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
Ali Saied                         Belal Rubaa
Huthiefa Al-Absi           Mohammed Abu-Hamdiay

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

Examine committee signature

Department Head signature
دédication

إلى من أعطاني اسمه ودمه ...
واضن ...
وسيد ...
منه ...
إليك يا ...
أهديتي صحتها وشبابها ...
العين الساهرة ...
أين ...
إليك يا ... 
أشاركم ...
طفلها ...
إليك يا ...
أيديهم ...
إليك ...
أنتين ...
إليك ...
الطاهرة ...
الأنبياء ...
باركها ...
حواليها ...
والكبراء ...
إليك فلسطين ...

وقررني ...
عائلتي ...
ببيتانا ...
وعرين المعلمين ...
الثمين ...
إليك ...
الشامخ ...
إليكم ...
الجبيل ...
إليكم يا ... 
أمي ...
إليك ...
الجسد ...
وأرض ...
أشار ...
مدها ...
إليك ...
العين الساهرة ...
الرجل ...
إليك ...
المدرسة ...
وصنعاء ...
الحب ...
أني ...
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المن ...
إليك ...
القلب ...
إليك يا ... 
أمي ...
إليك ...
الجسم ...
وأرض ...
أشار ...
مدها ...
إليك ...
القلب ...
إليك ...
أمي ...
Acknowledgement

Our thanks go first to our project supervisor Eng. Islam Shabaneh, his guidance and support made this work possible.

We wish to thank Dr. Ishaq sieder, Eng. Kazem Osaily, Eng. Mohammed Awad

We believe that this work would not be accomplished without their inspiration.

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 (m²). 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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<td>Figure 5-1</td>
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<td>Figure 5-2</td>
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<tr>
<td>Figure 5-3</td>
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CHAPTER ONE

INTRODUCTION
CHAPTER 1

1.1 Introduction

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 (m²). 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:**

<table>
<thead>
<tr>
<th>No</th>
<th>Name of the Floor</th>
<th>The area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basement “3” floor</td>
<td>410</td>
</tr>
<tr>
<td>2</td>
<td>Basement “2” floor</td>
<td>2965</td>
</tr>
<tr>
<td>3</td>
<td>Basement “1” floor</td>
<td>3209</td>
</tr>
<tr>
<td>4</td>
<td>Ground floor</td>
<td>3825</td>
</tr>
<tr>
<td>5</td>
<td>First floor</td>
<td>2675</td>
</tr>
<tr>
<td>6</td>
<td>Second floor</td>
<td>2245</td>
</tr>
<tr>
<td>7</td>
<td>Third floor</td>
<td>2245</td>
</tr>
<tr>
<td>8</td>
<td>Forth floor</td>
<td>1600</td>
</tr>
<tr>
<td>9</td>
<td>Fifth floor</td>
<td>1600</td>
</tr>
</tbody>
</table>
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>
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<th>Table (1-2) Time table.</th>
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<tr>
<td><strong>First semester</strong></td>
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<tr>
<td><strong>Task</strong></td>
</tr>
<tr>
<td><strong>Week</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>Choosing the Project idea</td>
</tr>
<tr>
<td>Choosing the building and overview Previous projects</td>
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<tr>
<td>Overall heat transfer coefficient calculations for walls, ceiling, floor, doors, windows and calculations of Heating and cooling load</td>
</tr>
<tr>
<td>Air conditioning</td>
</tr>
<tr>
<td>Task</td>
</tr>
<tr>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>Firefighting System calculations and design</td>
</tr>
<tr>
<td>Medical Gases calculations and design</td>
</tr>
<tr>
<td>Mechanical Drawings</td>
</tr>
<tr>
<td>Equipment Selection</td>
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<tr>
<td>Auditing our work in the project</td>
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CHAPTER TWO

Heating and Air Conditioning System
CHAPTER 2

2.1 Introduction

Hospitals need 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 feels uncomfortably warm. The body responds by increasing the rate of perspiration in order to increase the heat loss through evaporation of body moisture. Additionally, if the surrounding air is too humid, the air is nearly saturated and it is more difficult to evaporate body moisture. If the temperature of the air surrounding the body is too low, however, the body loses more heat than it can produce. The body responds by constricting the blood vessels of the skin to reduce heat loss.

2.1.3 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 a 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 psychrometric 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 78°F [25.6°C] 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](image)

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

<table>
<thead>
<tr>
<th>Room or Area</th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Db Degrees C (Degrees F)</td>
<td>RH Percent</td>
</tr>
<tr>
<td>Auditoriums</td>
<td>24 (76)</td>
<td>60</td>
</tr>
<tr>
<td>AIDS Patient Areas</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Autopsy Suites</td>
<td>24 (76)</td>
<td>60</td>
</tr>
<tr>
<td>Bathrooms &amp; Toilet Rooms</td>
<td>25 (78)</td>
<td>--</td>
</tr>
<tr>
<td>BMT (Bone Marrow Transplant) Patient Areas</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Computer Rooms</td>
<td>21 (70)</td>
<td>40 (±5)</td>
</tr>
<tr>
<td>CT Scanner</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Dialysis Rooms</td>
<td>25 (78)</td>
<td>50</td>
</tr>
<tr>
<td>Dining Rooms</td>
<td>25 (78)</td>
<td>50</td>
</tr>
<tr>
<td>Dry Labs</td>
<td>25 (78)</td>
<td>50</td>
</tr>
<tr>
<td>Electrical Equipment Rooms</td>
<td>Ventilation Only</td>
<td></td>
</tr>
<tr>
<td>Elevator Machine Rooms, Electric Drive</td>
<td>36 (94)</td>
<td>--</td>
</tr>
<tr>
<td>Elevator Machine Rooms, Hydraulic</td>
<td>36 (94)</td>
<td>--</td>
</tr>
<tr>
<td>Emergency Generator</td>
<td>36 (97)</td>
<td>--</td>
</tr>
<tr>
<td>Examination Rooms</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>ICUs (Coronary, Medical, Surgical)</td>
<td>23–29 (75–85)</td>
<td>30–60</td>
</tr>
<tr>
<td>Room or Area</td>
<td>Summer</td>
<td>Winter</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td></td>
<td>Db Degrees C (Degrees F)</td>
<td>RH Percent</td>
</tr>
<tr>
<td>Isolation Suites</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Kitchens</td>
<td>27 (82)</td>
<td>60</td>
</tr>
<tr>
<td>Laboratories</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Laundries</td>
<td>28 (84)</td>
<td>60</td>
</tr>
<tr>
<td>Linear Accelerators</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Locker Rooms</td>
<td>25 (78)</td>
<td>50</td>
</tr>
<tr>
<td>Lounges</td>
<td>25 (78)</td>
<td>50</td>
</tr>
<tr>
<td>Mechanical Equipment Rooms (MERs)</td>
<td>Ventilation Only</td>
<td>10 (50)</td>
</tr>
</tbody>
</table>

**Medical Media:**

<table>
<thead>
<tr>
<th>Room or Area</th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Db Degrees C (Degrees F)</td>
<td>RH Percent</td>
</tr>
<tr>
<td>MRI Units</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Offices, Conference Rooms</td>
<td>25 (78)</td>
<td>50</td>
</tr>
<tr>
<td>Operating Rooms (O.R.s)</td>
<td>18–27 (62-80)</td>
<td>45-55</td>
</tr>
<tr>
<td>Patient Rooms</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>22 (72)</td>
<td>50</td>
</tr>
<tr>
<td>Radiation Therapy</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Recovery Units</td>
<td>23 (75)</td>
<td>50</td>
</tr>
</tbody>
</table>

**SPECIAL PROCEDURE ROOMS***

<table>
<thead>
<tr>
<th>Room or Area</th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Db Degrees C (Degrees F)</td>
<td>RH Percent</td>
</tr>
<tr>
<td>Bronchoscope</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Cardiac Catheterization</td>
<td>17–27 (62-80)</td>
<td>45-55</td>
</tr>
<tr>
<td>Colonoscopy/EGD</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Cystoscopy</td>
<td>22 (72)</td>
<td>50</td>
</tr>
<tr>
<td>Endoscopy</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Fluoroscopy</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>GI (Gastrointestinal)</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Proctoscopy</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Room or Area</td>
<td>Summer</td>
<td>Winter</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td>Db Degrees C</td>
<td>RH Percent</td>
</tr>
<tr>
<td></td>
<td>(Degrees F)</td>
<td></td>
</tr>
<tr>
<td>Sigmoidoscopy</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Spinal Cord Injury Units (SCIUs)</td>
<td>22 (72)</td>
<td>50</td>
</tr>
<tr>
<td>Supply Processing Distribution (SPD)</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Ethylene Oxide (ETO) MERs</td>
<td>Ventilation only</td>
<td></td>
</tr>
<tr>
<td>Steam Sterilizer MERs</td>
<td>Ventilation only</td>
<td></td>
</tr>
<tr>
<td>Treatment Rooms</td>
<td>24 (76)</td>
<td>50</td>
</tr>
<tr>
<td>Warehouses</td>
<td>Ventilation Only</td>
<td>15 (60)</td>
</tr>
</tbody>
</table>

### 2.1.6 Outside Design Condition

From the Palestinian code[4].

2.1.6.1 Outside Design Condition For Summer:

\[ T_{\text{dry bulb max}} = 35.8 \ [^\circ\text{C}] \]

Relative humidity = 57 %

\[ T_{\text{wet}} = 25 \ [^\circ\text{C}] \]

Max wind speed = 1.4 [m/s]

Design month = July

2.1.6.2 Outside Design Condition For Winter:

\[ T_{\text{dry bulb average}} = 5 \ [^\circ\text{C}] \]

Relative humidity = 72%

\[ T_{\text{wet}} = 2 \ [^\circ\text{C}] \]

Max wind speed = 3 [m/s]

Design month = January
2.1.7 Over All Heat Transfer Coefficient “U” :

\[
U = \frac{1}{R_{th}} = \frac{1}{\frac{1}{h_i} + \frac{1}{\frac{\Delta x_1}{k_1} + \frac{\Delta x_2}{k_2} + \ldots + \frac{1}{h_0}}}
\]

[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.

<table>
<thead>
<tr>
<th>Construction detail</th>
<th>Construction material</th>
<th>Material thickness [m]</th>
<th>Thermal conduction [W/m.°C]</th>
<th>U [W/m².°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside walls</td>
<td>1- stone</td>
<td>0.07</td>
<td>1.7</td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td>2-Concrete</td>
<td>0.2</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3-Insulation</td>
<td>0.03</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4- Block</td>
<td>0.01</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5- plaster</td>
<td>0.03</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Inside walls</td>
<td>1- plaster</td>
<td>0.02</td>
<td>1.2</td>
<td>2.95</td>
</tr>
<tr>
<td></td>
<td>2- Block</td>
<td>0.01</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3- plaster</td>
<td>0.02</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Layer</td>
<td>Diagram</td>
<td>Material</td>
<td>R-value</td>
<td>U-factor</td>
</tr>
<tr>
<td>-------</td>
<td>---------</td>
<td>----------</td>
<td>---------</td>
<td>----------</td>
</tr>
<tr>
<td>1</td>
<td>Asphalt</td>
<td>0.02</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Concrete</td>
<td>0.05</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Insulation</td>
<td>0.02</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Concrete</td>
<td>0.06</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Block</td>
<td>0.18</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Plaster</td>
<td>0.02</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>1-2</td>
<td></td>
<td>1.08</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Roof**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Diagram</th>
<th>Material</th>
<th>R-value</th>
<th>U-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tiles</td>
<td>0.02</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Concrete</td>
<td>0.12</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mortar</td>
<td>0.02</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sand</td>
<td>0.1</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Rocks</td>
<td>0.5</td>
<td>1.05</td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td></td>
<td>1.03</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ground**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Diagram</th>
<th>Material</th>
<th>R-value</th>
<th>U-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Windows**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Diagram</th>
<th>Material</th>
<th>R-value</th>
<th>U-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wood</td>
<td>0.04</td>
<td>0.17</td>
<td></td>
</tr>
</tbody>
</table>

**Doors**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Diagram</th>
<th>Material</th>
<th>R-value</th>
<th>U-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wood</td>
<td>0.04</td>
<td>0.17</td>
<td></td>
</tr>
</tbody>
</table>

**Doors**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Diagram</th>
<th>Material</th>
<th>R-value</th>
<th>U-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wood</td>
<td>0.04</td>
<td>0.17</td>
<td></td>
</tr>
</tbody>
</table>

**Doors**
2.2 CoolingLoad

2.2.1 Heat Gain Through Sunlit Walls And Roofs

\[ Q = U \cdot A \cdot (\text{CLTD})_{\text{corr}} \]  \hspace{1cm} [2-2]

Q : cooling load [kw].

U: over all heat transfer coefficient [W/m².°C].

A : surface area [m²].

CLTD corr: corrected cooling load temperature deference .

\[ (\text{CLTD})_{\text{corr}} = (\text{CLTD} + \text{LM})k + (25.5 - \text{Ti}) + (\text{To,m} - 29.4)f \]  \hspace{1cm} [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 .

To,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

\[ Q = U \cdot A \cdot T \]  \hspace{1cm} [2-4]

Q: loading load gain inside walls.

A: inside walls area.
U: overall heat transfer coefficient.

T: temperature difference between inside air conditioning space and beside air temp space.

2.2.3 Heat Gain Due To Glass Windows

\[ Q_{tr} = A \text{ (SHG)} \text{ (SC)} \text{ (CLF)} \]

\[ Q_{tr} \]: 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

\[ Q_{\text{total for occupant}} = Q_{\text{sensible}} + Q_{\text{latent}} \]; (from appendix A) Table(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/m² for apartment so we will take 10W/m².

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

Q_{inl} = \frac{v_i}{v_{outside}} * h_o - h_i \[2-8\]

From psychometric chart we get :-

- \( v_{outside} = 0.95 \) m³
- \( h_o = 90 \) kJ/kg
- \( h_i = 45 \) kJ/kg
- \( v_i \rightarrow 7 \) L/sec per person.
2.2.7 Heat gain Due To people

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

2.2.8 Heat Gain Due To Ventilation

\[ Q_{\text{ven}} = m' \times C_{\text{pair}} \times (T_{\text{out}} - T_{\text{in}})_{\text{air}} \] [2-10]

\( m' \): total flow rate for fresh air \((\text{kg/s}) = \frac{V_f}{v} \)

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

\( T_{\text{in}} \): the inside temperature \(^\circ\text{C}\).

\( T_{\text{out}} \): the outside temperature \(^\circ\text{C}\).

\( V_f \): rate of ventilation = no. of people \times \text{outdoor air}.

\( \text{outdoor air} = (7L/s)/\text{person} \).

\( v \): specific volume for air \( @ t \text{ max} = 35.8 \text{ C}^\circ \) and \( \Phi = 57\% ; v = 0.95 (m^3/\text{kg dry air}) \)

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 (ΔT 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:

\[ Q = U \times A \times \Delta T \]  

\[ Q = \text{the rate at which heat transfer in watts [W].} \]
\[ U = \text{overall heat-transfer coefficient of the surface [W/m}^2\text{. K].} \]
\[ A = \text{Area of the layer which heat flow through, which in our project may be an area of wall, window, or ceiling…[m}^2\text{].} \]
\[ \Delta T = \text{desired indoor dry-bulb temperature (Ti) minus the design outdoor dry bulb temperature (To), [°C].} \]

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:

\[ Q_{inf} = \frac{V_{inf}}{V_{outside}} \cdot h_o - h_i \]  \hspace{1cm} \text{[2-12]}

\[ V_{inf} = K \cdot L \cdot (0.613 \cdot (s1 \cdot s2 + v)^2)^{2/3} \]  \hspace{1cm} \text{[2-13]}

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

\( V_{inf} \): the volumetric flow rate of infiltrated air [m³/s].

\( V_{outside} \): the outside volumetric flow rate [m³/Kg dry air].

