gas anesthesia or analgesia equipment. AGSS incorporate a mechanical pump to assist with the disposal of the waste gas.

Table(5.5)AGSS gas calculation are the same as the previous gas but there is a difference in flow rate equation as shown:

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	130	0	$Q = V + [(n – 1)V/4] =$	0

5.5 Calculation Of Medical Gases

5.5.1 Flow Of Gases, And Sample Calculation Of Basement Floor. For Room #R5 From Resuscitation Room

1- Oxygen (O_2)

Q=100+(n-1)6/4. From Table (6.2). [5-1]

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

n: Number of beds.

Q=100+(2-1)6/4

Q=101.5 L/m

2- Nitrous Oxide (NO_2)

Q=15+(n-1)6/4. From Table (6.3). [5-2]

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

n: Number of beds.

Q=15+(2-1)6/4

Q=16.5 L/m

3- Medical Vacuum

Q=80*2+[(n-2)80/2]. From Table (6.5). [5-3]

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

n: Number of beds.

Q=80*2+[(2-2)80/2] =160 L/m

This table(5.6) shows the flow of medical gas in the all of the floors of the hospital.

Floor	**Oxygen [L/m]**	**Nitrous Oxide [L/m]**	**Medical Air [L/m]**	**Medical Vacuum [L/m]**	**AGSS [L/m]**
Basement2	164.5	165	1040	1080	840
Basement 1	24.4	___	___	___	___
Ground	25	___	140	140	___
First Floor	105	33	619	240	2520
Second Floor	100.5	33	980	290	480
Third Floor	131	___	1440	350	___
Fourth floor	131	___	1440	350	___
Fifth floor	131	___	1440	350	___
Total	812	231	7751	2100	3840

5.6 Calculating the radius of the medical gas pipes:

To choose the appropriate pipe diameter is necessary to know the following things:

a- System pressure: **This table(5.7) shows Nominal pressure which is taken from HTM0201 code**

Service	Location	Nominal pressure (kPa)
Oxygen	Operating rooms and rooms in which N_2O is provided for anaesthetic purposes	400
	All other areas	400
Nitrous oxide	All areas	400
Nitrous oxide/ oxygen mixture	LDRP (labour, delivery, recovery, post-partum) rooms	310(2)
	All other areas	400
Medical air 400 kPa	Operating rooms	400
	Critical care areas, neonatal, high dependency units	400
	Other areas	400
Surgical air/ nitrogen	Orthopaedic and neurosurgical operating rooms	700
Vacuum	All areas	40 (300 mm Hg below atmospheric pressure)
Helium/oxygen mixture	Critical care areas	400

b- Equivalent length of pipe: which's can be calculated be knowing the length of the pipe and replacing all the fitting used by their actual length form HTM0201 code.

This table(5.8) shows the Equivalent length for different type of fittings .

	6 mm	8 mm	10 mm	12 mm	15 mm	22 mm	28 mm	35 mm	42 mm	54 mm	76 mm
Ball valve	0.10	0.10	0.20	0.30	0.30	0.60	0.90	0.90	1.10	1.20	1.20
Tee (Thru')	0.12	0.15	0.18	0.21	0.32	0.42	0.54	0.70	0.82	1.05	1.56
Tee (Branch)	0.46	0.52	0.70	0.80	0.95	1.26	1.60	2.10	2.45	3.14	4.67
90° Elbow	0.17	0.20	0.25	0.33	0.47	0.63	0.80	1.05	1.23	1.58	2.36

c- The allowed loses of pressure in pipe:

To calculate the loss in pressure allowed

Must know the equivalent length of pipe and pressure allowed in addition to the flow rate

Note: the maximum pressure loss allowed is 5% of the nominal pressure of the system except for vacuum system.

Table (5.9) below shows the loss in the Red copper piping systems operating pressure of 400 kpa.

Example :

Red cupper pipe to transfear O2 gas with an equivalent length of [12 m],an outside diameter of [15mm]and aflow rate of 800[L/m]

British Standard Size Tube BS EN 1057: R250, Table X		Distance from source (m) at 400 kPa for 7, 14, 21 kPa (1, 2, 3 psi) pressure loss																
Outside Diameter (mm)	Pressure loss (kPa)	8	15	30	61	91	122	152	183	213	244	274	305	335	366	396	427	457
		Free air flow rate (L/min)																
12	7	311	209	141	95	75	64	56	50	46	43	40	37	35	34	32	31	30
	14	455	307	207	139	110	94	82	74	68	63	59	55	52	50	47	45	44
	21	564	382	258	174	138	117	103	93	85	78	73	69	65	62	59	57	55
15	7	[illegible]	[illegible]	263	177	140	119	105	94	86	80	75	70	66	63	60	58	56
	14	845	[illegible]	386	260	207	175	154	139	127	118	110	104	98	93	89	85	82
	21	[illegible]	711	481	325	258	219	192	173	159	147	137	129	122	117	111	107	102
22	7	1677	1135	768	518	411	349	307	277	254	235	220	207	196	186	178	170	164

1)The nearest value for the equivalent length is [15m].

2)The nearest value for the flow rate is [771 L/M].

3)from these points we have pressure loss of[21 KPa].

Or By using a known equation from HTM0201 code

The pressure drop Δp across the pipe can be calculated from the formula

$$\Delta p = \frac{\text{Measured length of pipe}}{\text{Nearest length of pipe from Table A1}} \times \left[\frac{\text{Design flow}}{\text{Nearest flow from Table A1}}\right]^2 \times \text{Pressure drop from Table A1}$$

So;

$$\Delta p = \frac{12}{15} \times \left[\frac{800}{711}\right]^2 \times 21 = 21.3\ \text{kPa.}$$

5.7 Mechanical Equipment

5.7.1 Oxygen Cylinder.

The amount of oxygen gas L/h = F×60 min. From Medical Gas. [5-4]

F : The amount of oxygen gas flowing in all hospital L/m. also add to them 8% for futher demand

The amount of oxygen gas L/h=1461.6×60=87,696 L/h.

The amount of oxygen gas L/Day assuming 8 hours of demand 87,696 *8=701,568L/Day

- Number of cylinder Oxygen gases = The amount of oxygen gas L/Day capacities of oxygen gas cylinders m^3.

- Capacities of oxygen gas cylinders =6540 Liters.
- Number of cylinder Oxygen gases =701,568/6540

≈27 Cylinders.

5.7.2 Nitrous Oxide Cylinder.

The amount of Nitrous Oxide gas L/h = F×60 min. From Medical Gas.

F : The amount of Nitrous Oxide gas flowing in all hospital L/m.

The amount of Nitrous Oxide gas L/h=213×60=13860 L/h.

The amount of Nitrous Oxide gas L/Day assuming 8 hours of demand 110880 *8=27,720 L/Day

- Number of cylinder Nitrous Oxide = The amount of oxygen gas L/Day capacities of Nitrous Oxide gas cylinders m^3.

- Capacities of Nitrous Oxide gas cylinders =8900 Liters.
- Number of cylinder Nitrous Oxide gases =27,720/8900

≈3 Cylinders.

5.7.3 Compressor of Medical Air.

The amount of medical air gas m^3/h = F×60 min/1000 Lit. From Medical Gas.

F : The amount of medical air gas flowing in all hospital L/m.

The amount of Medical Air gas m^3/h =7751×60/1000 = 465 m^3/h.

-We need three compressors can compress 155 m^3/h (for each) of the medical air gases.

These compressors distributed as shown on drawings.

5.7.4 Pump Of Medical Vacuum.

The amount of medical vacuum gas m^3/h = F×60 min/1000 Lit. From Medical Gas.

F : The amount of medical vacuum gas flowing in all hospital L/m.

The amount of Medical Vacuum gas m^3/h =2100×60/1000 =126 m^3/h.

-We need three pumps to be able to suction 42 m^3/h (for each) of the gas to the outside air.

These pumps distributed as shown on drawings.

5.7.5 Pump (AGSS).

The amount of **(AGSS)** gas m^3/h = F×60 min/1000 Lit. From Medical Gas.

F : The amount of **(AGSS)** gas flowing in all hospital L/m.

The amount of **(AGSS)** gas m^3/h = 3840×60/1000

=230 m^3/h.

- We need three pumps to be able suction 77m^3/h (for each) of the gas to the outside air.

These pumps distributed as shown on drawings.

BILL OF QUANTITIES

Itom NO	DISCRIPTION	Unit	Quality	Price/Unit
1.1	**DRAINAGE WORKS**			
1 .1.1	Supply and installUPVC pipes S.N.8 for rain water ,drain pipes vertical ,horizantal under ground ,suspended to the ceiling ,price include all fittinges such as welding sockets,T,elbowes,reducers,electro fusion adapters, clean out closers in the end of the lines , digging and removing dirt installing concrete on the under ground pipes ,holder for suspended pipes 2.5 hilti type ,and HDPE expansion joint each 4 meters maximum, holes by coring machine, price shall include all the scaffoldings.			
1.1.1.1	6"	L. M	335	
1.1.1.2	4"	L. M	525	
	2"	L. M	206	
1.1.2	Supply and install 4" PVC floor trap (siphon) FT4" complete with floor collector with vertical outlet 110 mm for the 2",1 1/2" PVC pipes and chrome plated cover 15x15 cm			
1.1.3	Ditto but clean out	unit	108	
1.1.4	Ditto but floor drain 4/2"	unit	220	
	FORWARDED TOTAL			
1.2	**COLD AND HOT WATER SYSTEM**			
1.2.1	Supply and install Galvamized steel pipes sch.40 with all the fittings ,elbowes,reducers,T, unions including copper to steel adapters where there is connection between copper and steel ,for pipes above ceiling, in walls, and under ground. Price include all the digging and holes and removing dirt's and sleeves through walls, concrete layer for pipes in ground and walls ,pipes suspended to ceiling has Hilti holders each 1.5m ,pipes connection to existing steel heating pipes ,all holes by coring machine and through sleeves.			
1.2.1.1	2"	L. M	150	
1.2.1.2	11/2"	L. M	50	
1.2.1.3	11/4"	L. M	80	
1.2.1.4	1 "	L. M	100	
1.2.1.5	3/4"	L. M	240	
1.2.1.6	1/2"	L. M	65	

1.2.2	Supply and install 13 mm insulation wrapped by 10 cm PVC tape for the hot pipes diameters			
1.2.2.1	11/4"	L. M	80	
1.2.2.2	1"	L. M	100	
1.2.2.3	3/4"	L. M	240	
1.2.2.4	1/2"	L. M	65	
1.2.3	Supply and install copper water collector with branch valve for each exist, suspended in ceiling or in cabinet or fix to wall ,price include shut of valve with records ,air vents ,end piece,collecter holders , branch valve with copper nipple 16 mm , all as drawings and details as a complete job			
1.2.3.1	copper collector 3/4"	unit	60	
1.2.3.2	copper collector 1/2"	unit	20	
	Total Carried To The Next Page			
	FORWARDED TOTAL			
1.3	**SANITARY FIXTURES**			
	Supply and install the following sanitary fixtures with the required original fixing accessories and materials, the price of the sanitary fixture shall include supply ,connection and install of all the 2" PVC pipes from the sanitary fixture to the floor drain connection box ,or sewage pipes .			
1.3.1	Supply and install wall hung W.C bowel class A, white color with the necessary original connections,including cocealed flush valve for wall ,with steel reinforcing legs and . price includes cover seat from same type ,boltes and nuts connection to cold water and drainage and casting reinforced concrete B 250 20cm thick, Ø 8mmx20x20 cm around thesteel reinforced legs as a complete job	unit	4	
1.3.2	Supply and install wash basin class A white color with semi pedistal size 55x42 with 2 angle valves 1/2"-3/8" Nil type complete with chrome plated siphon Art siphon as a complete job	unit	161	
1.3.3	Supply and install chrome plated mixer for the wash basin type ideal standard price include connection to water outlets and two angle valve 1/2"-3/8" type Nil as a complete job	unit	161	
1.3.4	Supply and install Top filling basin mounted soap dispensers price include all fixing accessories and stainless steel screws coring in the granite as a complete job	unit	161	
1.3.5	Supply and install stain less steel kitchen sink size 60x40 complete with original siphon and 1/2"-3/8" valve and connection to cold & hot water as a complete job	unit	4	
1.3.6	Ditto but scrub sink with chrome lever mixer as specification	unit	4	