\( h_o , h_i \): are the outside and inside enthalpies 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 (\( v_{out} \)) 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**

<table>
<thead>
<tr>
<th>Season</th>
<th>( T_{out} ) (°C)</th>
<th>( v_{out} )%</th>
<th>( v_{out} )(m³/Kg dry air)</th>
<th>( h_{out} )(K/Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>5</td>
<td>72</td>
<td>0.854</td>
<td>41</td>
</tr>
</tbody>
</table>

*Table (2-3)*

**Values for indoor design conditions**

<table>
<thead>
<tr>
<th>Season</th>
<th>( T_{in} ) (°C)</th>
<th>( h_{in} )%</th>
<th>( h_{in} )(K/Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>22</td>
<td>50</td>
<td>5</td>
</tr>
</tbody>
</table>

*Table (2-4)*

23
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].

\[ Q = U \cdot A \cdot T \]

- Roof

\[ Q_R = 1.08 \cdot (6.45 \cdot 7.45) \cdot (35.8 - 22) = 716.2 \text{ W}. \]

- Ground

\[ Q_G = 1.03 \cdot (6.45 \cdot 7.45) \cdot (22 - 15) = 346 \text{ W}. \]


\[ Q = U \cdot A \cdot (CLTD)_{\text{corrected}} \]

\[ (CLTD)_{\text{corr}} = (CLTD + LM)k + (25.5 - T_i) + (T_{o,m} - 29.4)f \]

- East

\[ 25.5 - 22 = 3.5 \text{ C}^\circ. \]
\[ 35.8 - 29.4 = 6.4 \text{ C}^\circ. \]

\[ (CLTD)_{\text{corr}} = (2 + 0.5) \cdot 0.83 + (3.5) + (6.4) = 12 \text{ C}^\circ. \]

\[ Q_{NE} = 0.81 \cdot (45) \cdot 12 = 437.4 \text{ W}. \]

- North

\[ (CLTD)_{\text{corr}} = (0 + 0.5) \cdot 0.83 + (3.5) + (6.4) = 10.4 \text{ C}^\circ. \]

\[ Q_{NW} = 0.81 \cdot (4 \cdot 7.45) \cdot 10.4 = 248.6 \text{ W}. \]

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

\[ Q_u = A \cdot (SHG) \cdot (SC) \cdot (CLF) \]

\[ A = 3 \cdot (1.2) = 3.6 \text{ m}^2. \]

\[ SHG = 126 \text{ W/m}^2, \text{ (from appendix A) Table(3)}. \]

\[ SC = 0.83, \text{ (from appendix A) Table(4)}. \]

\[ CLF = 0.69, \text{ (from appendix A) Table(5)}. \]

\[ Q_u = 3.6 \cdot (126) \cdot (0.83) \cdot (0.69) = 260 \text{ W}. \]
4-Heat Gain Due To Occupants, from equation [2-6].
Q total for occupant = Q sensible + Q latent

\[ Q_{\text{latent}} = 56 \times 4 \times 0.5 = 112 \text{ W.} \]
\[ Q_{\text{sensible}} = 0 \times 15 \times 4 \times 0.5 = 0 \text{ W.} \]
\[ Q_{\text{oc}} = 112 \text{ W.} \]

5-Heat Gain Due To Lights, from equation [2-7].
\[ Q_{\text{Lt}} = \text{lighting intensity} \times A \times \text{CLF} \times \text{ballast factor} \]
\[ Q_{\text{Lt}} = 10 \times (48) \times 0.75 \times 1.2 = 432 \text{ W.} \]

6-Heat Gain Due To Infiltration, from equation [2-8].
\[ Q_{\text{inl}} = \frac{V_f}{V_{\text{outside}}} \times h_{\text{o}} - h_{\text{i}} \]
\[ Q_{\text{inl}} = \frac{4 \text{ person} \times 7}{0.95(1000)} \times 90 - 45 = 1326 \text{ W} \]

7- Heat Gain Due To People, from equation [2-9].
\[ Q_{\text{people (total)}} = n \times \text{total heat gain per person} \]
\[ Q_{\text{people (total)}} = 4 \times (114) = 456 \text{ W} \]

8-Heat Gain Due To Ventilation, from equation [2-10].
\[ Q_{\text{ven}} = m \times C_{\text{air}} \times (t_{\text{out}} - t_{\text{in}}) \]
\[ m = \frac{V_f}{V} = \frac{4 \times (7 \text{ ft/s})}{0.95(1000)} = 0.03 \text{ kg/sec.} \]
\[ Q_{\text{ven}} = 0.03 \times 1.005 \times (35.8 - 22) = 416 \text{ W.} \]
\[ Q_{\text{total Cooling Load}} = \sum Q = 4.75 \text{ Kw.} \]

**2.4.2 Heating Load Calculation**

1-For Outside Wall, from equation [2-11].
\[ Q_{\text{wall}} = U \times A \times t \]
Q_{wall} = 0.81 \times [(6.45 \times 4) - (3 \times 1) + (7.45 \times 4)] \times (22 - 5) = 724.3 \text{ W}

a- For Inside Wall.

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

b- For Roof

\[ Q_{roof} = 1 \times (48) \times (22 - 5) = 816 \text{ W} \]

c- For Floor

\[ Q_{floor} = 1.03 \times (48) \times (22 - 5) \text{ = 840.4 W} \]

d- For Window

\[ Q_{window} = 3.2 \times (3 \times 1) \times (22 - 5) \text{ = 163.2 W} \]

e- For Door

\[ Q_{door} = 3.1 \times (2.1 \times 0.9) \times (22 - 5) \text{ = 99.6 W} \]

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

\[ Q_{inf} = \frac{V_{inf}}{v_{outside}} \times h_o - h_i \]

\[ V_{inf} = K \times L \times (0.613(s1 + s2 \times v)^2)^{2/3} \]

\[ V_{inf} = 0.45 \times [2 \times 3 + 1 \times 3] \times [0.613 \times (1 + 0.65 \times 3)^2]^{2/3} \text{ = 6.04 W} \]

\[ Q_{inf} = \frac{6.04}{0.854} \times 90 - 45 \text{ = 246 W} \]

\[ Q \text{ total heating Load} = \sum Q = 2690.49 \text{ = 3.8 Kw}. \]
2.5 Total Cooling And Heating Loads For Hospital

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

<table>
<thead>
<tr>
<th>No of room</th>
<th>Name of room</th>
<th>Cooling load (Kw)</th>
<th>Heating load(Kw)</th>
<th>Area (m^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Treatment room</td>
<td>12.2</td>
<td>8.13</td>
<td>150</td>
</tr>
<tr>
<td>R2</td>
<td>Treatment room</td>
<td>19.5</td>
<td>13</td>
<td>110</td>
</tr>
<tr>
<td>R3</td>
<td>Doctor room</td>
<td>3.4</td>
<td>3</td>
<td>22.7</td>
</tr>
<tr>
<td>R4</td>
<td>Resuscitation room</td>
<td>2.7</td>
<td>1.97</td>
<td>31</td>
</tr>
<tr>
<td>R5</td>
<td>Resuscitation room</td>
<td>2.9</td>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>R6</td>
<td>Office room</td>
<td>27.9</td>
<td>16.6</td>
<td>214</td>
</tr>
<tr>
<td>R7</td>
<td>Plaster room</td>
<td>1.47</td>
<td>0.98</td>
<td>12.6</td>
</tr>
<tr>
<td>a</td>
<td>Corridor a</td>
<td>27.6</td>
<td>18.4</td>
<td>271</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>93.27</strong></td>
<td><strong>63.25</strong></td>
<td><strong>843.3</strong></td>
</tr>
</tbody>
</table>
Table (2-6) Total cooling and heating loads for basement 1 floor.

<table>
<thead>
<tr>
<th>No of room</th>
<th>Name of room</th>
<th>Cooling load (Kw)</th>
<th>Heating load(Kw)</th>
<th>Area (m^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>X-Ray room</td>
<td>13.6</td>
<td>9.1</td>
<td>116.8</td>
</tr>
<tr>
<td>F2</td>
<td>Processing room</td>
<td>0.91</td>
<td>0.6</td>
<td>7.8</td>
</tr>
<tr>
<td>F3</td>
<td>X-Ray room</td>
<td>3.3</td>
<td>2.7</td>
<td>22.2</td>
</tr>
<tr>
<td>F4</td>
<td>X-Ray room</td>
<td>6.14</td>
<td>5.4</td>
<td>40.7</td>
</tr>
<tr>
<td>F5</td>
<td>Fluoroscopy room</td>
<td>0.9</td>
<td>0.6</td>
<td>8</td>
</tr>
<tr>
<td>F6</td>
<td>Processing room</td>
<td>0.5</td>
<td>0.3</td>
<td>6</td>
</tr>
<tr>
<td>F7</td>
<td>Store</td>
<td>0.47</td>
<td>0.28</td>
<td>5.5</td>
</tr>
<tr>
<td>F8</td>
<td>Class room</td>
<td>5.75</td>
<td>3.8</td>
<td>49.3</td>
</tr>
<tr>
<td>F9</td>
<td>Physiotherapy room</td>
<td>6.2</td>
<td>4.2</td>
<td>53.2</td>
</tr>
<tr>
<td>F10</td>
<td>Worker resting room</td>
<td>5.3</td>
<td>4.5</td>
<td>36.5</td>
</tr>
<tr>
<td>F11</td>
<td>Worker room</td>
<td>2.05</td>
<td>1.3</td>
<td>17.6</td>
</tr>
<tr>
<td>F12</td>
<td>Physiotherapy +Reception room</td>
<td>2.8</td>
<td>1.8</td>
<td>24</td>
</tr>
<tr>
<td>F13</td>
<td>Office</td>
<td>1.2</td>
<td>0.7</td>
<td>17.2</td>
</tr>
<tr>
<td>F14</td>
<td>Office</td>
<td>1.2</td>
<td>0.7</td>
<td>17.2</td>
</tr>
<tr>
<td>F15</td>
<td>Pathology room</td>
<td>1.9</td>
<td>1.35</td>
<td>28.3</td>
</tr>
<tr>
<td>F16</td>
<td>Registration</td>
<td>1.7</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>F17</td>
<td>Lapatatory</td>
<td>4.2</td>
<td>2.7</td>
<td>35.7</td>
</tr>
<tr>
<td>F18</td>
<td>Microplogy room</td>
<td>13.67</td>
<td>9.115</td>
<td>117.5</td>
</tr>
<tr>
<td>F19</td>
<td>Lapatory</td>
<td>4.46</td>
<td>2.97</td>
<td>38.5</td>
</tr>
<tr>
<td>F20</td>
<td>Kitchen head</td>
<td>3.5</td>
<td>2.3</td>
<td>30.8</td>
</tr>
<tr>
<td>F21</td>
<td>Kitchen</td>
<td>20.8</td>
<td>13.9</td>
<td>179</td>
</tr>
<tr>
<td>B</td>
<td>Corridor</td>
<td>5.8</td>
<td>3.8</td>
<td>57</td>
</tr>
<tr>
<td>C</td>
<td>Corridor</td>
<td>4</td>
<td>2.6</td>
<td>40</td>
</tr>
<tr>
<td>D</td>
<td>Corridor</td>
<td>8.6</td>
<td>5.7</td>
<td>84</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>118.92</strong></td>
<td><strong>81.32</strong></td>
<td><strong>1053.8</strong></td>
</tr>
</tbody>
</table>
Table (2-7) Total cooling and heating loads for ground floor.

<table>
<thead>
<tr>
<th>No of room</th>
<th>Name of room</th>
<th>Cooling load (Kw)</th>
<th>Heating load (Kw)</th>
<th>Area (m^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Hart clinic</td>
<td>4.75</td>
<td>3.8</td>
<td>48</td>
</tr>
<tr>
<td>A2</td>
<td>Venereal clinic</td>
<td>4.5</td>
<td>3</td>
<td>38.65</td>
</tr>
<tr>
<td>A3</td>
<td>store</td>
<td>1.1</td>
<td>0.94</td>
<td>13.93</td>
</tr>
<tr>
<td>A4</td>
<td>Class room</td>
<td>4.75</td>
<td>3.8</td>
<td>48.7</td>
</tr>
<tr>
<td>A5</td>
<td>clinic</td>
<td>4.5</td>
<td>3</td>
<td>38.3</td>
</tr>
<tr>
<td>A6</td>
<td>store</td>
<td>0.99</td>
<td>0.8</td>
<td>12</td>
</tr>
<tr>
<td>A7</td>
<td>Plaster clinic</td>
<td>4.7</td>
<td>4.2</td>
<td>31.5</td>
</tr>
<tr>
<td>A8</td>
<td>secretary</td>
<td>3.6</td>
<td>3.2</td>
<td>23.8</td>
</tr>
<tr>
<td>A9</td>
<td>Men clinic</td>
<td>4.5</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>A10</td>
<td>Women clinic</td>
<td>4.4</td>
<td>3.9</td>
<td>29.8</td>
</tr>
<tr>
<td>A11</td>
<td>secretary</td>
<td>3.8</td>
<td>3.4</td>
<td>25.5</td>
</tr>
<tr>
<td>A12</td>
<td>Women clinic</td>
<td>4.5</td>
<td>4</td>
<td>29.89</td>
</tr>
<tr>
<td>A13</td>
<td>Chest clinic</td>
<td>3.6</td>
<td>2.4</td>
<td>41.6</td>
</tr>
<tr>
<td>A14</td>
<td>Skin clinic</td>
<td>5.12</td>
<td>3.4</td>
<td>50.22</td>
</tr>
<tr>
<td>A15</td>
<td>Children clinic</td>
<td>3.6</td>
<td>2.4</td>
<td>41.34</td>
</tr>
<tr>
<td>A16</td>
<td>Children clinic</td>
<td>3.7</td>
<td>2.5</td>
<td>42.4</td>
</tr>
<tr>
<td>A17</td>
<td>pharmacy</td>
<td>15.2</td>
<td>10.2</td>
<td>131</td>
</tr>
<tr>
<td>A22</td>
<td>Meeting room</td>
<td>4.6</td>
<td>3.13</td>
<td>45.9</td>
</tr>
<tr>
<td>A23</td>
<td>Admin room</td>
<td>5.2</td>
<td>4.7</td>
<td>35.9</td>
</tr>
<tr>
<td>A24</td>
<td>Vice admin room</td>
<td>3.8</td>
<td>3.3</td>
<td>25.4</td>
</tr>
<tr>
<td>e-f-g-h-i</td>
<td>Corridor</td>
<td>75.6</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>A26</td>
<td>Office room</td>
<td>5</td>
<td>3.3</td>
<td>49.4</td>
</tr>
<tr>
<td>A27</td>
<td>Office room</td>
<td>5.2</td>
<td>3.4</td>
<td>53.7</td>
</tr>
<tr>
<td>A28+29</td>
<td>Office room</td>
<td>6.2</td>
<td>4.3</td>
<td>63.2</td>
</tr>
<tr>
<td>A30</td>
<td>Office room</td>
<td>5.3</td>
<td>3.4</td>
<td>54.5</td>
</tr>
<tr>
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<td>Office room</td>
<td>6.3</td>
<td>4.4</td>
<td>64.1</td>
</tr>
<tr>
<td>A32</td>
<td>Office of public relations</td>
<td>2.9</td>
<td>1.9</td>
<td>27.3</td>
</tr>
<tr>
<td>A33</td>
<td>Wait room</td>
<td>1.9</td>
<td>1.3</td>
<td>18.9</td>
</tr>
<tr>
<td>A34</td>
<td>Archive</td>
<td>3.1</td>
<td>2.8</td>
<td>20.8</td>
</tr>
<tr>
<td>A35</td>
<td>Reception</td>
<td>2.4</td>
<td>2.1</td>
<td>16.3</td>
</tr>
<tr>
<td>A36</td>
<td>Security room</td>
<td>3.2</td>
<td>2.9</td>
<td>22.2</td>
</tr>
<tr>
<td>A37</td>
<td>Gift shop</td>
<td>1.6</td>
<td>1.0</td>
<td>15.16</td>
</tr>
<tr>
<td>A38</td>
<td>Barber</td>
<td>1.7</td>
<td>1.1</td>
<td>17.6</td>
</tr>
<tr>
<td>A39</td>
<td>Cafeteria</td>
<td>3.2</td>
<td>21.3</td>
<td>250.7</td>
</tr>
<tr>
<td>A40</td>
<td>Store</td>
<td>0.7</td>
<td>0.5</td>
<td>8.3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>247</td>
<td>176.77</td>
<td>2298.75</td>
</tr>
</tbody>
</table>
Table (2-8) Total cooling and heating loads for first floor.

<table>
<thead>
<tr>
<th>No of room</th>
<th>Name of room</th>
<th>Cooling load (Kw)</th>
<th>Heating load(Kw)</th>
<th>Area (m^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Surgery room</td>
<td>3.5</td>
<td>2.3</td>
<td>30.5</td>
</tr>
<tr>
<td>B2</td>
<td>Medicine room</td>
<td>0.5</td>
<td>0.35</td>
<td>4.4</td>
</tr>
<tr>
<td>B3</td>
<td>Reception room</td>
<td>1.4</td>
<td>0.9</td>
<td>10.7</td>
</tr>
<tr>
<td>B4</td>
<td>Recovery room</td>
<td>3.9</td>
<td>2.7</td>
<td>33.3</td>
</tr>
<tr>
<td>B5</td>
<td>Surgery room</td>
<td>5.8</td>
<td>3.8</td>
<td>57.2</td>
</tr>
<tr>
<td>B6</td>
<td>Nurse room</td>
<td>0.7</td>
<td>0.54</td>
<td>11</td>
</tr>
<tr>
<td>B7</td>
<td>Store room</td>
<td>0.6</td>
<td>0.48</td>
<td>7.3</td>
</tr>
<tr>
<td>B8</td>
<td>Recovery room</td>
<td>2</td>
<td>1.3</td>
<td>17.6</td>
</tr>
<tr>
<td>B9</td>
<td>Reception</td>
<td>2.1</td>
<td>1.4</td>
<td>18.3</td>
</tr>
<tr>
<td>B10</td>
<td>Archive</td>
<td>1.8</td>
<td>1.2</td>
<td>16</td>
</tr>
<tr>
<td>B11</td>
<td>Recovery room</td>
<td>3.7</td>
<td>2.6</td>
<td>31.7</td>
</tr>
<tr>
<td>B12</td>
<td>Surgery room</td>
<td>5.8</td>
<td>3.8</td>
<td>50</td>
</tr>
<tr>
<td>B13</td>
<td>Medicine room</td>
<td>0.82</td>
<td>0.6</td>
<td>7.3</td>
</tr>
<tr>
<td>B14</td>
<td>Medicine room</td>
<td>0.82</td>
<td>0.6</td>
<td>7.3</td>
</tr>
<tr>
<td>B15</td>
<td>Doctors Changing room</td>
<td>0.82</td>
<td>0.6</td>
<td>7.3</td>
</tr>
<tr>
<td>B16</td>
<td>Doctors Changing room</td>
<td>0.82</td>
<td>0.6</td>
<td>7.3</td>
</tr>
<tr>
<td>B17</td>
<td>Surgery room</td>
<td>7</td>
<td>4.6</td>
<td>60</td>
</tr>
<tr>
<td>B18</td>
<td>ICU</td>
<td>17.3</td>
<td>11.5</td>
<td>148.6</td>
</tr>
<tr>
<td>B19</td>
<td>CCU</td>
<td>17.3</td>
<td>11.5</td>
<td>148.6</td>
</tr>
<tr>
<td>B20</td>
<td>Class room</td>
<td>5.2</td>
<td>4.4</td>
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Table (2-9) Total cooling and heating loads for second floor.

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<th>Area (m²)</th>
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</tr>
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</tr>
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Table (2-10) Total cooling and heating loads for third floor.

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<tr>
<th>No of room</th>
<th>Name of room</th>
<th>Cooling load (Kw)</th>
<th>Heating load (Kw)</th>
<th>Area (m^2)</th>
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</thead>
<tbody>
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<td>D1</td>
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</tr>
<tr>
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<td>0.6</td>
<td>9</td>
</tr>
<tr>
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<td>1.02</td>
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</tr>
<tr>
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</tr>
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Table (2-11) Total cooling and heating loads for fourth floor.

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<th>Heating load (Kw)</th>
<th>Area (m^2)</th>
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<td>2.7</td>
<td>35.3</td>
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<td>35.3</td>
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<td>0.9</td>
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Table (2-12) Total cooling and heating loads for fifth floor.

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<th>Heating load (Kw)</th>
<th>Area (m^2)</th>
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</thead>
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<td>35.3</td>
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<td>2.7</td>
<td>35.3</td>
</tr>
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<td>2.7</td>
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</tr>
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<td>2.7</td>
<td>35.3</td>
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<td>2.7</td>
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<tr>
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<tr>
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</tr>
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<td>Archive</td>
<td>2.1</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
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<td>Reception</td>
<td>1.5</td>
<td>1.2</td>
<td>10</td>
</tr>
<tr>
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<td>Staff resting room</td>
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<td>1.9</td>
<td>23</td>
</tr>
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<td>12.5</td>
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<tr>
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</tr>
<tr>
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<td>2.7</td>
<td>35.5</td>
</tr>
<tr>
<td>E19</td>
<td>Patient room</td>
<td>4.1</td>
<td>2.7</td>
<td>35.5</td>
</tr>
<tr>
<td>E20</td>
<td>Patient room</td>
<td>4.1</td>
<td>2.7</td>
<td>35.5</td>
</tr>
<tr>
<td>E21</td>
<td>Patient room</td>
<td>4.7</td>
<td>3.1</td>
<td>40.6</td>
</tr>
<tr>
<td>E22</td>
<td>Patient room</td>
<td>4.7</td>
<td>3.1</td>
<td>40.6</td>
</tr>
<tr>
<td>V</td>
<td>Corridor</td>
<td>7.2</td>
<td>4.8</td>
<td>72</td>
</tr>
<tr>
<td>W</td>
<td>Corridor</td>
<td>22.6</td>
<td>15</td>
<td>222</td>
</tr>
<tr>
<td>X</td>
<td>Corridor</td>
<td>7.3</td>
<td>4.8</td>
<td>74</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>105.4</td>
<td>107.2</td>
<td>963.4</td>
</tr>
</tbody>
</table>
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.

2.6.2 Fan 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).

2.6.3 Fan 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.

2.6.3.1 Sample of fan coil:

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

\[ Q_{total} = m_s \times C_p \times (T_{water \, out} - T_{water \, in}) \]  

\[ 17.5 = m_{water} \times 4.18 \times (7) \]

\[ m_{water} = 0.6 \, \text{kg/s} \]

\[ m_{water} = \rho \times \dot{V} \]  

\[ 0.6 = 1000 \times \dot{V} \]

\[ \dot{V} = 6 \times 10^{-4} \]

\[ \dot{V} = A \times V \]  

\[ 6 \times 10^{-4} = A \times 0.7 \]

\[ A = 8.57 \times 10^{-4} \]

\[ d = \frac{A}{\pi/4} \]  

\[ d = \frac{2}{\pi/4} \times \frac{8.57 \times 10^{-4}}{\pi/4} = 0.03 \, \text{m} = 1.25 \]

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 pipes of fan coils in basement 2 floor

<table>
<thead>
<tr>
<th>Room</th>
<th>Q (kw)</th>
<th>Q (Ton)</th>
<th>( I ) (kg/s)</th>
<th>Diameter (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_1</td>
<td>12.20</td>
<td>3.48</td>
<td>0.42</td>
<td>1.25</td>
</tr>
<tr>
<td>R_2</td>
<td>19.5</td>
<td>5.5</td>
<td>0.6</td>
<td>1.25</td>
</tr>
<tr>
<td>R_3</td>
<td>3.5</td>
<td>1</td>
<td>0.116</td>
<td>0.75</td>
</tr>
<tr>
<td>R_4</td>
<td>2.7</td>
<td>0.77</td>
<td>0.09</td>
<td>0.50</td>
</tr>
<tr>
<td>R_5</td>
<td>2.9</td>
<td>0.82</td>
<td>0.09</td>
<td>0.50</td>
</tr>
<tr>
<td>R_6</td>
<td>27.9</td>
<td>7.97</td>
<td>0.95</td>
<td>1.50</td>
</tr>
<tr>
<td>R_7</td>
<td>1.47</td>
<td>0.42</td>
<td>0.05</td>
<td>0.50</td>
</tr>
<tr>
<td>Corridor a</td>
<td>27.6</td>
<td>7.9</td>
<td>0.95</td>
<td>1.50</td>
</tr>
</tbody>
</table>

The total load of room (R1) in basement 2 = 12.20 kw = 3.48 ton
from catalogue of fan coil (PETRA) we are selected the (DC18)

![Figure](image.png)

(2-2) From Petra catalogue

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

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Load KW</th>
<th>Flow kg/s</th>
<th>Diameter Selection. inch</th>
<th>Flow cfm</th>
<th>Fan Coil Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F1</td>
<td>19.5</td>
<td>0.60</td>
<td>1.25</td>
<td>1224</td>
<td>42CED004</td>
</tr>
<tr>
<td>2</td>
<td>F2</td>
<td>19.5</td>
<td>0.60</td>
<td>1.25</td>
<td>1224</td>
<td>42CED004</td>
</tr>
</tbody>
</table>
### Table (2-15) F1 duct and grills specifications.

<table>
<thead>
<tr>
<th>NO</th>
<th>Branch Name</th>
<th>Flow m³/s</th>
<th>Velocity m/s</th>
<th>Grill size Inch</th>
<th>Duct Size Inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A-B</td>
<td>2.62</td>
<td>5</td>
<td>12*12</td>
<td>20W * 10H</td>
</tr>
<tr>
<td>2</td>
<td>B-C</td>
<td>1.71</td>
<td>5</td>
<td>12*12</td>
<td>16W * 10H</td>
</tr>
<tr>
<td>3</td>
<td>C-D</td>
<td>0.87</td>
<td>5</td>
<td>12*12</td>
<td>10W * 10H</td>
</tr>
</tbody>
</table>

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.

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

### Table (2.17) F1 duct and grills specifications

<table>
<thead>
<tr>
<th>NO</th>
<th>Branch Name</th>
<th>Flow m³/s</th>
<th>Velocity m/s</th>
<th>Grill size Inch</th>
<th>Duct Size Inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A-B</td>
<td>2.6</td>
<td>5</td>
<td>6*6</td>
<td>18W * 10 H</td>
</tr>
<tr>
<td>2</td>
<td>B-C</td>
<td>2.2</td>
<td>5</td>
<td>6*6</td>
<td>16W * 10H</td>
</tr>
<tr>
<td>3</td>
<td>C-D</td>
<td>1.8</td>
<td>5</td>
<td>6*6</td>
<td>14W * 10H</td>
</tr>
</tbody>
</table>
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.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>D-F</td>
<td>1.5</td>
<td>5</td>
<td>6*6</td>
<td>12W * 10H</td>
</tr>
<tr>
<td>5</td>
<td>F-G</td>
<td>1.1</td>
<td>5</td>
<td>6*6</td>
<td>10W * 10H</td>
</tr>
<tr>
<td>6</td>
<td>G-H</td>
<td>0.7</td>
<td>5</td>
<td>6*6</td>
<td>8W * 10H</td>
</tr>
<tr>
<td>7</td>
<td>H-I</td>
<td>0.3</td>
<td>5</td>
<td>6*6</td>
<td>6W *10 H</td>
</tr>
</tbody>
</table>
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 branches surgery room B17 at First floor, temperature and relative humidity of 50%. The supply air temperature is 38°C. The inside design conditions is 16°C dbtemperature.

for the surgery room (B17) in the first floor

\[ Q_{\text{total}} = Q_{\text{latent}} + Q_{\text{sensible}} \]  \[ Q_{\text{total}} = 7 \text{ Kw} \]  [4-5]

\[ Q_I = \frac{\text{Heat from person \times No. of person}}{1000} \]  \[ [4-6] \]

Heat from person: - 30w

Number of person: - 4 person for each room

\[ Q_I = \frac{30 \times 4}{1000} = 0.12 \text{ kw} \]

\[ Q_{\text{sensible}} = Q_{\text{total}} - Q_{\text{latent}} \]
\[ Q_{\text{sensible}} = 7 - 0.12 = 6.88 \text{ kw} \]

\[ Q_{\text{sensible}} = \dot{m}_s \times C_p \times (T_{\text{supply}} - T_{\text{coil}}) \]

\[ Q_{\text{sensible}} = \rho \times \dot{V} \times C_p \times (T_{\text{supply}} - T_{\text{coil}}) \]

\( \rho \):- density of air = 1.25 kg/m³

\( \dot{V} \):- flow rate

\( C_p \):- 1.0 kJ/kg.K

\( T_{\text{supply}} \):- 38°C

\( T_{\text{coil}} \):- 16°C

\[ 6.88 = 1.25 \times \dot{V} \times 1 \times (38 - 16) \]

\[ \dot{V} = 0.250 \text{ m}^3/\text{s} \]

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) = 8 m/s

-the velocity of air in the branch = 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 fine the duct size of the branch by duct sizer program:

For the room (B1,B4,B5,B8,B11,B12,B17)
\[ Q_{\text{Total sensible}} = 3.38 + 3.78 + 5.68 + 1.88 + 3.58 + 5.68 + 6.88 \]
\[ = 30.86 \text{ kw} \]
the total flow rate \((\dot{V}) = 1.122 \text{ m}^3/\text{s}\)
from duct sizer the main duct size is \((500 \times 300)\) as shows:

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

(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

<table>
<thead>
<tr>
<th>NO</th>
<th>Room name</th>
<th>location</th>
<th>Total load kW</th>
<th>Unit Name</th>
<th>Flow L/s</th>
<th>Unit selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Surgery room</td>
<td>First floor</td>
<td>3.38</td>
<td>AHU1</td>
<td>122</td>
<td>YMA 970/950</td>
</tr>
<tr>
<td>B4</td>
<td>Recovery room</td>
<td>First floor</td>
<td>3.78</td>
<td>AHU1</td>
<td>137</td>
<td>YMA 970/950</td>
</tr>
<tr>
<td>B5</td>
<td>Surgery room</td>
<td>First floor</td>
<td>5.68</td>
<td>AHU1</td>
<td>206</td>
<td>YMA 970/950</td>
</tr>
<tr>
<td>B8</td>
<td>Recovery room</td>
<td>First floor</td>
<td>1.88</td>
<td>AHU1</td>
<td>68</td>
<td>YMA 970/950</td>
</tr>
<tr>
<td>B11</td>
<td>Recovery room</td>
<td>First floor</td>
<td>3.58</td>
<td>AHU1</td>
<td>130</td>
<td>YMA 970/950</td>
</tr>
<tr>
<td>B12</td>
<td>Surgery room</td>
<td>First floor</td>
<td>5.68</td>
<td>AHU1</td>
<td>206</td>
<td>YMA 970/950</td>
</tr>
<tr>
<td>B17</td>
<td>Surgery room</td>
<td>First floor</td>
<td>6.88</td>
<td>AHU1</td>
<td>250</td>
<td>YMA 970/950</td>
</tr>
<tr>
<td>B18</td>
<td>ICU</td>
<td>First floor</td>
<td>17.18</td>
<td>AHU2</td>
<td>624</td>
<td>YMA 970/950</td>
</tr>
<tr>
<td>B19</td>
<td>CCU</td>
<td>First floor</td>
<td>17.18</td>
<td>AHU2</td>
<td>624</td>
<td>YMA 970/950</td>
</tr>
<tr>
<td>C2</td>
<td>Surgery room</td>
<td>Second floor</td>
<td>7.68</td>
<td>AHU3</td>
<td>279</td>
<td>YMA 970/950</td>
</tr>
<tr>
<td>C4</td>
<td>Patient recovery room</td>
<td>Second floor</td>
<td>12.96</td>
<td>AHU3</td>
<td>471</td>
<td>YMA 970/950</td>
</tr>
<tr>
<td>C6</td>
<td>Surgery room</td>
<td>Second floor</td>
<td>10.35</td>
<td>AHU3</td>
<td>376</td>
<td>YMA 970/950</td>
</tr>
<tr>
<td>C27</td>
<td>Surgery room</td>
<td>Second floor</td>
<td>5.08</td>
<td>AHU4</td>
<td>184</td>
<td>YMA</td>
</tr>
</tbody>
</table>
Note :- (The location and details of all AHU shown in the drawing)

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

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

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

<table>
<thead>
<tr>
<th>NO of room</th>
<th>The sensible load (kw)</th>
<th>TR</th>
<th>CFM</th>
<th>Grill size mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>7.68</td>
<td>0.96</td>
<td>384</td>
<td>6*12</td>
</tr>
<tr>
<td>C4</td>
<td>12.96</td>
<td>1.08</td>
<td>432</td>
<td>10*12</td>
</tr>
<tr>
<td>C6</td>
<td>10.35</td>
<td>1.62</td>
<td>648</td>
<td>6*12</td>
</tr>
<tr>
<td>C27</td>
<td>5.08</td>
<td>0.53</td>
<td>212</td>
<td>8*12</td>
</tr>
<tr>
<td>C30</td>
<td>5.08</td>
<td>1.02</td>
<td>408</td>
<td>10*12</td>
</tr>
</tbody>
</table>
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:
\[ \text{total number of air change (CFM)} = \frac{V(M^3)n}{1.7} \]  
\( n \): from ASHRE ventilation for acceptable air quality (CFM/m² room)  
\( V \): volume of the space

<table>
<thead>
<tr>
<th>Application</th>
<th>Estimated Maximum* Smokers or 100 m² or Total Person</th>
<th>Outdoor Air Requirements</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>0.25</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Bedroom</td>
<td>0.30</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Living room</td>
<td>0.15</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Bath</td>
<td>0.20</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Kitchen</td>
<td>0.10</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Dining room</td>
<td>0.10</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Garage</td>
<td>0.05</td>
<td>0.05</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 (2-5) from ASHRAE
Example: For mechanical store in Basement 3:

\[
\text{total number of air change (CFM) = } \frac{V(M^3) \times n}{1.7} \]

\[
\text{total number of air change (CFM) = } \frac{778 \text{ M}^3 \times 1}{1.7} = 457.6 \text{ CFM}
\]

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:

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

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
\[ Q_{\text{cooling}} = 98.35 \text{ ton} \] (the cooling load of AHU & Fan coil in connected to chiller 1)
by multiply of safety factor 1.5
\[ Q_{\text{cooling}} = 98.35 \times 1.5 = 147.5 \text{ ton} \]
\[ = 516.25 \text{ KW} \]
So, the chiller selected from career company is model no. **30XW/30XWH1552**.
- 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.

\[ Q_{heating} = 64 \text{ ton} \] (the heating load of AHU & Fan coil in zone 1)

by multiply of safety factor 1.5

\[ Q_{heating} = 64 \times 1.5 = 96 \text{ ton} \]

\[ = 336 \text{ KW} \]

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

Table (2-22) The summary of boiler selection

<table>
<thead>
<tr>
<th>Boiler No.</th>
<th>Location</th>
<th>( Q_{heating} )</th>
<th>Model no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mechanical store</td>
<td>344 KW</td>
<td>ideal 350V-600H.</td>
</tr>
<tr>
<td></td>
<td>In basement 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Mechanical store</td>
<td>739.2 KW</td>
<td>ideal 400V-600H</td>
</tr>
<tr>
<td></td>
<td>In basement 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mechanical store</td>
<td>390.6KW</td>
<td>ideal 400V-600H</td>
</tr>
<tr>
<td></td>
<td>In basement 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Pump No.</th>
<th>Location</th>
<th>Flow rate ( Q=\text{[gpm]} )</th>
<th>Head[m]</th>
<th>Model no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Roof plan</td>
<td>354gpm</td>
<td>40.2 m</td>
<td>NB 65-200/219 50 Hz</td>
</tr>
<tr>
<td>2</td>
<td>Roof plan</td>
<td>507.24gpm</td>
<td>40.2 m</td>
<td>NB 65-160/177 60 Hz.</td>
</tr>
<tr>
<td>3</td>
<td>Roof plan</td>
<td>402gpm</td>
<td>24.45m</td>
<td>NB 65-142/115 50 Hz</td>
</tr>
</tbody>
</table>

Note: Each chiller have another stand by pump having the same Characteristics .
<table>
<thead>
<tr>
<th>Pump No.</th>
<th>Location</th>
<th>Flow rate Q=[gpm]</th>
<th>Head[m]</th>
<th>Model no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mechanical store In basement 3</td>
<td>236gpm</td>
<td>40.2 m</td>
<td>CR 45-3-3, 3400V-50 Hz.</td>
</tr>
<tr>
<td>2</td>
<td>Mechanical store In basement 2</td>
<td>507gpm</td>
<td>40.2 m</td>
<td>NB 65-160/177, 3 400V-50 Hz.</td>
</tr>
<tr>
<td>3</td>
<td>store In basement 2</td>
<td>268gpm</td>
<td>24.45m</td>
<td>CR 45-3-2, 3 400V-50 Hz.</td>
</tr>
</tbody>
</table>
CHAPTER THREE

Plumbing System
CHAPTER 3

3.1 Introduction

Plumbing 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.