1.3.8	Supply, install, test and commission Porcelain shower of size 80x80 cm.	unit	88	
1.3.9	Supply, install, test and commission Chrome plated gear mixer type	unit	88	
	Total Carried To The Next Page			
	FORWARDED TOTAL			
1.3.12	Supply, install, test and commission Recessed soap disk .	unit	9	
1.3.14	Supply, install, test and commission Care toilet seat open front with cover white color specially used for handicapped people.	unit	8	
1.3.15	Supply, install, test and commission Stainless steel Paper holder for single roll fixed to wall.	unit	125	
1.3.16	Supply and install surface mounted multi-roll toilet tissue dispenser . price include all fixing accessories and stainless steel screws as a complete job	unit	26	
1.3.17	Supply and install surface mounted wall hand dryer stainless steel cover with all the necessary fixing acessories and screws and connecting to power socket as a complte job	unit	125	
1.4	**HVAC SYSTEM**			
1.4.1	Supply and install black steel sch.40 with all the fittings ,elbowes,reducers,T, unions including copper to steel adapters where there is connection between copper and steel ,for pipes above ceiling, in walls, and under ground. Price include all the digging and holes and removing dirt's and sleeves through walls, concrete layer for pipes in ground and walls ,pipes suspended to ceiling has Hilti holders each 2.5 m ,pipes connection to existing steel heating pipes ,all holes by coring machine and through sleeves,price also include 13 mm vedioflex insullation wraped with 10 cm PVC tape			
1.4.1.1	4"	LM	31	
1.4.1.2	3"	LM	23	
1.4.1.3	2"	LM	35	
1.4.1.4	11/2"	LM	44	
1.4.1.5	11/4"	LM	163	
1.4.1.6	1"	LM	56	
1.4.1.7	3/4"	LM	121	
1.4.1.8	1/2""	LM	550	

1.4.2	Supply and install air cooled liquid chiller , complete with reinforced concrete base of 20 cm thick, spring type shock absorbers, neoprene pads between the base and the slab, and 50x50x5 mm angle around the base.The chiller shall be equipped with the followings:*high/low pressure switch *internal thermal and over current *compressor protection *internal thermal and over current motor protection *compressor short cycling delay relay *control circuit fuse *thermal expansion valve and filterdrier *control circuit fuse *chilled water tempurature control thermostat *automatic defrost control *anti freeze (water)thermostat *main disconnect switch * thermal board allows for field connection of operation indicator and safety pilot lights *price shall includes for electrical connections according to electrical drawing			
1.4.2.1	Approved manuf. As materials approval hydronic module of capacity 515 Kw	unit	1	
1.4.2.2	Approved manuf. As materials approval hydronic module of capacity 740 Kw	unit	1	
1.4.2.3	Approved manuf. As materials approval hydronic module of capacity 568Kw	unit	1	
1.4.3	Supply and install rectangular galvanized steel metal sheet manufactured in thickness according to ASHRAE, including 2" acoustic glass fiber insulation of density 48 kg/m3 connection to F/C unit.	sq m	1150	
1.4.4	Same as item 1.4.3 but not insulated duct for fresh air and cladding for the exposed duct work on roof. The price shall include for special sealant for the duct joints	sq m	1232	
1.4.5	Supply and install closed expansion tank 1400 l. as shown on drawings complete with all fittings such as automatic air vent,valves,unions,etc..Price includes pressure reducing valve, gate valve, T, union piping installation for water and expansion from main cold water pipe. Maximum pressure of tank is 6 atm.	unit	3	
1.4.8	Supply and instal flexible tubes 8" to connect between ceiling diffuser and main exhaust duct including all necessary clamps.	unit	600	

1.4.10	Supply and install air ceiling difusers and grilles , four-way type or two-way, complete with removable core,key opposed-blade volume damper and equalizing grid,suitable for mounting flush with false ceiling. The unit price shall include connection to duct,and all accessories and works required to complete the work as shown on the drawings such as all openings in walls, wooden frame, plastering, and as per the preambles, the specifications and supervision engineer's requirements			
1.4.10.1	12"x12"	unit	200	
1.4.10.3	9"x9"	unit	60	
1.4.10.4	6"x8"	unit	100	
1.4.11	6"x10"	unit	40	
1.4.11.1	10"x12"	unit	100	
1.4.12	Same as item 22.8 but for fresh air grills and grilles.			
1.4.12.1	size 6"x8"	unit	100	
1.4.14	Supply and install fan coil units including the followings:			
	* 3 rows heating coil.			
	* 1/2" copper tubes with aluminum fins.			
	* 3 speed fan.			
	* 3 way motorized valve.			
	* Flexible connection between fan coil and grille.			
	* Bronze shut-off valves.			
	* Air filter.			
	* Supply and return grilles.			
	* Contron Panel (wall mounted) with 3 speed switch.			
	* Thermostat- honeywell or Satchwell			
	* Manual summer/winter change over.			
	* Insulated drain pans.			
	* Connection to drain piping.			
	* Installation above the suspended ceiling all electrical connections and wiring from fan coil to thermostat including the supply of wires and conduits in addition to service door in false ceiling.			
	Ceiling Suspended model:			
1.4.14.1	PETRA.3KW	unit	31	
	PETRA.5KW	unit	15	
	PETRA.7KW	unit	24	
1.4.14.2	PETRA.12KW	unit	32	
1.4.15	Supply and install horizontal multi space mini central air handling units including:			
	Ceiling suspension installation.			

	½ HP fan motor.			
	Rigid construction of galvanized sheet metal.			
	½"fiber glass internal insulation.			
	½" copper tubes, 10 FPI aluminum fins heat exchanger.			
	Washable air filter.			
	Duct insulation with flexible duct connection adapter.			
	Disconnect valves.			
	Three way solenoid.			
1.4.15.1	MFCI- 10 / 3 7.8 kwatt cooling capacity	unit		
1.4.15.2	MFCI- 12 / 3 8.2 k watt cooling capacity	unit		
1.4.15.3	MFCI- 12 / 4 22 k watt cooling capacity	unit		
1.4.15.4	MFCI- 12 / 6 30 k watt cooling capacity	unit		
1.4.16	supply and install circulation vertical in- line (centrifugal) pumps 15m3/h&13m.h for heating .price includes supply and install all complete shut- off valve and pressure gauges on both side off pump and check valve connected of the discharge side and a strainer on the suction side. price to includes connected all wires and cables to complete job.	unit	27	
1.4.17	Supply and install Exhaust Fan 1000 cfm with 0.25 S.P. Ventilation of sturdy , galvanized steel parts and aluminum impeller, all fans are direct drive and all motors are I.P 65, 380V/50Hz, 850rpm. Price shall include all needed material for complete installation and shall be as per detailed drawings, including weather proof disconnect switch for service and maintenance.	unit	4	
1.4.18	Supply and install in line extract fan of capacity 120cfm for toilets . Price includes all upvc plastic pipes to roof with vent cap and external exhaust grille and all opening in coring machine,and all necessary works all as completen job and site engineer request	unit	45	
1.5	**FIRE FIGHTING**			
1.5.1	Supply and istall galvanized steel pipes to ASTM-A53 grade "A" schedule-40 for fire fighting system pipework, inside building. The unit price shall include valves, fittings, and all accessories and works required to complete the work and as per preambles, specifications, and the supervision of engineer's requirements. The unit price shall also include the connection to existing system in boiler room complete with cutting, taking branch, etc..			
1.5.1.1	6"	L. M	65	
1.5.1.2	4"	L. M	165	
1.5.1.3	11/2"	L. M	62	

1.5.2	Supply and install dry powder fire extinguishers , capacity 6 kg, complete with pressure gaug as per lahavot*. Location to be determined by architect	unit	103	
1.5.3	ditto but CO2 6 kg	unit	30	
1.5.3	Supply and install stainless steel gauge 22 fire cabinets size 80x80 cm.The cabinet shall be divided to two compartments; one for the hose reel and the other for the fire extinguisher and shall include the following:			
	Fir hose 3/ 4” in diameter, 25 meter long, light weight, made of red rubber with working pressure of 150 psi.			
	Hose reel of the swinging type, up to 180 degrees full swing complete with guide arm.			
	Chrome plated 3/ 4” in diameter nozzle capable of complete shut-off			
	Gate valve 1” in diameter.			
	Fire hose 2” in diameter, 15 meter long, light weight, made of linen.			
	Chrome plated 2” in diameter nozzle capable of complete shut-off.			
	Angle valve 2” in diameter of best quality.			
	Hose adapter 2” in diameter.			
	3 Kgs. Chemical fire extinguisher with spray hose and nozzle.	unit	30	
1.6	**Medical gas works**			
1.6.1	**MEDICAL AIR PLANT**			
	Supply, install, test & commission modular medical air plant, complying fully to the requirements of both C11 and HTM0201. Using at least three number, directly-driven, oil lubricated rotary-vane air compressors, duplex desiccant dryers & filter assembly & steel receiver vessel(s). Suitable for 3 phase 50Hz electrical supply.			
1.6.2	**Retractable Pendent**			
	Intended to distribute medical gases AGSS			
	and electrical servicto the Operating table.			
	Ceiling mounted Height adjustable columns Complete			
	with first fix plate and ceiling shroud			
	The height of undesired of pendent can be adjusted			
	300mm predetermined rang.			
	A maximum of 9 medical gas and AGSS terminal unit	unit	194	
1.6.3	**Ceiling pendent**			
	Multi movement type with			
	Motorized ARM for anesthesia and			

	Two Oxygen outlets.	unit	45	
	Two VAC outlets	unit	16	
	Two Air outlets.	unit	18	
	Price includes all type of Valves and Fixation plates.			
1.6.4	**ZONE SERVICE UNITS**			
	Supply, install, test & commission Emergency isolation valve complying to HTM2022 and C11, housed within a lockable box with 'break glass' safety feature emergency access, including NIST connection ports.	unit	50	
	ZSU Assembly -- All Gases			
1.6.6	**COPPER PIPE LINE**			
1.6.6.1	N2OPipework c/w fittings & brackets - 22mm	L. M	220	
1.6.6.2	A4&O2 Pipework c/w fittings & brackets - 22mm	L. M	320	
1.6.6.3	ASSG Pipework c/w fittings & brackets - 28mm	L. M	220	
1.6.6.4	vac Pipework c/w fittings & brackets - 42mm	L. M	220	
1.6.7	Supply abd install combined local alarm with non-breakable front panel including:			
	* Shut-off valves			
	* pressure gauges			
	* Polycarbonate box front mounted on aluminum profile.			
	the system must be german original manuf.			
	greggesen- or draiger			
1.6.7	O2 cylinders	unit	27	
	N2O cylinders	unit	3	
	pump for medical air with total amount of 42m3/h	unit	3	
	pump for AGSS gas with total amount of 230m3/h	unit	3	
	medical air compressor with total amount of155m3/h	unit	3	

APPENDIX (A)

Table(1)

LE 9-4 Cooling load temperature differences (CLTD) for various construction groups of sunlit walls, °C.