3.1.1 Water 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. It's composed of two parts: the pipes which convey 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 estimation):

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

We have 194 bed in our hospital

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

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:

<table>
<thead>
<tr>
<th>Fixture Type</th>
<th>Demand per fixture (FU)</th>
<th>No of fixtures</th>
<th>Total demand for cold water</th>
<th>Total demand for hot water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory (General)</td>
<td>2*3/4</td>
<td>20</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Shower head (General)</td>
<td>4*3/4</td>
<td>3</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Separate Shower (private)</td>
<td>2*3/4</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>WC (General) flush tank</td>
<td>5</td>
<td>12</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>Kitchen sink (General)</td>
<td>4*3/4</td>
<td>4</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

Total for basement 2: 114 (gpm) 54 (gpm)

<table>
<thead>
<tr>
<th>Fixture Type</th>
<th>Demand per fixture (FU)</th>
<th>No of fixtures</th>
<th>Total demand for cold water</th>
<th>Total demand for hot water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory (General)</td>
<td>2*3/4</td>
<td>13</td>
<td>19.5</td>
<td>19.5</td>
</tr>
<tr>
<td>Shower head (General)</td>
<td>4*3/4</td>
<td>2</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>WC (General) flush tank</td>
<td>5</td>
<td>9</td>
<td>45</td>
<td>0</td>
</tr>
</tbody>
</table>

Total for basement 1: 70.5 (gpm) 25.5 (gpm)

<table>
<thead>
<tr>
<th>Fixture Type</th>
<th>Demand per fixture (FU)</th>
<th>No of fixtures</th>
<th>Total demand for cold water</th>
<th>Total demand for hot water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory (General)</td>
<td>2*3/4</td>
<td>20</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Shower head (General)</td>
<td>4*3/4</td>
<td>1</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Urinal (general)</td>
<td>2*3/4</td>
<td>4</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>WC (General) flush tank</td>
<td>5</td>
<td>19</td>
<td>95</td>
<td>0</td>
</tr>
</tbody>
</table>

Total for ground floor: 149 (gpm) 48 (gpm)

56 (gpm) 28 (gpm)
<table>
<thead>
<tr>
<th>Fixture Type</th>
<th>Demand per fixture (FU)</th>
<th>No of fixtures</th>
<th>Total demand for cold water</th>
<th>Total demand for hot water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory (General)</td>
<td>2*3/4</td>
<td>28</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Shower head (General)</td>
<td>4*3/4</td>
<td>14</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>WC (General) flush tank</td>
<td>5</td>
<td>11</td>
<td>55</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total for 1st floor</strong></td>
<td></td>
<td></td>
<td><strong>139</strong></td>
<td><strong>84</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>52 (gpm)</strong></td>
<td><strong>40 (gpm)</strong></td>
</tr>
<tr>
<td>Lavatory (General)</td>
<td>2*3/4</td>
<td>20</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Shower head (General)</td>
<td>4*3/4</td>
<td>12</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>WC (General) flush tank</td>
<td>5</td>
<td>14</td>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total 2nd floor</strong></td>
<td></td>
<td></td>
<td><strong>136</strong></td>
<td><strong>66</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>52.2 (gpm)</strong></td>
<td><strong>35 (gpm)</strong></td>
</tr>
<tr>
<td>Lavatory (General)</td>
<td>2*3/4</td>
<td>20</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Shower head (General)</td>
<td>4*3/4</td>
<td>16</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Separate Shower (private)</td>
<td>2*3/4</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>WC (General) flush tank</td>
<td>5</td>
<td>20</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total for both 3rd 4th and 5th floors</strong></td>
<td></td>
<td></td>
<td><strong>181</strong></td>
<td><strong>81</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>67 (gpm)</strong></td>
<td><strong>40 (gpm)</strong></td>
</tr>
</tbody>
</table>
3.2.2 Water 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 height) * 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 following equation:

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

The recommended velocity for all fixture units should not exceed 8 fps, except for water closet With flush valve of 4 fps.

a- For cold water system:

Total length from pump to riser = 3.4 m.
Total length from floor to floor = 32 m.
Total length from riser to collector = 7 m
Total length from collector to fixture unit = 8.7 m.
Total length = 51.1 m.
Total equivalent length = 51.1 * 1.5 * 3.28 = 251 ft.
b- For hot water system:

Total length from boiler to riser1 = 8 m.
Total length floor to floor = 36 m.
Total length from riser to collector = 6 m
Total length from collector to fixture unit = 8 m.
Total length = 58 m.
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) = 15 psi.
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) = 17 psi.
Uniform friction loss = friction/100ft = available friction head/ total equivalent length.
Friction/100ft = 17 psi/(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):

<table>
<thead>
<tr>
<th>Type of FU</th>
<th>Demand per FU</th>
<th>Number of FU</th>
<th>cold water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory</td>
<td>2* 3/4</td>
<td>10</td>
<td>16.5</td>
</tr>
<tr>
<td>Water closet</td>
<td>5</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Shower</td>
<td>2* 3/4</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total 1st floor</strong></td>
<td></td>
<td></td>
<td>51.5 Fu</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of FU</th>
<th>Demand per FU</th>
<th>Number of FU</th>
<th>Cold water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory</td>
<td>2* 3/4</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>Water closet</td>
<td>5</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Shower</td>
<td>2* 3/4</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total 2nd floor</strong></td>
<td></td>
<td></td>
<td>57 Fu</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of FU</th>
<th>Demand per FU</th>
<th>Number of FU</th>
<th>cold water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory</td>
<td>2* 3/4</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Water closet</td>
<td>5</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Shower</td>
<td>2* 3/4</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total 3rd, 4th and 5th floor</strong></td>
<td></td>
<td></td>
<td>48 Fu</td>
</tr>
</tbody>
</table>

Calculation of Branch connected to riser 2:-

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

<table>
<thead>
<tr>
<th>Branch’s of riser 2</th>
<th>Flow rate (gpm)</th>
<th>Total equivalent length (ft)</th>
<th>Friction (psi/100ft)</th>
<th>Pipe size (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st floor</td>
<td>30</td>
<td>190.2</td>
<td>7.8</td>
<td>1 ¼</td>
</tr>
<tr>
<td>2nd floor</td>
<td>32</td>
<td>228.8</td>
<td>6.5</td>
<td>1 ¼</td>
</tr>
<tr>
<td>3rd floor</td>
<td>28</td>
<td>211.5</td>
<td>7</td>
<td>1 ¼</td>
</tr>
<tr>
<td>4th floor</td>
<td>28</td>
<td>231.2</td>
<td>6.4</td>
<td>1 ¼</td>
</tr>
<tr>
<td>5th floor</td>
<td>28</td>
<td>251</td>
<td>6</td>
<td>1 ¼</td>
</tr>
</tbody>
</table>

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 riser 2:
Table (3.4) The sizing pipe of riser 2 for cold water.

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

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):

<table>
<thead>
<tr>
<th>Type of FU</th>
<th>Demand per FU</th>
<th>Number of FU</th>
<th>Hot water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory</td>
<td>2* 3/4</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Laundry</td>
<td>3* 3/4</td>
<td>7</td>
<td>15.5</td>
</tr>
<tr>
<td>Shower</td>
<td>2* 3/4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total for basement 2</strong></td>
<td></td>
<td></td>
<td><strong>23 Fu</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15.5 gpm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of FU</th>
<th>Demand per FU</th>
<th>Number of FU</th>
<th>Hot water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory</td>
<td>2* 3/4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Laundry</td>
<td>3* 3/4</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Shower</td>
<td>2* 3/4</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total for basement 1</strong></td>
<td></td>
<td></td>
<td><strong>24Fu</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16 gpm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of FU</th>
<th>Demand per FU</th>
<th>Number of FU</th>
<th>Hot water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory</td>
<td>2* 3/4</td>
<td>5</td>
<td>7.5</td>
</tr>
<tr>
<td><strong>Total for ground and 1st floor</strong></td>
<td></td>
<td></td>
<td><strong>7.5Fu</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.5 gpm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of FU</th>
<th>Demand per FU</th>
<th>Number of FU</th>
<th>Hot water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lavatory</td>
<td>2* 3/4</td>
<td>5</td>
<td>7.5</td>
</tr>
<tr>
<td>Shower</td>
<td>2* 3/4</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total 2nd floor</strong></td>
<td></td>
<td></td>
<td><strong>16.5Fu</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12 gpm</td>
</tr>
<tr>
<td>Type of FU</td>
<td>Demand per FU</td>
<td>Number of FU</td>
<td>Hot water</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------</td>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Lavatory</td>
<td>2* 3/4</td>
<td>9</td>
<td>13.5</td>
</tr>
<tr>
<td>Bathtub</td>
<td>3* 3/4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Shower</td>
<td>2* 3/4</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td><strong>Total 3rd, 4th and 5th floor</strong></td>
<td><strong>37.5Fu</strong></td>
<td><strong>24 gpm</strong></td>
<td><strong>24 gpm</strong></td>
</tr>
</tbody>
</table>

**Calculation of Branch connected to riser 1:-**

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

<table>
<thead>
<tr>
<th>Branch’s of riser 1</th>
<th>Flow rate (gpm)</th>
<th>Total equivalent length (ft)</th>
<th>Friction (psi/100ft)</th>
<th>Pipe size (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>basement 2 floor</td>
<td>15.5</td>
<td>155</td>
<td>10.9</td>
<td>1</td>
</tr>
<tr>
<td>basement 1 floor</td>
<td>16</td>
<td>174.6</td>
<td>9.7</td>
<td>1</td>
</tr>
<tr>
<td>ground floor</td>
<td>6.5</td>
<td>177.6</td>
<td>9.6</td>
<td>3/4</td>
</tr>
<tr>
<td>first floor</td>
<td>6.5</td>
<td>202.2</td>
<td>8.4</td>
<td>1</td>
</tr>
<tr>
<td>second floor</td>
<td>12</td>
<td>222.3</td>
<td>7.6</td>
<td>1 ¼</td>
</tr>
<tr>
<td>third floor</td>
<td>24</td>
<td>246</td>
<td>7</td>
<td>1 ¼</td>
</tr>
<tr>
<td>forth floor</td>
<td>24</td>
<td>265.6</td>
<td>6.4</td>
<td>1 ¼</td>
</tr>
<tr>
<td>fifth floor</td>
<td>24</td>
<td>285.3</td>
<td>6</td>
<td>1 ¼</td>
</tr>
</tbody>
</table>

**Table (3.7) Pipe sizing of riser1:**

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

<table>
<thead>
<tr>
<th>Fixture unit</th>
<th>No. of Fixture</th>
<th>Drainage Fixture Unit value, dfu</th>
<th>dfu value (Horizontal Branch)</th>
<th>Diameter of Pipe, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Table (4)</td>
<td></td>
<td>Table (3)</td>
</tr>
<tr>
<td>Lavatory. Stack(D)</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>1 ½</td>
</tr>
<tr>
<td>WC. Stack(D)</td>
<td>3</td>
<td>6</td>
<td>18</td>
<td>2 ½</td>
</tr>
<tr>
<td>Lavatory. Stack(E)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1 ½</td>
</tr>
<tr>
<td>WC. Stack(E)</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Stack Type</td>
<td>Floors</td>
<td>dfu value (Stack)</td>
<td>Diameter of Pipe, in.</td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td>--------</td>
<td>-------------------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td>Shower. Stack(E)</td>
<td>1, 2, 2, 1 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavatory. Stack(F)</td>
<td>5, 1, 5, 1 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WC. Stack(F)</td>
<td>2, 6, 12, 2 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavatory. Stack(G)</td>
<td>5, 1, 5, 1 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WC. Stack(G)</td>
<td>2, 6, 12, 2 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavatory. Stack(H)</td>
<td>3, 1, 3, 1 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WC. Stack(H)</td>
<td>1, 6, 6, 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shower. Stack(H)</td>
<td>1, 2, 2, 1 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavatory. Stack(I)</td>
<td>1, 1, 1, 1 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WC. Stack(I)</td>
<td>1, 6, 6, 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shower. Stack(I)</td>
<td>1, 2, 2, 1 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laundry. Stack(V)</td>
<td>2, 2, 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laundry. Stack(W)</td>
<td>5, 2, 10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavatory. Stack(12)</td>
<td>1, 1, 1, 1 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WC. Stack(12)</td>
<td>2, 6, 12, 2 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shower. Stack(12)</td>
<td>2, 2, 4, 1 ½</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Stack 4</th>
<th>dfu value (Stack)</th>
<th>Diameter of Pipe, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>From floor 5</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>From floor 4</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>From floor 3</td>
<td>27</td>
<td>2 ½</td>
</tr>
<tr>
<td>From floor 2</td>
<td>36</td>
<td>2 ½</td>
</tr>
<tr>
<td>From floor B1</td>
<td>40</td>
<td>2 ½</td>
</tr>
<tr>
<td>From floor B2</td>
<td>57</td>
<td>2 ½</td>
</tr>
<tr>
<td>To M.H59</td>
<td>57</td>
<td>2 ½</td>
</tr>
</tbody>
</table>
Table (3.10) For vertical stack in hospital:

<table>
<thead>
<tr>
<th>Stack</th>
<th>dfu value (Stack)</th>
<th>Diameter of Pipe, in. Table (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>13</td>
<td>2 ½</td>
</tr>
<tr>
<td>B</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>16</td>
<td>2 ½</td>
</tr>
<tr>
<td>D</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>E</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>F</td>
<td>17</td>
<td>2 ½</td>
</tr>
<tr>
<td>G</td>
<td>17</td>
<td>2 ½</td>
</tr>
<tr>
<td>H</td>
<td>11</td>
<td>2 ½</td>
</tr>
<tr>
<td>I</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>J</td>
<td>32</td>
<td>3</td>
</tr>
<tr>
<td>K</td>
<td>38</td>
<td>3</td>
</tr>
<tr>
<td>L</td>
<td>13</td>
<td>2 ½</td>
</tr>
<tr>
<td>M</td>
<td>13</td>
<td>2 ½</td>
</tr>
<tr>
<td>N</td>
<td>13</td>
<td>2 ½</td>
</tr>
<tr>
<td>O</td>
<td>12</td>
<td>2 ½</td>
</tr>
<tr>
<td>P</td>
<td>13</td>
<td>2 ½</td>
</tr>
<tr>
<td>Q</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>R</td>
<td>36</td>
<td>2 ½</td>
</tr>
<tr>
<td>S</td>
<td>36</td>
<td>2 ½</td>
</tr>
<tr>
<td>T</td>
<td>36</td>
<td>2 ½</td>
</tr>
<tr>
<td>U</td>
<td>36</td>
<td>2 ½</td>
</tr>
<tr>
<td>V</td>
<td>69</td>
<td>3</td>
</tr>
<tr>
<td>W</td>
<td>37</td>
<td>2 ½</td>
</tr>
<tr>
<td>X</td>
<td>27</td>
<td>2 ½</td>
</tr>
<tr>
<td>Y</td>
<td>36</td>
<td>2 ½</td>
</tr>
<tr>
<td>X</td>
<td>13</td>
<td>2 ½</td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>2 ½</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td>2 ½</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>2 ½</td>
</tr>
<tr>
<td>5</td>
<td>36</td>
<td>2 ½</td>
</tr>
<tr>
<td>6</td>
<td>64</td>
<td>3</td>
</tr>
</tbody>
</table>
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 be 1.5%.

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.

<table>
<thead>
<tr>
<th>Depth Range</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>(50-100) cm</td>
<td>60 cm</td>
</tr>
<tr>
<td>(100-150) cm</td>
<td>80 cm</td>
</tr>
<tr>
<td>(150-250) cm</td>
<td>100 cm</td>
</tr>
<tr>
<td>&gt; 250 cm</td>
<td>120 cm</td>
</tr>
</tbody>
</table>

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:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>65</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>36</td>
<td>2 ½</td>
</tr>
<tr>
<td>9</td>
<td>78</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>58</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>53</td>
<td>3</td>
</tr>
<tr>
<td>13</td>
<td>34</td>
<td>2 ½</td>
</tr>
<tr>
<td>14</td>
<td>33</td>
<td>2 ½</td>
</tr>
<tr>
<td>15</td>
<td>33</td>
<td>2 ½</td>
</tr>
</tbody>
</table>
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:

\[ Y = \frac{(S \times \text{Slope}) + 5}{100} \]

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:

\[ Y = \frac{(4.00 \times 1.5) + 5}{100} \]

\[ = \frac{(4.00 \times 1.5) + 5}{100} \]

\[ = 0.11 \text{ m} \]

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:

<table>
<thead>
<tr>
<th>Manhole #</th>
<th>Top level (m)</th>
<th>Invert level (m)</th>
<th>Depth (m)</th>
<th>Diameter (m)</th>
<th>Cover type</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>+0.00</td>
<td>-0.60</td>
<td>0.60</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>------------------</td>
</tr>
<tr>
<td>M2</td>
<td>+0.00</td>
<td>-0.71</td>
<td>0.71</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M3</td>
<td>+0.00</td>
<td>-0.84</td>
<td>0.84</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M4</td>
<td>+0.00</td>
<td>-1.00</td>
<td>1.00</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M5</td>
<td>+0.00</td>
<td>-1.16</td>
<td>1.16</td>
<td>0.80</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M6</td>
<td>+0.00</td>
<td>-1.35</td>
<td>1.35</td>
<td>0.80</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M7</td>
<td>+0.00</td>
<td>-1.43</td>
<td>1.43</td>
<td>0.80</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M8</td>
<td>+0.00</td>
<td>-1.52</td>
<td>1.52</td>
<td>1.00</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M9</td>
<td>+0.00</td>
<td>-1.65</td>
<td>1.65</td>
<td>1.00</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M10</td>
<td>+0.00</td>
<td>-1.75</td>
<td>1.75</td>
<td>1.00</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M11</td>
<td>+0.00</td>
<td>-1.83</td>
<td>1.83</td>
<td>1.00</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M12</td>
<td>+0.00</td>
<td>-1.92</td>
<td>1.92</td>
<td>1.00</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M13</td>
<td>+0.00</td>
<td>-2.00</td>
<td>2.00</td>
<td>1.00</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M14</td>
<td>+0.00</td>
<td>-2.16</td>
<td>2.16</td>
<td>1.00</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M15</td>
<td>+0.00</td>
<td>-2.34</td>
<td>2.34</td>
<td>1.00</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M16</td>
<td>+0.00</td>
<td>-2.45</td>
<td>2.45</td>
<td>1.00</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M17</td>
<td>+0.00</td>
<td>-2.61</td>
<td>2.61</td>
<td>1.20</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M18</td>
<td>+0.00</td>
<td>-2.80</td>
<td>2.80</td>
<td>1.20</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M19</td>
<td>+0.00</td>
<td>-2.93</td>
<td>2.93</td>
<td>1.20</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M20</td>
<td>+8.00</td>
<td>+7.40</td>
<td>0.60</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M21</td>
<td>+8.00</td>
<td>+7.40</td>
<td>0.60</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M22</td>
<td>+8.00</td>
<td>+7.30</td>
<td>0.70</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td>D M23</td>
<td>+8.00</td>
<td>+7.15</td>
<td>0.85</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td>D.M24</td>
<td>+7.50</td>
<td>+6.90</td>
<td>0.60</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td>M25</td>
<td>+7.50</td>
<td>+6.80</td>
<td>0.70</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td>D.M26</td>
<td>+7.00</td>
<td>+6.20</td>
<td>0.60</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td>D.M27</td>
<td>+5.50</td>
<td>+4.90</td>
<td>0.60</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td>D.M28</td>
<td>+5.00</td>
<td>+4.40</td>
<td>0.60</td>
<td>0.60</td>
<td>Medium duty</td>
</tr>
<tr>
<td>---</td>
<td>-------</td>
<td>-------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td>+4.45</td>
<td>+0.00</td>
<td>-0.83</td>
<td>-0.89</td>
<td>-1.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.60</td>
<td>0.89</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.60</td>
<td>0.60</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 the 4"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 ≤3" the minimum slope is 1/4 in/ft.

For pipes of diameter ≥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:

<table>
<thead>
<tr>
<th>Pump No.</th>
<th>Location</th>
<th>Flow rate Q=[gpm]</th>
<th>Head[m]</th>
<th>Model no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mechanical store</td>
<td>125gpm</td>
<td>40.2 m</td>
<td>HYDRO MULTI-E 2 CR 32-3</td>
</tr>
<tr>
<td></td>
<td>In basement 3</td>
<td></td>
<td></td>
<td>50 Hz</td>
</tr>
<tr>
<td>2</td>
<td>Mechanical store</td>
<td>76gpm</td>
<td>40.2 m</td>
<td>HYDRO MULTI-E 2 CME10-</td>
</tr>
<tr>
<td></td>
<td>In basement 2</td>
<td></td>
<td></td>
<td>03 50 Hz</td>
</tr>
<tr>
<td>3</td>
<td>store</td>
<td>105gpm</td>
<td>24.45m</td>
<td>HYDRO MULTI-E 2 CR 32-3</td>
</tr>
<tr>
<td></td>
<td>In basement 2</td>
<td></td>
<td></td>
<td>50 Hz</td>
</tr>
</tbody>
</table>
Table (3.13) selection of Hor water pump:

<table>
<thead>
<tr>
<th>Pump No.</th>
<th>Location</th>
<th>Flow rate Q=[gpm]</th>
<th>Head[m]</th>
<th>Model no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mechanical store</td>
<td>91gpm</td>
<td>40.2 m</td>
<td>CR 20-6 A-A-A-E-HQQE</td>
</tr>
<tr>
<td></td>
<td>In basement 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Mechanical store</td>
<td>65gpm</td>
<td>40.2 m</td>
<td>CR 18-8 A-F-G-E-HQQE</td>
</tr>
<tr>
<td></td>
<td>In basement 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>store</td>
<td>73gpm</td>
<td>40.2 m</td>
<td>CR 15-8 A-F-A-E-HQQE</td>
</tr>
<tr>
<td></td>
<td>In basement 2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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:

![Fire Triangle Diagram]

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](image)
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=20ft²) 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:
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:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Light (Low) Hazard Occupancy</th>
<th>Ordinary (Moderate) Hazard Occupancy</th>
<th>Extra (High) Hazard Occupancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Rated single extinguisher</td>
<td>2-A</td>
<td>2-A</td>
<td>4-A</td>
</tr>
<tr>
<td>Maximum floor area per unit of A</td>
<td>3,000 ft²</td>
<td>1,500 ft²</td>
<td>1,000 ft²</td>
</tr>
<tr>
<td>Maximum floor area for extinguisher</td>
<td>11,250 ft²</td>
<td>11,250 ft²</td>
<td>11,250 ft²</td>
</tr>
<tr>
<td>Maximum travel distance to extinguisher</td>
<td>75 ft.</td>
<td>75 ft.</td>
<td>75 ft.</td>
</tr>
</tbody>
</table>
The following table(4.3) shows the fire extinguisher size and placement for class B hazard:

<table>
<thead>
<tr>
<th>Type of Hazard</th>
<th>Basic Minimum Extinguisher Rating</th>
<th>Maximum Travel Distance to Extinguisher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light (Low)</td>
<td>5-B</td>
<td>30 ft.</td>
</tr>
<tr>
<td></td>
<td>10-B</td>
<td>50 ft.</td>
</tr>
<tr>
<td>Ordinary (Moderate)</td>
<td>10-B</td>
<td>30 ft.</td>
</tr>
<tr>
<td></td>
<td>20-B</td>
<td>50 ft.</td>
</tr>
<tr>
<td>Extra (High)</td>
<td>40-B</td>
<td>30 ft.</td>
</tr>
<tr>
<td></td>
<td>80-B</td>
<td>50 ft.</td>
</tr>
</tbody>
</table>

- **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:

![Extinguisher color code](image)

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:-

<table>
<thead>
<tr>
<th>Type of hazard</th>
<th>Type of Fire extinguisher</th>
<th>Type of room</th>
<th>No. of fire extinguisher</th>
<th>Wight (kg)</th>
<th>Coverage area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary</td>
<td>Co2</td>
<td>Service store</td>
<td>3</td>
<td>6kg</td>
<td>129m²</td>
</tr>
<tr>
<td>Ordinary</td>
<td>Co2</td>
<td>Mechanical store</td>
<td>5</td>
<td>6kg</td>
<td>316m²</td>
</tr>
<tr>
<td>light</td>
<td>Dry powder</td>
<td>Emergency</td>
<td>7</td>
<td>6kg</td>
<td>471m²</td>
</tr>
<tr>
<td>Ordinary</td>
<td>Co2</td>
<td>laundry</td>
<td>5</td>
<td>6kg</td>
<td>1058m²</td>
</tr>
</tbody>
</table>

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](image)
b) House Rack:

![House Rack Image]

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
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:

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 one 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 30 minutes 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%.

![Fire fighting characteristic curve](image)

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

\[ Q_{\text{total}} = Q_{\text{pump}} = Q_{\text{sprinkler}} + Q_{\text{FHC}} + Q_{\text{FH}} \], we have used only FHC

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*100 gpm) = 1500 gpm.
Calculating the flow rate needed the 2nd pump room connected with risers 2, 3 and 4
The total flow rate for riser 2 = (10*100 gpm) + 250 gpm (as factor of safety for each riser add to the first riser “from code NPFA= 1500 gpm.

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

<table>
<thead>
<tr>
<th>No. of pump</th>
<th>Name of risers</th>
<th>1 load (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1500</td>
</tr>
<tr>
<td></td>
<td>Total load</td>
<td>1500 gpm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No of pump</th>
<th>Name of risers</th>
<th>load (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>1250</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>950</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>750</td>
</tr>
<tr>
<td></td>
<td>Total load</td>
<td>2950 gpm</td>
</tr>
</tbody>
</table>

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 = 15 ft/100 ft (6 psi/100 ft = 0.413 bar) from figure (1) in appendix [B].
The static head = 118 ft (51 psi = 3.5 bar).
The FHC Residual pressure 4.5 bar from NPAF10.

So, we need 1500gpm and 8.413 bar

**Table (4.6) selection of pump**

<table>
<thead>
<tr>
<th>No of pump</th>
<th>Q total (gpm)and head(m)</th>
<th>Selection of pump type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1500 gpm &amp; 32m</td>
<td>Seffco pump100/24</td>
</tr>
<tr>
<td>2</td>
<td>2950 gpm &amp; 32m</td>
<td>Seffco pump100/24</td>
</tr>
</tbody>
</table>

See the catalog,

![SFFECO Fire Pumps](image)

**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):

![Fire extinguisher](image)

**Fig (4.11) Fire extinguisher**
And 6 kg of CO2 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:**

\[ Q = 500 \text{ gpm} \]

\[ \text{Time} = 60 \text{ m (from NPFA13 ordinary hazard)} \]

\[ \text{Tank volume} = Q \times \text{Time} \]

\[ \text{Tank volume} = 500 \times 60 = 30000 \text{ Gallon} \]

\[ \text{Tank volume} = 114 \text{ m}^3 \]

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

\[ Q = \left[ (\text{Diesel engine (HP) rating} \times 1 \text{(Gal/HP)} + 10\% \text{ (factor of safety)}) \right] \]

From catalog the Jokey pump rating is 270HP

\[ Q = [270 \times 1 \text{Gal/HP} + 10\%] = 270 \times 3.785/1000 \text{L} + 10\% = 1.24 \text{m}^3 \text{ total fuel tank volume} \]
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 plumbing 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 outlets, without regard for any diversity, is called the total connected load. If the total connected load were used for sizing purposes, the result would be a vastly oversized system, since not all of the stations in the facility will be used at the same time. A diversity, or simultaneous-use factor, is used to allow for the fact that not all of the stations will be used at once. It is used to reduce the system flow rate in conjunction with the total connected load for sizing mains and branch piping to all parts of the distribution system. This factor varies for different areas throughout any facility.

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**:

![Diagram showing terminal unit location](image)

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*

<table>
<thead>
<tr>
<th>Department</th>
<th>O₂</th>
<th>N₂O</th>
<th>N₂O₂</th>
<th>MA</th>
<th>SAT</th>
<th>VAC</th>
<th>AGSS</th>
<th>He/O₂</th>
<th>AVSU</th>
<th>Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident and Emergency</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>2 sets*</td>
<td>1 set (3)</td>
</tr>
<tr>
<td>Note: One set either side of the trolley space, if installed in fixed location, e.g. trunking; or both sets in an articulated supply pendant that can be positioned either side of the bed space.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major treatment/placer room per trolley space</td>
<td>1</td>
<td>1</td>
<td>lp</td>
<td>1p</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>1 set/8 TUs</td>
<td></td>
</tr>
<tr>
<td>Note: One set either side of the trolley space, if installed in fixed location, e.g. trunking; or both sets in an articulated supply pendant that can be positioned either side of the bed space.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment room/ward</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1 set/8 TUs</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operating department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaesthetic room (all)</td>
</tr>
<tr>
<td>Operating room, orthopaedic:</td>
</tr>
<tr>
<td>For anaesthetist</td>
</tr>
<tr>
<td>Note: Orthopaedic surgery is normally performed in operating rooms provided with ultra-clean systems. Such systems are more effective in terms of airflow when provided with partial or full 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.</td>
</tr>
<tr>
<td>Operating room, neurosurgery</td>
</tr>
<tr>
<td>Anaesthetist</td>
</tr>
<tr>
<td>Surgeon</td>
</tr>
</tbody>
</table>

Figure (5.4) from HTM 0201 Code
5.4 Type Of Medical Gases

5.4.1 Oxygen (O₂)

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 (O₂)in HTM0201 code

<table>
<thead>
<tr>
<th>Department</th>
<th>Design flow for each terminal unit (L/min)</th>
<th>n</th>
<th>Diversified flow Q (L/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-patient accommodation (ward units):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single 4-bed rooms and treatment room</td>
<td>10</td>
<td>0</td>
<td>Qₘ = 10 + [(n – 1)6/4] = 0</td>
</tr>
<tr>
<td>Ward block/department</td>
<td>10</td>
<td>0</td>
<td>Qₜ = Qₘ[1 + (nW – 1)/2] = 0</td>
</tr>
<tr>
<td>Accident &amp; emergency:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Room Type</td>
<td>Q Calculation</td>
<td>Result</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>----------------------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>Resuscitation room, per trolley space</td>
<td>( Q = 100 + [(n - 1)6/4] = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major treatment/plaster room, per trolley space</td>
<td>( Q = 10 + [(n - 1)6/4] = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-anesthesia recovery, per trolley space</td>
<td>( Q = 10 + [(n - 1)6/8] = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment room/cubicle</td>
<td>( Q = 10 + [(n - 1)6/10] = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anaesthetic rooms</td>
<td>( Q = \text{no addition made} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating rooms</td>
<td>( Q = 100 + (nT - 1)10 = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-anesthesia recovery</td>
<td>( Q = 10 + (n - 1)6 = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternity:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDRP rooms:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother</td>
<td>( Q = 10 + [(n - 1)6/4] = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baby</td>
<td>( Q = 10 + [(n - 1)3/2] = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating suites:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anesthetist</td>
<td>( Q = 100 + (nS - 1)6 = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pediatrician</td>
<td>( Q = 10 + (n - 1)3 = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-anesthesia recovery</td>
<td>( Q = 10 + [(n - 1)3/4] = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-patient accommodation:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single/multi-bed wards</td>
<td>( Q = 10 + [(n - 1)6/6] = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nursery, per cot space</td>
<td>( Q = 10 + [(n - 1)3/2] = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special care baby unit</td>
<td>( Q = 10 + (n - 1)6 = 0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiological:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service/Department</td>
<td>N</td>
<td>Q</td>
<td>Formula</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>------</td>
<td>-----</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>All anesthetic and procedures rooms</td>
<td>100</td>
<td>0</td>
<td>$Q = 10 + \left( n - 1 \right)6/3 = 0$</td>
</tr>
<tr>
<td>Critical care areas</td>
<td>10</td>
<td>0</td>
<td>$Q = 10 + \left( n - 1 \right)6/3 = 0$</td>
</tr>
<tr>
<td>Coronary care unit</td>
<td>10</td>
<td>0</td>
<td>$Q = 10 + \left( n - 1 \right)6/3 = 0$</td>
</tr>
<tr>
<td>High-dependency unit (HDU)</td>
<td>10</td>
<td>0</td>
<td>$Q = 10 + \left( n - 1 \right)6/3 = 0$</td>
</tr>
<tr>
<td>Renal</td>
<td>10</td>
<td>0</td>
<td>$Q = 10 + \left( n - 1 \right)6/3 = 0$</td>
</tr>
<tr>
<td>CPAP ventilation</td>
<td>75</td>
<td>0</td>
<td>$Q = 75 \times 75%$</td>
</tr>
<tr>
<td>Adult mental illness accommodation:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electro-convulsive therapy (ECT) room</td>
<td>10</td>
<td>0</td>
<td>$Q = 10 + \left( n - 1 \right)6/4 = 0$</td>
</tr>
<tr>
<td>Post-anesthesia, per bed space</td>
<td>10</td>
<td>0</td>
<td>$Q = 10 + \left( n - 1 \right)6/4 = 0$</td>
</tr>
<tr>
<td>Adult acute day care accommodation:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment rooms</td>
<td>10</td>
<td>0</td>
<td>$Q = 10 + \left( n - 1 \right)6/4 = 0$</td>
</tr>
<tr>
<td>Post-anesthesia recovery per bed space</td>
<td>10</td>
<td>0</td>
<td>$Q = 10 + \left( n - 1 \right)6/4 = 0$</td>
</tr>
<tr>
<td>Oral surgery/orthodontic:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consulting rooms, type 1</td>
<td>10</td>
<td>0</td>
<td>$Q = 10 + \left( n - 1 \right)6/2 = 0$</td>
</tr>
<tr>
<td>Consulting rooms, types 2 &amp; 3</td>
<td>10</td>
<td>0</td>
<td>$Q = 10 + \left( n - 1 \right)6/3 = 0$</td>
</tr>
<tr>
<td>Recovery room, per bed space</td>
<td>10</td>
<td>3</td>
<td>$Q = 10 + \left( n - 1 \right)6/6 = 12$</td>
</tr>
<tr>
<td>Out-patient:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.4.2 Nitrous Oxide (NO₂)