th ude ll ng	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Hour of Max. CLTD	Min. CLTD	Max. CLTD	Difference CLTD
	Group A Walls																											
	8	8	8	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	8	8	2	6	8	2
E	11	11	10	10	10	9	9	9	8	8	8	9	9	9	9	10	10	10	11	11	11	11	11	11	22	8	11	3
.	14	13	13	13	12	12	11	11	10	10	10	11	11	12	12	13	13	13	14	14	14	14	14	14	22	10	14	4
E	13	13	13	12	12	11	11	10	10	10	10	10	10	11	11	12	12	13	13	13	13	13	13	13	22	10	13	3
	11	11	11	11	10	10	9	9	9	8	8	8	8	8	8	8	9	9	10	10	11	11	11	11	23	8	11	3
V	14	14	14	14	13	13	12	12	11	11	10	10	10	9	9	10	10	10	11	12	13	13	14	14	24	9	14	5
r	15	15	15	14	14	14	13	13	12	12	11	11	10	10	10	10	10	11	11	12	13	14	14	15	1	10	15	5
N	12	12	11	11	11	11	10	10	10	9	9	8	8	8	8	8	8	8	9	9	10	11	11	11	1	8	12	4
	Group B Walls																											
I	8	8	8	7	7	6	6	6	5	5	5	5	5	5	5	6	6	7	7	8	8	8	8	8	24	5	8	3
E	11	10	10	9	9	8	7	7	7	7	8	8	9	9	10	10	11	11	11	12	12	12	11	11	21	7	12	5
(	13	13	12	11	10	10	9	8	8	9	9	10	12	13	13	14	14	15	15	15	15	15	14	14	20	8	15	7
E	13	12	12	11	10	10	9	8	8	8	8	9	10	11	12	13	14	14	14	14	14	14	14	14	21	8	14	6
;	12	11	11	10	9	9	8	7	7	6	6	6	6	7	8	9	10	11	11	12	12	12	12	12	23	6	12	6
N	15	15	14	13	13	12	11	10	9	9	8	8	7	7	8	9	10	11	13	14	15	15	16	16	24	7	16	9
V	16	16	15	14	14	13	12	11	10	9	9	8	8	8	8	8	9	11	12	14	15	16	16	17	24	8	17	9
W	13	12	12	11	11	10	9	9	8	7	7	7	6	6	7	7	8	8	9	11	12	13	13	13	24	6	13	7
	Group C Walls																											
(	9	8	7	7	6	5	5	4	4	4	4	4	5	5	6	6	7	8	9	9	9	10	9	9	22	4	10	6
E	10	10	9	8	7	6	6	6	6	7	8	10	10	11	12	12	12	13	13	13	13	12	12	11	20	6	13	7
3	13	12	11	10	9	8	7	7	8	9	11	13	14	15	16	16	17	17	16	16	16	15	14	13	18	7	17	10
E	13	12	11	10	9	8	7	6	7	7	9	10	12	14	15	16	16	16	16	16	16	15	14	13	19	6	16	10
;	12	11	10	9	8	7	6	6	5	5	5	5	6	8	9	11	12	13	14	14	14	14	13	12	20	5	14	9
W	16	15	14	12	11	10	9	8	7	7	6	6	6	7	8	10	12	14	16	18	18	18	13	17	22	6	18	12
V	17	16	15	14	13	11	10	9	8	7	7	7	7	7	8	9	11	13	16	18	19	20	19	18	22	7	20	13

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

Table(2)

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

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

Table(3)

TABLE 9-7 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

Table(4)

TABLE 9-8 Shading coefficient (SC) for glass windows without interior shading.[1]

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

Table(5)

TABLE 9–10 Cooling load factors (CLF) for glass windows without interior shading, north latitudes.

Glass Facing	Building Construction	Solar Time, h 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
N 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
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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
SSW	L	0.10	0.08	0.07	0.06	0.05	0.06	0.09	0.11	0.15	0.19	0.27	0.39	0.52	0.62	0.67	0.65	0.58
	M	0.14	0.12	0.11	0.09	0.08	0.09	0.11	0.13	0.15	0.18	0.25	0.35	0.46	0.55	0.59	0.59	0.53
	H	0.15	0.14	0.13	0.12	0.11	0.12	0.14	0.16	0.18	0.21	0.27	0.37	0.46	0.53	0.57	0.55	0.49
	L	0.12	0.10	0.08	0.06	0.05	0.06	0.08	0.10	0.12	0.14	0.16	0.24	0.36	0.49	0.60	0.66	0.66
SW	L	0.12	0.10	0.08	0.06	0.05	0.06	0.08	0.10	0.12	0.14	0.16	0.24	0.36	0.49	0.60	0.66	0.66
	M	0.15	0.14	0.12	0.10	0.09	0.09	0.10	0.12	0.13	0.15	0.17	0.23	0.33	0.44	0.53	0.58	0.59
	H	0.15	0.14	0.13	0.12	0.11	0.12	0.13	0.14	0.16	0.17	0.19	0.25	0.34	0.44	0.52	0.56	0.56
WSW	L	0.12	0.10	0.08	0.07	0.05	0.06	0.07	0.09	0.10	0.12	0.13	0.17	0.26	0.40	0.52	0.62	0.66
	M	0.15	0.13	0.12	0.10	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.17	0.24	0.35	0.46	0.54	0.58
	H	0.15	0.14	0.13	0.12	0.11	0.11	0.12	0.13	0.14	0.15	0.16	0.19	0.26	0.36	0.46	0.53	0.56

Table(6)

TABLE 9–13 Heat gain rate from miscellaneous appliances, W.[a]

Appliances	Without Hood			With Hood
	Sensible	Latent	Total	All Sensible
Hair dryers (Blower type)	675	120	795	—
Hair dryers (Helmet type)	550	100	650	—
Coffee brewer (electrical)	225	65	290	95
Coffee brewer (gas)	490	210	700	415
Water heater	1,130	335	1,465	—
Coffee urn (electrical)	1,075	350	1,425	440
Coffee urn (gas)	1,460	625	2,085	415
Deep fat fryer (electrical)	820	1,930	2,750	730
Deep fat fryer (gas)	2,080	2,080	4,160	830
Toaster	1,055	705	1,760	440
Domestic gas oven	2,430	1200	3,630	—
Roasting oven	500	320	820	—
Food warmer (gas)	1,550	400	1,950	400
Egg boiler	335	220	555	—
Frying griddle	13,600	7,200	20,800	4,150
Hotplate	1,550	1,060	2,610	780
Neon sign, per meter length	56	—	56	—
Sterilizer	190	350	540	—
Laboratory burner	470	120	590	—
Small copy machine	1,760	—	1,760	—
Large copy machine	3,515	—	3,515	—
Motors:				
400–2,000 W	1,100	—	1,100	—
2,000–15,000 W	2,430	—	2,430	—

Table(7)

TABLE 9-14 Cooling load factor (CLF)$_L$, for lights.[a]

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(8)

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

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

(a) Adjusted heat dissipation is based on the percentage of men, women and children for the application.

Table(9)

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

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

Table(10)

TABLE 6–3 Values of the factor S_1 of Eq. (6–7).

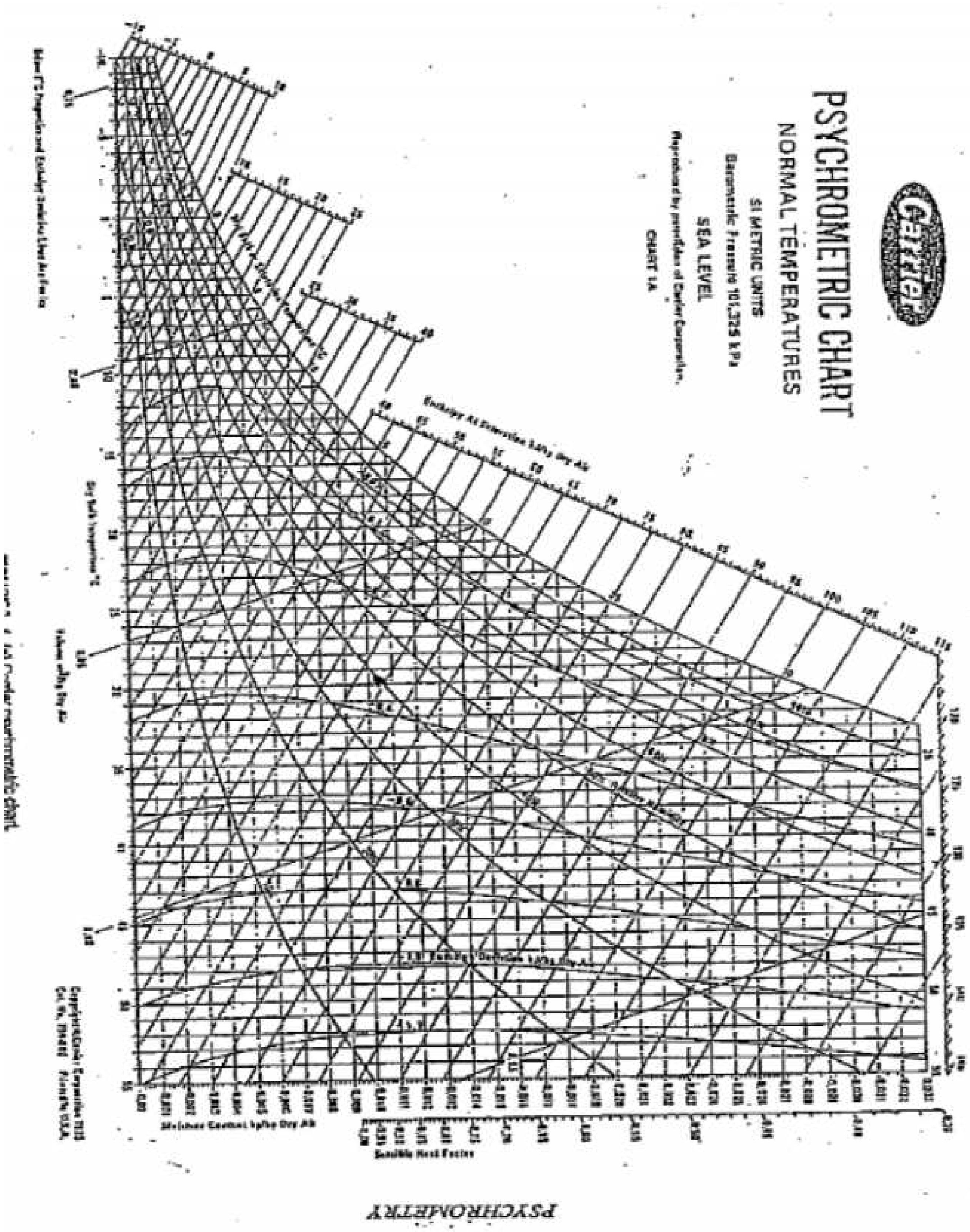
№	Topography of Location	Value of S_1
1	Protected locations by hills or buildings (wind speed = 0.5 m/s)	0.9
2	Unprotected locations such as sea shores, hill tops, etc.	1.1
3	Locations other than that listed in item (1) or (2) of this table.	1.0

Table(11)

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

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

Figure (1)


PSYCHROMETRIC CHART
NORMAL TEMPERATURES
SI METRIC UNITS
Barometric Pressure 101.325 kPa
SEA LEVEL
CHART 1A

APPENDIX (B)

Table(1)

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(2)

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(3)

Table 9.1 Minimum Pressure Required by Typical Plumbing Fixtures

Fixture Type	*Minimum Pressure, psi*
Sink and tub faucets	8
Shower	8
Water closet—tank flush	8
Flush valve—urinal	15
Flush valve—siphon jet bowl	
floor-mounted	15
wall-mounted	20
Flush valve—blowout bowl	
floor-mounted	20
wall-mounted	25
Garden hose	
5/8-in. sill cock	15
3/4-in. sill cock	30
Drinking fountain	15

Source. *EPA Manual of Individual Water Supply System,* *1975* and manufacturers' data.