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

<table>
<thead>
<tr>
<th>Department</th>
<th>Design flow for each terminal unit (L/min)</th>
<th>n</th>
<th>Diversified flow Q (L/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident &amp; emergency: resuscitation room, per trolley space</td>
<td>10</td>
<td>0</td>
<td>( Q = 10 + [(n - 1)6/4] = 0 )</td>
</tr>
<tr>
<td>Operating</td>
<td>15</td>
<td>0</td>
<td>( Q = 15 + (nT - 1)6 = 0 )</td>
</tr>
<tr>
<td>Maternity: operating suites</td>
<td>15</td>
<td>0</td>
<td>( Q = 15 + (nS - 1)6 = 0 )</td>
</tr>
<tr>
<td>Radiological: all anesthetic and procedures rooms</td>
<td>15</td>
<td>0</td>
<td>( Q = 10 + [(n - 1)6/4] = 0 )</td>
</tr>
<tr>
<td>Critical care areas</td>
<td>15</td>
<td>0</td>
<td>( Q = 10 + [(n - 1)6/4] = 0 )</td>
</tr>
<tr>
<td>Oral surgery/orthodontic: consulting rooms, type 1</td>
<td>10</td>
<td>0</td>
<td>( Q = 10 + [(n - 1)6/4] = 0 )</td>
</tr>
<tr>
<td>Other departments</td>
<td>10</td>
<td>0</td>
<td>No additional flow included = 0</td>
</tr>
<tr>
<td>Equipment service rooms</td>
<td>15</td>
<td>0</td>
<td>No additional flow included = 0</td>
</tr>
</tbody>
</table>
### 5.4.3 Medical Air

Medical Air is primarily used for respiratory therapy. It is 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:

<table>
<thead>
<tr>
<th>Department</th>
<th>Design flow for each terminal unit (L/min)</th>
<th>n</th>
<th>Diversified flow $Q$ (L/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In-patient accommodation (ward units):</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single 4-bed rooms and treatment room</td>
<td>20</td>
<td>0</td>
<td>$Q_w = 20 + [(n - 1)10/4] = 0$</td>
</tr>
<tr>
<td>Ward block/department</td>
<td>20</td>
<td>0</td>
<td>$Q_d = Q_w[1 + (nW - 1)/2] = 0$</td>
</tr>
<tr>
<td><strong>Accident &amp; emergency:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resuscitation room, per trolley space</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)20/4] = 0$</td>
</tr>
<tr>
<td>Major treatment/plaster room, per trolley space</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)20/4] = 0$</td>
</tr>
<tr>
<td>Post-anesthesia recovery, per trolley space</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)40/4] = 0$</td>
</tr>
<tr>
<td><strong>Operating:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anaesthetic rooms</td>
<td>40</td>
<td>0</td>
<td>$Q = \text{no addition made}$</td>
</tr>
<tr>
<td>Operating rooms</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(nT - 1)40/4] = 0$</td>
</tr>
<tr>
<td>Post-anesthesia recovery</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)10/4] = 0$</td>
</tr>
<tr>
<td><strong>Maternity:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Flow Rate</td>
<td>Additional Flow</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td>LDRP rooms:</td>
<td>40</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Baby</td>
<td>40</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Operating suites:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anesthetist</td>
<td>40</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Post-anesthesia recovery</td>
<td>40</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Neonatal unit (SCBU)</td>
<td>40</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Radiological:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All anesthetics and procedures rooms</td>
<td>40</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Critical care areas</td>
<td>80</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>High-dependency unit (HDU)</td>
<td>80</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Renal</td>
<td>20</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Oral surgery/orthodontic:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major dental/oral surgery rooms</td>
<td>40</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>All other departments</td>
<td>40</td>
<td>No additional flow allowance to be made</td>
<td></td>
</tr>
<tr>
<td>Equipment service rooms</td>
<td>40</td>
<td>No additional flow included</td>
<td></td>
</tr>
</tbody>
</table>

### 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

<table>
<thead>
<tr>
<th>Department</th>
<th>Design flow for each terminal unit (L/min)</th>
<th>n</th>
<th>Diversified flow $Q$ (L/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-patient accommodation (ward units):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ward unit</td>
<td>40</td>
<td>0</td>
<td>$Q = 40$</td>
</tr>
<tr>
<td>Multiple ward units</td>
<td>40</td>
<td>0</td>
<td>$Q_d = 40 + [(n - 1)40/4] = 0$</td>
</tr>
<tr>
<td>Accident &amp; emergency:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resuscitation room, per trolley space</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)40/4] = 0$</td>
</tr>
<tr>
<td>Major treatment/plaster room, per trolley space</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)40/4] = 0$</td>
</tr>
<tr>
<td>Post-anesthesia recovery, per trolley space</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)40/4] = 0$</td>
</tr>
<tr>
<td>Treatment room/cubicle</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)40/8] = 0$</td>
</tr>
<tr>
<td>Operating:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anaesthetic rooms</td>
<td>40</td>
<td>0</td>
<td>No additional flow included</td>
</tr>
<tr>
<td>Operating rooms:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anesthetist</td>
<td>40</td>
<td>0</td>
<td>$Q = 40$</td>
</tr>
<tr>
<td>Surgeon</td>
<td>40</td>
<td>0</td>
<td>$Q = 40$</td>
</tr>
<tr>
<td>Operating suites</td>
<td>40</td>
<td>0</td>
<td>$Q_8 = 80 + [(nS - 1)80/2] = 0$</td>
</tr>
<tr>
<td>Post-anesthesia recovery</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)40/4]$</td>
</tr>
</tbody>
</table>
### Maternity:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LDRP rooms:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + \left\lfloor \frac{(n - 1)40}{4} \right\rfloor = 0$</td>
</tr>
<tr>
<td>Baby</td>
<td>40</td>
<td>0</td>
<td>No additional flow included</td>
</tr>
<tr>
<td><strong>Operating suites:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anesthetist</td>
<td>40</td>
<td>0</td>
<td>$Q = 40$</td>
</tr>
<tr>
<td>Obstetrician</td>
<td>40</td>
<td>0</td>
<td>$Q = 40$</td>
</tr>
<tr>
<td>Operating suites</td>
<td>80</td>
<td>0</td>
<td>$Q_s = 80 + \left\lfloor \frac{(nS - 1)80}{2} \right\rfloor = 0$</td>
</tr>
<tr>
<td>Post-anesthesia recovery</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + \left\lfloor \frac{(n - 1)40}{4} \right\rfloor = 0$</td>
</tr>
<tr>
<td><strong>In-patient accommodation:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ward unit comprising single, multi-bed and treatment room</td>
<td>40</td>
<td>0</td>
<td>$Q = 40$</td>
</tr>
<tr>
<td>Multi-ward units</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + \left\lfloor \frac{(n - 1)40}{2} \right\rfloor = 0$</td>
</tr>
<tr>
<td>Nursery, per cot space</td>
<td>40</td>
<td>0</td>
<td>No additional to be included</td>
</tr>
<tr>
<td>SCBU</td>
<td>40</td>
<td></td>
<td>$Q = 40 + \left\lfloor \frac{(n - 1)40}{4} \right\rfloor = 0$</td>
</tr>
<tr>
<td><strong>Radiological:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All anesthetic and procedures rooms</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + \left\lfloor \frac{(n - 1)40}{8} \right\rfloor = 0$</td>
</tr>
<tr>
<td>Critical care areas</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + \left\lfloor \frac{(n - 1)40}{4} \right\rfloor = 0$</td>
</tr>
<tr>
<td>High-dependency unit (HDU)</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + \left\lfloor \frac{(n - 1)40}{4} \right\rfloor = 0$</td>
</tr>
<tr>
<td>Renal</td>
<td>40</td>
<td>0</td>
<td>$Q_d = 40 + \left\lfloor \frac{(n - 1)40}{4} \right\rfloor = 0$</td>
</tr>
<tr>
<td>Adult mental illness</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### accommodation:

<table>
<thead>
<tr>
<th>Room Description</th>
<th>Capacity</th>
<th>Additional Allowance</th>
<th>Formula</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electro-convulsive therapy (ECT) room</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)40/4]$</td>
<td>0</td>
</tr>
<tr>
<td>Post-anesthesia, per bed space</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)40/4]$</td>
<td>0</td>
</tr>
</tbody>
</table>

### Oral surgery/orthodontic:

<table>
<thead>
<tr>
<th>Room Description</th>
<th>Capacity</th>
<th>Additional Allowance</th>
<th>Formula</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consulting rooms, type 1</td>
<td>40</td>
<td>0</td>
<td>Dental vacuum only</td>
<td>0</td>
</tr>
<tr>
<td>Consulting rooms, types 2 &amp; 3</td>
<td>40</td>
<td>0</td>
<td>Dental vacuum only</td>
<td>0</td>
</tr>
<tr>
<td>Recovery room, per bed space</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)40/8]$</td>
<td>0</td>
</tr>
</tbody>
</table>

### Out-patient:

<table>
<thead>
<tr>
<th>Room Description</th>
<th>Capacity</th>
<th>Additional Allowance</th>
<th>Formula</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment rooms</td>
<td>40</td>
<td>0</td>
<td>$Q = 40 + [(n - 1)40/8]$</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Room Description</th>
<th>Capacity</th>
<th>Additional Allowance</th>
<th>Formula</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment service rooms, sterile services etc</td>
<td>40</td>
<td></td>
<td>Residual capacity will be adequate without an additional allowance</td>
<td></td>
</tr>
</tbody>
</table>

#### 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:

<table>
<thead>
<tr>
<th>Department</th>
<th>Design flow for each terminal unit (L/min)</th>
<th>n</th>
<th>Diversified flow $Q$ (L/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident &amp; emergency resuscitation room (per trolley space)</td>
<td>130</td>
<td>0</td>
<td>$Q = V + [(n - 1)V/4] = 0$</td>
</tr>
<tr>
<td>Operating departments</td>
<td>130</td>
<td>0</td>
<td>$Q = V + (nT - 1)V = 0$</td>
</tr>
<tr>
<td>Maternity operating suites</td>
<td>130</td>
<td>0</td>
<td>$Q = V + (nS - 1)V = 0$</td>
</tr>
<tr>
<td>Radio diagnostic (all an aesthetic and procedures room)</td>
<td>130</td>
<td>0</td>
<td>$Q = V + [(n - 1)V/4] = 0$</td>
</tr>
<tr>
<td>Oral surgery/orthodontic</td>
<td>130</td>
<td>0</td>
<td>$Q = V + [(n - 1)V/4] = 0$</td>
</tr>
</tbody>
</table>

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).

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

$n$: Number of beds.

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

$Q=101.5\text{ L/m}$

[5-1]
2- Nitrous Oxide (NO₂)

\[ Q = 15 + (n-1) \frac{6}{4} \] From Table (6.3).

\[ Q: \text{The flow of nitrous oxide gases (L/m).} \]
\[ n: \text{Number of beds.} \]
\[ Q = 15 + (2-1) \frac{6}{4} \]
\[ Q = 16.5 \text{ L/m} \]

3- Medical Vacuum

\[ Q = 80 \times 2 + [(n-2) \frac{80}{2}] \] From Table (6.5).

\[ Q: \text{The flow of medical vacuum gases (L/m).} \]
\[ n: \text{Number of beds.} \]
\[ Q = 80 \times 2 + [(2-2) \frac{80}{2}] = 160 \text{ L/m} \]

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

<table>
<thead>
<tr>
<th>Floor</th>
<th>Oxygen [L/m]</th>
<th>Nitrous Oxide [L/m]</th>
<th>Medical Air [L/m]</th>
<th>Medical Vacuum [L/m]</th>
<th>AGSS [L/m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basement 2</td>
<td>164.5</td>
<td>165</td>
<td>1040</td>
<td>1080</td>
<td>840</td>
</tr>
<tr>
<td>Basement 1</td>
<td>24.4</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Ground</td>
<td>25</td>
<td>—</td>
<td>140</td>
<td>140</td>
<td>—</td>
</tr>
<tr>
<td>First Floor</td>
<td>105</td>
<td>33</td>
<td>619</td>
<td>240</td>
<td>2520</td>
</tr>
<tr>
<td>Second Floor</td>
<td>100.5</td>
<td>33</td>
<td>980</td>
<td>290</td>
<td>480</td>
</tr>
<tr>
<td>Third Floor</td>
<td>131</td>
<td>—</td>
<td>1440</td>
<td>350</td>
<td>—</td>
</tr>
<tr>
<td>Fourth Floor</td>
<td>131</td>
<td>—</td>
<td>1440</td>
<td>350</td>
<td>—</td>
</tr>
<tr>
<td>Fifth floor</td>
<td>131</td>
<td>—</td>
<td>1440</td>
<td>350</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>812</td>
<td>231</td>
<td>7751</td>
<td>2100</td>
<td>3840</td>
</tr>
</tbody>
</table>
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.

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

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.

<table>
<thead>
<tr>
<th></th>
<th>6 mm</th>
<th>8 mm</th>
<th>10 mm</th>
<th>12 mm</th>
<th>15 mm</th>
<th>18 mm</th>
<th>22 mm</th>
<th>28 mm</th>
<th>35 mm</th>
<th>42 mm</th>
<th>54 mm</th>
<th>76 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball valve</td>
<td>0.10</td>
<td>0.10</td>
<td>0.20</td>
<td>0.30</td>
<td>0.30</td>
<td>0.60</td>
<td>0.90</td>
<td>1.10</td>
<td>1.20</td>
<td>1.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tec (Thru)</td>
<td>0.12</td>
<td>0.15</td>
<td>0.18</td>
<td>0.21</td>
<td>0.32</td>
<td>0.42</td>
<td>0.54</td>
<td>0.70</td>
<td>0.82</td>
<td>1.05</td>
<td>1.56</td>
<td></td>
</tr>
<tr>
<td>Tec (Branch)</td>
<td>0.46</td>
<td>0.52</td>
<td>0.70</td>
<td>0.80</td>
<td>0.95</td>
<td>1.26</td>
<td>1.60</td>
<td>2.10</td>
<td>2.45</td>
<td>3.14</td>
<td>4.67</td>
<td></td>
</tr>
<tr>
<td>90° Elbow</td>
<td>0.17</td>
<td>0.20</td>
<td>0.25</td>
<td>0.33</td>
<td>0.47</td>
<td>0.63</td>
<td>0.80</td>
<td>1.05</td>
<td>1.23</td>
<td>1.58</td>
<td>2.36</td>
<td></td>
</tr>
</tbody>
</table>

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 copper pipe to transfer O2 gas with an equivalent length of [12 m], an outside diameter of [15 mm] and a flow rate of [800 L/m]

![Table Image](image_url)

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

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

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 further 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=701,568 L/Day

- Number of cylinder Oxygen gases = The amount of oxygen gas L/Day capacities of oxygen gas cylinders m³.
- 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 m³.
- 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 m³/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 m³/h = 7751 × 60/1000 = 465 m³/h.

-We need three compressors can compress 155 m³/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 m³/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 m³/h = 2100 × 60/1000 = 126 m³/h.

-We need three pumps to be able to suction 42 m³/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 m³/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 m³/h = 3840 × 60/1000

= 230 m³/h.

- We need three pumps to be able suction 77 m³/h (for each) of the gas to the outside air.
These pumps distributed as shown on drawings.
BILL OF QUANTITIES
<table>
<thead>
<tr>
<th>Item NO</th>
<th>DISCRIPTION</th>
<th>Unit</th>
<th>Quality</th>
<th>Price/Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td><strong>DRAINAGE WORKS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.1</td>
<td>Supply and install UPVC pipes S.N.8 for rain water, drain pipes vertical, horizontal under ground, suspended to the ceiling, price include all fittings such as welding sockets, T, elbows, 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.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.1.1</td>
<td>6&quot;</td>
<td>L. M</td>
<td>335</td>
<td></td>
</tr>
<tr>
<td>1.1.1.2</td>
<td>4&quot;</td>
<td>L. M</td>
<td>525</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2&quot;</td>
<td>L. M</td>
<td>206</td>
<td></td>
</tr>
<tr>
<td>1.1.2</td>
<td>Supply and install 4&quot; PVC floor trap (siphon) FT4&quot; complete with floor collector with vertical outlet 110 mm for the 2&quot;, 1 1/2&quot;, 1 1/4&quot;, 1&quot; PVC pipes and chrome plated cover 15x15 cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.3</td>
<td>Ditto but clean out</td>
<td>unit</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>1.1.4</td>
<td>Ditto but floor drain 4/2&quot;</td>
<td>unit</td>
<td>220</td>
<td></td>
</tr>
<tr>
<td>1.1.5</td>
<td>FORWARDED TOTAL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td><strong>COLD AND HOT WATER SYSTEM</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2.1</td>
<td>Supply and install Galvanized steel pipes sch.40 with all the fittings, elbows, 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.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2.1.1</td>
<td>2&quot;</td>
<td>L. M</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>1.2.1.2</td>
<td>11/2&quot;</td>
<td>L. M</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>1.2.1.3</td>
<td>11/4&quot;</td>
<td>L. M</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>1.2.1.4</td>
<td>1 &quot;</td>
<td>L. M</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>1.2.1.5</td>
<td>3/4&quot;</td>
<td>L. M</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>1.2.1.6</td>
<td>1/2&quot;</td>
<td>L. M</td>
<td>65</td>
<td></td>
</tr>
</tbody>
</table>
### 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 includes shut off valve with records, air vents, end piece, collector 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.

<p>| 1.3.1 | Supply and install wall hung W.C bowel class A, white color with the necessary original connections, including concealed flush valve for wall, with steel reinforcing legs and . price includes cover seat from same type, bolts and nuts connection to cold water and drainage and casting reinforced concrete B 250 20cm thick, Ø 8mmx20x20 cm around the steel reinforced legs as a complete job | unit 4 |
| 1.3.2 | Supply and install wash basin class A white color with semi pedestal size 55x42 with 2 angle valves 1/2&quot;-3/8&quot; 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&quot;-3/8&quot; 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&quot;-3/8&quot; valve and connection to cold &amp; hot water as a complete job | unit 4 |
| 1.3.6 | Ditto but scrub sink with chrome lever mixer as specification | unit 4 |</p>
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3.8</td>
<td>Supply, install, test and commission Porcelain shower of size 80x80 cm.</td>
<td>unit</td>
<td>88</td>
</tr>
<tr>
<td>1.3.9</td>
<td>Supply, install, test and commission Chrome plated gear mixer type</td>
<td>unit</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Total Carried To The Next Page</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3.12</td>
<td>Supply, install, test and commission Recessed soap disk</td>
<td>unit</td>
<td>9</td>
</tr>
<tr>
<td>1.3.14</td>
<td>Supply, install, test and commission Care toilet seat open front with cover white color specially used for handicapped people.</td>
<td>unit</td>
<td>8</td>
</tr>
<tr>
<td>1.3.15</td>
<td>Supply, install, test and commission Stainless steel Paper holder for single roll fixed to wall.</td>
<td>unit</td>
<td>125</td>
</tr>
<tr>
<td>1.3.16</td>
<td>Supply and install surface mounted multi-roll toilet tissue dispenser, price include all fixing accessories and stainless steel screws as a complete job</td>
<td>unit</td>
<td>26</td>
</tr>
<tr>
<td>1.3.17</td>
<td>Supply and install surface mounted wall hand dryer stainless steel cover with all the necessary fixing accessories and screws and connecting to power socket as a complete job</td>
<td>unit</td>
<td>125</td>
</tr>
<tr>
<td>1.4</td>
<td>HVAC SYSTEM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4.1</td>
<td>Supply and install black steel sch.40 with all the fittings, elbows, 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</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4.1.1</td>
<td>4&quot;</td>
<td>LM</td>
<td>31</td>
</tr>
<tr>
<td>1.4.1.2</td>
<td>3&quot;</td>
<td>LM</td>
<td>23</td>
</tr>
<tr>
<td>1.4.1.3</td>
<td>2&quot;</td>
<td>LM</td>
<td>35</td>
</tr>
<tr>
<td>1.4.1.4</td>
<td>11/2&quot;</td>
<td>LM</td>
<td>44</td>
</tr>
<tr>
<td>1.4.1.5</td>
<td>11/4&quot;</td>
<td>LM</td>
<td>163</td>
</tr>
<tr>
<td>1.4.1.6</td>
<td>1&quot;</td>
<td>LM</td>
<td>56</td>
</tr>
<tr>
<td>1.4.1.7</td>
<td>3/4&quot;</td>
<td>LM</td>
<td>121</td>
</tr>
<tr>
<td>1.4.1.8</td>
<td>1/2&quot;&quot;</td>
<td>LM</td>
<td>550</td>
</tr>
</tbody>
</table>
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 temperature 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 568 Kw | 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 install flexible tubes 8” to connect between ceiling diffuser and main exhaust duct including all necessary clamps. | unit | 600 |
### 1.4.10
Supplement and install air ceiling diffusers 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.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Unit</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4.10.1</td>
<td>12&quot;x12&quot;</td>
<td>unit</td>
<td>200</td>
</tr>
<tr>
<td>1.4.10.3</td>
<td>9&quot;x9&quot;</td>
<td>unit</td>
<td>60</td>
</tr>
<tr>
<td>1.4.10.4</td>
<td>6&quot;x8&quot;</td>
<td>unit</td>
<td>100</td>
</tr>
<tr>
<td>1.4.11</td>
<td>6&quot;x10&quot;</td>
<td>unit</td>
<td>40</td>
</tr>
<tr>
<td>1.4.11.1</td>
<td>10&quot;x12&quot;</td>
<td>unit</td>
<td>100</td>
</tr>
<tr>
<td>1.4.12</td>
<td>Same as item 22.8 but for fresh air grills and grilles.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4.12.1</td>
<td>size 6&quot;x8&quot;</td>
<td>unit</td>
<td>100</td>
</tr>
</tbody>
</table>

### 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.
- Control 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:

<table>
<thead>
<tr>
<th>Code</th>
<th>Model</th>
<th>Unit</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4.14.1</td>
<td>PETRA.3KW</td>
<td>unit</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>PETRA.5KW</td>
<td>unit</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>PETRA.7KW</td>
<td>unit</td>
<td>24</td>
</tr>
<tr>
<td>1.4.14.2</td>
<td>PETRA.12KW</td>
<td>unit</td>
<td>32</td>
</tr>
<tr>
<td>1.4.15</td>
<td>Same as item 22.8 but for fresh air grills and grilles.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Supply and install horizontal multi space mini central air handling units including:

Ceiling suspension installation.
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4.15.1</td>
<td>MFCI- 10 / 3 7.8 kwatt cooling capacity</td>
<td>unit</td>
<td>1.4.15.2</td>
</tr>
<tr>
<td>1.4.16</td>
<td>supply and install circulation vertical in-line (centrifugal) pumps 15m³/h&amp;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.</td>
<td>unit</td>
<td>27</td>
</tr>
<tr>
<td>1.4.17</td>
<td>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.</td>
<td>unit</td>
<td>4</td>
</tr>
<tr>
<td>1.4.18</td>
<td>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 complete job and site engineer request.</td>
<td>unit</td>
<td>45</td>
</tr>
<tr>
<td>1.5</td>
<td>FIRE FIGHTING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5.1</td>
<td>Supply and install galvanized steel pipes to ASTM-A53 grade &quot;A&quot; 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..</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5.1.1</td>
<td>6&quot;</td>
<td>L. M</td>
<td>65</td>
</tr>
<tr>
<td>1.5.1.2</td>
<td>4&quot;</td>
<td>L. M</td>
<td>165</td>
</tr>
<tr>
<td>1.5.1.3</td>
<td>11/2&quot;</td>
<td>L. M</td>
<td>62</td>
</tr>
</tbody>
</table>
### 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

<table>
<thead>
<tr>
<th>Unit</th>
<th>103</th>
</tr>
</thead>
</table>

### 1.5.3
Supply and install stainless steel gauge 22 fire cabinets, size 80x80 cm. The cabinet shall be divided into two compartments; one for the hose reel and the other for the fire extinguisher and shall include the following:

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fir hose 3/4” in diameter, 25 meter long, light weight, made of red rubber</td>
<td></td>
</tr>
<tr>
<td>with working pressure of 150 psi.</td>
<td></td>
</tr>
<tr>
<td>Hose reel of the swinging type, up to 180 degrees full swing complete with</td>
<td></td>
</tr>
<tr>
<td>guide arm.</td>
<td></td>
</tr>
<tr>
<td>Chrome plated 3/4” in diameter nozzle capable of complete shut-off</td>
<td></td>
</tr>
<tr>
<td>Gate valve 1” in diameter.</td>
<td></td>
</tr>
<tr>
<td>Fire hose 2” in diameter, 15 meter long, light weight, made of linen.</td>
<td></td>
</tr>
<tr>
<td>Chrome plated 2” in diameter nozzle capable of complete shut-off.</td>
<td></td>
</tr>
<tr>
<td>Angle valve 2” in diameter of best quality.</td>
<td></td>
</tr>
<tr>
<td>Hose adapter 2” in diameter.</td>
<td></td>
</tr>
<tr>
<td>3 Kgs. Chemical fire extinguisher with spray hose and nozzle.</td>
<td></td>
</tr>
</tbody>
</table>

### 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

#### 1.6.3 Ceiling pendent
Multi movement type with Motorized ARM for anesthesia and
<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Oxygen outlets</td>
<td>unit</td>
<td>45</td>
</tr>
<tr>
<td>Two VAC outlets</td>
<td>unit</td>
<td>16</td>
</tr>
<tr>
<td>Two Air outlets</td>
<td>unit</td>
<td>18</td>
</tr>
<tr>
<td>Price includes all type of Valves and Fixation plates.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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.  

**1.6.6 ZSU Assembly -- All Gases**

**COPPER PIPE LINE**

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>N2OPipework c/w fittings &amp; brackets - 22mm</td>
<td>L. M</td>
<td>220</td>
</tr>
<tr>
<td>A4&amp;O2 Pipework c/w fittings &amp; brackets - 22mm</td>
<td>L. M</td>
<td>320</td>
</tr>
<tr>
<td>ASSG Pipework c/w fittings &amp; brackets - 28mm</td>
<td>L. M</td>
<td>220</td>
</tr>
<tr>
<td>vac Pipework c/w fittings &amp; brackets - 42mm</td>
<td>L. M</td>
<td>220</td>
</tr>
</tbody>
</table>

**1.6.7 Supply and 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

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>O2 cylinders</td>
<td>unit</td>
<td>27</td>
</tr>
<tr>
<td>N2O cylinders</td>
<td>unit</td>
<td>3</td>
</tr>
<tr>
<td>Pump for medical air with total amount of 42m3/h</td>
<td>unit</td>
<td>3</td>
</tr>
<tr>
<td>Pump for AGSS gas with total amount of 230m3/h</td>
<td>unit</td>
<td>3</td>
</tr>
<tr>
<td>Medical air compressor with total amount of 155m3/h</td>
<td>unit</td>
<td>3</td>
</tr>
</tbody>
</table>
APPENDIX (A)
Table(2)

| Lat. | Month     | N  | NNE | NNW | NE  | N  | ENE | NW  | W   | E   | W   | ESE | SE  | SSW | SSW | S   | S   | Horizontal Roof  |
|------|-----------|----|-----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---------------|
| 16   | December  | -2.2| -3.3| -4.4| -4.4| -2.2| -0.5| 2.2 | 5.0 | 7.2 | 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| -3.8| 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 |

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### Table 6.8 Shading coefficient (SC) for glass windows without interior shading.1

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<tr>
<td>N</td>
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<td>0.17 0.14 0.11 0.09 0.06 0.33 0.24 0.46 0.56 0.61 0.71 0.76 0.80 0.82 0.82 0.75 0.75</td>
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<td>M</td>
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<td>Shaded</td>
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<tr>
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<td>M</td>
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<td></td>
<td>M</td>
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<tr>
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<td>H</td>
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<td>H</td>
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<td>L</td>
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Table 9-10 Cooling load factors (CLF) for glass windows without interior shading, north latitudes.
### Table 9-13 Heat gain rate from miscellaneous appliances, W

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<th>With Hood</th>
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<td>Hair dryers (Helmet type)</td>
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<td>Coffee brewer (gas)</td>
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<td>210</td>
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<td>Water heater</td>
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<td>Coffee urn (gas)</td>
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<td>Deep fat fryer (electrical)</td>
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<td>Deep fat fryer (gas)</td>
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<td>Toaster</td>
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<td>Roasting oven</td>
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<td>Food warmer (gas)</td>
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<td>Small copy machine</td>
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### Table 9-14 Cooling load factor (CLF)u, for lights

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<th>Fixture Y&lt;sup&gt;c&lt;/sup&gt;</th>
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<td>0.99</td>
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<td>0.15</td>
<td>0.36</td>
<td>0.05</td>
<td>0.20</td>
</tr>
<tr>
<td>Type of Activity</td>
<td>Typical Application</td>
<td>Total Heat Dissipation</td>
<td>Total Adjusted(a) Heat Dissipation</td>
<td>Sensible Heat, W</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------</td>
<td>------------------------</td>
<td>--------------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Seated at rest</td>
<td>Theater:</td>
<td>111.5</td>
<td>94.0</td>
<td>64.0</td>
</tr>
<tr>
<td></td>
<td>Matinee</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evening</td>
<td>111.5</td>
<td>100.0</td>
<td>70.0</td>
</tr>
<tr>
<td>Seated, very light work</td>
<td>Offices, hotels,</td>
<td>128.5</td>
<td>114.0</td>
<td>70.0</td>
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<tr>
<td></td>
<td>apartments,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>restaurants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderately active office</td>
<td>Offices, hotels,</td>
<td>135.5</td>
<td>128.5</td>
<td>71.5</td>
</tr>
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<td>work</td>
<td>apartments</td>
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<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>retail store,</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>supermarkets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>Drug store</td>
<td>157.0</td>
<td>143.0</td>
<td>71.5</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking, seated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standing, walking slowly</td>
<td>Bank</td>
<td>157.0</td>
<td>143.0</td>
<td>71.5</td>
</tr>
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<td>Restaurant</td>
<td>163.5</td>
<td>157.0</td>
<td>78.5</td>
</tr>
<tr>
<td>Light bench work</td>
<td>Factory</td>
<td>238.0</td>
<td>214.0</td>
<td>78.0</td>
</tr>
<tr>
<td></td>
<td>Small-Parts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>assembly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate work</td>
<td>Dance-halls</td>
<td>257.0</td>
<td>243.0</td>
<td>87.0</td>
</tr>
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<td>Moderate dancing</td>
<td>Factory</td>
<td>286.0</td>
<td>285.0</td>
<td>107.0</td>
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<td>Walking at 1.5 m/s</td>
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<td></td>
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<td></td>
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<tr>
<td>Bowling (participant)</td>
<td>Bowling alley</td>
<td>428.5</td>
<td>414.0</td>
<td>166.0</td>
</tr>
<tr>
<td>Heavy work</td>
<td>Factory</td>
<td>428.5</td>
<td>414.0</td>
<td>166.0</td>
</tr>
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</table>

\(a\) Adjusted heat dissipation is based on the percentage of men, women and children for the application.
### Table 6-2 Values of infiltration air coefficient $K$.[2] for windows.

<table>
<thead>
<tr>
<th>Window Type</th>
<th>Infiltration Air Coefficient $K$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
</tr>
<tr>
<td>Sliding</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>0.36</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.43</td>
</tr>
<tr>
<td>Hung</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>0.25</td>
</tr>
<tr>
<td>Aluminum (side pivoted)</td>
<td>0.36</td>
</tr>
<tr>
<td>Aluminum (horizontal pivoted)</td>
<td>0.30</td>
</tr>
<tr>
<td>PVC</td>
<td>0.10</td>
</tr>
</tbody>
</table>

### Table 6-3 Values of the factor $S_1$ of Eq. (6-7).

<table>
<thead>
<tr>
<th>No</th>
<th>Topography of Location</th>
<th>Value of $S_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Protected locations by hills or buildings (wind speed = 0.5 m/s)</td>
<td>0.9</td>
</tr>
<tr>
<td>2</td>
<td>Unprotected locations such as sea shores, hill tops, etc.</td>
<td>1.1</td>
</tr>
<tr>
<td>3</td>
<td>Locations other than that listed in item (1) or (2) of this table</td>
<td>1.0</td>
</tr>
</tbody>
</table>
### Table 6-4 Values of the factor $S_2$ of Eq. (6-7).