Figure (1)

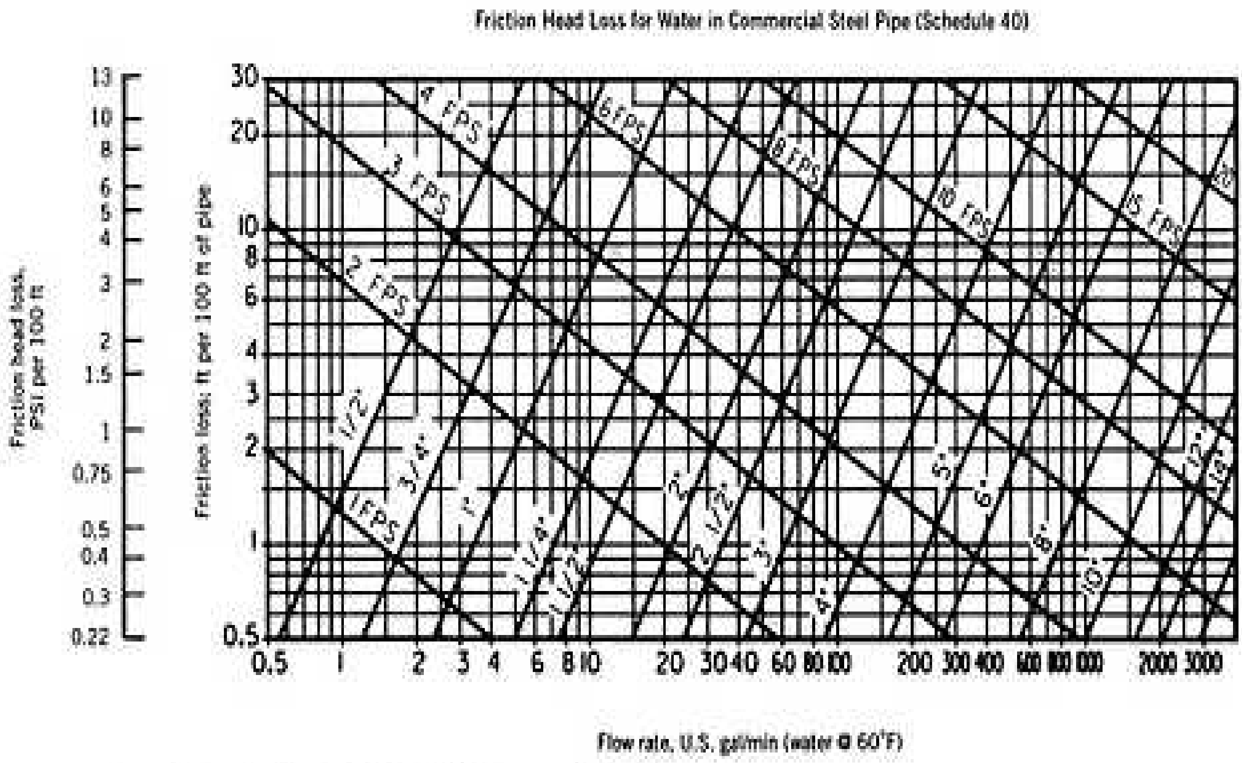


Figure 9.5 Chart of friction head loss in Schedule 40 black iron or steel pipe, for water at 60°F, in feet of water and psi per 100 ft of equivalent pipe length. Pipe sizes are nominal. (Reprinted by permission of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, Georgia, from the 1993 *ASHRAE Handbook—Fundamentals*.)

Table (4)

TABLE 10–1 Recommended and maximum air velocities used in warm air heating systems[2].

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

Table (5)

up to 150 CFM	8*12 inch
From 151 - 220 CFM	6*16 or 8*12 inch
From 221-250 CFM	8*16 inch
From 251-324 CFM	10*12 or 8*18 or 6*20 inch
From 325-440 CFM	10*16 or 8*20 inch
From 441-550 CFM	6*30 or 10*24 or 10*20 inch
From 551-600 CFM	8*30 or 12*20 inch
From 601- 750 CFM	8*36 or 12*24 or 14*20 inch
From 626-800 CFM	10*30 inch
From 751-800 CFM	10*30 or 14*24 inch
From 801-1000 CFM	10*36 or 12*30 or 14*24 inch
From 1001-1150 CFM	12*36 or 14*30 inch
From 1151-1400 CFM	14*36 or 16*30 inch
From 1401-2000 CFM	18*36 inch

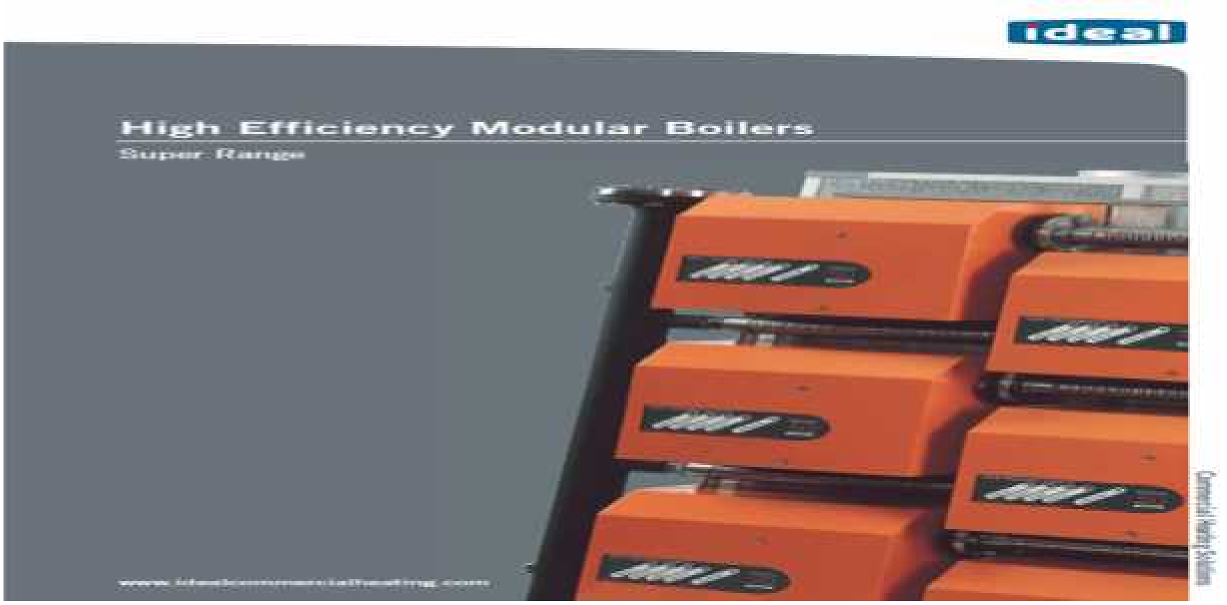
Catalogue

1) Catalogue of chiller

TECHNICAL DATA 30XW / 30XWH

Standard range		452	552	602	652	702	802	852	1002	1052	1152	1252	1352	1452	1552	1652	1702
Nominal cooling capacity*	kW	476	535	548	658	721	780	839	1016	1060	1155	1232	1345	1475	1566	1638	1704
Energy efficiency ratio (EER)	kW/kW	5.6	5.6	5.5	5.6	5.6	5.6	5.6	5.6	5.4	5.8	5.9	5.8	5.8	5.4	5.6	5.7
EUROVENT class, cooling		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
European Seasonal Energy Efficiency Ratio (ESEER)		6.6	6.4	6.7	6.4	6.3	6.3	6.2	6.7	7.4	7.5	7.2	7.1	7.0	6.6	6.8	6.8
Heating capacity*	kW	506	580	616	-	-	-	-	1 081	1 127	1 284	-	-	-	-	-	-
Coefficient of performance (COP)	kW/kW	4.6	4.7	4.8	-	-	-	-	4.6	4.5	4.9	-	-	-	-	-	-
EUROVENT class, heating		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Refrigerant		← R134a →															
Nb refrigerant circuit/Compressor		1/1	1/1	1/1	1/1	1/1	1/1	1/1	2/2	2/2	2/2	2/2	2/2	2/2	2/2	2/2	2/2
Length	mm	2742	2742	2742	3048	3048	3048	2768	4085	4085	4093	4796	4796	4796	4809	4872	4872
Width	mm	936	936	936	1038	1038	1038	1050	1036	1036	1036	1153	1153	1153	1153	1683	1683
Height	mm	1693	1693	1693	1900	1900	1900	1950	1870	1870	1926	2109	2100	2100	2100	1798	1798
Operating weight	kg	2810	2850	2890	-	-	-	-	5550	5590	6100	-	-	-	-	-	-
Sound power level Lw	db(A)	99	99	99	-	-	-	-	102	102	102	-	-	-	-	-	-

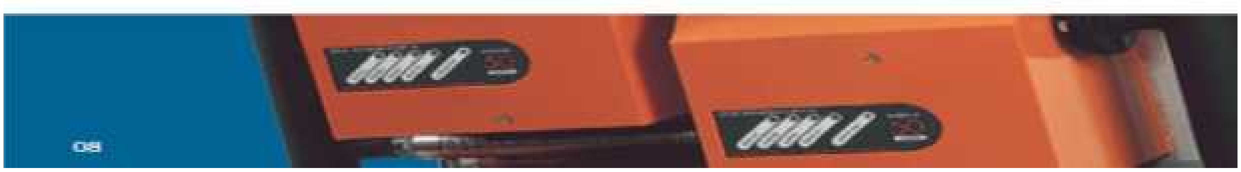
2) Catalogue of boiler



General data 350V - 600H

Model		350V	400V	450V	500V	550V	600V	450VA	500H	550H	600H
No. of Modules		7	8	9	10	11	12	9	10	11	12
Boiler Input	kW	411.6	470.2	529.2	588.0	646.8	705.6	529.2	588.0	646.8	705.6
	Btu/h	1404	1605	1805	2006	2207	2407	1806	2006	2207	2407
Boiler Output	kW	350	400	450	500	550	600	450	500	550	600
	Btu/h	1194	1365	1535	1706	1877	2047	1535	1706	1877	2047
Gas Rate	m^3/h	38.6	44.1	49.7	55.2	60.7	66.2	49.7	55.2	60.2	60.7
	ft^3/h	1363	1557	1752	1947	2143	2336	1752	1947	2143	2336
Approx Flue Gas Volume 9.0% CO_2 120°C	m^3/s	0.191	0.219	0.246	0.273	0.301	0.328	0.246	0.273	0.301	0.328
at 120°C (248°F) 9.0% CO_2 248°F	ft^3/m	406	464	522	580	638	696	522	580	638	696
Hydraulic Resistance	kN/m^2	12.5									
	in.wg	50									
Power Consumption	watts	1050	1200	1350	1500	1650	1800	1350	1500	1650	1800
Flow Tappings & Return Tappings	mm	100	100	125	125	125	125	125	125	125	125
	in	4	4	5	5	5	5	5	5	5	5
Maximum Static Water Head	m	61									
	ft	200									
Required Water Flow Rate +/-10%	l/s	7.49	8.50	9.63	10.70	11.77	12.84	9.63	10.70	11.77	12.84
	gpm	98.7	112.8	126.9	141.0	155.1	169.2	126.9	141.0	155.1	169.2
Gas Inlet Connection	Rc	2									
	in. BSP	2									
Minimum Dynamic Gas Pressure Required at the Boiler Inlet for the Rated Input	mbar (gauge)	15.0									
	in.wg	6.0									
Electricity Supply		230V – 50Hz single phase									
Nominal Flue Size (to BS 835)	mm	350	350	400	400	450	450	400	400	450	450
	in	14	14	16	16	18	18	16	16	18	18
Diverter Outlet Socket Internal Diameter	mm	400	400	450	450	501	501	450	450	501	501
	in	15¾	15¾	17¾	17¾	19¾	19¾	17¾	17¾	19¾	19¾
Weight Modules	kg	371	424	477	530	583	636	477	530	583	636
	lb	818	935	1052	1168	1282	1402	1052	1168	1282	1402
Weight Casing / Insulation	kg	134	126	197	190	182	175	197	190	182	175
	lb	295	278	435	418	402	386	435	418	402	386
Weight Gas / Water Headers	kg	260	263	311	313	315	318	298	300	302	304
	lb	573	580	686	690	694	701	657	661	665	670
Water Content	l	63.3	68.1	97.6	102.4	107.2	112.0	92.6	97.4	102.2	107.0
	gal	14.1	15.1	21.6	22.7	23.9	24.9	20.5	21.6	22.7	23.7
Seasonal Efficiency	%	84.96									

Note: To obtain gas consumption in l/s, divide gross heat input (kW) by a calorific value of 37.8 (MJ/m³).
Note: Flange sizes to BS 4504: Part 1: Table 16.



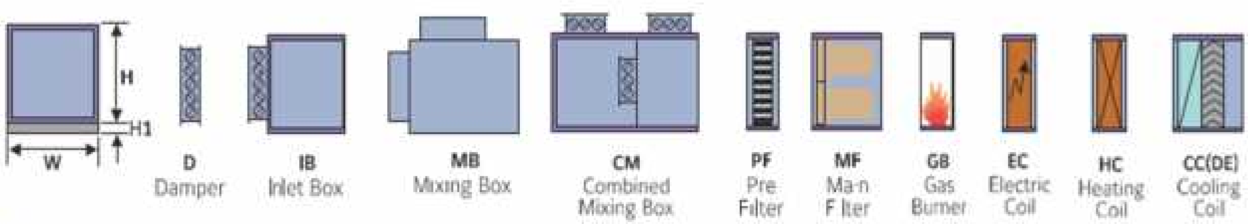
3) Catalogue of AHU

YMA

Custom Air Handling Units

A complete range from 0.25 to 50 m³/s

YMA "Quick Size" Guide



YMA Size	Duty (m³/s)	Cross Section (mm)			D 1/1	D 1/2	IB (1)		MB		CM (1a)		PF		MF		GB		EC		HC
		H	H1	W	kg	kg	l	kg	l	kg	l	kg	l	kg	l	kg	l	kg	l	kg	l
610/750	0.25-0.44	610	100	750	9	5	350	40	500	43	1000	71	350	34	800	66	N/A	#	450	77	350
690/900	0.42-0.74	690	100	900	12	6	350	49	500	49	1000	82	350	39	800	76	N/A	#	450	84	350
690/1050	0.55-0.95	690	100	1050	15	8	350	57	500	56	1000	93	350	44	800	86	N/A	#	450	93	350
970/950	0.79-1.39	970	100	950	18	9	350	61	600	66	1200	111	350	47	800	86	on duty & application. e for verification.		450	125	350
970/1150	1.08-1.90	970	100	1150	22	11	350	70	600	75	1200	124	350	52	800	96			450	153	350
970/1350	1.37-2.40	970	100	1350	26	13	350	80	600	81	1200	138	350	58	800	109			450	187	350
1210/1250	1.63-2.86	1210	100	1250	27	14	350	82	800	103	1600	181	350	60	800	110			450	181	350
1210/1500	2.11-3.70	1210	100	1500	34	17	350	94	800	113	1600	198	350	66	800	124			450	209	350
1210/1700	2.50-4.37	1210	100	1700	39	19	350	104	800	123	1600	215	350	72	800	136			450	237	350
1210/2000	3.07-5.38	1210	100	2000	43	21	350	114	800	132	1600	232	350	78	800	145			450	265	350
1530/1500	2.77-4.85	1530	100	1500	39	20	350	106	1000	150	2000	268	350	72	800	139			450	320	350
1530/1750	3.40-5.95	1530	100	1750	48	24	350	120	1000	162	2000	289	350	79	800	152			450	343	350
1530/2000	4.03-7.06	1530	100	2000	54	27	350	131	1000	173	2000	310	350	87	800	171			450	356	350
1530/2200	4.54-7.94	1530	100	2200	59	29	350	142	1000	185	2000	331	350	93	800	180			450	369	350

4) Catalogue of fan coil unit

Cooling 3 - Rows

Aluminium Mesh Filter				Entering Wet Bulb Temperature (°F)											
				63				65				67			
MODEL	Fan speed	AFR	DBT	Total Cap	Sensible CAP	GPM	WPD	Total Cap	Sensible CAP	GPM	WPD	Total Cap	Sensible CAP	GPM	WPD
DC 6	H	682	76	20022	15017	4.00	6.51	23826	14959	4.77	8.99	27810	14850	5.56	11.99
			78	20335	16349	4.07	6.70	24000	16224	4.80	9.11	28069	16168	5.61	12.20
			80	20497	17628	4.10	6.80	24318	17557	4.86	9.34	28298	17460	5.66	12.39
			85	20920	20795	4.18	7.06	24641	20698	4.93	9.57	28718	20648	5.74	12.73
	M	561	76	17767	12934	3.55	5.21	20856	12847	4.17	7.02	24166	12784	4.83	9.23
			78	17963	14011	3.59	5.32	21077	13932	4.22	7.16	24444	13884	4.89	9.43
			80	18164	15112	3.63	5.43	21298	15037	4.26	7.30	24607	14961	4.92	9.55
			85	18636	17797	3.73	5.69	21743	17721	4.35	7.58	25072	17651	5.01	9.89
	L	457	76	15422	10963	3.08	4.01	18030	10926	3.61	5.33	20758	10877	4.15	6.96
			78	15638	11885	3.13	4.11	18211	11819	3.64	5.46	21065	11817	4.21	7.15
			80	15862	12801	3.17	4.22	18479	12750	3.70	5.60	21259	12713	4.25	7.27
			85	16350	15058	3.27	4.47	18960	15016	3.79	5.88	21710	14958	4.34	7.56
DC 8	H	875	76	23451	18221	4.69	8.73	28232	18125	5.65	12.33	33325	18029	6.67	16.81
			78	23564	19794	4.71	8.81	28341	19669	5.67	12.42	33416	19582	6.68	16.90
			80	23802	21398	4.76	8.97	28424	21232	5.69	12.49	33481	21127	6.70	16.96
			85	25215	25215	5.04	9.99	28795	25195	5.76	12.80	33897	25084	6.78	17.35
	M	681	76	20106	15039	4.02	6.56	23802	14924	4.76	8.97	27817	14854	5.56	12.00
			78	20319	16337	4.06	6.69	24116	16254	4.82	9.19	28054	16159	5.61	12.19
			80	20483	17595	4.10	6.79	24279	17529	4.86	9.31	28192	17394	5.64	12.30
			85	20800	20738	4.16	6.98	24582	20673	4.92	9.53	28703	20637	5.74	12.72
	L	561	76	17752	12941	3.55	5.20	20855	12846	4.17	7.02	24196	12800	4.84	9.25
			78	17937	14009	3.59	5.30	21105	13950	4.22	7.17	24432	13878	4.89	9.42
			80	18102	15079	3.62	5.39	21282	15025	4.26	7.29	24664	14971	4.93	9.59
			85	18619	17799	3.72	5.68	21823	17743	4.37	7.64	25174	17698	5.04	9.96
DC 10	H	1048	76	26191	20874	5.24	10.72	31750	20733	6.35	15.36	37715	20630	7.54	21.19
			78	26264	22692	5.25	10.78	31829	22566	6.37	15.43	37795	22450	7.56	21.27
			80	26315	24526	5.26	10.82	31873	24351	6.38	15.47	37848	24260	7.57	21.33
			85	29023	29023	5.81	12.99	32174	28957	6.44	15.74	37902	28768	7.58	21.39
	M	875	76	23476	18217	4.70	8.75	28188	18097	5.64	12.30	33196	17992	6.64	16.69
			78	23598	19799	4.72	8.83	28278	19653	5.66	12.37	33442	19597	6.69	16.92
			80	23697	21351	4.74	8.90	28545	21295	5.71	12.59	33515	21148	6.70	16.99
			85	25267	25267	5.05	10.03	28794	25195	5.76	12.80	33902	25088	6.78	17.36
	L	681	76	20123	15652	4.03	6.57	23844	14950	4.77	9.00	27889	14893	5.58	12.06
			78	20305	16323	4.06	6.68	24112	16251	4.82	9.19	28030	16145	5.61	12.17
			80	20459	17595	4.09	6.77	24276	17328	4.86	9.31	28240	17424	5.65	12.34
			85	20898	20773	4.18	7.04	24594	20659	4.92	9.54	28565	20567	5.71	12.61
DC 12	H	1223	76	33463	25900	6.69	3.82	39986	25671	8.00	5.34	47160	25561	9.43	7.29
			78	33703	28142	6.74	3.87	40210	27905	8.04	5.40	47372	27807	9.47	7.35
			80	33899	30374	6.78	3.92	40750	30277	8.15	5.54	47719	30063	9.54	7.45
			85	36042	36042	7.21	4.39	41513	35952	8.30	5.73	48550	35781	9.71	7.70
	M	1056	76	30489	23111	6.10	3.21	36411	22975	7.28	4.48	42402	22770	8.48	5.97
			78	30750	25092	6.15	3.26	36725	25010	7.35	4.55	42854	24855	8.57	6.09
			80	31251	27157	6.25	3.36	36985	26962	7.40	4.61	43332	26909	8.67	6.21
			85	32141	32141	6.43	3.54	37862	32031	7.57	4.82	43864	31801	8.77	6.36
	L	863	76	26889	19764	5.38	2.54	31611	19399	6.32	3.43	36741	19510	7.35	4.56
			78	27226	21454	5.45	2.60	32040	21307	6.41	3.52	37167	21222	7.43	4.66
			80	27522	23118	5.50	2.65	32391	22998	6.48	3.60	37531	22931	7.51	4.74
			85	28431	27351	5.69	2.83	33523	27258	6.67	3.79	38390	27104	7.68	4.95

5) Catalogue of cooled water pump

GRUNDFOS

Company name:
Created by:
Phone:
Date:

Position	Qty.	Description
	1	HYDRO MULTI-E 2 CME10-03

Note! Product picture may differ from actual product

Product No.: 98494961

GRUNDFOS Hydro Multi-E booster sets are designed for the transfer and pressure boosting of clean water in waterworks, blocks of flats, hotels, industry, hospitals, schools, etc.
GRUNDFOS Hydro Multi-E booster set consists of 2 to 3 CME pumps coupled in parallel and mounted on a common base frame provided with all the necessary fittings.

Hydro Multi-E is mounted on a common base frame made of electro galvanized steel.
On the suction side are fitted a suction manifold of electro galvanized steel, a pressure switch and an isolating valve. On the discharge side of the pumps are fitted a non-return valve, an isolating valve, a pressure gauge, a pressure transmitter mounted on a drainable valve, a diaphragm tank and a of electro galvanized discharge manifold

The Hydro Multi-E is fitted with an on/off-switch for the supply voltage.

The Hydro Multi-E is designed for maintaining a constant pressure regardless of flow changes and fluctuation.

The internal PI-controller regulates the number of running pumps and the speed of the pumps according to the required flow.

The system can be operated directly on the panel of any of the pumps or via Grundfos GO (available as accessory)

When delivered, the GRUNDFOS Hydro Multi-E booster set is factory tested and ready for operation.

Liquid:

Pumped liquid:	Drinking water
Liquid temperature range:	5 .. 50 °C
Liquid temp:	20 °C
Density:	998.2 kg/m³
Kinematic viscosity:	1 mm2/s

Technical:

Actual calculated flow:	76 US GPM
Resulting head of the pump:	41 m

Materials:

Pump housing:	Cast iron

Installation:

Maximum operating pressure:	10 bar
Maximum inlet pressure:	PN10 bar

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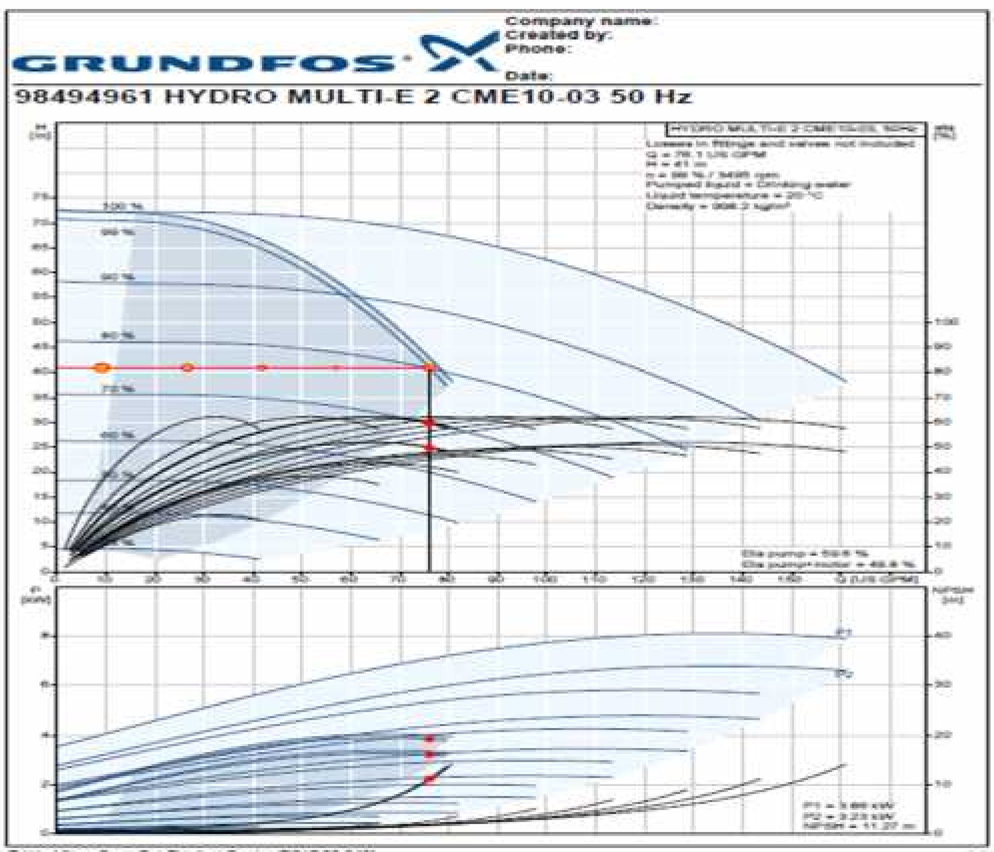
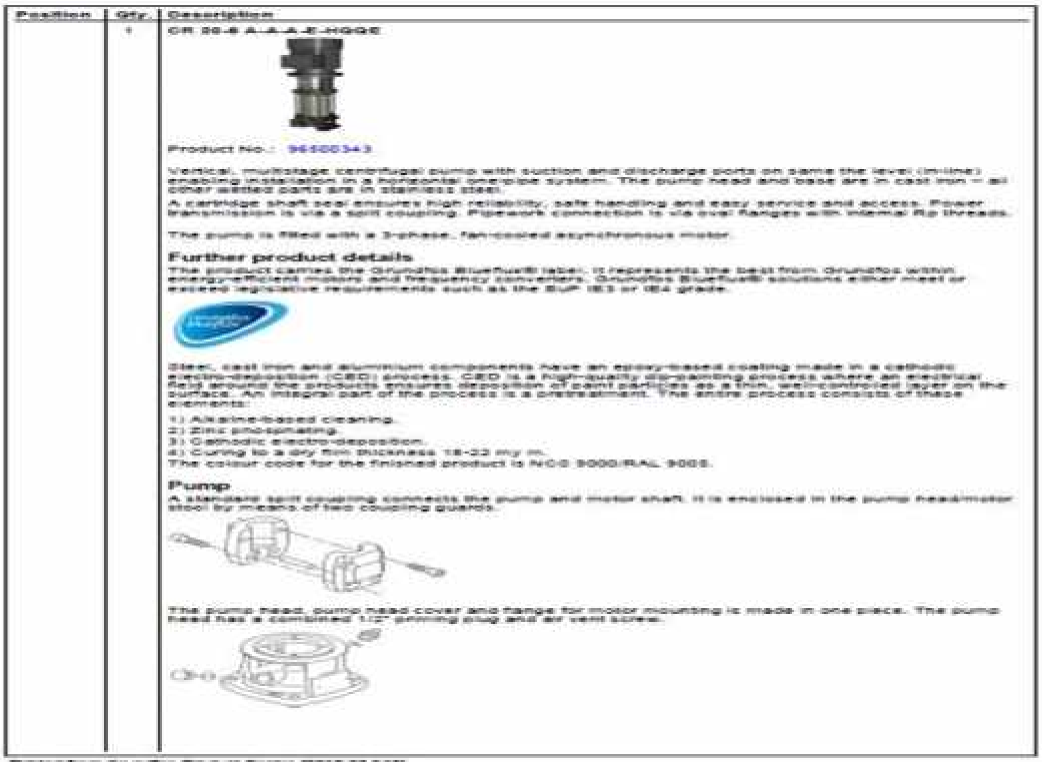


6) Catalogue of hot water pump



Position	Qty.	Description
	1	CR 20-6 A-A-A-E-HQQE

Product No.: 96500343

Vertical, multistage centrifugal pump with suction and discharge ports on same the level (in-line) enabling installation in a horizontal one-pipe system. The pump head and base are in cast iron – all other wetted parts are in stainless steel.

A cartridge shaft seal ensures high reliability, safe handling and easy service and access. Power transmission is via a split coupling. Pipework connection is via oval flanges with internal Rp threads.

The pump is fitted with a 3-phase, fan-cooled asynchronous motor.

Further product details

The product carries the Grundfos Blueflux® label. It represents the best from Grundfos within energy-efficient motors and frequency converters. Grundfos Blueflux® solutions either meet or exceed legislative requirements such as the EuP IE3 or IE4 grade.

Steel, cast iron and aluminium components have an epoxy-based coating made in a cathodic electro-deposition (CED) process. CED is a high-quality dip-painting process where an electrical field around the products ensures deposition of paint particles as a thin, well-controlled layer on the surface. An integral part of the process is a pretreatment. The entire process consists of these elements:

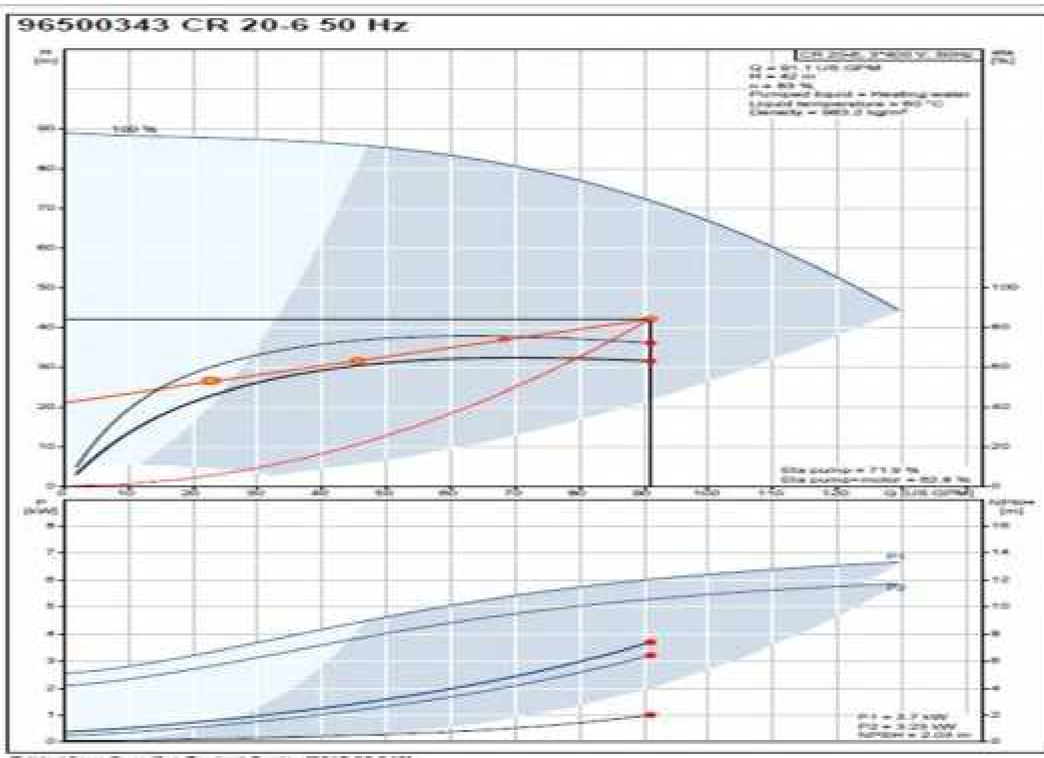
1) Alkaline-based cleaning.
2) Zinc phosphating.
3) Cathodic electro-deposition.
4) Curing to a dry film thickness 18-22 my m.
The colour code for the finished product is NCS 9000/RAL 9005.

Pump

A standard split coupling connects the pump and motor shaft. It is enclosed in the pump head/motor stool by means of two coupling guards.

The pump head, pump head cover and flange for motor mounting is made in one piece. The pump head has a combined 1/2" priming plug and air vent screw.

Printed from Grundfos Product Centre [2016.03.043]



Printed from Grundfos Product Centre [2016.03.043]

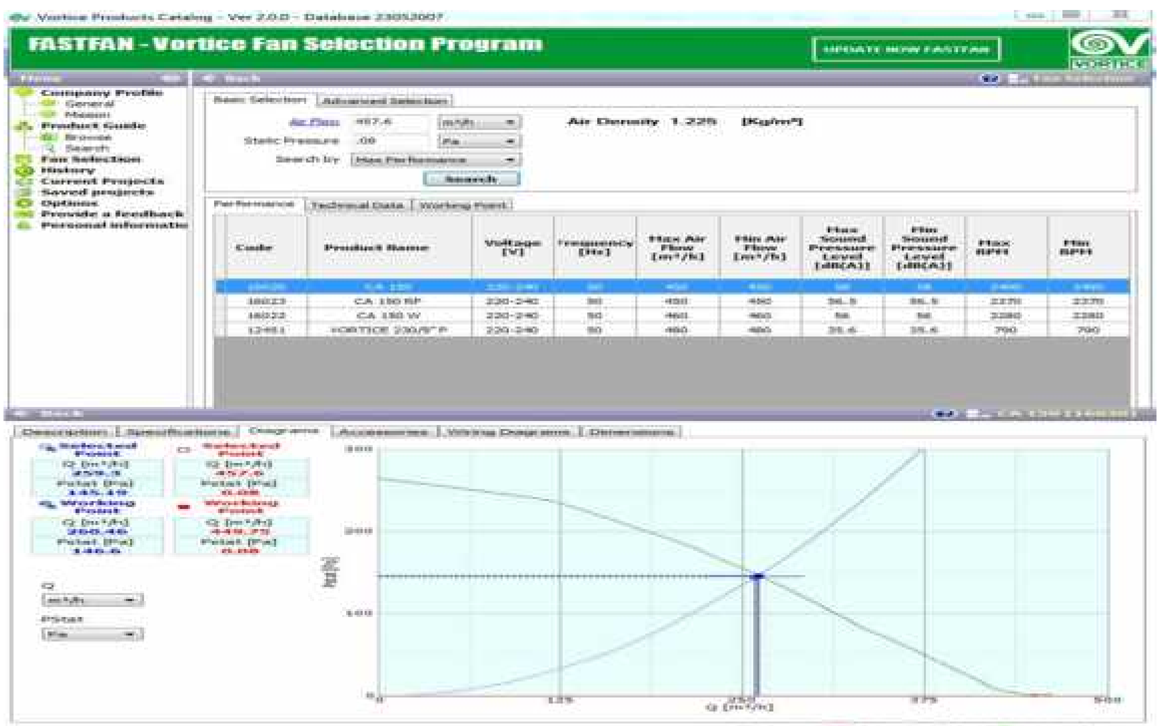
7) Catalogue of ventilation fan

Description

- Suitable for commercial and industrial applications: kitchens, bathrooms, offices, laboratories, factories, stores, dry cleaners, shops, restaurants, bars, theatres, dance halls, etc.
- Ball-bearing-mounted motor with external rotor motor and hand-operated resettable thermal cut out.
- TÜV certified sound pressure level.
- IMQ certified performances.
- IPX 4 protected.
- Complies with the CEI EN 60335-2-80 standard.
- Turbine fan balanced directly on the motor.
- Motor-holder made of steel and paint-finished with furnace-hammered epoxy powder for perfect weather protection.
- Speed can be adjusted using an optional controller.
- Complete with mounting bracket.
- Operating temperatures from –25° to +50/55° C.

Specifications

Parameter	Value
Sound Pressure Level Min (3m)	58
Sound Pressure Level Max (3m)	58
Tension (V)	220-240
Rpm Max	2490
IP	X4
Insulation Class	Cl. I°
Max Temperature (°C)	55
Min Delivery (m³/h)	450
Max Delivery (m³/h)	450
Weight (Kg)	3.4
Max Absorbed Current (A)	0.4
Max Absorbed Power (W)	85
Min Absorbed Power (W)	85



8) Catalogue of ciller pump


GRUNDFOS

Company name:
Created by:
Phone:
Date:

Position	Qty.	Description
	1	NB 65-160/177 D-F-A-BAQE

Note! Product picture may differ from actual product

Product No.: On request

Non-self priming, single-stage centrifugal pump according to EN 1092-2.

The pump is for the pumping of thin, clean or slightly contaminated liquids without abrasive or long-fibred solids.

The pump is directly coupled with an IEC-flanged 3-phase AC motor.

The impeller is hydraulically as well as dynamically balanced.

The pump has the following characteristics:
- flange dimensions according to EN 1092-2,
- Cast iron volute pump housing,
- stainless steel shaft and Cast iron impeller and bronze wear rings,
- unbalanced mechanical shaft seal according to EN 12756.

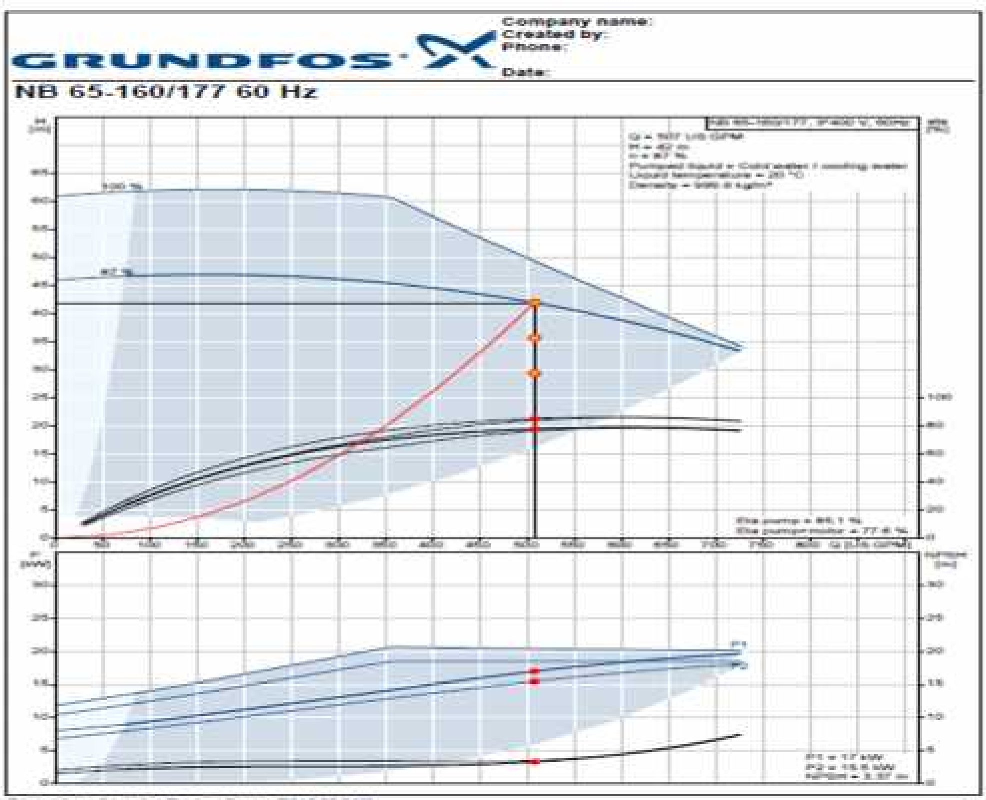
Liquid:

Pumped liquid:	Cold water / cooling water
Liquid temperature range:	0 .. 120 °C
Liquid temp:	20 °C
Density:	998.2 kg/m³
Kinematic viscosity:	1 mm2/s

Technical:

Speed for pump data:	3520 rpm
Actual calculated flow:	507 US GPM
Resulting head of the pump:	42 m
Actual impeller diameter:	177 mm
Impeller nom:	160 mm
Impeller max:	177 mm
Shaft seal:	BAQE
Secondary shaft seal:	NONE
Curve tolerance:	ISO9906:2012 3B

Printed from Grundfos Product Centre [2016.03.043]



9) Catalogue of boiler pump

GRUNDFOS

Submittal Data

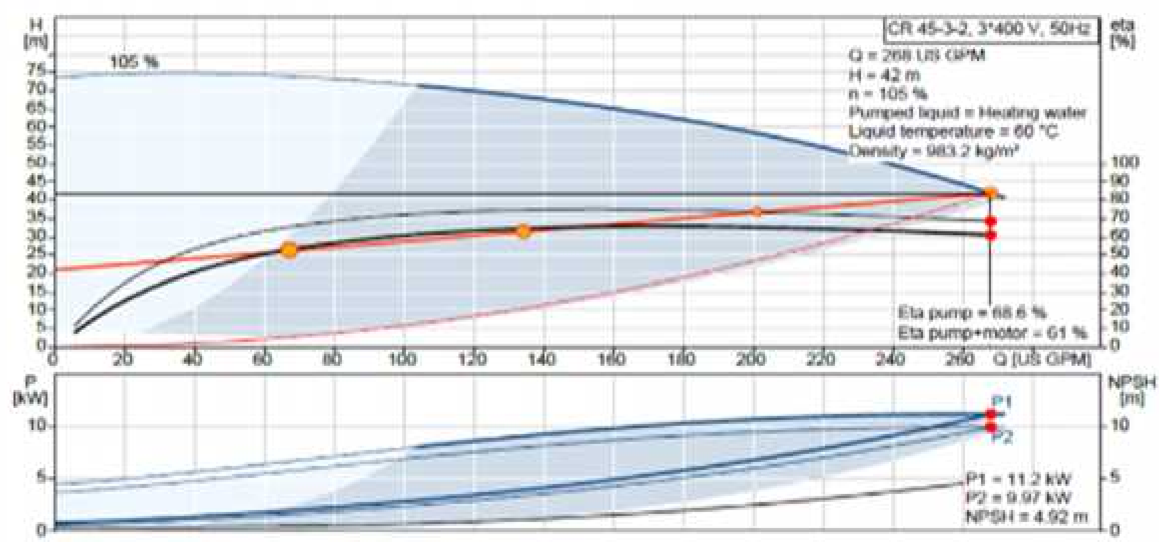
PROJECT:		UNIT TAG:		QUANTITY:	
		TYPE OF SERVICE:			
REPRESENTATIVE:		SUBMITTED BY:		DATE:	
ENGINEER:		APPROVED BY:		DATE:	
CONTRACTOR:		ORDER NO.:		DATE:	

CR 45-3-2

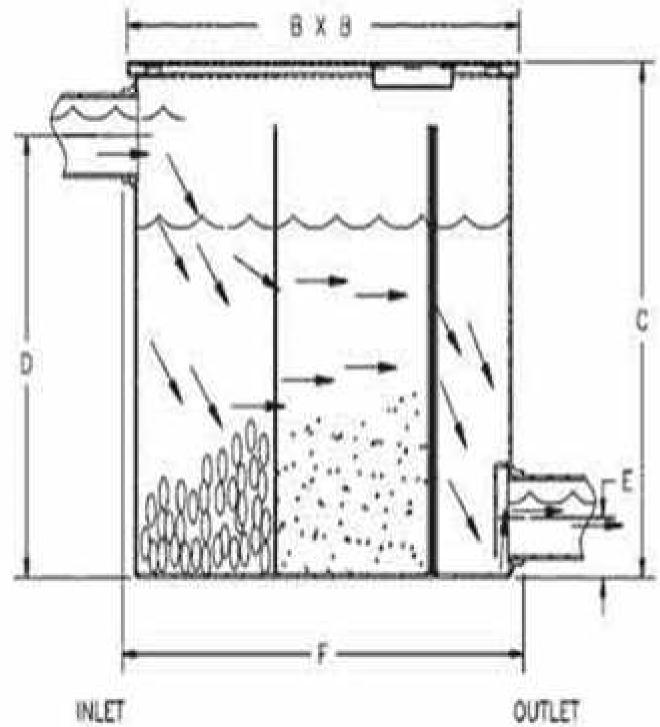
Note! Product picture may differ from actual product

Vertical, multistage centrifugal pump with suction and discharge ports on the same level. The pump head and base are in cast iron. All other wetted parts are in stainless steel (EN 1.4301)

Conditions of Service		Pump Data		Motor Data	
Flow:	268 US GPM	Max pressure at stated temp:	16 bar / 120 °C	Rated power - P2:	11 kW
Head:	42 m	Liquid temperature range:	-30 .. 120 °C	Rated voltage:	220-240 D/380-415 Y V
Efficiency:		Maximum ambient temperature:	60 °C	Mains frequency:	50 Hz
Liquid:	Heating water	Approvals:	CE,TR	Enclosure class:	55 Dust/Jetting
Temperature:	60 °C	Shaft seal:	HQQE	Insulation class:	F
NPSH required:		Flange standard:	DIN	Motor protection:	PTC
Viscosity:	1 mm2/s	Pipe connection:	DN 80	Motor type:	160MB
Specific Gravity:		Product number:	96122750	Motor_efficiency:	91,2-91,2 %



10) Catalogue of grease tank in kitchen



Dimensional Data (inches and [mm])					
B	B	C	D	E	F
17 [432]	17 [432]	16 1/2 [419]	13 1/2 [343]	3 1/4 [82]	17 1/4 [438]
25 [635]	25 [635]	20 [508]	17 [432]	3 1/4 [82]	25 1/2 [648]
33 [838]	33 [838]	28 [711]	25 [635]	4 [102	34 [864]
40 [1016]	40 [1016]	35 [889]	32 [813]	4 [102]	41 [1041]
45 [1143]	45 [1143]	40 [1016]	36 [914]	5 [127]	46 [1168]
48 [1219]	48 [1219]	43 [1092]	39 [991]	5 [127]	49 [1245]
52 [1321]	52 [1321]	47 [1194]	43 [1092]	5 [127]	53 [1346]

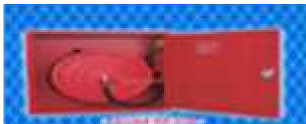
11) Catalogue of Fire extinguisher (Fir fighting)

HEBA

Stored Pressure Powder Extinguisher

SPECIFICATIONS / ITEM PART NO.		PX1	PX2	PX3	PX4.5	PX6	PX10	PX12
NOMINAL CAPACITY	kg (lb)	1 (2.20)	2 (4.40)	3 (6.60)	4.5 (10.00)	6 (13.22)	10 (22.00)	12 (26.50)
EXTINGUISHING AGENT		ABC	ABC	ABC	ABC	ABC	ABC	ABC
SHELL MATERIAL		CRS	CRS	CRS	CRS	CRS	CRS	CRS
AVE.GROSS WEIGHT	kg (lb)	1.65 (5.50)	3.80 (8.36)	5.27 (11.55)	7.70 (16.94)	9.50 (20.90)	15.00 (33.00)	17.50 (38.16)
MINIMUM DISCHARGE TIME	Sec	8	8	9	9	10	12	12
AVE.UNIT HEIGHT	mm (in)	330 (12.99)	395 (15.55)	470 (18.50)	500 (19.69)	510 (19.30)	600 (20.75)	660 (26.40)
AVE.UNIT LENGTH	mm (in)	264 (10.39)	298 (11.73)	367 (14.45)	391 (15.39)	408 (16.06)	510 (20.08)	547 (21.54)
SHELL DIAMETER	mm (in)	85 (3.35)	110 (4.33)	120 (4.73)	150 (5.91)	160 (6.30)	180 (7.09)	190 (7.48)
MINIMUM DISCHARGE DISTANCE	m (ft)	3 (9.84)	3 (9.84)	3.5 (9.84)	5.5 (16.40)	5 (16.40)	6 (16.40)	6 (16.40)
SHELL COLOR		RED	RED	RED	RED	RED	RED	RED
ELECTRICAL NON- CONDUCTIVITY UP TO 1 KV (1000VOLT)		OK	OK	OK	OK	OK	OK	OK
OPERATING TEMPERATURE	UPPER RANGE °C °F	+60 +140	+60 +140	+60 +140	+60 +140	+60 +140	+60 +140	+60 +140
	LOWER RANGE °C °F	-20 -4	-20 -4	-20 -4	-20 -4	-20 -4	-20 -4	-20 -4
OPERATING PRESSURE Measured at ambient temperature	bar psi	15 (218)	15 (218)	15 (218)	15 (218)	15 (218)	15 (218)	15 (218)

Note: All technical specifications changes are reserved
Contact HEBA Fire Fighting Equip. Mfg. or call your local distributor for assistance.



Fire Cabinet SF 300

Cabinets made of steel.
Rubber hose of 30 meter available in manual and automatic model.
Available in different sizes & design to meet architectural requirements.

Fire Cabinet SF 300M

New design from SFFECO.
Cabinets made of steel.
Available in manual and automatic models.

Fire Cabinet SF 300S

Cabinets made of stainless steel no 304
Manual and automatic models.
Available in different sizes & design.
Cabinets in stainless steel with hairline or mirror finish available on request.

Fire Cabinet SF 600

Available in manual and automatic models.
Two door steel cabinets, one is equipped with hose reel and the other with fire extinguisher.

Fire Cabinet SF 600S

Similar to SF600 but in stainless steel.
Available in manual and automatic models.
Cabinets in stainless steel with hairline or mirror finish available on request.

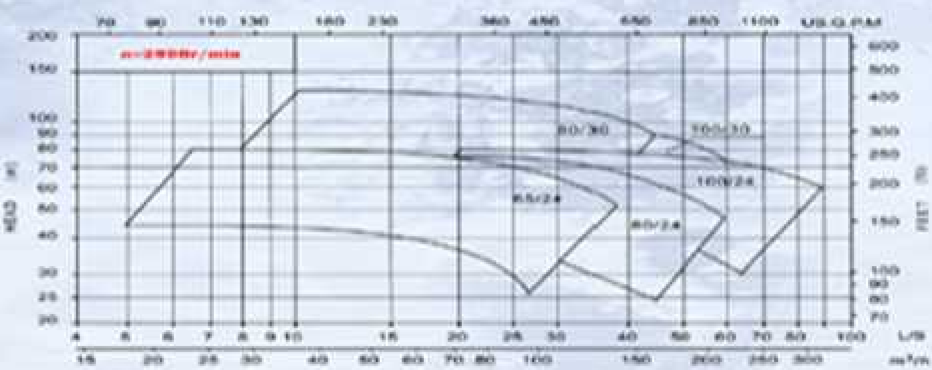
Optional: Dry riser, Fire blanket or Fire axe can be fitted in place of extinguisher in SF600 / SF600S.

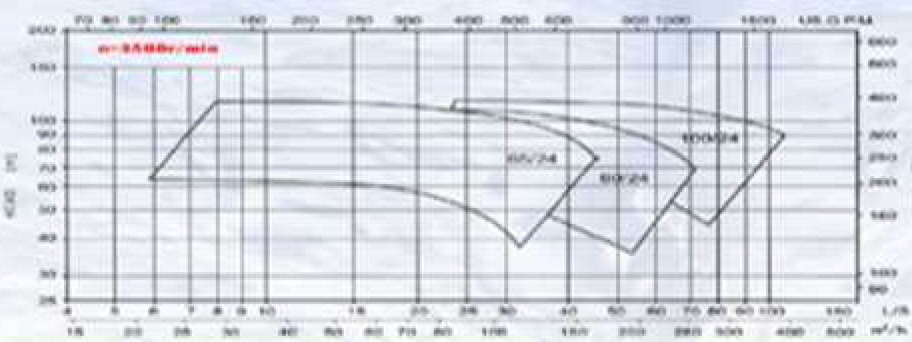
MODEL	INSIDE DIMENSIONS SURFACE, RECESS & SEMI RECESS TYPE			WALL OPENING SIZE RECESS & SEMI RECESS (Approximately)		
	Width (mm)	Hight (mm)	Depth (mm)	Width (mm)	Hight (mm)	Depth (mm)
SF-300	800	800	250	820	820	240
SF-300A	800	800	250	820	820	260
SF-300AS	800	800	250	820	820	260
[illegible]	700	700	200	720	720	210
[illegible]	700	700	250	720	720	260
[illegible]	700	700	250	720	720	260
[illegible]	700	700	250	720	720	260
SF-600	1050	880	230	1070	900	240
SF-600A	1050	880	250	1070	826	260
SF-600AS	1050	880	250	1070	826	260

MODEL	INSIDE DIMENSIONS SURFACE TYPE			
	Width (mm)	Hight (mm)		Depth (mm)
		Front	Back	
[illegible]	730	750	605	250

Note: All dimensions in mm.

Pump Performance Range





12) Catalogue of medical gas

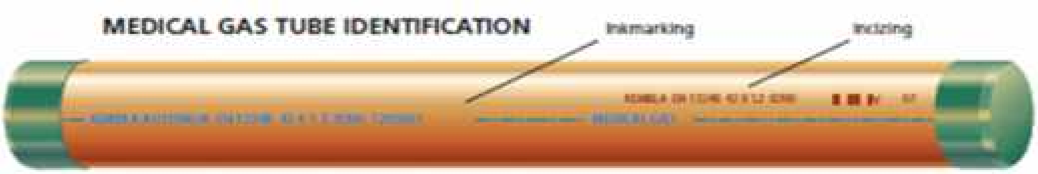
KEMBLA® MEDICAL GAS TUBE TO BS EN 13348

Nominal Diameter (mm)	Nominal Thickness (mm)	Mass /Length (kg / 5.8m)	Tube Temper #	Safe Working Pressure * (kPa)	Lengths per Bundle
10	0.8	1.20	HD	8100	100
15	0.7	1.63	HH	4500	100
22	0.9	3.09	HH	3900	50
28	0.9	3.98	HH	3100	50
35	1.2	6.61	HD	3300	50
42	1.2	7.98	HD	2700	50
54	1.2	10.33	HD	2100	30
67	1.2	12.81	HD	1700	25
76	1.5	18.24	HD	1800	25
108	1.5	26.04	HD	1300	10
133	1.5	32.15	HD	1000	10
159	2.0	51.18	HD	1200	5

* Based on annealed temper after brazing for temperatures of 50°C

\# HD (R290 - hard drawn), HH (R250 - half hard)

MEDICAL GAS TUBE IDENTIFICATION



specifications

The Digital Medical Gas Manifold shall be an Amico Alert-2 Heavy Duty series. This manifold shall also include a five-year warranty which warrants a defect-free product.

The Manifold shall be a digital, fully automatic type and shall switch from "Bank in Use" to "Reserve" bank without fluctuation in delivery supply line pressure and without the need for external power. After the switch-over, the "Reserve" bank shall then become the "Bank in Use" and the "Bank in Use" shall become the "Reserve" bank. The manifold shall have a microprocessor based digital display panel. The unit will be compact, measuring 16-3/4" high x 17" wide x 9" deep.

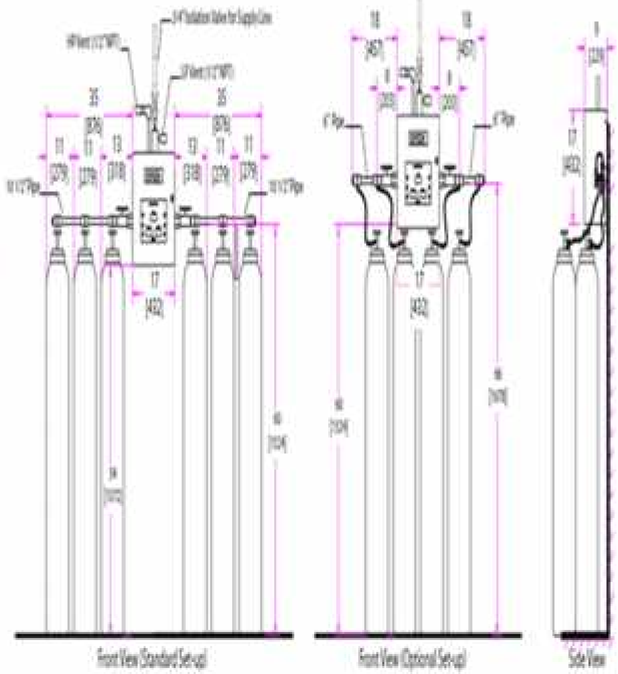
The control panel incorporates three large, red, illuminated LED displays for the Left Bank, the Right Bank and for the Supply Pressure. The control panel also uses six LED's, two Green for "Bank in Use", two Amber for "Bank Ready" and two Red for "Bank Empty".

PLEASE NOTE:

- The manifold shall be equipped with a 3/4" outlet shutoff valve. The valve comes complete with a 3/4" type "K" 6-3/4" [172 mm] long pipe extension and 1/8" port for an optional pressure switch.

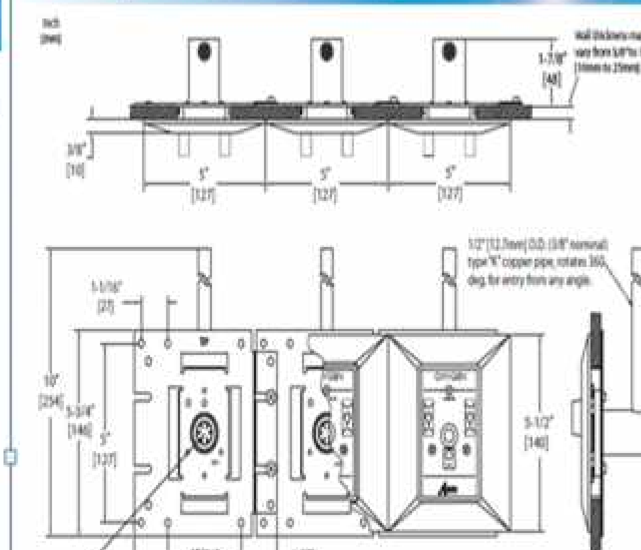
features

alert - 2 medical gas manifold - digital dual line regulator - NFPA



NOTE: Header bar pipes can be changed from standard 10 1/2" to 8 1/2" or 6"

wall outlet quick disconnect - chemetron compatible



NOTE:
Amico recommends that you have a blank space between outlets and slides. Maximum 3 outlets may be ganged together without additional support.

[1]**NOTE:** For CSA/ISO, suction inlets are not supplied with a secondary check valve. A pressure plug is provided for testing purposes, rated at 150 psi [1,034 kPa].

model numbers

O-CHWAL-L-XXX

The L defines the Language:
U = English (NFPA) Oxy, Air, Vac and WAG only
E = English (CSA/ISO)
S = Spanish (NFPA)

The XXX defines the Gas:

Oxygen	= OXY
Medical Air	= AIR
Nitrous Oxide	= N2O
Carbon Dioxide	= CO2
MedVac	= VAC
Waste Anesthetic Gas Disposal (NFPA)	= WAG
Anesthetic Gas Scavenging System[1] (CSA)	= AGS

Example: Oxygen NFPA = **O-CHWAL-U-OXY**

M.R.I. model numbers

O-CHWALM-L-XXX

References:

[1] The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

[2] Mohammad A. Hammed. 1996, Heating and Air conditioning, 3rd edition, Mohammad A. Alsaad, Jordan.

[3] Refrigeration & Air conditioning Technology; sixth edition.

[4] SAMSUNG Air Conditioner 2009, DVM Technical Data Book.

[5] Internet.