<table>
<thead>
<tr>
<th>Location Class</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Building Height, m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.47</td>
<td>0.52</td>
<td>0.56</td>
<td>0.55</td>
</tr>
<tr>
<td>5</td>
<td>0.50</td>
<td>0.55</td>
<td>0.60</td>
<td>0.60</td>
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<td>10</td>
<td>0.58</td>
<td>0.62</td>
<td>0.67</td>
<td>0.69</td>
</tr>
<tr>
<td>15</td>
<td>0.64</td>
<td>0.69</td>
<td>0.74</td>
<td>0.78</td>
</tr>
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<td>0.79</td>
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<td>0.79</td>
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<td>0.90</td>
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<tr>
<td>40</td>
<td>0.89</td>
<td>0.93</td>
<td>0.97</td>
<td>0.95</td>
</tr>
<tr>
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<td>0.94</td>
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<td>1.00</td>
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<td>1.07</td>
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<td>1.10</td>
<td>1.13</td>
<td>1.09</td>
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<td>120</td>
<td>1.10</td>
<td>1.13</td>
<td>1.15</td>
<td>1.11</td>
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<tr>
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<tr>
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<td>1.17</td>
<td>1.19</td>
<td>1.15</td>
</tr>
<tr>
<td>180</td>
<td>1.16</td>
<td>1.19</td>
<td>1.20</td>
<td>1.17</td>
</tr>
<tr>
<td>200</td>
<td>1.18</td>
<td>1.21</td>
<td>1.22</td>
<td>1.18</td>
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</table>
Figure (1)
APPENDIX (B)
Table 9.3 Water Supply Fixture Units and Fixture Branch Sizes

<table>
<thead>
<tr>
<th>Fixture*</th>
<th>Use</th>
<th>Type of Supply Control</th>
<th>Fixture Unitsb</th>
<th>Min. Size of Fixture Branch² in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathroom group*</td>
<td>Private</td>
<td>Flushometer</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Bathroom group*</td>
<td>Private</td>
<td>Flush tank for closet</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Bathtub</td>
<td>Private</td>
<td>Faucet</td>
<td>2</td>
<td>½</td>
</tr>
<tr>
<td>Bathtub</td>
<td>General</td>
<td>Faucet</td>
<td>4</td>
<td>½</td>
</tr>
<tr>
<td>Clothes washer</td>
<td>Private</td>
<td>Faucet</td>
<td>2</td>
<td>½</td>
</tr>
<tr>
<td>Clothes washer</td>
<td>General</td>
<td>Faucet</td>
<td>4</td>
<td>½</td>
</tr>
<tr>
<td>Combination fixture</td>
<td>Private</td>
<td>Faucet</td>
<td>3</td>
<td>½</td>
</tr>
<tr>
<td>Dishwasher²</td>
<td>Private</td>
<td>Automatic</td>
<td>1</td>
<td>½</td>
</tr>
<tr>
<td>Drinking fountain</td>
<td>Offices, etc.</td>
<td>Faucet ¾ in.</td>
<td>0.25</td>
<td>½</td>
</tr>
<tr>
<td>Kitchen sink</td>
<td>Private</td>
<td>Faucet</td>
<td>2</td>
<td>½</td>
</tr>
<tr>
<td>Kitchen sink</td>
<td>General</td>
<td>Faucet</td>
<td>4</td>
<td>½</td>
</tr>
<tr>
<td>Laundry trays (1–3)</td>
<td>Private</td>
<td>Faucet</td>
<td>3</td>
<td>½</td>
</tr>
<tr>
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<td>Private</td>
<td>Faucet</td>
<td>1</td>
<td>¾</td>
</tr>
<tr>
<td>Lavatory</td>
<td>General</td>
<td>Faucet</td>
<td>2</td>
<td>½</td>
</tr>
<tr>
<td>Separate shower</td>
<td>Private</td>
<td>Mixing valve</td>
<td>2</td>
<td>½</td>
</tr>
<tr>
<td>Service sink</td>
<td>General</td>
<td>Faucet</td>
<td>3</td>
<td>½</td>
</tr>
<tr>
<td>Shower head</td>
<td>Private</td>
<td>Mixing valve</td>
<td>2</td>
<td>½</td>
</tr>
<tr>
<td>Shower head</td>
<td>General</td>
<td>Mixing valve</td>
<td>4</td>
<td>½</td>
</tr>
<tr>
<td>Urinal</td>
<td>General</td>
<td>Flushometer</td>
<td>5</td>
<td>¾*</td>
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<td>Urinal</td>
<td>General</td>
<td>Flush tank</td>
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<td>½</td>
</tr>
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<td>Water closet</td>
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<tr>
<td>Water closet</td>
<td>Private</td>
<td>Flushometer/tank</td>
<td>3</td>
<td>½</td>
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<td>Flushometer</td>
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<td>Water closet</td>
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<td>Flushometer/tank</td>
<td>5</td>
<td>½</td>
</tr>
<tr>
<td>Water closet</td>
<td>General</td>
<td>Flush tank</td>
<td>5</td>
<td>½</td>
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</table>

Water supply outlets not listed above shall be computed at their maximum demand, but in no case less than the following values:
### Table 9.4 Table for Estimating Demand

<table>
<thead>
<tr>
<th>Load, WSFU*</th>
<th>Demand, gpm</th>
<th>Load, WSFU*</th>
<th>Demand, gpm</th>
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<tr>
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<td>9000</td>
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<tr>
<td>10,000</td>
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<td>790</td>
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</table>
Table 9.1 Minimum Pressure Required by Typical Plumbing Fixtures

<table>
<thead>
<tr>
<th>Fixture Type</th>
<th>Minimum Pressure, psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sink and tub faucets</td>
<td>8</td>
</tr>
<tr>
<td>Shower</td>
<td>8</td>
</tr>
<tr>
<td>Water closet—tank flush</td>
<td>8</td>
</tr>
<tr>
<td>Flush valve—urinal</td>
<td>15</td>
</tr>
<tr>
<td>Flush valve—siphon jet bowl</td>
<td></td>
</tr>
<tr>
<td>floor-mounted</td>
<td>15</td>
</tr>
<tr>
<td>wall-mounted</td>
<td>20</td>
</tr>
<tr>
<td>Flush valve—blowout bowl</td>
<td></td>
</tr>
<tr>
<td>floor-mounted</td>
<td>20</td>
</tr>
<tr>
<td>wall-mounted</td>
<td>25</td>
</tr>
<tr>
<td>Garden hose</td>
<td></td>
</tr>
<tr>
<td>¾-in. sill cock</td>
<td>15</td>
</tr>
<tr>
<td>½-in. sill cock</td>
<td>30</td>
</tr>
<tr>
<td>Drinking fountain</td>
<td>15</td>
</tr>
</tbody>
</table>

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.**

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### Table (5)

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<td>From 151-220 CFM</td>
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<td>From 221-250 CFM</td>
<td>6”18 inch</td>
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<td>From 325-440 CFM</td>
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<td>From 441-550 CFM</td>
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<td>From 551-600 CFM</td>
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<td>From 601-750 CFM</td>
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<td>From 1001-1160 CFM</td>
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<td>From 1151-1400 CFM</td>
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Catalogue
1) Catalogue of chiller

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TECHNICAL DATA 30XW / 30XWH

THE PRODUCT OF EXPERIENCE
2) Catalogue of boiler

### High Efficiency Modular Boilers
#### Super Range

![Image of Ideal boilers](https://www.idealcommercialheating.com)

### General data 350V - 600H

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Note: To obtain gas consumption in kW, divide gross heat input (kW) by a calorific value of 37.8 (MJ/m³).

Notes: Flange tolerances to BS 4504, Part 1, Table 15.
3) Catalogue of AHU

YMA
Custom Air Handling Units
A complete range from 0.25 to 50 m³/s

YMA “Quick Size” Guide

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<th>Cross Section (mm)</th>
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<th>D 1/2</th>
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<th>MB</th>
<th>CM (1a)</th>
<th>PF</th>
<th>MF</th>
<th>GB</th>
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Note: For detailed specifications and additional options, please consult the manufacturer's manual.
4) Catalogue of fan coil unit
5) Catalogue of cooled water pump

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**Product No.:** 98494961

**Company name:**

**Created by:**

**Phone:**

**Data:**

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**Technical:**

- **Actual calculated flow:** 74 US GPM
- **Residual head of the pump:** 41 m

**Material:**

- **Pump Housing:** Cast Iron
- **Installation:**
  - Maximum operating pressure: 10 bar
  - Maximum inlet pressure: PN16 bar

**Liquid:**

- **Pumped liquid:** Drinking water
- **Liquid temperature range:** 5 - 46 °C
- **Specific gravity:** 1.000 - 1.005
- **Kinematic viscosity:** 1 mm²/s

**Technical:**

- **Actual calculated flow:** 74 US GPM
- **Residual head of the pump:** 41 m

**Material:**

- **Pump Housing:** Cast Iron
- **Installation:**
  - Maximum operating pressure: 10 bar
  - Maximum inlet pressure: PN16 bar

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  - Maximum inlet pressure: PN16 bar

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- **Pumped liquid:** Drinking water
- **Liquid temperature range:** 5 - 46 °C
- **Specific gravity:** 1.000 - 1.005
- **Kinematic viscosity:** 1 mm²/s
6) Catalogue of hot water pump
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.
- IPX4 protected.
- Complies with the CEI EN 60335-2-80 standard.
- Turbine fan balanced directly on the motor.
- Motor-holer 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 +50/65° C.

Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound Pressure Level Min (3m)</td>
<td>56</td>
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<tr>
<td>Sound Pressure Level Max (3m)</td>
<td>58</td>
</tr>
<tr>
<td>Tension (V)</td>
<td>220-240</td>
</tr>
<tr>
<td>RPM Max</td>
<td>2450</td>
</tr>
<tr>
<td>IP</td>
<td>X4</td>
</tr>
<tr>
<td>Insulation Class</td>
<td>C1 1/2</td>
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<tr>
<td>Max Temperature (°C)</td>
<td>55</td>
</tr>
<tr>
<td>Min Delivery (m³/h)</td>
<td>450</td>
</tr>
<tr>
<td>Max Delivery (m³/h)</td>
<td>460</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>3.4</td>
</tr>
<tr>
<td>Max Absorbed Current (A)</td>
<td>0.4</td>
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<tr>
<td>Min Absorbed Power (W)</td>
<td>85</td>
</tr>
<tr>
<td>Min Absorbed Power (W)</td>
<td>85</td>
</tr>
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</table>

[Image of ventilation fan]

[Image of specifications table]

[Image of software interface]

[Image of graph]
8) Catalogue of ciller pump
9) Catalogue of boiler pump

**GRUNDFOS**

**Submittal Data**

<table>
<thead>
<tr>
<th>PROJECT:</th>
<th>UNIT TAG:</th>
<th>TYPE OF SERVICE:</th>
<th>QUANTITY:</th>
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<table>
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<tr>
<th>REPRESENTATIVE:</th>
<th>SUBMITTED BY:</th>
<th>ENGINEER:</th>
<th>APPROVED BY:</th>
<th>ORDER NO.:</th>
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<table>
<thead>
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<th>DATE:</th>
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<tbody>
<tr>
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</tbody>
</table>

**CR 45-3-2**

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).

**Note:** Product picture may differ from actual product.

### Conditions of Service

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td>268 US GPM</td>
</tr>
<tr>
<td>Head</td>
<td>42 m</td>
</tr>
<tr>
<td>Efficiency</td>
<td></td>
</tr>
<tr>
<td>Liquid</td>
<td>Heating water</td>
</tr>
<tr>
<td>Temperature</td>
<td>60 °C</td>
</tr>
<tr>
<td>NPSH required</td>
<td></td>
</tr>
<tr>
<td>Viscosity</td>
<td>1 mm²/s</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td></td>
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</table>

### Pump Data

<table>
<thead>
<tr>
<th>Condition</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max pressure at stated temp</td>
<td>16 bar / 120 °C</td>
</tr>
<tr>
<td>Liquid temperature range</td>
<td>-30 ... 120 °C</td>
</tr>
<tr>
<td>Maximum ambient temperature</td>
<td>60 °C</td>
</tr>
<tr>
<td>Approvals</td>
<td>CE, TR</td>
</tr>
<tr>
<td>Shaft seal</td>
<td>HQQE</td>
</tr>
<tr>
<td>Flange standard</td>
<td>DIN</td>
</tr>
<tr>
<td>Pipe connection</td>
<td>DN 80</td>
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<tr>
<td>Product number</td>
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### Motor Data

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<th>Condition</th>
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<tbody>
<tr>
<td>Rated power</td>
<td>P2: 11 kW</td>
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<tr>
<td>Rated voltage</td>
<td>220-240 V/380-415 Y V</td>
</tr>
<tr>
<td>Mains frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Enclosure class</td>
<td>55 Dust/Jetting</td>
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<tr>
<td>Insulation class</td>
<td>F</td>
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<td>Motor protection</td>
<td>PTC</td>
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<tr>
<td>Motor type</td>
<td>160MB</td>
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<tr>
<td>Motor efficiency</td>
<td>91.2-91.2 %</td>
</tr>
</tbody>
</table>

---

**Diagram:**

- **Q = 268 US GPM**
- **H = 42 m**
- **Pumped liquid = Heating water**
- **Liquid temperature = 60 °C**
- **Density = 983.2 kg/m³**

**eta [%]**

- **Eta pump = 68.6 %**
- **Eta pump+motor = 61 %**

**P1:**

- **P1 = 11.3 kW**
- **P2 = 9.97 kW**
- **NPSH = 4.52 m**
10) Catalogue of grease tank in kitchen
11) Catalogue of Fire extinguisher (Fir fighting)

<table>
<thead>
<tr>
<th>ITEM PART NO.</th>
<th>PX1</th>
<th>PX2</th>
<th>PX3</th>
<th>PX4.5</th>
<th>PX6</th>
<th>PX10</th>
<th>PX12</th>
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<tbody>
<tr>
<td>SPECIFICATIONS</td>
<td></td>
<td></td>
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<tr>
<td>NOMINAL CAPACITY kg</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>4.5</td>
<td>6</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>(lbs)</td>
<td>(20)</td>
<td>(40)</td>
<td>(20)</td>
<td>(10)</td>
<td>(12)</td>
<td>(22)</td>
<td>(26)</td>
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<td>EXTINGUISHING AGENT</td>
<td>ABC</td>
<td>ABC</td>
<td>ABC</td>
<td>ABC</td>
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<td>SHELL MATERIAL</td>
<td>CRS</td>
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<tr>
<td>AVERAGE GROSS WEIGHT kg</td>
<td>3.6</td>
<td>3.8</td>
<td>3.7</td>
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<tr>
<td>(lbs)</td>
<td>(8.0)</td>
<td>(8.4)</td>
<td>(8.2)</td>
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<td>MINIMUM DISCHARGE RATE LPS</td>
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<td>6.0</td>
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<tr>
<td>MAXIMUM DISCHARGE RATE LPS</td>
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<td>8.0</td>
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<tr>
<td>AVERAGE UNIT LENGTH (m)</td>
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<td>2.9</td>
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<tr>
<td>SHELL DIAMETER (mm)</td>
<td>85</td>
<td>90</td>
<td>90</td>
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<td>MINIMUM DISCHARGE M</td>
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<tr>
<td>DOTE</td>
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<tr>
<td>SHEL COLOR</td>
<td>RED</td>
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<td>ELECTRICAL NON-CONDUCTIVITY</td>
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<td>OK</td>
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<tr>
<td>OPERATING RANGE (°C)</td>
<td>UPPER °C</td>
<td>-60</td>
<td>-60</td>
<td>-60</td>
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<td>OPERATING TEMPERATURE</td>
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<tr>
<td>OPERATING PRESSURE</td>
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<td>15</td>
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<tr>
<td>Measured at ambient temperature</td>
<td>psig</td>
<td>(210)</td>
<td>(210)</td>
<td>(210)</td>
<td>(210)</td>
<td>(210)</td>
<td>(210)</td>
</tr>
</tbody>
</table>

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 SFPEGO.
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 Heat, Fire blanket or Fire axe can be fitted in place of extinguisher in SF600 / SF600S.

<table>
<thead>
<tr>
<th>MODEL</th>
<th>INSIDE DIMENSIONS</th>
<th>WALL OPENING SIZE</th>
<th>INSIDE DIMENSIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF 300</td>
<td>Width (mm) Height (mm) Depth (mm)</td>
<td>Width (mm) Height (mm) Depth (mm)</td>
<td>Width (mm) Height (mm) Depth (mm)</td>
</tr>
<tr>
<td>SF 300A</td>
<td>900</td>
<td>900</td>
<td>750</td>
</tr>
<tr>
<td>SF 300B</td>
<td>720</td>
<td>720</td>
<td>600</td>
</tr>
<tr>
<td>SF 300C</td>
<td>1200</td>
<td>1200</td>
<td>1000</td>
</tr>
<tr>
<td>SF 300D</td>
<td>1500</td>
<td>1500</td>
<td>1250</td>
</tr>
</tbody>
</table>

Note: All dimensions in mm.

Pump Performance Range

Graph showing performance range for various models at different speeds (r/min) and flow rates (L/min).

- Graph for 1500 r/min
- Graph for 3000 r/min

Legend:
- 80/2A
- 80/2B
- 100/2A
- 100/2B
- 125/2A
- 125/2B
- 150/2A
- 150/2B
- 200/3A
- 200/3B

12) Catalogue of medical gas
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 hose extension and 1/8” port for an optional pressure switch.

features
References:


