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College of Engineering and Technology

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Design Of Mechanical System For Ibn Sina Specialists Hospital In Jenin

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Design of Mechanical System for Ibn Sina Specialist Hospital in Jenin

By

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Abstract

This project aims to design the mechanical systems for Ibn sina specialist hospital which is located in Jenin city . This building consist of seven floors with total area of 17000 m^2 .

The design of this project include making the calculations, drawings, material selection and determine the table of quantity for the air conditioning system, ventilation system, water system, drainage system, the firefighting system, medical gases system and refrigeration system for refrigerator .

These services are certainly designed to verify human comfort.

الملخص :

يهدف هذا المشروع الى تصميم الانظمه الميكانيكيه الخاصه بمستشفى ابن سينا التخصصي في مدينه جنين ، يتكون مبنى المشروع من سبعه طوابق بمساحه اجماليه تقدر ب 17000 $م^2$.

يشمل المشروع تصميم و عمل الحسابات و عمل جداول الكميات لكل من نظام التكييف ، نظام التهوية ، نظام تزويد المياه ، نظام الصرف الصحي ، نظام مكافحة الحريق ، نظام الغازات الطبيه .

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To who supported us in all the steps of our lives to our parents

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We wish to thank Dr. Ishaq sider , Eng. Mohammed Awad , We sincerely believe that they are widen our gaze .

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Chapter 1 : Introduction

1.1 Introduction

Hospitals in Palestine have an essential and vital rule in enhancing the general health of the Palestinians people. Hospitals are one of the necessities of treatment and therefore the basics of design, you can save a 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.

1.2 Project Objectives

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

1) calculations and design of HVAC system.
2) calculations and design of plumping system.
3) calculations and design of Central Heating System.
4) calculations and design of Fire fighting.
5) 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.

1.3 Hospital Description

The hospital named (Ibn Sina Specialist Hospital) is located in Jenin city, it is planned to service thousands of habitants living in the city and near Villages.

It consists of total number of (150) bed and a total area of 17000 (m^2).

Table 1.1 : The area for each Floor

No	Name of the Floor	The area (m^2)
1	Basement floor	4000
2	Ground floor	2500
3	First floor	2500
4	Second floor	2500
5	Third floor	1500
6	Fourth floor	2500
7	Fifth floor	1500

1.4 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 .

1.5 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:- VRF System

Chapter Four :-Plumbing 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 Five :-Firefighting System

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

Chapter Sex :-Medical Gases

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

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.

1.6 The Time Table

Table 1.2 : Time table

Second Semester															
Activity / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Selection of the project															
Search about information															
Search for previous projects															
Search for video for the systems in the Internet															
Heating & Cooling Load Calculations															
WSFU & DFU Calculations															
Studying the Fire Fighting Systems															
Studying the Medical Gases Systems															
Project Documentation															
Project Printing															

first Semester															
Activity / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Firefighting System calculations and design															
Medical Gases calculations and design															
Mechanical Drawings															
Equipment Selection															
Auditing our work in the project															
Project documentation															

CHAPTER 2 Heating and Air Conditioning

2.1 Introduction

Hospitals needs heating , 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 .

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 is often used by the industry.

2.2 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.

2.3 Human Comfort

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

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

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

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

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

2.3.1 Factors Affecting Human Comfort

1) Dry Air: The dry air is a complex mixture of several gases such as nitrogen , oxygen ,carbon dioxide and other gases such as argon ,carbon monoxide and neon .It does not contain water vapor .the presence of nitrogen in the air represents about 78% by volume while the oxygen occupies about 21% by volume .The other gases represent less than 1%.
2) Moist Air: The moist air is mechanical mixture of dry air and water vapor. Thus, when moist air is cooled, it loses moisture due to the condensation of the water vapor in the air.
3) Humidity: The moisture content of the air is referred to as its humidity. This moisture content can be expressed in terms of volume, masses, moles and 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 Hygrometer .

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.

2.3.2 ASHRAE Comfort Chart:

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

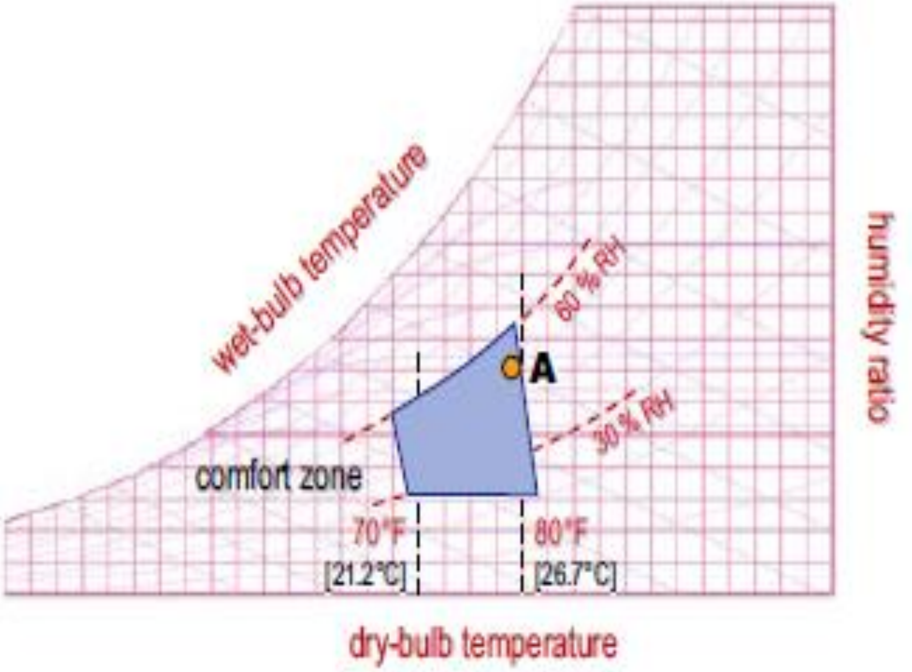


Figure 2.1 : Comfort Zone For Operating And Temperature And Relative Humidity

2.3.3 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 .

Table 2.1: Indoor Design Conditions

Room or Area	Summer		Winter	
	Db Degrees C (Degrees F)	RH Percent	Db Degrees C (Degrees F)	RH Percent
Auditoriums	24 (76)	60	22 (72)	--
AIDS Patient Areas	24 (76)	50	25 (78)	30
Autopsy Suites	24 (76)	60	24 (76)	30

Room or Area	Summer		Winter	
	Db Degrees C (Degrees F)	RH Percent	Db Degrees C (Degrees F)	RH Percent
Bathrooms & Toilet Rooms	25 (78)	--	22 (72)	--
BMT (Bone Marrow Transplant) Patient Areas	24 (76)	50	25 (78)	30
Computer Rooms	21 (70)	40 (±5)	21 (70)	40 (±5)
CT Scanner	24 (76)	50	25 (78)	30
Dialysis Rooms	25 (78)	50	22 (72)	30
Dining Rooms	25 (78)	50	22 (72)	30
Dry Labs	25 (78)	50	22 (72)	30
Electrical Equipment Rooms	Ventilation Only		10 (50)	--
Elevator Machine Rooms, Electric Drive	36 (94)	--	10 (50)	--
Elevator Machine Rooms, Hydraulic	36 (94)	--	10 (50)	--
Emergency Generator	36 (97)	--	4 (40)	--
Examination Rooms	24 (76)	50	25 (78)	30
ICUs (Coronary, Medical, Surgical)	23–29 (75–85)	30–60	23–29 (75–85)	30-60
Isolation Suites	24 (76)	50	25 (78)	30
Kitchens	27 (82)	60	21 (70)	--
Laboratories	24 (76)	50	22 (72)	30
Laundries	28 (84)	60	19 (68)	-
Linear Accelerators	24 (76)	50	25 (78)	30
Locker Rooms	25 (78)	50	22 (72)	30
Lounges	25 (78)	50	22 (72)	30
Mechanical Equipment Rooms (MERs)	Ventilation Only		10 (50)	--
Medical Media:				
MRI Units	24 (76)	50	25 (78)	30
Offices, Conference Rooms	25 (78)	50	22 (72)	30
Operating Rooms (O.R.s)	18–27 (62-80)	45-55	18-27 (62-80)	45-55

Room or Area	Summer		Winter	
	Db Degrees C (Degrees F)	**RH Percent**	**Db Degrees C (Degrees F)**	**RH Percent**
Patient Rooms	24 (76)	50	25 (78)	30
Pharmacy	22 (72)	50	22 (72)	30
Radiation Therapy	24 (76)	50	25 (78)	30
Recovery Units	23 (75)	50	23 (75)	30
SPECIAL PROCEDURE ROOMS*				
Bronchoscope	24 (76)	50	25 (78)	30
Cardiac Catheterization	17–27 (62-80)	45-55	17-27 (62-80)	45-55
Colonoscopy/EGD	24 (76)	50	25 (78)	30
Cystoscopy	22 (72)	50	25 (78)	50
Endoscopy	24 (76)	50	25 (78)	30
Fluoroscopy	24 (76)	50	25 (78)	30
GI (Gastrointestinal)	24 (76)	50	25 (78)	30
Proctoscopy	24 (76)	50	25 (78)	30
Sigmoidoscopy	24 (76)	50	25 (78)	30
Spinal Cord Injury Units (SCIUs)	22 (72)	50	27 (82)	30
Supply Processing Distribution (SPD)	24 (76)	50	22 (72)	30
Ethylene Oxide (ETO) MERs	Ventilation only			
Steam Sterilizer MERs	Ventilation only			
Treatment Rooms	24 (76)	50	25 (78)	30
Warehouses	Ventilation Only		15 (60)	--

2.4 Outside Design Condition

2.4.1 Outside Design Condition For Summer:

$T_{\text{dry bulb max}}$ =31.9 [°C]

Relative humidity = 61.7 %

Design month is august .

2.4.2 Outside Design Condition For Winter :

$T_{\text{dry bulb average}}$ =5.7 [°C]

Relative humidity = 68%

Design month is January .

2.5 Over All Heat Transfer Coefficient “U” :

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

Where :

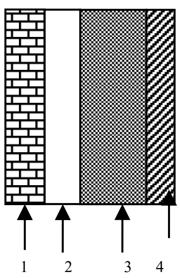
h_i : Convection coefficient (surface conductance) of inside wall, floor, or ceiling ($h_i = 9.37\ W/m^2.C^0$) from the Palestinian code.

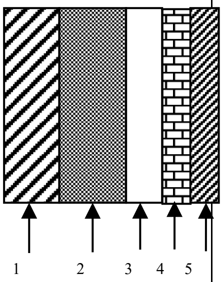
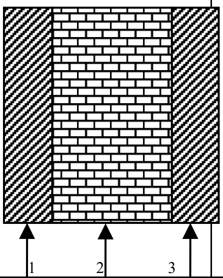
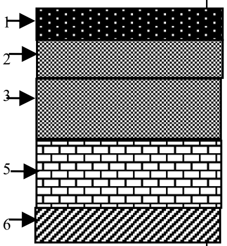
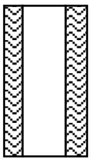
h_0 : Convection coefficient (surface conductance) of outside wall, floor, or roof ($h_0 = 22.7\,W/m^2.C^0$) from the Palestinian code.

Δx : Thickness of the wall in meter .

K : Thermal Conductivity of the wall material in ($W/m^2.C^0$) .

Table 2.2 : Overall Heat Transfer Coefficients “ U “ for Building Walls .

	Construction detail	Construction material	Material thickness [m]	Thermal conduction [W/m.ºC]	U [W/m^2.ºC]
Outside walls for Basement Floor		1) Block 2) 2-Insulation 3) Concrete 4) plaster	0.1 0.05 0.3 0.02	1 0.03 1.75 1.4	0.4754

Outside walls For up Floor		1) stone 2) Concrete 3) Insulation (air) 4) Block 5) plaster	0.1 0.17 0.03 0.01 0.03	2.2 1.75 0.04 0.95 1.2	0.81
Inside walls		1) plaster 2) Block 3) plaster	0.02 0.1 0.02	1.4 1 1.4	2.95
Ceiling & Roof		1) Tiles 2) morter 3) sand 4) Concrete 5) plaster	0.025 0.025 0.1 0.25 0.02	1.2 1.4 0.3 1.85 0.95 1.4	1.3607
Windows		Double glass Aluminum frame	6 mm air gap	-	3.5
Doors		1) Wood 2) Cork 3) Wood	0.025 0.05 0.025	0.2 0.08 0.2	0.9187

2.6 Cooling Load

Heat Gain Through Sunlit Walls and Roofs :

$$Q=U.A.(CLTD)_{corrected}. \quad (2.2)$$

Q : cooling load [kW].

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

A : surface area [m^2].

CLTD $_{correct}$: corrected cooling load temperature deference .

$$(CLTD)_{corr}= (CLTD+LM)k+(25.5-Ti)+(To,m-29.4)f \quad (2.3)$$

CLTD : cooling load temperature deference correction.

LM : latitude correction factor.

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

f: roof fan factor equal 1 because there is no attic .

T_i : inside design wall temp .

$T_{o,m}$: outside 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.

Heat Gain Through Inside Walls and Ground

$$Q=U.A.\Delta T \quad (2.4)$$

Q: loading load gain inside walls.

A: inside walls area.

U: overall heat transfer coefficient.

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

Heat Gain Due To Glass Windows

$$Q_{tr}=A\ (SHG)\ (SC)\ (CLF) \quad (2.5)$$

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

(a) solar heat gain factor (SHG):

This factor represents the amount of solar energy they would be received by floor, furniture and the inside walls of the room and can be extracted.

(b) Shading coefficient (SC):

It accounts from for different shading effects of the glass wall or window and can be extracted. 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 . For glass with interior shading. It accounts for the variation of shag factor with time, mass capacity of the structure and the internal shading.

Heat Gain Due To Occupants

Q total for occupant = Q sensible + Q latent . **(2.6)**

Q latent = heat gain latent * No. of people* Diversity Factor ;(Diversity Factor = 0.6).

Q sensible = heat gain sensible * No. of people* CLF* Diversity Factor ;(CLF = 0.84).

Heat Gain Due To Lights

$$Q_{Lt} = \text{lighting intensity}*A*CLF*\text{ ballast factor} \quad (2.7)$$

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

A : floor area.

CLF = cooling load factor, dimensionless.

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.

Heat gain Due To infiltration

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

From psychometric chart we get :-

- $V_{outside} = 0.889\ m^3/Kg$
- $h_o = 79.66\ kJ/kg$
- $h_i = 45.47\ kJ/kg$
- $V_f \rightarrow 17.5\ L/\text{sec}\ per\ person.$

Heat gain Due To people

Q_{people} (total) = n * total heat gain per person. **(2.9)**

Heat Gain Due To Ventilation

$Q\ ven = m^{\cdot} * C_{pair} * (T_{out}-T_{in})air$ **(2.10)**

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

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

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

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

V_f : rate of ventilation= no. of people * 17.5 .
outdoor air = (17.5L/s)/person.

v : specific volume for air @ t_{max} = 31.9 C ^{o} and Φ = 61.9 % ;v = 0.889 (m^3/kg dry air) .

2.7 Heating load

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

Many systems are used for this purpose, such as heating by hot water or heating by warm air, sometime small heaters are used for this purpose, there are many criteria's that will be taken to select the suitable system such as cost, efficiency, flexibility and type of building.

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

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

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

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

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

$$\mathbf{Q = U \times A \times \Delta T} \quad \textbf{(2.11)}$$

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

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

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

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

Heat Loss By Infiltration

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

$$\mathbf{Q_{inf}} = \frac{\mathbf{V_{inf}}}{\mathbf{V_{outside}}} * (\mathbf{h_o} - \mathbf{h_i}) \quad \textbf{(2.12)}$$

$$\mathbf{V_{inf} = K*L*(0.613(s1 * s2 * v)\text{^}2)^{2/3}} \quad \textbf{(2.13)}$$

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

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

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

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

K: the coefficient of infiltration air for windows.

L: the crack length [m].

s_1: the factor that depends on the topography of the location of the building .

s_2: another coefficient that depends on the height of the building and terrain of its location.

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

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

To obtain these values from psychometric chart .

Table 2.3 : Values for outdoor design conditions

Season	T_{out} (°C)	Φ_{out}%	v_{out} (m^3/Kg dry air)	h_{out} (KJ/Kg)
Heating	5.7	68	0.794	14.42

Table 2.4 :Values for indoor design conditions

Season	T_{in} (°C)	Φ_{in}%	h_{in} (KJ/Kg)
Heating	24	45	45.47

2.8 Sample Calculation Of Heating And Cooling Load

For ground floor.
For room GR 01 plain x-ray room .

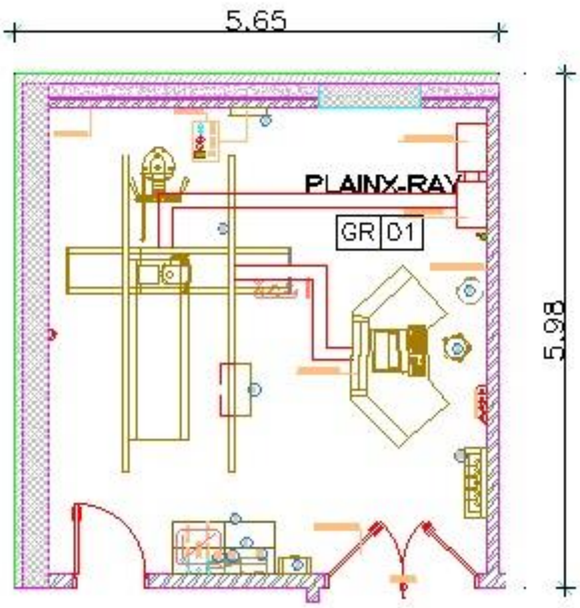


Figure 2.2 : Room number GR01 .

2.8.1 Cooling Load Calculation

1) For Roof and Ground, from equation (2.11) .

   Q=U*A*ΔT

-Cilling

Q_c =1.3607*27.6*(24-24)=0 W.

-Ground

Q_G=1.3607*27.6*(27-24)=525.774 W.

2) Heat Gain Through Sunlit Walls, from equation (2.3)

Q=U.A.(CLTD)corrected

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

- East

25.5 – 24 =1.5 C^o.

31.9 – 29.4 =2.5 C^o.

$(CLTD)_{corr}$=(6 + 0.5)*0.65 +(1.5) + (2.5)*1=8.225C^o.

Q_s=2.6832 *(16.94)*8.225=372.9715 W.

Q=U*A*ΔT

Q=2.9238*11.4*(27-24) = 99.9939 W.

- West

$(CLTD)_{corr}$=(6+0)*0.65 + (1.5) +(2.5)*1=7.9 C^o.

Q_W=0.7176*(15.96) *7.9=90.1377 W.

3) Heat Gain Due To Occupants, from equation

Q total for occupant = Q sensible + Q latent

Q latent = 57*3*0.6 =102.6 W.

Q sensible = 71.5*3*84*0.5 =90.09 W.

Q_{oc}=192.69 W.

4) Heat Gain Due To Lights,from.

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

Q_{Lt}=30*(27.6)*1.2*0.5 =432.216 W.

5) Heat Gain Due To Infiltration.

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

$$Q_{inf} = \frac{17.5}{0.889} * (79.66 - 45.47) = 673.0315 \text{ W.}$$

6) Heat Gain Due To People, from equation [2-9].

Q_{people} (total) = n * total heat gain per person
Q_{people} (total) =3 * (135.5) =406.5 W

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

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

$$m^{\cdot} = \frac{V_f}{V} = \frac{3*(17.5\ l/s)}{0.889} = 0.059 \text{ kg/sec.}$$

Q_{ven}=0.059*1.005*(31.9 – 24)=468.8681 W.

$Q_{total\ Cooling\ Load} = \sum Q$ = 3.0454 kW .

2.8.2 Heating Load Calculation

1) ForOutside Wall ,from equation .

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

-South

Qs=2.6832 * 16.94 *(24-5.7)=831.797 W

East

Q e=2.9238 * 15.96 *(24-24)=0 W

-West .

Q_w=0.7176* 15.96*(24-5.7) =209.587 W

For Cilling

Q_c = 1.3607 * (27.6) * (24-24) **= 0** W

-For Floor

Q_{floor}=1.3607 * (27.6) * (24-10) =525.774 W

-For Door

Q_{door}=0.9187* (4.5) (24 - 24) = 0W.

2) For Infiltration Due Windows, from equation .

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

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

V_{inf}=0.45*[1.8*2+2.5*2] * $[0.613*(1*0.65*3)^2]^{2/3}$ =6.80 W.

$Q_{inf} = \frac{6.8}{0.794} * (45.47 - 15.42)$ =257.335 W.

$Q_{\text{total heating Load}} = \sum Q$ =1.824 kW

Cooling Load Summary is listed in tables in the appendix-B

2.9 Mechanical 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.

There are two ways for Ventilation:

- "Natural ventilation" covers uncontrolled inward air leakage through cracks, windows, doorways and vents (infiltration) as well as air leaving a room (exfiltration) through the same routes. Natural ventilation is strongly affected by weather conditions and is often unreliable.
- 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.

The air flow rate into a room space, for general mechanical supply and extract systems, is usually expressed in:

1. Air changes per hour
2. An air flow rate per person
3. An air flow rate per unit floor area

An air change per hour (ACH) is the most frequently used basis for calculating the required airflow. Air changes per hour are the number of times in one hour an equivalent room volume of air will be introduced into, or extracted from the room space.

Air flow rate per person are generally expressed as liters per person (L/P), and are usually used where fresh air ventilation is required within occupied spaces.

Airflow rates per unit floor area are similar in effect to air changes per hour except that the height of the room is not taken into consideration.

Mechanical ventilation system in this project is just for bathrooms and kitchens.

2.9.1 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.

2.9.2 Designing of mechanical ventilation

Steps of designing mechanical ventilation:

- Calculate the required ventilating rate of air by using "Ventilation Rates Calculator" software
- Calculate the volume of the room in (m^3)
- Calculate the flow rate of air by using air changes per hour method

2.9.3 Sample calculation

Using room No. L1 83:

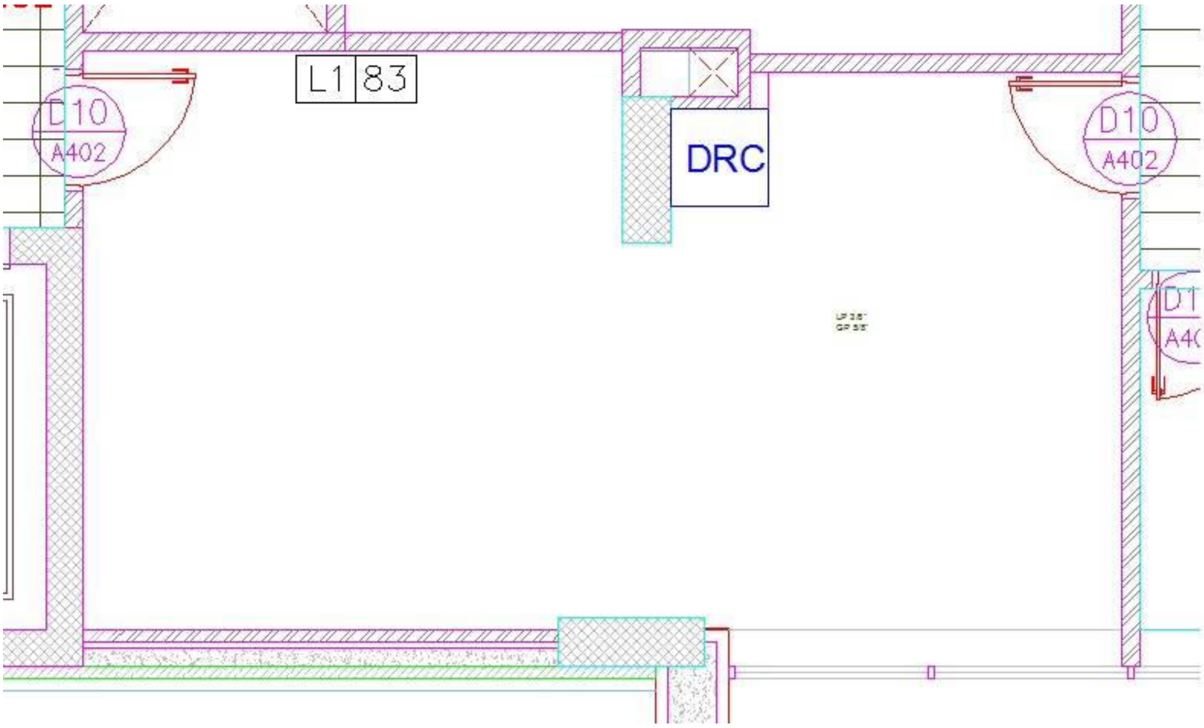


Figure (2.3): SAMPLE ROOM

- The volume is 122 m^3

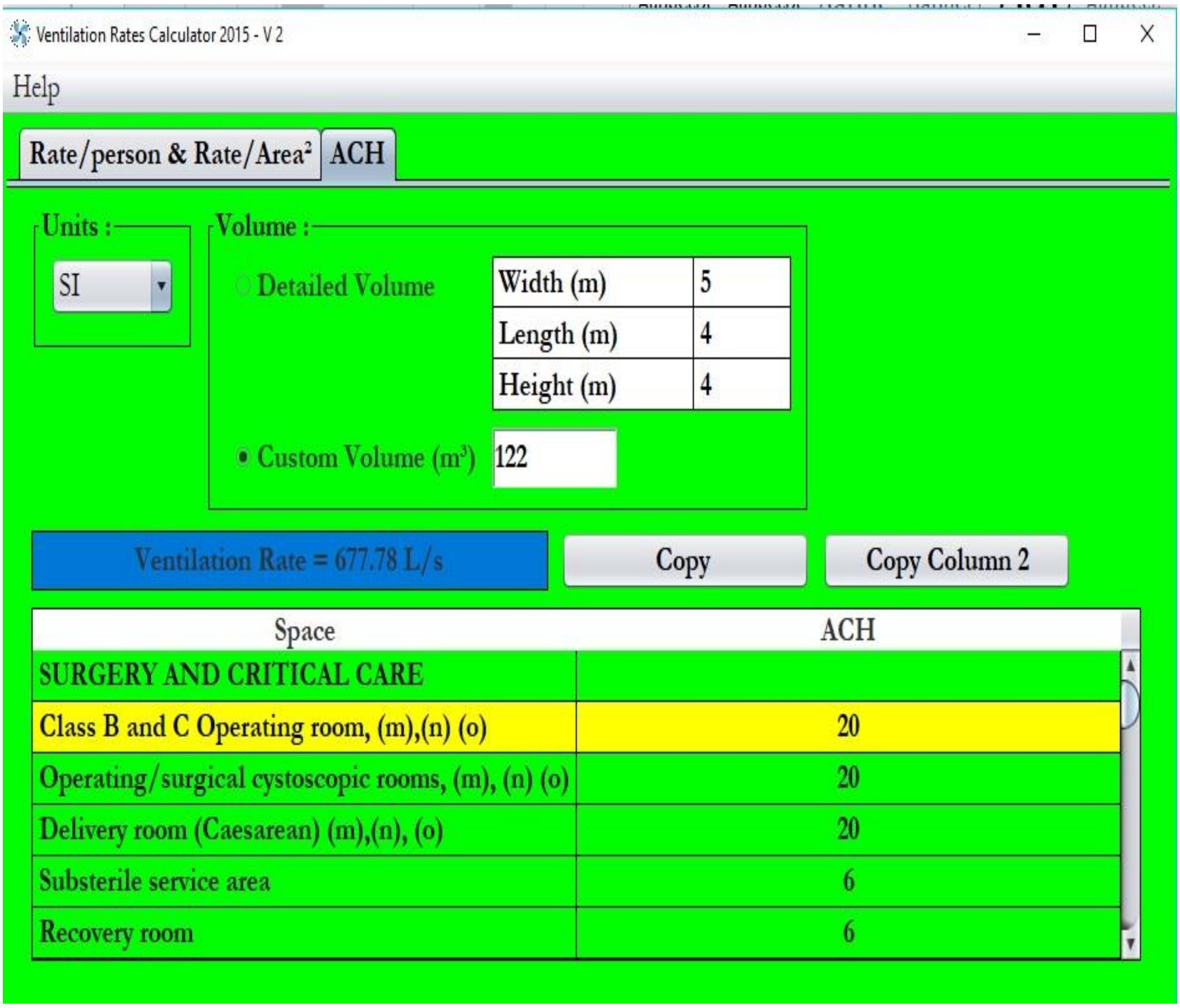


Figure (2.4): Ventilation rates calculation .

Chapter Three

Variable Refrigerant Flow System

3.1 Variable Refrigerant Flow System

3.1.1 Overview

The primary function of all air-conditioning systems is to provide thermal comfort for building occupants. There are a wide range of air conditioning systems available, starting from the basic window-fitted units to the small split systems, to the medium scale package units, to the large chilled water systems, and currently to the variable refrigerant flow (VRF) systems.

Variable refrigerant flow (VRF) is an air conditioning system configuration where there is one outdoor condensing unit and multiple indoor units. The term variable refrigerant flow refers to the ability of the system to control the amount of refrigerant flowing to the multiple evaporators (indoor units), enabling the use of many evaporators of differing capacities and configurations connected to a single condensing unit. The arrangement provides an individualized comfort control, and simultaneous heating and cooling in different zones.

Currently widely applied in large buildings especially in Japan and Europe, these systems are just starting to be introduced in the U.S. The VRF technology/system was developed and designed by Daikin Industries, Japan who named and protected the term variable refrigerant volume (VRV) system so other manufacturers use the term VRF "variable refrigerant flow". In essence both are same.

3.1.2 Variable refrigerant flow description

VRF systems are similar to the multi-split systems which connect one outdoor section to several evaporators. VRF systems continually adjust the flow of refrigerant to each indoor evaporator. The control is achieved by continually varying the flow of refrigerant through a pulse modulating valve (PMV) whose opening is determined by the microprocessor receiving information from the thermistor sensors in each indoor unit. The indoor units are linked by a control wire to the outdoor unit which responds to the demand from the indoor units by varying its compressor speed to match the total cooling and/or heating requirements.

VRF systems promise a more energy-efficient strategy (estimates range from 11% to 17% less energy compared to conventional units) at a somewhat higher cost.

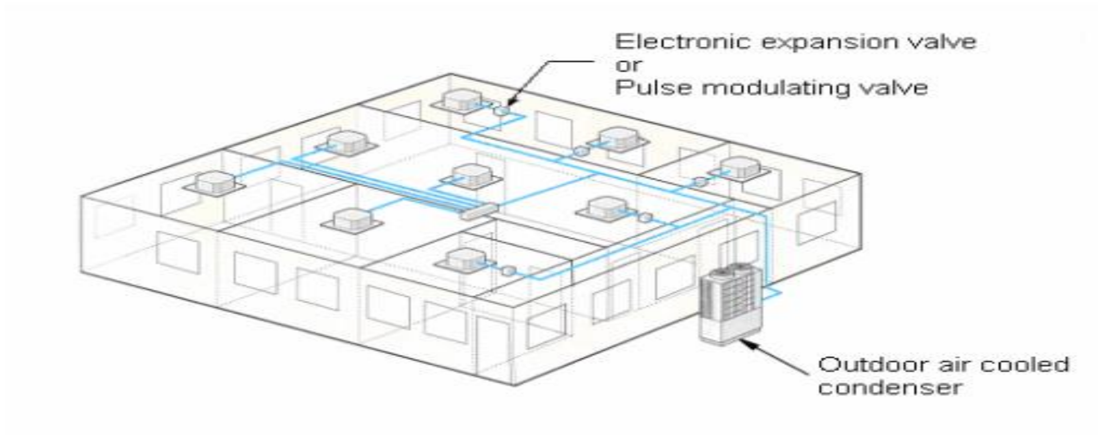
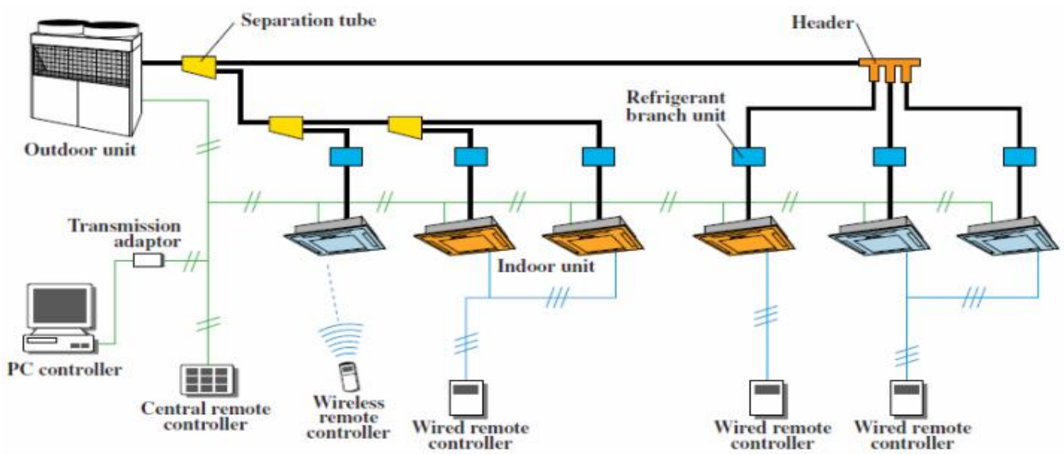


Figure (3.1): VRF System with multiple indoor evaporate units

The modern VRF technology uses an inverter-driven scroll compressor and permits as many as 48 or more indoor units to operate from one outdoor unit (varies from manufacturer to manufacturer). The inverter scroll compressors are capable of changing the speed to follow the variations in the total cooling/heating load as determined by the suction gas pressure measured on the condensing unit. The capacity control range can be as low as 6% to 100%.

Refrigerant piping runs of more than 200 ft are possible, and outdoor units are available in sizes up to 240,000 Btu/ h (60478.98 kW).

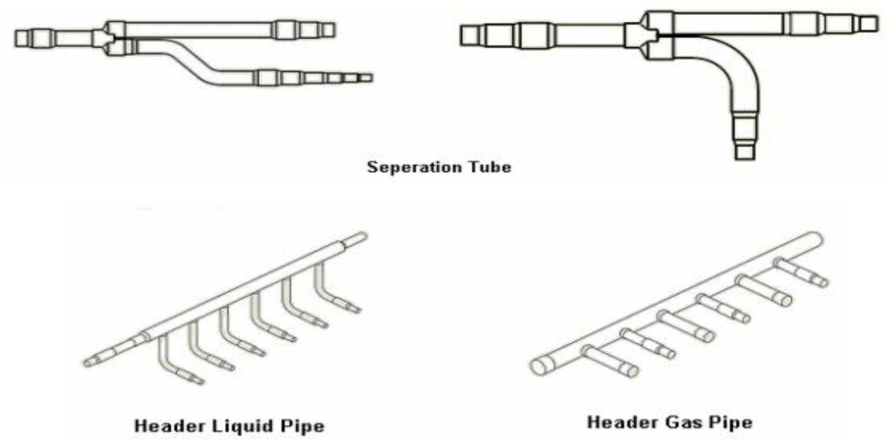
A schematic VRF arrangement is indicated below:



[9] Figure (3.2): A schematic VRF arrangement

VRF systems are engineered systems and use complex refrigerant and oil control circuitry. The refrigerant pipe-work uses a number of separation tubes and/or headers (refer schematic figure above).

A separation tube has 2 branches whereas a header has more than 2 branches. Either of the separation tube or header, or both, can be used for branches. However, the separation tube is never provided after the header because of balancing issues.



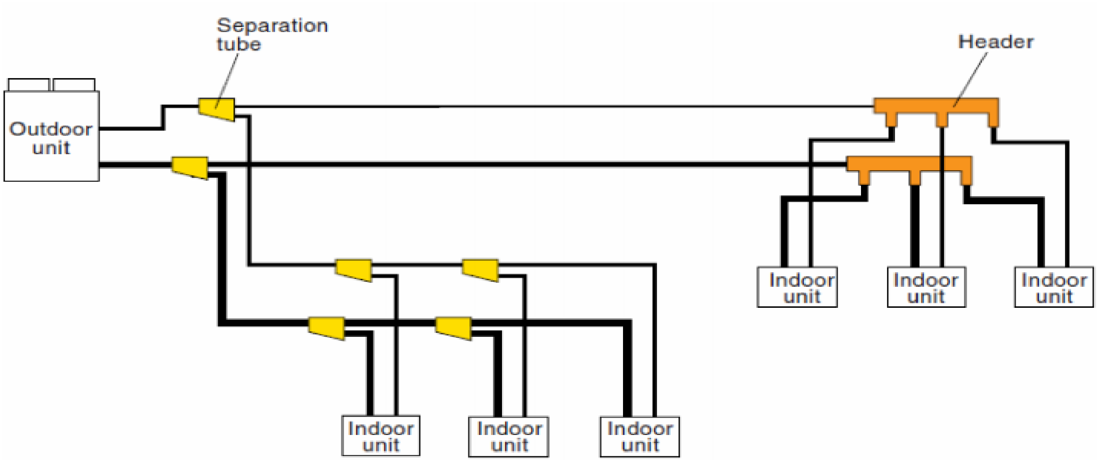
[9] Figure (3.3): Separation and header tubes

3.1.3 Types of VRF

VRV/VRF systems can be used for cooling only, heat pumping or heat recovery. On heat pump models there are two basic types of VRF system: heat pump systems and energy recovery.

<u>VRF heat pump systems</u>

VRF heat pump systems permit heating or cooling in all of the indoor units but not operate simultaneous heating and cooling. When the indoor units are in the cooling mode they act as evaporators, when they are in the heating mode they act as condensers. These are also known as two-pipe systems.



[9] Figure (3.4): VRF heat pump systems

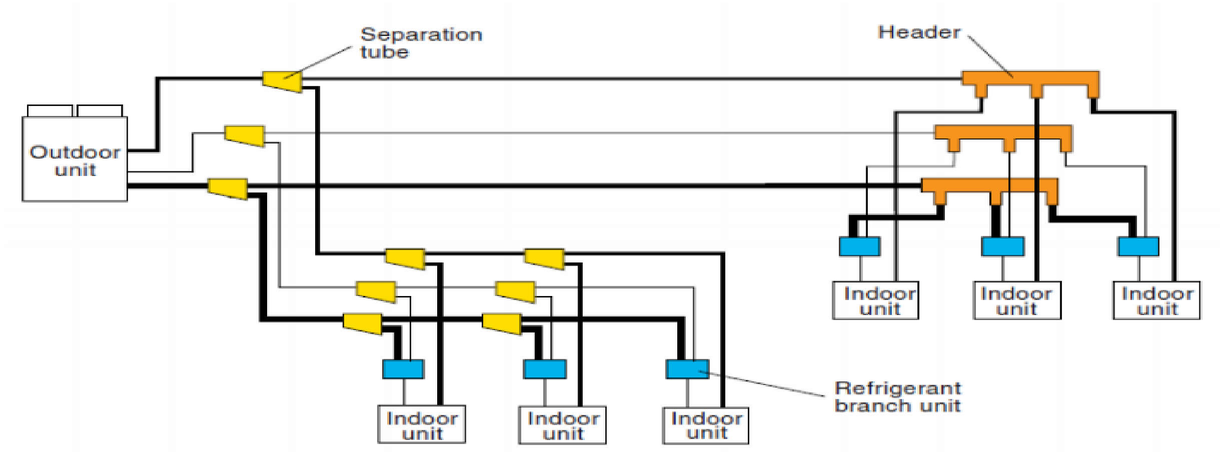
VRF heat pump systems are effectively applied in open plan areas, retail stores, cellular offices and any other areas that require cooling or heating during the same operational periods.

<u>Heat Recovery VRF system (VRF-HR)</u>

Variable refrigerant flow systems with heat recovery (VRF-HR) capability can operate simultaneously in heating and/or cooling mode, enabling heat to be used rather than rejected as it would be in traditional heat pump systems. VRF-HR systems are equipped with enhanced features like inverter drives, pulse modulating electronic expansion valves and distributed controls that allow system to operate in net heating or net cooling mode, as demanded by the space.

Each manufacturer has its own proprietary design (2-pipe or 3-pipe system), but most uses a three-pipe system (liquid line, a hot gas line and a suction line) and special valving arrangements. Each indoor unit is branched off from the 3 pipes using solenoid valves. An indoor unit requiring cooling will open its liquid line and suction line valves and act as an evaporator. An indoor unit requiring heating will open its hot gas and liquid line valves and will act as a condenser.

Typically, extra heat exchangers in distribution boxes are used to transfer some reject heat from the superheated refrigerant exiting the zone being cooled to the refrigerant that is going to the zone to be heated. This balancing act has the potential to produce significant energy savings.



[9] Figure (3.5): Heat recovery type VRF system

VRF-HR mixed mode operation leads to energy savings as both ends of the thermodynamic cycle are delivering useful heat exchange. If a system has a cooling COP (Coefficient of Performance) of 3, and a heating COP of 4, then heat recovery operation could yield a COP as high as 7.

VRF-HR systems work best when there is a need for some of the spaces to be cooled and some of them to be heated during the same period. This often occurs in the winter in medium-sized to large sized buildings with a substantial core or in the areas on the north and south sides of a building.

This project deals with VRF heat pump systems.

3.1.4 Refrigerant modulation in a VRF system

VRV/VRF technology is based on the simple vapor compression cycle (same as conventional split air conditioning systems) but gives you the ability to continuously control and adjust the flow of refrigerant to different internal units, depending on the heating and cooling needs of each area of the building. The refrigerant flow to each evaporator is adjusted precisely through a pulse wave electronic expansion valve in conjunction with an inverter and multiple compressors of varying capacity, in response to changes in the cooling or heating requirement within the air conditioned space. [9]

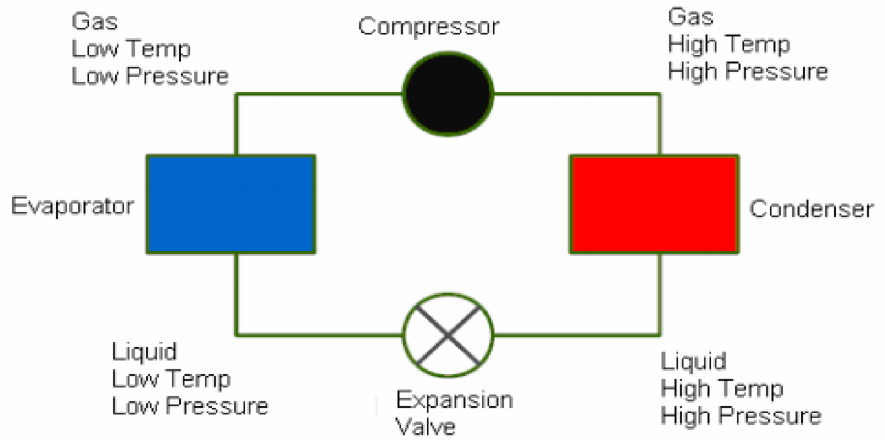


Figure (3.6): Basic refrigeration cycle

The fundamental of an air conditioning system is the use of a refrigerant to absorb heat from the indoor environment and transfer it to the external environment. In the cooling mode, indoor units are supplied with liquid refrigerant. The amount of refrigerant flowing through the unit is controlled via an expansion valve located inside the unit. When the refrigerant enters the coil, it undergoes a phase change (evaporation) that extracts heat from the space, thereby cooling the room. The heat extracted from the space is exhausted to the ambient air.

Refrigeration systems can operate on reverse cycle mode with an inclusion of special 4-way reversing valve, enabling the absorption of heat from the external environment and using this heat to raise the internal temperature. When in the heating mode, indoor units are supplied with a hot gas refrigerant. Again, the amount of hot gas flowing through the unit is controlled via the same electronic expansion valve. As with the liquid refrigerant, the hot gas undergoes a phase change (condensation), which releases heat energy into the space. These are called heat pump systems. Heat pumps provide both heating and cooling from the same unit and due to added heat of compression, the efficiency of a heat pump in the heating mode is higher compared to the cooling cycle.

valve is the component that controls the rate at which liquid refrigerant can flow into an evaporator coil.

As the evaporator load increases, available refrigerant will boil off more rapidly. If it is completely evaporated prior to exiting the evaporator, the vapor will continue to absorb heat (superheat). Although superheating ensures total evaporation of the liquid refrigerant before it goes into the compressor, the density of vapor which quits the evaporator and enters the compressor is reduced leading to reduced refrigeration capacity.

The inadequate or high super heat in a system is a concern.

- Too little: liquid refrigerant entering a compressor washes out the oil causing premature failure.
- Too much: valuable evaporator space is wasted and possibly causing compressor overheating problems.

The shortcomings of thermostatic expansion valve (TXV) are offset by the modern electronic expansion valve. With an electronic expansion valve (EEV), you can tell the system what superheat you want and it will set it up.

EEV in a VRF system functions to maintain the pressure differential and also distribute the precise amount of refrigerant to each indoor unit. It allows for the fine control of the refrigerant to the evaporators and can reduce or stop the flow of refrigerant to the individual evaporator unit while meeting the targeted superheat.

3.1.5 Design considerations for VRF system

Deciding what HVAC system best suits your application will depend on several variables such as building characteristics, cooling and heating load requirements, peak occurrence, simultaneous heating and cooling requirements, fresh air needs, accessibility requirements, minimum and maximum outdoor temperatures, sustainability, and acoustic characteristics. [9]

Building Characteristics

VRF systems are typically distributed systems – the outdoor unit is kept at a far off location like the top of the building or remotely at grade level and all the evaporator units are installed at various locations inside the building. Typically the refrigerant pipe-work (liquid and suction lines) is very long, running in several hundreds of feet in length for large multi-story buildings. Obviously, the long pipe lengths will introduce pressure losses in the suction line and, unless the correct diameter of pipe is selected, the indoor units will be starved of refrigerant resulting in insufficient cooling to the end user. So it is very important to make sure that the pipe sizing is done properly, both for the main header pipe as well as the feeder pipes that feed each indoor unit. The maximum allowable length varies among different manufacturers; however the general guidelines are as follows:

- The maximum allowable vertical distance between an outdoor unit and its farthest indoor unit is 164 ft
- The maximum permissible vertical distance between two individual indoor units is 49 ft
- The maximum overall refrigerant piping lengths between outdoor and the farthest indoor unit is up to 541 ft

Note: The longer the lengths of refrigerant pipes, the more expensive the initial and operating costs.

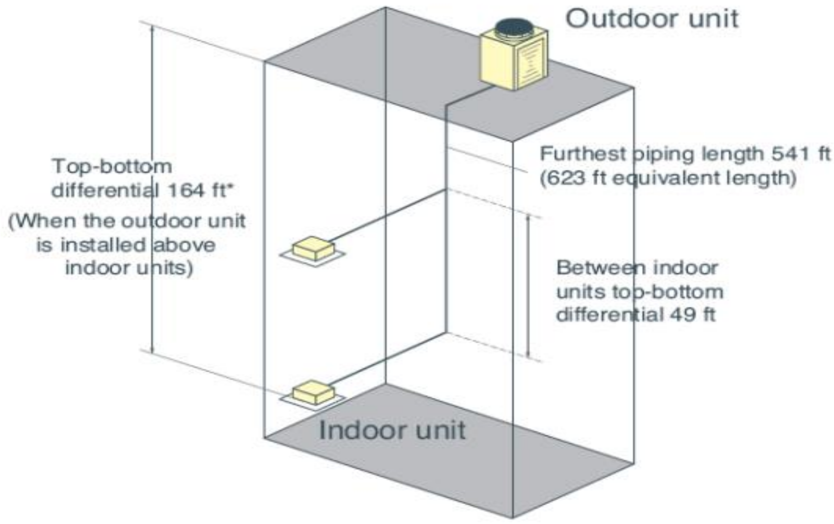
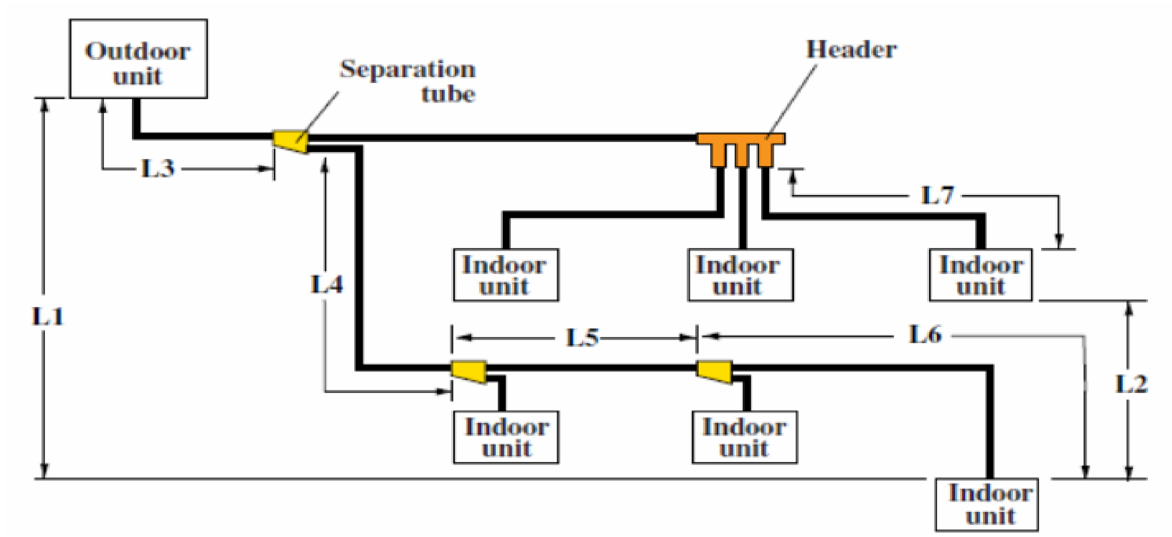


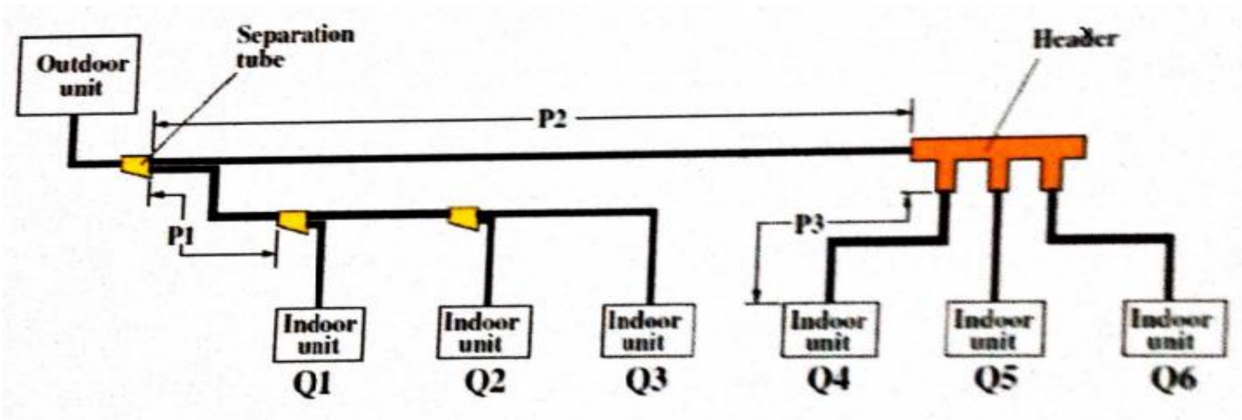
Figure (3.7): Design limits in VRF system

As stated, the refrigerant piping criteria varies from manufacturer to manufacture, for example for one of the Japanese manufacturer (Fujitsu), the system design limits are:



[9] Figure (3.8): Design limits in (Fujitsu) VRF system

- L1: Maximum height difference between outdoor unit and indoor unit = 50m
- L2: Maximum height difference between indoor unit and indoor unit = 15m
- L3: Maximum piping length from outdoor unit to first separation tube = 70m
- [L3+L4+L5+L6]: Maximum piping length from outdoor unit to last indoor unit = 100m
- L6 & L7: Maximum piping length from header to indoor unit = 40m
- Total piping length = 200m (Liquid pipe length)



[9] Figure (3.9): Pipe sizing for VRF system

- Size of P1: Depends on the total capacity of (Q1+Q2+Q3)
- Size of P2: Depends on the total capacity of (Q4+Q5+Q6)
- Size of P3: Depends on the total capacity of (Q4)

Building Load Profile

When selecting a VRF system for a new or retrofit application, the following assessment tasks should be carried out:

- Determine the functional and operational requirements by assessing the cooling load and load profiles including location, hours of operation, number/type of occupants, equipment being used, etc.
- Determine the required system configuration in terms of the number of indoor units and the outdoor condensing unit capacity by taking into account the total capacity and operational requirements, reliability and maintenance considerations

Building a load profile helps determine the outdoor condensing unit compressor capacity. For instance, if there are many hours at low load, it is advantageous to install multiple compressors with at least one with inverter (speed adjustment) feature.

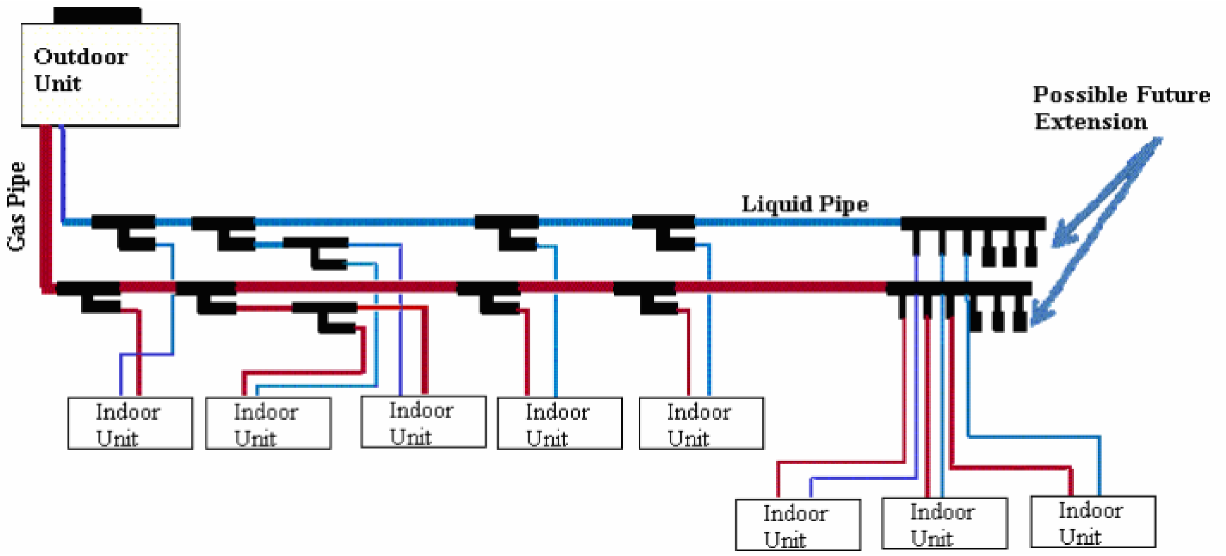
The combined cooling capacity of the indoor sections can match, exceed, or be lower than the capacity of the outdoor section connected to them. But as a normal practice:

- The indoor units are typically sized and selected based on the greater of the heating or cooling loads in the zone it serves, i.e. maximum peak load expected in any time of the year.
- The outdoor condensing unit is selected based on the load profile of the facility which is the peak load of all the zones combined at any one given time. The important thing here is that it is unlikely that all zones will peak at a given time so an element of diversity is considered for economic sizing. Adding up the peak load for each indoor unit and using that total number to size the outdoor unit will result in an unnecessarily oversized condensing unit. Although an oversized condensing unit with multiple compressors is capable of operating at lower capacity, too much over sizing sometimes reduces or ceases the modulation function of the expansion valve. As a rule of thumb, an engineer can specify an outdoor unit with a capacity anywhere between 70% and 130% of the combined capacities of the indoor units.

Sustainability

One attractive feature of the VRF system is its higher efficiency compared to conventional units. Cooling power in a VRF system is regulated by means of adjusting the rotation speed of the compressor which can generate an energy saving around 30%.

A VRF system permits easy future expansion when the conditions demand. Oversizing however, should be avoided unless a future expansion is planned.



[9] Figure (3.10): Pipe work schematic

Other sustainability factors include:

- Use of non-ozone depleting environment-friendly refrigerants such as R 410a
- Opting for heat pump instead of electrical resistance heating in areas demanding both cooling and heating.

Heat pumps offer higher energy efficiency.

Simultaneous Heating and Cooling

Some manufacturers offer a VRF system with heat recovery feature which is capable of providing simultaneous heating and cooling. The cost of a VRF-HR is higher than that of a normal VRF heat pump unit and therefore its application should be carefully evaluated.

More economical design can sometimes be achieved by combining zones with similar heating or cooling requirements together. For example, the areas that may require simultaneous heating and cooling are the parametric and interior zones. Parametric areas with lot of glazing and exposure especially towards west and south will have high load variations. A VRF heat pump type system is capable of providing simultaneous heating and cooling exceeding 6 tons cooling requirement.

Using VRF heat pump units for heating and cooling can increase building energy efficiency. The designer must evaluate the heat output for the units at the outdoor design temperature. Supplemental heating with electric resistors shall be considered only when the heating capacity of the VRF units is below the heating capacity required by the application. Even though supplemental heating is considered, the sequence of operation and commissioning must specify and prevent premature activation of supplemental heating.

<u>First Costs</u>

The installed cost of a VRF system is highly variable, project dependent, and difficult to pin down. Studies indicate that the total installed cost of a VRF system is estimated to be 5% to 20% higher than air or water cooled chilled water system, water source heat pump, or rooftop DX system providing equivalent capacity. This is mainly due to long refrigerant piping and multiple indoor evaporator exchanges with associated controls. Building owners often have no incentive to accept higher first costs, even if the claimed payback period is short, as the energy savings claims are highly unpredictable.

3.1.6 Advantages of VRF system

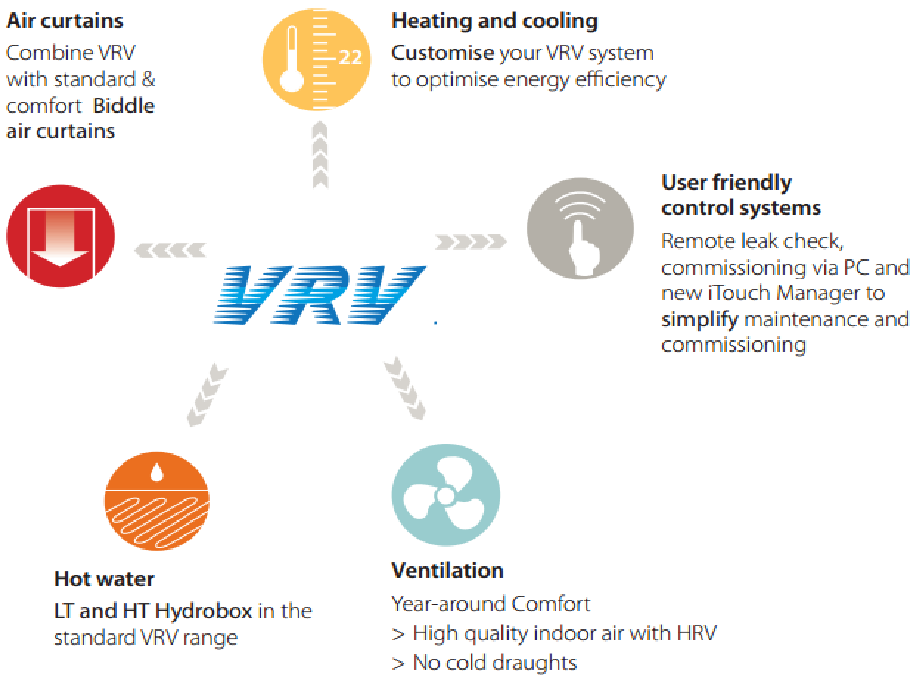


Figure (3.11): VRV provides a total solution for integrated climate control

VRF systems have several key benefits, including:

1. Installation Advantages.

   VRF systems are lightweight and modular. Each module can be transported easily and fits into a standard elevator.

2. Design Flexibility.

   A single condensing unit can be connected to many indoor units of varying capacity (e.g., 0.6 to 4 tons [2.2 to 14 kW]) and configurations (e.g., ceiling recessed, wall mounted, floor console). Current products enable up to 20 indoor units to be supplied by a single condensing unit. Modularity also makes it easy to adapt the HVAC system to expansion or reconfiguration of the space, which may require additional capacity or different terminal units.

3. Maintenance and Commissioning**.**

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

4. Comfort.

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

5. Energy Efficiency.

   The energy efficiency of VRF systems derives from several factors. The VRF essentially eliminates duct losses, which are often estimated to be between (10-20) percent of total airflow in a ducted system. VRF systems typically include two to three compressors, one of which is variable speed, in each condensing unit, enabling wide capacity modulation. This approach yields high part-load efficiency, which translates into high seasonal energy efficiency, because HVAC systems typically spend most of their operating hours in the range of 40% to 80% of maximum capacity.

6. Refrigerant piping runs of more than 200 feet (60.96 m) are possible and outdoor units are available in sizes up to 240,000 Btu/ h (60478.98 kW).

3.1.7 Selection units

This section talks about selection of outdoor and indoor units of VRF system, depending on the "Samsung VRF catalogue", since this company product is existing in Hebron.

Outdoor and indoor units are selected according to the thermal load of the building.

<u>Indoor unit</u>

In this project there are many types of indoor units selected, which are wall mounted , cassette M.S.P duct and slim Duct units.

`

The figure below shows two types of selected units:

MODEL NAME

AVX	C	S	H	022	E	E
①	②	③	④	⑤	⑥	⑦

① Classification

Indoor unit (R410A)	AVX

② Classification by product group

Cassette type	C
Duct type	D
Wall mounted type	W
Convertible type	T

③ Product notation

Cassette type	Slim 1way	S
	2way	2
	Mini 4way	M
	4way	4
Duct type	Slim	S
	Middle static pressure	U
Wall mounted type	MB	B
	Neo Forte	N
	Vivace	V
Convertible type	Ceiling	F
	Console	J

④ Mode

Heat Pump/Heat Recovery	H

⑤ Capacity

x 1/10 kW (3 digits)

Notation	Cooling	Heating
022	2.2	2.5
028	2.8	3.2
036	3.6	4.0
045	4.5	5.0
056	5.6	6.3
060	6.0	6.8
071	7.1	8.0
090	9.0	10.0
112	11.2	12.5
128	12.8	13.8
140	14.0	16.0

⑥ Rating voltage

1Ø, 220V, 60Hz	B
1Ø, 208~230V, 60Hz	C
1Ø, 220~240V, 50Hz	E

⑦ Version

Domestic (KOREA)	0~9
Export	A~Z

[10] Figure (3.12): wall mounted and cassette indoor units

From Samsung DVM plus 3 technical data book

By determining the load of each room and determining the actual heating and cooling capacity for the Indoor Units depends on the outside and inside design conditions as follows :

Table (3.1): nominal and actual indoor capacity

Nominal Capacity (KW)	Actual cooling capacity (KW)	Actual heating capacity (KW)
2.2	2.1	2.2
2.8	2.6	2.7
3.6	3.4	3.4
4.5	4.2	4.2
5.6	5.3	5.3
6	5.6	5.6
7.1	6.7	6.8
9	8.4	8.4
11.2	10.5	10.6
12.8	12	11.7
12	13.1	13.5

And the selection of each unit done by determining the code of it using the code system from DVM plus 3 technical data book as shown in figure below :

<u>Outdoor unit</u>

After doing the calculation of heating and cooling load for the building , then we have to select the outdoor units depends on two things ; the total actual cooling load and the capacity ratio , the capacity ratio is a ratio between the total capacity of the indoor and outdoor capacity , and its ranged between 70% – 130 % , for the use of hospital , the best is select a capacity ratio of 100% , and the outdoor units selection as follow :

Table (3.2): nominal and actual outdoor capacity

FLOOR	Number of VRF system	Capacity for each system (hp)		Outdoor selection (code)	
		System 1	System 2	System 1	System 2
Basment	1	51.9	-------	4(RVXVRT160GE)	-------
Ground	2	40.4	52.9	3(RVXVRT120GE) 1(RVXVRT160GE)	4(RVXVRT160GE)
First	2	22.9	49.7	3(RVXVRT100GE)	1(RVXVRT120GE) 3(RVXVRT160GE)
Second	2	48.2	53.6	1(RVXVRT120GE) 3(RVXVRT160GE)	4(RVXVRT160GE)
Third	2	48.52	53.3	1(RVXVRT120GE) 3(RVXVRT160GE)	4(RVXVRT160GE)
Fourth	2	35.7	43.4	2(RVXVRT100GE) 1(RVXVRT120GE) 1(RVXVRT140GE)	1(RVXVRT140GE)
Fifth	2	29.6	51.4	1(RVXVRT120GE) 1(RVXVRT140GE)	4(RVXVRT160GE)

Chapter 4 : Plumbing System

4.1 Introduction

There are two main functions of using plumping systems:

1- Water supply system; which provides the building with the required amount of water.

2- Sanitary drainage system; which removes all the usable water from the building.

It is the plumbing technologists’ responsibility to design the entire water service and distribution systems for all uses, recognizing the pressure and flow limitations.

In the project up feed distribution system will be used for both cold and hot water systems. Fixture units at the building are designed for private and general uses, flush tanks used for water closets because it needs low pressure, steel pipes will be used for hot and cold water systems, seven risers will be used for cold and hot water supply systems, The critical fixture unit in the system is the lavatory fixture unit which is located at the fourth floor of the building .

4.2 Sanitary Drainage System

The main objective of drainage system is to carry the waste water from the fixture unit to manhole and from the manhole to the septic tank or to the municipal sewage system.

The provision of drainage systems:

- Sanitary drainage
- Storm drainage

4.2.1 Drainage system components

The main components of drainage system are:

1) Fixture units
2) Trap
3) Clean out
4) Drainage pipe
5) Stack and vent pipes
6) Manholes
7) Septic tank or municipal sewage system
8) Accessories

4.3 Design procedure and pipe sizing

Pipe size is calculated by using a concept of fixture units (DFU) instead of using gpm of drainage water. This unit takes into account not only the fixtures water use but also its frequency of use, which is the DFU has a built–in diversity factor. This enables us, exactly as for water supply to add DFU of various fixtures to obtain the maximum expected drainage flow. Drainage pipes sized for a particular number of drainage fixture units, according to Tables ((A-23),(A-24)) These tables are built into the fill factors, which are:

- 50% fill in branches (horizontal pipes)
- (25-33)% fills in stack (vertical pipes)
- 50% fill in building and swear drains

The recommended velocity for drainage piping:

- For branches the recommended velocity is 2 ft/s
- For building pipes the recommended velocity is 3 ft/s
- For greasy flow the recommended velocity is 4 ft/s

Velocity of water flow through drainage piping depends on:

- Pipe diameter
- Slope

Minimum slope requirements for horizontal drainage piping:

- For pipes of diameter ≤ 3" the minimum slope is 1/4”/ft (2%)
- For pipes of diameter ≥ 4" the minimum slope is 1/8”/ft (4%)

4.3.1 Design procedure:

1) Calculation of the number of DFU for each branch by using Table (A-23)
2) Calculation of the number of DFU for each stack
3) Choosing the branch pipe diameter by using Table (A-18)
4) Choosing the stack pipe diameter by using Table (A-18)
5) Comparing the stack pipe diameter with branch diameter
6) Choosing the building drain pipe diameter by using Table (A-17)

To achieve the recommended velocities which are 3 fps in building drain, it will be chosen the slope and flow velocity in building drain by using Table (A-17)

The following figure and tables shows the sizing of stacks:

Table 4.1: Sizing of black water stack 1

Stack 1	Total dfu value	Diameter (inch)
From fifth floor (branch)	12	3
From fifth floor to fourth floor (stack)	12	3
From fourth floor (branch)	12	3
From fourth floor to third floor (stack)	24	3
From third floor (branch)	42	4
From third floor to second floor (stack)	66	4
From second floor (branch)	42	4
From second floor to first floor (stack)	108	4
From first floor (branch)	54	4
From first floor to ground floor (stack)	162	4
From ground floor (branch)	24	4
From ground floor to basement floor (stack)	186	4
From basement floor to building drain (branch)	12	4
Building drain (stack)	198	4

We choice 4(inch) for all stack as shown in drawing.

4.4 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 be0.5% for rain waer and 1.5% for gray and black water.

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.

ϕ60 cm for manhole depth (50-100) cm.

ϕ80 cm for manhole depth (100-150) cm.

ϕ100 cm for manhole depth (150-250) cm.

ϕ120 cm for manhole depth > 250 cm.

The table of all manholes shown in drawing .

4.5 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 will use the up feed distribution system for cold water and up feed distribution system for hot water, and up feed system for softened cold water , the supply of water for the hospital is received from the municipal, 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.

4.5.1 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 puplic street main(usually 35psi for residential structures ,and about 50 psi for the other buildings).
2- Private water supply enters into a pneumatic tank(pressurized tank)and its pressurized from approximately 35 to 60 psi.

4.5.2 Calculation for the water well volume needed for the hospital :

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

We have **150 bed** in our hospital

So (500L/1000)m^3*150=75 m^3 ber day

For 3 days

We need 225 m^3

4.6 Calculations for hot and cold water system

4.6.1 Water sevice sizing for 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 Tables 4.2 shows the total water supply fixture unit for each floor

Table 4.2 : water supply fixture unit for each floor:

Floor	Total WSFU CW	Total WSFU HW	Total WSFU SW
BS floor	271	280	263
GR floor	48	45	17
1ST floor	26	28	19
2nd floor	81	79	24
3rd floor	88	91	29
4th floor	70	83	32
5th floor	52	21	11

4.6.2 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 3.9 m.

Static head = ((no.of floors*floor to floor hight)*3.28) +1

Static head = ((7*3.9)*3.28)+1 =90.5 ft.
So the static pressure = static head * 0.433 psi/ft = 90.5 * 0.433 = 39.2 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 water pipes are using up feed system we will need the following equation:

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

Must be taken into Account that the velocity for all fixture units should not exceed 8 fps , except for water closet

With flush valve of 4fps.

a- For cold water system:

Total length from pump to riser = 51.9 m .

Total length from floor to floor = 27.3 m.

Total length from riser to collector = 79.7 m

Total length form collector to fixture unit = 7.02 m.

Total length = 165.9 m.

Total equivalent length=165.9*1.5*3.28=**816.32 ft**

b- For hot water system:

Total length from boiler to riser =52.9m .

Total length floor to floor =27.3m.

Total length from riser to collector =79.2m

Total length form collector to fixture unit =7.02m.

Total length =166.42m.

Total equivalent length=166.42*1.5*3.28=**818.78 ft**.

c- For softened cold water system:

Total length from boiler to riser =53.7m .

Total length floor to floor =27.3m.

Total length from riser to collector =61.3m

Total length form collector to fixture unit =1.4m.

Total length =143.7m.

Total equivalent length=143.7*1.5*3.28=**707 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 head pressure =Friction head + static pressure + minimum flow pressure

Friction head = 200–(39.2+8)= 152.8psi.

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

Friction/100ft =152.8 psi/(**816.32** /100 ft) = 18.7 (psi/100ft).

b- For hot water system:

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

Friction head = 105 – (39.2+8) = 57.8psi.

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

Friction/100ft =57.8psi/(818.78/100 ft) = 7.05 (psi/100ft).

c- For softened cold water system:

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

Friction head = 196 – (39.2+8) = 148.8psi.

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

Friction/100ft =148.8psi/(707/100 ft) = 21.04 (psi/100ft).

Flow Range (GPM)		Pipe Size (Inch)	Pressure Drop Range (of water / 100 ft)	Flow Range (LPS)		Pipe Size (MM)
From	To			From	To	
0	2	1/2	0 - 4	0.00	0.13	12.70
3	4	3/4	2.5 - 4	0.19	0.25	19.05
5	7.5	1	2 - 4	0.32	0.47	25.40
8	16	1 1/4	1.25 - 4	0.50	1.01	31.75
17	24	1 1/2	2 - 4	1.07	1.51	38.10
25	48	2	1.5 - 4	1.58	3.03	50.80
49	77	2 1/2	2 - 4	3.09	4.86	63.50
78	140	3	1.5 - 4	4.92	8.83	76.20
141	280	4	1.25 - 4	8.90	17.67	101.60
281	500	5	1.5 - 4	17.73	31.55	127.00
501	800	6	1.25 - 4	31.61	50.47	152.40
801	1700	8	1 - 4	50.54	107.25	203.20
1701	2500	10	1.25 - 2.75	107.32	157.73	254.00
2501	3600	12	1.25 - 2.25	157.79	227.12	304.80
3601	4200	14	1.25 - 2	227.19	264.98	355.60
4201	5500	16	1 - 1.75	265.04	347.00	406.40
5501	7000	18	0.9 - 1.5	347.06	441.63	457.20
7001	9000	20	0.8 - 1.25	441.69	567.81	508.00
9001	13000	24	0.6 - 1	567.87	820.17	609.60

Table 4.3 :All water pipe has been sized depends on flow rate range in each pipe as shown on

CHAPTER FIVE

FIRE FIGHTING SYSTEM

CHAPTER 5

5.1 The Fire Triangle :

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

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

Fuel – to vaporize and burn

Oxygen – to combine with fuel vapor

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

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

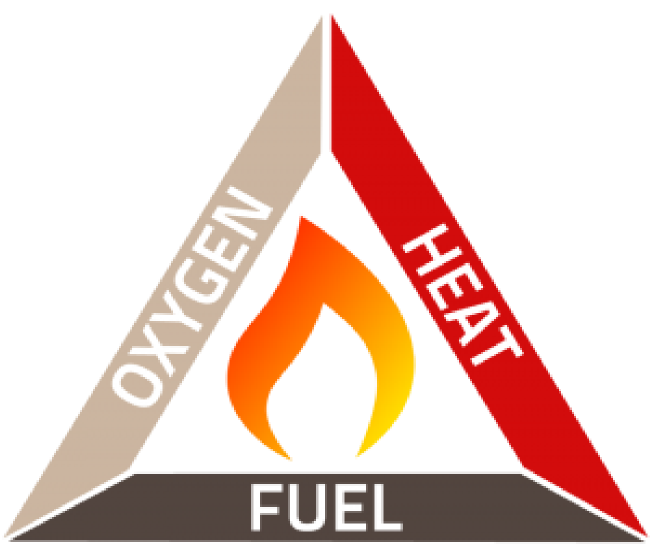


Figure (5.1) The fire triangle

5.2 Classifications of Fire:

Fires are classified into five groups as follows:

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:

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:

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.

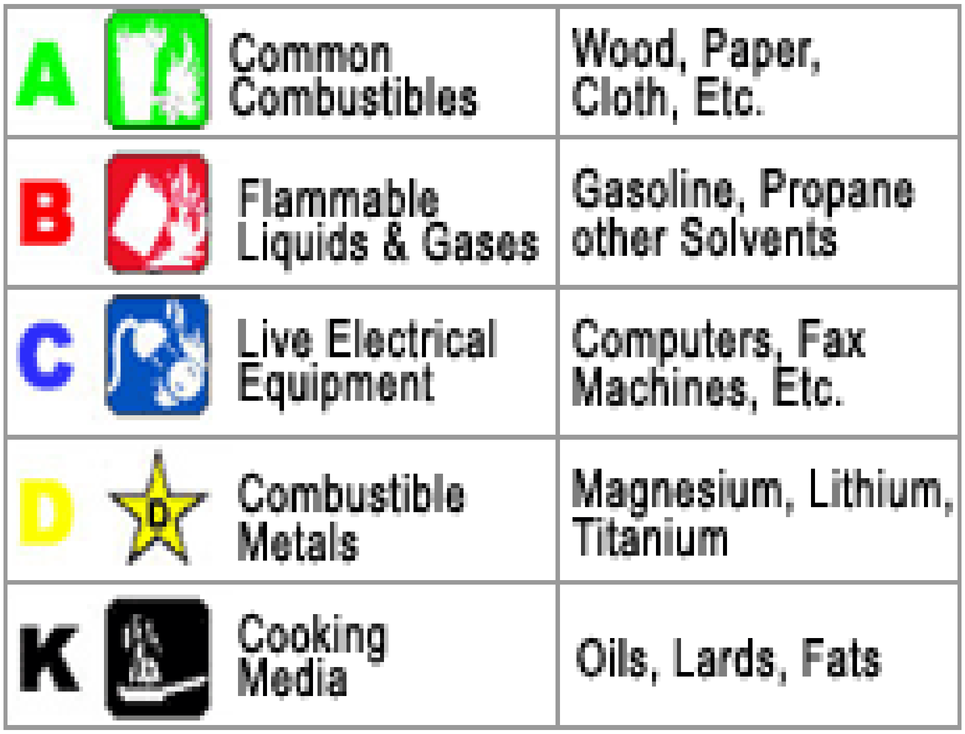
Class D:

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

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 **:-**



A	Common Combustibles	Wood, Paper, Cloth, Etc.
B	Flammable Liquids & Gases	Gasoline, Propane other Solvents
C	Live Electrical Equipment	Computers, Fax Machines, Etc.
D	Combustible Metals	Magnesium, Lithium, Titanium
K	Cooking Media	Oils, Lards, Fats

Figure (5.2) Types of fires as classified

5.2.1 Classifications of Hazard:

Light: Class A & little of Class B

Ordinary: Class A & B

Extra: Class A & B but with large quantity.

5.3 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

-CO_2

- FM200

b)Manual

- Extinguisher

3)foam system

a) Automatic

- High pressure(Foam nozzle)

-Low pressure (Foam generator)

b) Manual

- Extinguisher

5.4 Fire extinguisher :-

1-Fire extinguisher classification &UL rating :

-Class A

-Class B

-Class C

-Class D

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

Note: the UL rating is found on the extinguisher label like shown :

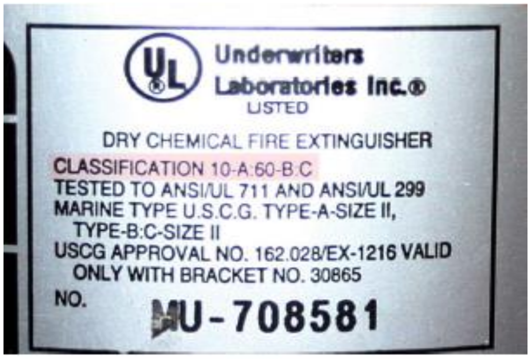


Figure (5.3) Extinguisher label

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

Table 5.1: Extinguisher types

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

2-Hazard classification:

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

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

3) Extra (high) hazard occupancy:

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

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

4) Mixed occupancies:

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

5) Specialized occupancies:

Aircraft hangar.

3-Extinguisher size & replacement:

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

-Hazard and hazard area.

-Rating &coverage area .

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

- Distributing the sprinkler per the allowable reveal distance for each type according to NPFA13.

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

Table (5.2) Extinguisher size and location for class A hazard

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

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

Table (5.3) Extinguisher size and location for class B hazard

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

• **Class C extinguishers**

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

Class D Locations

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

Class K Locations

• Class K hazards shall have a fire extinguisher located where there is a
Potential for a fire involving combustible cooking media (vegetable or
Animal oils and fats). The extinguisher shall be located no more than 30 ft. from the hazard.
Travel Distance for "A" Rating NFPA 10 .

5.4.1 Fire Extinguisher color code:

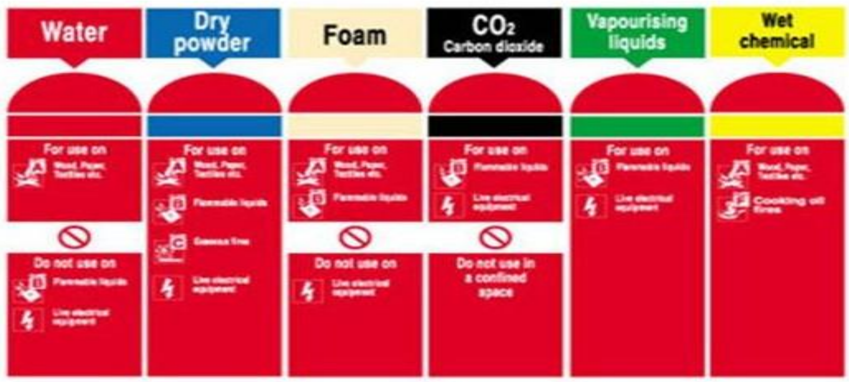


Figure (5.4) Extinguisher color code

5.4.2 Sample on Fire extinguisher:

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

Table (5.4): Extinguisher size and location:

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

5.5 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 (5.5) House Reel

b) House Rack:

Figure(5.6) 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.

5.6 Fire hydrant:

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

Fire Hydrant should be installed according to NPFA 14:

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

Figure (5.7) Fire hydrant

3) Siamese connection:

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

5.7 PUMP ROOM

5.7.1 Component and equipment used According to the drawing(Mechanical Room – Basment Floor) .

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

1- Gate valve.

2- check valve :

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

3- Suction header:

It prevents vortex.

4- Discharge header

5- Diesel pump:

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

6- Jockey pump:

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

7- Electric pumps

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

8- Pressure relief valve

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

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

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

9- Flow switch

It gives signal when a flow happened in a pipe.

10- Fuel tank

Which is used in diesel pump

5.7.2 Shut off of the pumps:

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

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

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

5.8 Selections of pump room Components:

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

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

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

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

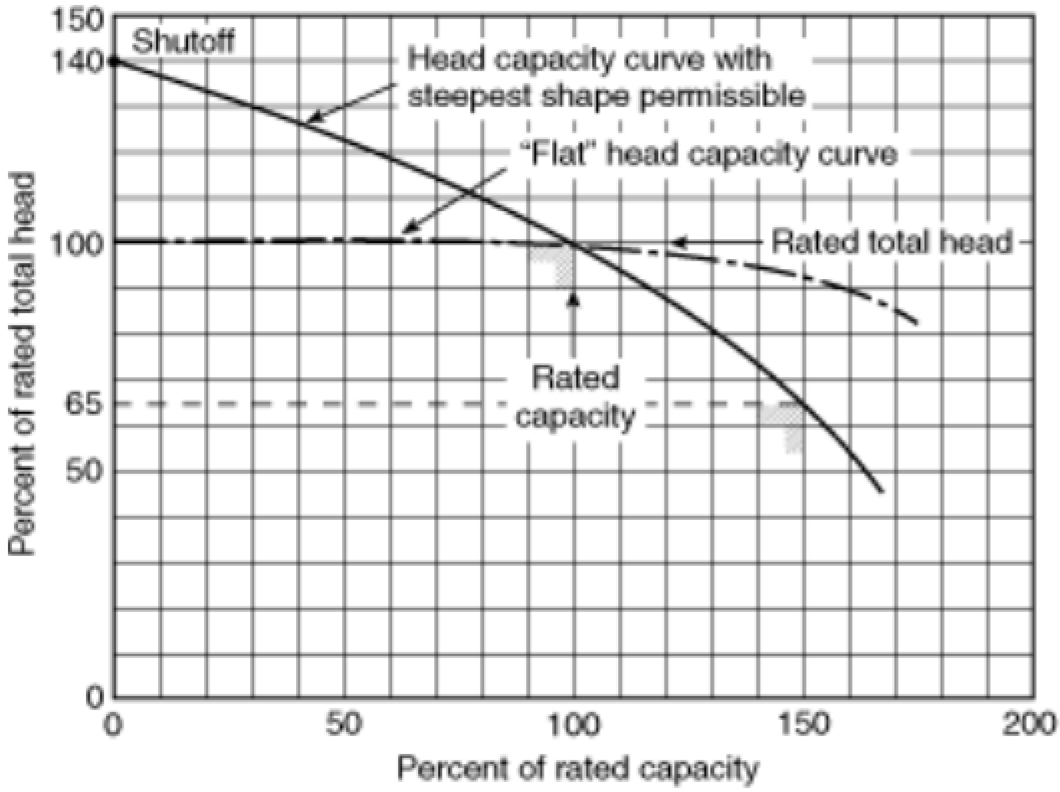


Figure (5.9) Fire fighting characteristic curve

5.8.1 Fire fighting pump Selection:

We have two pump room in basement 1 mechanical store .

Q total=Q pump=Q sprinkler +Q FHC+QFH ,we have used only FHC [5-1]

So :

Q total=Q pump= QFHC

Qt=Q pump =Q elec= Q diesel

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

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

Calculating the flow rate needed the 1st pump room connected with riser 1,2,3

which gives (10)FHC each one of them needs 100 gpm

So, The total flow rate= (10*100gpm) =1000gpm.

Calculating the flow rate needed the 2nd pump room connected with risers 4,5and 6

The total flow rate for riser4= (8*100gpm) +250gpm (as factor of safety for each riser add to the first riser "from code NPFA=1050gpm.

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

No. of pump	**Name of risers**	**l load (gpm)**
1	1	1000
	2	750
	3	750
	Total load	2500 gpm
No of pump	**Name of risers**	**load (gpm)**
2	2	1050
	3	950
	4	750
	Total load	2750 gpm

Table (5.5) The flow rate for each pump room

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 2500 gpm and 6 inch pipe diameter (seamless black steel schedule 40).

The head loses =30ft/100ft (13psi/100ft=0.1bar) from figuer (1) in appendix[B] **.**

The static head=95ft (41psi=2.8 bar).

The FHC Residual pressure 4.5 bar from NPAF10.

So, we need 2500gpm and 8. 3 bar

No of pump	**Q total (gpm)and head(m)**	**Selection of pump type**
1	2500 gpm&30m	**Seffco pump100/24**
2	2750gpm&30m	**Seffco pump100/24**

Table (5.6) selection of pump

See the catalog:

Figure (5.10) SFFECO Fire pump

5.9 Selections of fire extinguisher and fire house cabinet:

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

Fig (5.11) Fire extinguisher

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

Fig (5.12) Fire extinguisher

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

Fire Cabinet SF 600S

Figure (5.13) Fire extinguisher

5.10 calculation of the tank volume:

Q=750 gpm

Time = 30 min

Tank volume=Q * time   [5-2]

Tank volume =750 * 30=22500 Gallon

Tank volume = 85 m^3

CHAPTER SIX

MEDICAL GASES

CHAPTER 6

6.1 Introduction

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

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

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

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

1. Analyze each specific area of the health-care facility to determine the following items.
   A. piped medical-gas systems are required.
   B. Number of each different type of medical-gas outlet/inlet terminal is required.
   C. The outlet/inlet terminals be located for maximum efficiency and convenience.
2. Anticipate any building expansion and plan in which direction the expansion will take place (vertically or horizontally). Determine how the medical-gas system should be

sized and valued in order to accommodate the future expansion.

3. Determine locations for the various medical-gas supply sources.
4. Prepare the schematic piping layout locating the following :
   A. Zone valves.
   B. Isolation valves.
   C. Master alarms.
5. Calculate the anticipated peak demands for each medical-gas system. Appropriately size each particular section so as to avoid exceeding the maximum pressure drops allowed.

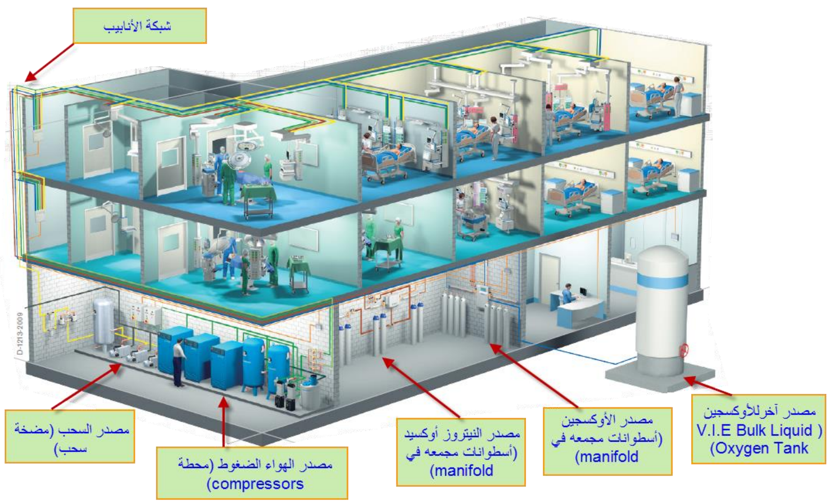


Figure 6-1 Medical gas Distribution in Hospital

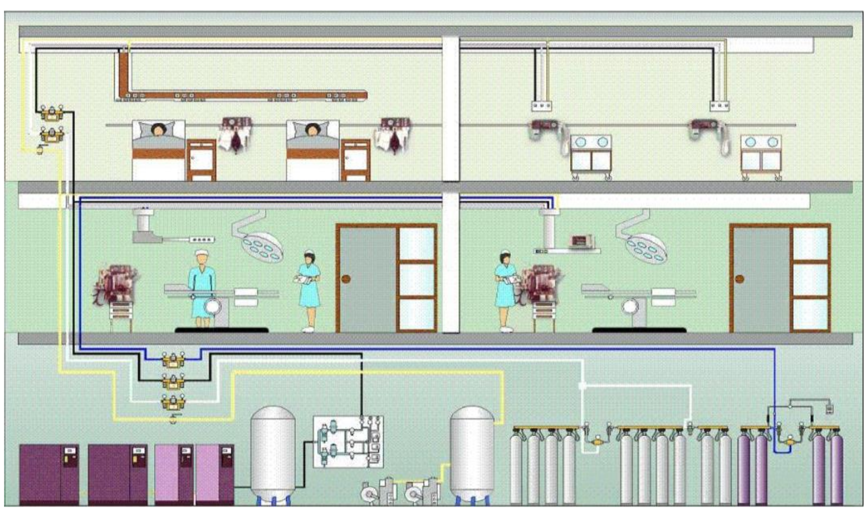


Figure 6-2: Medical gas Distribution in Hospital

6.2 Medical Gases Flow Rate

The flow rates and diversity factors vary for individual stations in each system depending on the total number of outlets and the type of care provided.

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

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

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

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

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

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

6.3 Provision Of Terminal Unit

A typical schedule of provision of terminal units is given in Table (5.1). Medical treatment policy is evolutionary, and therefore the project team should review the requirements for individual schemes.

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

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

When planning the installation of operating-room pendant fittings, the location of the operating luminaire and other ceiling-mounted devices should be taken into consideration. When the operating room is provided with an ultra-clean ventilation (UCV) system, it may be more practicable (and cost-effective) to have the services (both medical gas and electrical) incorporated as part of the UCV system partial walls. Terminal units that are wall mounted should be located as follows as recommended in **HTM 0201 code** :

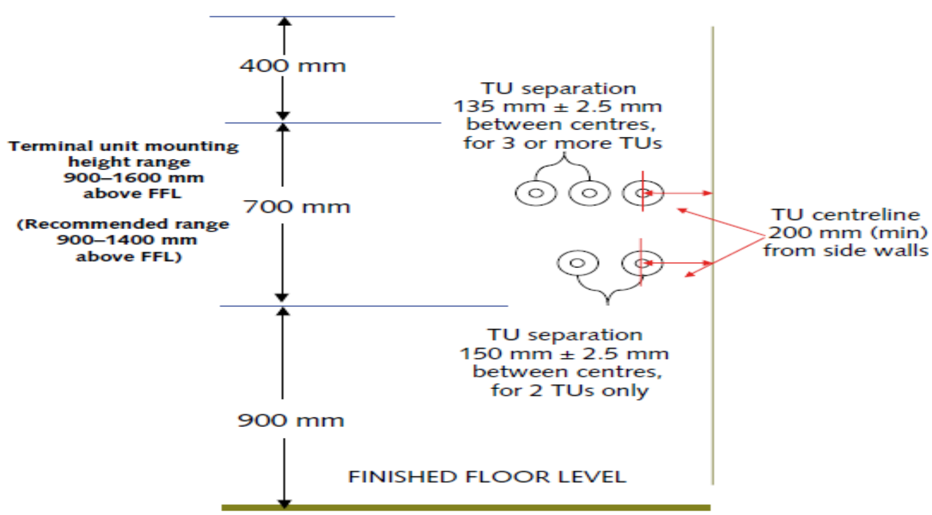


Figure (6-3): shows the location as recommended for terminal unit.

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

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

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

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

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

A sample of the table in the **HTM 0201 Code:**

Note: to determine the No. of terminal unit u need to know the type of room in hospital

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

Table (6.1): from HTM 0201 Code

6.4 Type Of Medical Gases

6.4.1 Oxygen (O_2)

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

Oxygen is generally supplied from:

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

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

To calculate the amount of hospital oxygen gas there is a Table (6.2) 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 shows the flow of oxygen (O_2)in HTM0201 code

Table (6.2): flow of oxygen (O_2)in HTM0201 code

Department	Design flow for each terminal unit (L/min)	n	Diversified flow *Q* (L/min)	
In-patient accommodation (ward units):				
Single 4-bed rooms and treatment room	10	0	Qw = 10 + [(n – 1)6/4] =	0

Ward block/department	10	0	$Qd = Qw[1 + (nW – 1)/2] =$	0
Accident & emergency:				
Resuscitation room, per trolley space	100	0	$Q = 100 + [(n – 1)6/4] =$	0
Major treatment/plaster room, per trolley space	10	0	$Q = 10 + [(n – 1)6/4] =$	0
Post-anesthesia recovery, per trolley space	10	0	$Q = 10 + [(n – 1)6/8] =$	0
Treatment room/cubicle	10	0	$Q = 10 + [(n – 1)6/10] =$	0
Operating:				
Anaesthetic rooms	100	0	Q = no addition made	
Operating rooms	100	0	$Q = 100 + (nT – 1)10 =$	0
Post-anesthesia recovery	10	0	$Q = 10 + (n – 1)6 =$	0
Maternity:				
LDRP rooms:				
Mother	10	0	$Q = 10 + [(n – 1)6/4] =$	0
Baby	10	0	$Q = 10 + [(n – 1)3/2] =$	0
Operating suites:				
Anesthetist	100	0	$Q = 100 + (nS – 1)6 =$	0
Pediatrician	10	0	$Q = 10 + (n – 1)3 =$	0
Post-anesthesia recovery	10	0	$Q = 10 + [(n – 1)3/4] =$	0

In-patient accommodation:				
Single/multi-bed wards	10	0	$Q = 10 + [(n - 1)6/6] =$	0
Nursery, per cot space	10	0	$Q = 10 + [(n - 1)3/2] =$	0
Special care baby unit	10	0	$Q = 10 + (n - 1)6 =$	0
Radiological:				
All anesthetic and procedures rooms	100	0	$Q = 10 + [(n - 1)6/3] =$	0
Critical care areas	10	0	$Q = 10 + [(n - 1)6]3/4 =$	0
Coronary care unit	10	0	$Q = 10 + [(n - 1)6]3/4 =$	0
High-dependency unit (HDU)	10	0	$Q = 10 + [(n - 1)6]3/4 =$	0
Renal	10	0	$Q = 10 + [(n - 1)6/4] =$	0
CPAP ventilation	75	0	$Q = 75n \times 75\%$	0
Adult mental illness accommodation:				
Electro-convulsive therapy (ECT) room	10	0	$Q = 10 + [(n - 1)6/4] =$	0
Post-anesthesia, per bed space	10	0	$Q = 10 + [(n - 1)6/4] =$	0
Adult acute day care accommodation:				
Treatment rooms	10	0	$Q = 10 + [(n - 1)6/4] =$	0

Post-anesthesia recovery per bed space	10	0	$Q = 10 + [(n - 1)6/4] =$	0
Oral surgery/orthodontic:				
Consulting rooms, type 1	10	0	$Q = 10 + [(n - 1)6/2] =$	0
Consulting rooms, types 2 & 3	10	0	$Q = 10 + [(n - 1)6/3] =$	0
Recovery room, per bed space	10	3	$Q = 10 + [(n - 1)6/6] =$	12
Out-patient:				
Treatment rooms	10	0	$Q = 10 + [(n - 1)6/4] =$	0

6.4.2 Nitrous Oxide (NO_2)

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

Nitrous Oxide calculation are the same as the oxygen calculation but here there is a difference in flow rate equation as shows in the following table .

Table (6.3): difference in flow rate equation between Nitrous Oxide and oxygen

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

6.4.3 Medical Air

Medical Air is primarily used for respiratory therapy. it supplied by a special air compressor to patient care areas using clean outside air. Pressure are maintained around 55 psi.

Medical Air gas calculations are the same as the previous gas but the difference between them is the flow rate equations as shows in the following table.

Table (6.4): Flow rate of Medical Air in HTM0201 code

Department	**Design flow for each terminal unit (L/min)**	**n**	**Diversified flow *Q* (L/min)**	
In-patient accommodation (ward units):				
Single 4-bed rooms and treatment room	20	0	*Q*w = 20 + [(*n* – 1)10/4] =	0
Ward block/department	20	0	*Q*d = *Q*w[1 + (*nW* – 1)/2] =	0
Accident & emergency:				
Resuscitation room, per trolley space	40	0	*Q* = 40 + [(*n* – 1)20/4] =	0
Major treatment/plaster room, per trolley space	40	0	*Q* = 40 + [(*n* – 1)20/4] =	0
Post-anesthesia recovery, per trolley space	40	0	*Q* = 40 + [(*n* – 1)40/4] =	0
Operating:				
Anaesthetic rooms	40	0	*Q* = no addition made	
Operating rooms	40	0	*Q* = 40 + [(*nT* – 1)40/4] =	0
Post-anesthesia recovery	40	0	*Q* = 40 + [(*n* – 1)10/4] =	0

Maternity:				
LDRP rooms:	40	0	$Q = 40 + [(n - 1)40/4] =$	0
Baby	40	0	$Q = 40 + [(n - 1)40/4] =$	0
Operating suites:				
Anesthetist	40	0	$Q = 40 + [(nS - 1)10/4] =$	0
Post-anesthesia recovery	40	0	$Q = 40 + [(n - 1)40/4] =$	
Neonatal unit (SCBU)	40	0	$Q = 40n$	
Radiological:				
All anesthetics and procedures rooms	40	0	$Q = 40 + [(n - 1)40/4] =$	0
Critical care areas	80	0	$Q = 80 + [(n - 1)80/2] =$	0
High-dependency unit (HDU)	80	0	$Q = 80 + [(n - 1)80/2] =$	0
Renal	20	0	$Q = 20 + [(n - 1)10/4] =$	0
Oral surgery/orthodontic:				
Major dental/oral surgery rooms	40	0	$Q = 40 + [(n - 1)40/2] =$	0
All other departments	40	0	No additional flow allowance to be made	0
Equipment service rooms	40		No additional flow included	0

6.4.4 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.

Medical vacuum gas calculation similar to the previous gas but there is a deference in flow rate as shows in the following table.

Table (6.5): flow of medical vacuum in HTM0201 code.

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

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

accommodation:				
Ward unit comprising single, multi-bed and treatment room	40	0	$Q = 40$	0
Multi-ward units	40	0	$Q = 40 + [(n - 1)40/2] =$	0
Nursery, per cot space	40	0	No additional to be included	0
SCBU	40		$Q = 40 + [(n - 1)40/4] =$	
Radiological:				
All anesthetic and procedures rooms	40	0	$Q = 40 + [(n - 1)40/8] =$	0
Critical care areas	40	0	$Q = 40 + [(n - 1)40/4] =$	0
High-dependency unit (HDU)	40	0	$Q = 40 + [(n - 1)40/4] =$	0
Renal	40	0	$Q\text{d} = 40 + [(n - 1)40/4] =$	0
Adult mental illness accommodation:				
Electro-convulsive therapy (ECT) room	40	0	$Q = 40 + [(n - 1)40/4] =$	0
Post-anesthesia, per bed space	40	0	$Q = 40 + [(n - 1)40/4] =$	0
Oral surgery/orthodontic:				

Consulting rooms, type 1	40	0	Dental vacuum only	0
Consulting rooms, types 2 & 3	40	0	Dental vacuum only	0
Recovery room, per bed space	40	0	$Q = 40 + [(n - 1)40/8]$ =	0
Out-patient:				
Treatment rooms	40	0	$Q = 40 + [(n - 1)40/8]$ =	0
Equipment service rooms, sterile services etc	40		Residual capacity will be adequate without an additional allowance	

6.4.5 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.

AGSS gas calculation are the same as the previous gas but there is a difference in flow rate equation as shows in the following table.

Table (6.6): flow of (AGSS) in HTM0201 code.

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

6.5 Calculation Of Medical Gases

6.5.1 Flow Of Gases, And Sample Calculation Of forth Floor. For Room #129 From Resuscitation Room

1- Oxygen (O_2)

$Q = 40 + [(n – 1)40/4]$. From Table (6.2).

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

n: Number of beds.

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

Q=101.5 L/m

2- MA4

Q = 40 + [(n – 1)40/4]. From Table (6.4).

Q: The flow of MA4 gases(L/m).

n: Number of beds.

Q=40+(2-1)10

Q=50 L/m

3- Medical Vacuum

Q = 40 + [(*n* – 1)40/8] . From Table (6.5).

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

n: Number of beds.

Q=40+[(n-1)40/8] =45 L/m

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

Table (6.7): Flow of medical gas needed in hospital

Floor	**Oxygen [L/m]**	**Nitrous Oxide [L/m]**	**Medical Air [L/m]**	**Medical Vacuum [L/m]**	**AGSS [L/m]**	**SA7 [L/m]**	**CO2**
Basement	106	21	120	240	163	___	___
Ground	118	27	200	560	195	___	___
First Floor	115	51	400	480	293	___	___
Second Floor	190	___	2280	2480	___	___	___
Third Floor	204	___	2640	2840	___	___	___
Fourth floor	282	81	4920	5400	488	400	126
Total	1015	179	10560	12000	1139	400	126

6.6 Calculation the radius of the medical gas pipe

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

a- System pressure: This table shows Nominal pressure which is taken from HTM0201 code

Table(6.8): Nominal pressure needed shown in HTM0201code

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

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 shows the Equivalent length for different type of fittings .

Table (6.9): Equivalent length for different type of fittings

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

b- 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 6.10 : below shows the loss in the Red copper piping systems operating pressure of 400 kpa.

6.6 Mechanical Equipment

6.7.1 Oxygen Cylinder.

The amount of oxygen gas L/h = F×60 min. From Medical Gas. [6-4]
F : The amount of oxygen gas flowing in all hospital L/m. also add to them 8% for futher demand

The amount of oxygen gas L/h=1096×60=65772 L/h.

The amount of oxygen gas L/Day assuming 8 hours of demand 65772 *8=526176L/Day

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

- Capacities of oxygen gas cylinders =6540 Liters.
- Number of cylinder Oxygen gases =526176/6540

≈81 Cylinders.

6.7.2 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=193×60=11599 L/h.

The amount of Nitrous Oxide gas L/Day assuming 8 hours of demand 11599 *8=92793 L/Day

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

- Capacities of Nitrous Oxide gas cylinders =8900 Liters.
- Number of cylinder Nitrous Oxide gases =92793/8900

≈11 Cylinders.

6.7.3 Compressor of Medical Air.

The amount of medical air gas m^3/h = F×60 min/1000 Lit. From Medical Gas.
F : The amount of medical air gas flowing in all hospital L/m.

The amount of Medical Air gas m^3/h =10560×60/1000 = 632.4 m^3/h.

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

6.7.4 Pump Of Medical Vacuum.

The amount of medical vacuum gas m^3/h = F×60 min/1000 Lit. From Medical Gas.
F : The amount of medical vacuum gas flowing in all hospital L/m.

The amount of Medical Vacuum gas m^3/h =12000×60/1000 =720 m^3/h.

-We need four pumps to be able to suction 180 m^3/h (for each) of the gas to the outside air.

6.7.5 Pump (AGSS).

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

The amount of **(AGSS)** gas m^3/h = 1139×60/1000

=68.34 m^3/h.

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

References

Books:

[1] Heating and air conditioning for residential buildings.

[2] Heat Transfer a Practical Approach, 2 edition.

[3]Building Technology Mechanical Electrical Systems .

[4] American Society of Heating, Refrigerating and Air-Conditioning Engineers –ASHRAE Standard (90-2010)

[5] American Society of Heating, Refrigerating and Air-Conditioning Engineers –ASHRAE Hand Book 2012 .

[4] Heating Ventilation and Air Conditioning Analysis and Design, 4 edition .

[5] Health Technical Memorandum (HTM 02-01) Medical Gas Pipeline System –(Department of Health) .

[6] National Fire Protection Association 10 .

[7] National Fire Protection Association 13 .

BILL OF QUANTITIES

Itom NO	DISCRIPTION	Unit	Quality	Price/ Unit
1	**VRF**			
1.1	Indoor Units			
1.1.1	slim 1- way cassette VRF indoor units. Price includes all required electrical and gas connections, and operating perfectly. Price includes hangers, isolating valves, and electrical connection to power source. All connections and installation should be executed according to manufacturer instructions. Selection to be based on medium speed, external air pressure of 0.25 ", indoor temperature of 24 C and outdoor temperature of 31.9 C (summer) 5.7 C (winter)			
1.1.1.1	nominal capacity 2.2	NO.	9	
1.1.2	mini 4-way cassette VRF indoor units. Price includes all required electrical and gas connections, and operating perfectly. Price includes hangers, isolating valves, and electrical connection to power source. All connections and installation should be executed according to manufacturer instructions. Selection to be based on medium speed, external air pressure of 0.25 ", indoor temperature of 24 C and outdoor temperature of 31.9 C (summer) 5.7 C (winter)			
1.1.2.1	nominal capacity 2.8	NO.	8	
1.1.2.2	nominal capacity 3.6	NO.	9	
1.1.2.3	nominal capacity 6	NO.	4	
1.1.3	4- way cassette VRF indoor units. Price includes all required electrical and gas connections, and operating perfectly. Price includes hangers, isolating valves, and electrical connection to power source. All connections and installation should be executed according to manufacturer instructions. Selection to be based on medium speed, external air pressure of 0.25 ", indoor temperature of 24 C and outdoor temperature of 31.9 C (summer) 5.7 C (winter)			
1.1.3.1	nominal capacity 4.5	NO.	91	
1.1.3.2	nominal capacity 7.1	NO.	66	
1.1.3.3	nominal capacity 11.2	NO.	78	
1.1.3.4	nominal capacity 14	NO.	23	
1.1.4	slim DUCT VRF indoor units. Price includes all required electrical and gas connections, and operating perfectly. Price includes hangers, isolating valves, and electrical connection to power source. All connections and installation should be executed according to manufacturer instructions. Selection to be based on medium speed, external air pressure of 0.25 ", indoor temperature of 24 C and outdoor temperature of 31.9 C (summer) 5.7 C (winter)			
1.1.4.1	nominal capacity 2.2	NO.	8	
1.1.4.2	nominal capacity 2.8	NO.	2	

1.1.4.3	nominal capacity 4.5	**NO.**	3	
1.1.4.4	nominal capacity 7.1	**NO.**	4	
1.1.4.5	nominal capacity 12.8	**NO.**	2	
1.1.5	M.S.P Duct VRF indoor units. Price includes all required electrical and gas connections, and operating perfectly. Price includes hangers, isolating valves, and electrical connection to power source. All connections and installation should be executed according to manufacturer instructions. Selection to be based on medium speed, external air pressure of 0.25 ", indoor temperature of 24 C and outdoor temperature of 31.9 C (summer) 5.7 C (winter)			
1.1.5.1	nominal capacity 2.2	**NO.**	44	
1.1.5.2	nominal capacity 2.8	**NO.**	81	
1.1.5.3	nominal capacity 3.6	**NO.**	77	
1.1.6	VIVACE Wall Mounted VRF indoor units. Price includes all required electrical and gas connections, and operating perfectly. Price includes hangers, isolating valves, and electrical connection to power source. All connections and installation should be executed according to manufacturer instructions. Selection to be based on medium speed, external air pressure of 0.25 ", indoor temperature of 24 C and outdoor temperature of 31.9 C (summer) 5.7 C (winter)			
1.1.6.1	nominal capacity 5.6	**NO.**	**56**	
1.1.6.2	nominal capacity 7.1	**NO.**	**43**	
1.1.6.3	nominal capacity 9	**NO.**	**28**	
1.1.6.4	nominal capacity 12.8	**NO.**	**46**	
1.2	Control			
1.2.1	wall mounted thermostat for indoor units including on-off, real time clock, fan control, temperature limit operation, and temperature set and display. Price includes all wiring and connection.		**682**	
1.3	Piping network			
	Supply and install drain and insulated copper pipes for refrigerant 410 between indoor units and outdoor unit with sizes according to manufacturer instructions and calculations. Price includes all required fittings, hanging, insulation and digging.			
1.3.1	1/4"	M.L	814	
1.3.2	3/8"	M.L	1476	
1.3.3	1/2"	M.L	939.5	
1.3.4	5/8"	M.L	1143	
1.3.5	3/4"	M.L	745	
1.3.6	7/8"	M.L	93	
1.3.7	1"	M.L	57	

1.3.8	1 1/8"	M.L	419	
1.3.9	1 1/4"	M.L	89	
1.3.10	1 1/2"	M.L	235	
1.3.11	1 3/4"	M.L	31	
2	**VENTLATION**			
	Centrifugal Exhaust Fans set (one duty and one stand-by), complete as per drawings and specifications.			
2.1	1357 l/s @ 220 Pa	SET	1	
2.2	79 l/s @ 135 Pa	SET	1	
2.3	1512 l/s @ 230 Pa	SET	1	
2.4	260 l/s @ 190 Pa	SET	1	
2.5	102 l/s @ 190 Pa	SET	1	
2.6	137 l/s @ 170 Pa	SET	1	
2.7	90 l/s @ 124 Pa	SET	1	
2.8	295 l/s @ 200 Pa	SET	1	
2.9	142 l/s @ 110 Pa	SET	1	
2.10	57 l/s @ 110 Pa	SET	1	
2.11	60 l/s @ 120 Pa	SET	1	
2.12	127 l/s @ 190 Pa	SET	1	
2.13	563 l/s @ 180 Pa	SET	1	
2.14	695 l/s @ 175 Pa	SET	1	
2.15	1694 l/s @ 240 Pa	SET	1	
2.16	974 l/s @ 180 Pa	SET	1	
2.17	90 l/s @ 90 Pa	SET	1	
2.18	506 l/s @ 185 Pa	SET	1	
2.19	536 l/s @ 185 Pa	SET	1	
2.20	224 l/s @ 90 Pa	SET	1	
2.21	970 l/s @ 185 Pa	SET	1	
2.22	2,400 l/s @ 260 Pa	SET	1	
2.23	1,680 l/s @ 220 Pa	SET	1	
3	**Water System**			
3.1	**Pumps**			
	Supply, install, test & commission water pump set including motor, interconnecting pipe work, complete with all valves, vents, manifolds, gauges, control panel, level switches, pressure vessel & frequency inverter etc., as per specifications and drawings.			
3.1.1	**L.P.** (Lifting pumps set /2 pumps)	SET	1	
3.1.2	**C.W.P.-1** (Set/2 booster pump) with	SET	1	
3.1.3	**C.W.P.-2** (Set/2 pumps feeds floors from roof tanks) with 1000L pressure vessel	SET	1	
3.1.4	**S.C.W.P.-1** (Set/2 pumps directly feeds floors and feeds hot water boiler with softened water) with 1000L pressure vessel	SET	1	
3.1.5	**RA.W.P.** (Set/2 (From rainwater well to sand filter and floors)	SET	1	
3.1.6	**H.W.P** (Set/2 (Directly feeds floors with hot water)	SET	1	
3.2	**Pipes**			
	Galvanized steel pipes to BS1387 of various sizes for domestic cold and hot water above false ceiling, in walls, etc.including fittings, supports, expansion loops, thermal insulation cladding of all external and trenches pipes.			
3.2.1	16 mm dia pipe (1/2")	ML	8,500	
3.2.2	20 mm dia pipe (3/4")	ML	4,480	
3.2.3	25 mm dia pipe (1")	ML	4,000	
3.2.4	32 mm dia pipe (11/4")	ML	3,100	
3.2.5	40 mm dia pipe (11/2")	ML	2,130	

3.2.6	50 mm dia pipe (2")	ML	1,175	
3.2.7	65 mm dia pipe (21/2")	ML	1,500	
3.2.8	80 mm dia pipe (3")	ML	300	
3.2.9	100 mm dia pipe (4")	ML	300	
3.3	**Water Manifolds**			
	Supply, install, test and commission wall hung type steel hot and cold water copper manifolds 16 mm dia outlets. The unit price shall include plug and washer, adaptors with O- rings, brackets, drain cocks, isolating ball valves with T-handle on all outlets, automatic air vent on each manifold, and all accessories and works required to complete the work as shown in the drawings and engineers instructions.			
3.3.1	25 mm dia collector, 5 outlets (average)	No.	464	
4	**Firefighting System**			
4.1	Fire hose reel cabinet (double compartment) including isolating valve with SS304 fully recessed cabinet, 19 mm dia x 30 m rubber hose, ABC 6 kg powder extinguisher and 4.5 kg CO_2 extinguisher.	No.	13	
4.2	Black seamless steel pipe work to ASTM A53 grade (A) schedule (40) including fittings, and supports tobe located in trench with all required protection for underground installation.			
4.2.1	32 mm dia pipe (11/4")	ML	400	
4.2.2	40 mm dia pipe (11/2")	ML	200	
4.2.3	50 mm dia pipe (2")	ML	120	
4.2.4	65 mm dia pipe (21/2")	ML	115	
4.2.5	100 mm dia pipe (4")	ML	70	
4.2.6	150 mm dia pipe (6")	ML	150	
4.2.7	200 mm dia pipe (8")	ML	50	
4.3	**Pumps** Supply, install, test and commission fire pumps set, complete with all components including duty pump, split case (electric driven), emergency pump (diesel), jockey pump, centrifugal (electric driven). Price shall include electric control panels, pressurized tank, cork and foundation bed, controllers, accessories for all pumps including wiring connections, all components, water measuring devices including flow meter and sensor, pressure gauges, relief valves, gate valves, check valves etc., all electrical works needed to complete the work according to engineer's instructions.			
4.3.1	Ref. dwg. #SCH01: **FP-01**	No.	1	
4.3.2	Ref. dwg. #SCH01: **JP-01**	No.	1	
4.4	Supply and install emergency relief vents of 700x250 mm dimension, complete as per detailed specifications and drawings	No.	3	
4.5	Supply and install staircase pressurization fan set (one duty and one stand-by), complete as per detailed specifications and drawings.	Set	3	
4.6	**Fire Extinguisher**			
4.7	K-type dry powder fire extinguishers.	No.	5	
4.8	CO_2 fire extinguishers.	No.	6	
4.9	Self automatic extinguisher ABC 10 Kg .	No.	8	
4.10	Siamese connection assembly complete with non-return valves. Outlet of 100m dia, and inlet of 65mm dia.	No.	2	

4.11	Supply and install landing valve 65 mm dia, complete with fire hose rack.	No.	13	
4.12	Supply and install clean agent system with all accessories such as valves, control, nozzles, etc. All complete as per detailed specifications and drawings.	Set	22	
4.13	Supply and install Fire hydrant, pedestal type and maintain stand spot fitted with 75mm twin faced flanged fire hydrant, complete with isolating valve, an automatic shut-off valve, complete wih all necessary mechanical fittings, and electrical workas as per detailed specifications and drawings	No.	4	
4.14	Supply and install Fire hydrant Cabinet, complete with all needed equipments., complete as per detailed specifications and drawings.	No.	3	
4.15	Supply, lift into position, install, test, set to work, and commission sprinkler head as following and as per drawings Sprinkler head pendent recessed center link type, 680C 15 mm (½ Inch) diameter - ORIFICE 15 mm (½ Inch) NPT male connection bronze finish UL/FM approved.	No.	280	
4.16	Supply and install fire system for kitchen consists of 6 nozels, heat detector sense fire and activate the wet chemical cylinder and wet chemical cylinders all according to drawings and specifications.	Set	1	
5	**Drainage System**			
5.1	**Counter Recessed Wash Basin**	No.	35	
5.2	**Wall-Hung, Half Pedestal Wash Basin**	No.	87	
5.3	**Water Closets**			
5.3.1	Supply, install and test European water closet , heavy duty seat and cover, connection to treated cold water supply and drainage network and all fittings and works required to complete the work as per drawings and as per engineer's instructions. Price shall include hand spray hose (connected to domestic cold water), holding paper, and paper basket.	No.	111	
5.4	**Shower Tray**			
5.4.1	Supply, install and test shower tray (80cmx80cm) White Vitreous China connected to domestic cold and hot water supply and drainage network and all fittings and works required to complete the work as per drawings and as per engineer's instructions. Price shall include chrome plated shower mixer, chrome plated hand shower complete with flexible hose 150 cm long and chrome plated shower hanger, Pex pipes, 2" and 4" UPVC pipes needed to connect the tray to the nearest main drainage and supply it with water, Single robe/clothes hook with concealed mounting type	No.	52	
5.5	**Kitchenette Sinks**			
5.5.1	Supply and install stainless steel single bowl kitchenette sink 60x50 cm, complete with faucet with mixer connection to domestic cold and hot water supply and drainage network and all fittings and works required to complete the work as per drawings, specifications and as per engineer's instructions.	No.	82	
5.6	**Laboratory Sinks**			
5.6.1	Supply and install laboratory molded sink 46x46 cm made of anti-corrosion polypropylene with high resistance to acids, alkalines and base chemicals. Price shall include incorporated overflow, complete with threaded drainpipe, made as a single piece without joints. All according to drawings and specifications and as per engineer's instructions	No.	14	
5.7	**UPVC Pipes**			

	Supply, install, and test UPVC pipes and fittings for waste, soil, and rain water drainage services . Price includes all kinds of digging in concrete slabs and walls, supports, hangers and all rubber joints and sealants, syphone and connection to floor drain and flexible connections and all types of fittings. All done according to drawings, specifications and engineer's instructions.			
5.7.1	110 mm dia. (4")	ML	90	
5.7.2	150 mm dia. (6")	ML	255	
5.7.3	200 mm dia (8")	ML	195	
5.8	**HDPE Pipes**			
	Supply, install, and test HDPE pipes and fittings. , for waste, soil, and rain water. Price include all type of fittings, supports, hooks, stainless steel fasteners and all excavation and quarrying, HDPE connections to be done according to specifications, all done according to drawings, specifications and the approval of the Engineer.			
5.8.1	50 mm dia. (2")	ML	716	
5.8.2	110 mm dia. (4")	ML	2,880	
5.8.3	150 mm dia (6")	ML	160	
5.9	**Floor Drains**			
	Supply, install, and test Floor drain 4" threaded 15x15cm chrome plated cover multi inlet adjustable with trap. All complete with floor clean out plug, HDPE syphone and all types of fittings. The rate shall include excavation and backfilling for all connections with drain pipes and fixtures. All done according to drawings, specifications . Floor Drain, Floor Trap & Floor Gully			
5.9.1	***FT-HDPE*** and with chromium plated cover, mesh and all accessories needed	No.	172	
5.9.2	***FD-HDPE*** and with chromium plated cover, mesh and all accessories needed	No.	90	
5.9.3	***FG-HDPE***	No.	13	
5.10	**Floor Cleanouts**			
	Supply, install, and test heavy duty non adjustable 11x11 cm floor clean out with HDPE body, with gas and water tight ABS plug and frame, complete with all needed elbow and all types of fittings, all done according to drawings, specifications and the approval of the engineer.			
5.10.1	***FLOOR C.O HDPE*** with chromium plated cover, mesh and all accessories needed.		70	
5.10.2	***WALL C.O HDPE*** with chromium plated cover, mesh and all accessories needed.		110	
5.11	**Roof Drains**			
	Supply install and test (HDPE) Roof rain water drain size 4" with cover of 20x20 plastic mesh to be connected to rain water vertical pipes with all required fittings, price shall include the piping works until the connection to the vertical rain pipe, all done according to drawings, specifications and the approval of the Engineer. Roof drain HDPE with cover (RD)			
5.11.1	50 mm dia. (2")	No.	13	
5.11.2	100 mm dia. (4")	No.	20	
5.12	**Roof Vent**			
	Supply and istall (HDPE) Roof vent with screened cap for vent stacks including connection to the vent pipe by solvent welding. The rate include all needed connection accessories, all done			

	according to drawings, specifications and the approval of the Engineer. Roof vent cap HDPE			
5.12.1	100 mm dia. (4")	No.	50	
5.13	**Grease Intercepter**			
	Supply, install and test acid resistant coated interior and exterior fabricated steel grease interceptor,with internal air relief by-pass, bronze cleanout plug, removable pressure equalizing/flow diffusing inlet baffle, fixed bottom outlet buffle, and visible double wall trap seal, gasketed non-skid secured cover complete with center tie down assembly, with flow control fitting. Regularly furnished with ahigh inlet and outlet connection.			
5.13.1	50 GPM capacity for kitchen	No.	1	
5.13.2	7 GPM capacity for cafeteria	No.	1	
5.14	**Manholes**			
	Supply, install and test precast concrete manholes of 15 cm thickness for walls and bottom slab with C.I. cover(medium cover) and frameall necessary excavation, blinding of 15cm thickness, back filling as specified to the required depth complete with iron steps, benching and plastering as shown in drawing and in accordance to specification, drawings, and approval of supervisor engineer. with C.I. cover(medium cover) and frame, iron steps as detailed on the drawings.			
5.14.1	Depth 60 cm - 100 cm Dia 60 cm	No.	10	
5.14.2	Depth 100 cm - 150cm. Dia 80 cm	No.	15	
5.14.3	Depth 150 cm - 250 cm. Dia 100 cm	No.	10	
6	**Medical Gases System**			
	This section shall be read in conjunction with HTM 2022, Engineering specification , Technical Specifications, and Mechanical Drawings.			
	`Fully Automatic Changeover Manifold and Emergency Standby Manifold			
6.1	**Oxygen**			
6.1.1	Supply, install, test and commission two racks (one duty and one Standby) . Each of the two racks shall contain six (6) oxygen cylinders of capacity of 6800 liters each, with a control panel, manifold headers and cylinder racks, tailpipes, an isolation valve and a pressure relief valve.and accessories. Price shall include all above and automatic change-over assembly, control panel, alarm panel and all electrical works.Automatic control panels comprise of regulators, changeover solenoid valves, pressure transducers, digital LED pressure indicators, gauges and integral monitoring and status panel, all housed in a molded enclosure with a transparent cover. Designed to meet the requirements of: HTM 2022 Medical Gas Pipeline Systems, and C11 NHS Model Engineering Specifications- Medical gases.	Set	1	
6.1.2	Supply, install, test and commission two racks . Each of the two racks shall contain three (3) oxygen cylinders of capacity of 6800 liters each for emergency use, with Pressure regulator, Manifold header and rack, Tailpipes, Pressure switch, Isolation valve and pressure relief valve, Non-return valves and Automatic manifold assembly and all necessary equipment fittings controls, and accessories.Price shall include all above and automatic change-over assembly, control panel, alarm panel and all electrical works. Designed to meet the requirements of: HTM 2022 Medical Gas	Set	1	

	Pipeline Systems, and C11 NHS Model Engineering Specifications-Medical gases.			
6.2	**Nitrous Oxide**			
6.2.1	Same as for oxygen but two racks, rack shall contain three (3) nitrous oxide cylinders of capacity of 9000 liters each.	Set	1	
6.2.2	Same as for oxygen but two racks, rack shall contain two (2) nitrous oxide cylinders for emergency use of capacity of 9000 liters each.	Set	1	
6.3	**Carbon dioxide**			
6.3.1	Same as for oxygen but two racks, each rack shall contain three (3) carbon dioxidr cylinders of capacity of 9000 liters each.	Set	1	
6.3.2	Same as for oxygen but two racks, rack shall contain two (2) carbon dioxide cylinders for emergency use of capacity of 9000 liters each.	Set	1	
6.4	**Nitrous Oxide/Oxygen**			
	Same as for oxygen but two racks, each rack shall contain three (3) nitrous oxid/oxygen cylinders of capacity of 9000 liters each. Same as for oxygen but two racks, rack shall contain two (2) nitrous oxide/oxygen cylinders cylinders for emergency use of capacity of 9000 liters each. Supply, install, test and commission only racks for empty cylinders with all necessary fittings and accessories.Supply, install, test and commission all required for the medical gas system safety relief valves as specified in HTM 2022, C-11 and Specifications. Price also include Supply, install, test and commission electrical installation work as specified in the Specifications.			
6.4.1	Two racks for three cylinders	Set	1	
6.4.2	Two racks for two cylinders	Set	1	
6.5	**Medical Air Plant.**			
6.5.1	Supply, install, test and commission at the position shown on the drawings a complete and full operational of medium pressure compressed air packaged plant having, such as, but not limited to: 1500 l/min, 380-450 V, 50Hz, 3-phase. Triplex factory tested package Triplex factory tested package Duplex desiccant dryers. Control panel comply HTM 2022. Anti-vibration mountings. Duplex Filters set. One Air receiver Tank. Pressure = 11 bars min. Complete with all necessary automatic. Controls, alarm panel, wiring cables, switches and starter etc. drainage traps and bacterial filters, silencers, valves, check valves Designed to meet the requirements of: HTM 2022 Medical gas pipe line system. C11 NHS Engineering specification –Medical gases. BS EN 737.	Set	1	
6.5.2	Duplex Pressure Reducing Sets for 4 bar and 7 bar Medical Air	Set	2	
6.6	**Medical Vacuum Plant.**			
6.6.1	Supply, install, test and commission at the position shown on the drawings a complete and full operational medical vacuum plant having such as, but not limited to 800 l/min at 450mm Hg free air, 380-450 V, 50 Hz, 3-phas. Triplex factory tested package. Triplex vacuum pump. Triplex bacterial filters. Control panel comply HTM 2022. Anti-vibration mountings. Multipurpose test point fitted to plant distribution pipeline. One vacuum receiver tank. Complete with all necessary automatic. Controls, alarm panel, wiring cables, switches and starter etc. drainage traps and bacterial filters, silencers, valves, check valves Designed to meet the requirements	Set	1	

	of: HTM 2022 Medical gas pipe line system. C11 NHS Engineering specification –Medical gases			
6.7	**De greased Copper pipes & Fittings:**			
	Medical quality copper tube cleaned, degreased, capped and bagged and complete with fittings, pipe clamps, solder and ID tape.Inside DIAMETERS OF PIPES All pipes and fittings will be delivered with a certificate of compliance and cleanliness. The certificate will state that the pipe is suitable for use in Medical Gas Systems All fittings are supplied in individually sealed protective polythene bags and are specifically designed for copper medical gas and vacuum systems Each fitting are engraved with unique branding together with the EN spec and fitting size where space permits. Fittings are supplied in re-enforced cardboard boxes, labeled with product information and outline drawing of fitting. All copper pipes stamp and label name of manufacturer and kite mark. Price shall include all labeling, accessories for the completion of the works			
6.7.1	Diam: 12 mm		500	
6.7.2	Diam: 15 mm		400	
6.7.3	Diam: 22 mm		400	
6.7.4	Diam: 28 mm		250	
6.7.5	Diam: 35 mm		250	
6.7.6	Diam: 42 mm		120	
6.7.7	Diam: 54 mm		40	
6.7.8	Diam: 76 mm		40	
6.8	**Area Valve & Service Units (AVSU)**			
	Supply, install, test and commission all areas, valve and service units (AVSU) in the hospital where shown on the drawings and as specified in HTM 2022, C11 NHS Engineering specification –Medical gases, BS EN 737-3 Pipeline for compressed medical gases and vacuum, BS EN 73 Low pressure hose assemblies for use with medical gasesand technical specifications with all necessary equipment, pipework, fittings, boxes, accessories, connectors pressure gauges, switches including the zone pressure alarm panel and all related electrical works. Price should also include Comprises an Ø22mm or Ø28mm ball valve with copper stub pipes for brazing to the fixed pipeline system. Access to the valve using the key or the emergency release lever with no risk of injury. NIST connectors either side of the valve to have complete and full operational AVSU units.			
6.8.1	AVSU for Oxygen	No.	22	
6.8.2	AVSU for Vacuum	No.	22	
6.8.3	AVSU for Air4	No.	21	
6.8.4	AVSU for Air7	No.	7	
6.8.5	AVSU for Air N2O	No.	12	
6.8.6	AVSU for Air N2O/O2	No.	1	
6.8.7	AVSU for CO2	No.	2	

Appendix - A

A-1: Description of wall construction groups

TABLE 9-5 Description of wall construction groups.

Group No.	Description Of Construction	$U_{ov.}$ W/m²·°C
	101.6 mm Face Brick + (Brick)	
C	Air space + 101.6 mm face brick	2.033
D	101.6 mm common brick	2.356
C	25.4 mm insulation or air space + 101.6 mm common brick	0.987-1.709
B	50.6 mm insulation + 101.6 mm common brick	0.630
B	203.2 mm common brick	1.714
A	Insulation or air space + 203.2 mm common brick	0.874-1.379
	101.6 mm Face Brick + (H.W. Concrete)	
C	Air space + 50.8 mm concrete	1.987
B	50.8 mm insulation + 101.6 mm concrete	0.658
A	Air space or insulation + 203.2 mm or more concrete	0.625-0.636
	101.6 mm Face Brick + (L.W. or H.W Concrete Block)	
E	101.6 mm block	1.811
D	Air space or insulation + 101.60 mm block	0.868-1.397
D	203.2 mm block	1.555
C	Air space or 25.4 mm insulation + 152.4 mm or 203.2 mm block	1.255-1.561
B	50.8 insulation + 203.2 mm block	0.545-0.607
	101.6 mm Face Brick + (Clay Tile)	
D	101.6 mm tile	2.163
D	Air space + 101.6 mm tile	1.595
C	Insulation + 101.6 mm tile	0.959
C	203.2 mm tile	1.561
B	Air space or 25.4 mm insulation + 203.2 mm tile	0.806-1.255
A	50.8 mm insulation + 203.2 mm tile	0.551
	L.W. Concrete Wall + (Finish)	
E	101.5 mm concrete	3.321
D	101.6 mm concrete + 25.4 mm or 50.8 mm insulation	1.136 - 0.675
C	50.8 mm insulation+101.6 mm concrete	0.675
C	203.2 mm concrete	2.782
B	203.2 mm concrete + 25.4 mm or 50.8 mm insulation	1.061 - 0.653
A	203.2 mm concrete + 50.8 mm insulation	0.653
B	304.8 mm concrete	2.390
A	304.8 mm concrete + insulation	0.642
	L.W. and H.W. Concrete Block + (Finish)	
F	101.6 mm block + air space/insulation	0.914-1.493
E	50.8 mm insulation + 101.6 mm block	0.596-0.647
E	203.2 mm block	1.669-2.282
D	203.2 mm block + air space/insulation	0.846-0.982
	Clay Tile + (Finish)	
F	101.6 mm tile	2.379
F	101.6 mm tile +air space	1.720
F	101.6 mm tile + 25.4 mm insulation	0.993
D	80.8 mm insulation + 10.4 mm tile	0.825
C	203.3 mm tile + air space/25.4 mm insulation	0.857-1.312
B	50.8 mm insulation + 203.2 mm tile	0.562
	Metal Curtain Wall	
G	With/without air space + 25.4 mm/58 to 76.2 mm insulation	0.516-1.306
	Frame Wall	
G	24.4 mm to 76.2 mm insulation	1.010 - 0.459

A-2: Approximate CLTD values for light, medium, and heavy weight construction walls

TABLE 9-6 Approximate CLTD values for light, medium, and heavy weight construction walls, °C.

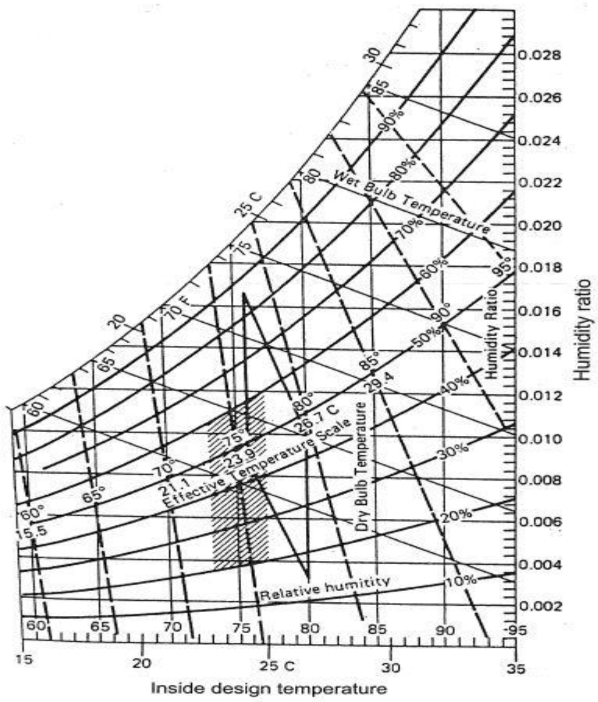
Solar Time	Wall construction											
	Light				Medium				Heavy			
	N	E	S	W	N	E	S	W	N	E	S	W
8:00	—	16	—	—	—	—	—	—	—	—	—	—
9:00	—	20	—	—	—	6	—	—	—	—	—	—
10:00	—	21	2	—	—	11	—	—	—	—	—	—
11:00	—	18	7	—	—	14	—	—	—	3	—	—
12:00	—	12	12	—	—	15	—	—	—	5	—	—
13:00	2	9	15	5	—	14	5	—	—	7	—	—
14:00	3	7	16	13	—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

A-3: Approximate CLTD values for sunlit roofs

TABLE 9-3 Approximate CLTD values for sunlit roofs, °C.

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

A-4: Inside design temperature



A-5: cooling load factor (CLF), for lights

Table (A-8) Cooling load factor $(CLF)_{Lt}$, for lights. [3]

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

[3] Adapted from Stoecker and Jones, 1982, "*Refrigeration and Air Conditioning*", 2nd ed., MacGraw Hill. (Fixture X = not vented recessed lights and Fixture Y = vented or free-hanging light.)

[4] Adapted from Jones, 1979 "*Air Conditioning applications and Design*", Edward Arnold.

A-6: Cooling load factor due to occupants (CLF), for sensible gain

Table (A-6-2) Cooling load factor due to occupants (CLF)occ. , for sensible heat gain.[5]

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

A-7: Cooling load temperature differences (CLTD) for convection heat gain for glass windows

Table (A-7) Cooling load temperature differences (CLTD) for convection heat gain for glass windows.

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

A-8: Cooling load factor (CLF) for glass windows without interior shading

Table (A-5-1) Cooling load factors (CLF) for glass windows without interior shading, north latitudes.

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

A-9: cooling load factors for glass windows with interior shading

Table (A-5-2) Cooling Load factors (CLF) for glass windows with interior shading, North latitude.

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

A-10: Shading coefficient for glass with interior shading

Table (A-4-2) Shading coefficient (SC) for glass windows with interior shading.

Type of Glass	Nominal Thickness, mm	Type of Interior Shading				
		Venetian Blinds		Roller Shade		
				Opaque		Translucent
		Medium	Light	Dark	White	Light
Single Glass						
Clear, regular	2.5-6.0	—	—	—	—	—
Clear, plate	6.0-12.0	—	—	—	—	—
Clear Pattern	3.0-12.0	0.64	0.55	0.59	0.25	0.39
Heat Absorbing	3	—	—	—	—	—
Pattern or Tinted(gray sheet)	5.0-5.5	—	—	—	—	—
Heat Absorbing, plate	5.0-6.0	0.57	0.53	0.45	0.30	0.36
Pattern or Tinted, gray sheet	3.0-5.5	—	—	—	—	—
Heat Absorbing Plate or Pattern Heat Absorbing	10	0.54	0.52	0.40	0.82	0.32
Heat Absorbing or Pattern	—	0.42	0.40	0.36	0.28	0.31
Reflective Coated Glass	—	0.30	0.25	0.23	—	—
	—	0.40	0.33	0.29	—	—
	—	0.50	0.42	0.38	—	—
	—	0.60	0.50	0.44	—	—
Double Glass						
Regular	3	0.57	0.51	0.60	0.25	—
Plate	6	0.57	0.51	0.60	0.25	—
Reflective	6	0.20-0.40	—	—	—	—
Insulating Glass						
Clear	2.5-6.0	0.57	0.51	0.60	0.25	0.37
Heat Absorbing	5.0-6.0	0.39	0.36	0.40	0.22	0.30
Reflective Coated	—	0.20	0.19	0.18	—	—
	—	0.30	0.27	0.26	—	—
	—	0.40	0.34	0.33	—	—

A-11: Shading coefficient for glass windows without interior shading

Table (A-4-1) Shading coefficient (SC) for glass windows without interior shading.[1]

Type of Glass	Nominal Thickness, mm	Solar Trans.	Shading Coefficient, $W/m^2 \cdot K$	
			$h_o = 22.7$	$h_o = 17.0$
Single Glass				
Clear	3	0.84	1.00	1.00
	6	0.78	0.94	0.95
	10	0.72	0.90	0.92
	12	0.67	0.87	0.88
Heat absorbing	3	0.64	0.83	0.85
	6	0.46	0.69	0.73
	10	0.33	0.60	0.64
	12	0.42	0.53	0.58
Double Glass				
Regular	3	—	0.90	—
Plate	6	—	0.83	—
Reflective	6	—	0.20-0.40	—
Insulating Glass				
Clear	3	0.71	0.88	0.88
	6	0.61	0.81	0.82
Heat absorbing*	6	0.36	0.55	0.58

A-12: Solar heat gain factor for sunlit glass

Table (A-3) Solar heat gain factor (SHG) for sunlit glass, W/m^2, for a latitude angle of 32 °N.

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

A-13: Values of infiltration air coefficient for windows

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

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

A-14: Infiltration rates due to door opening

TABLE 6–5 Infiltration rates due to door opening, m³ per passage.[4]

№ of Passage per Hour	Doors in One Wall Only			Doors in more than One Wall		
	Single Swing	Vestibule Swinging Doors	Revolving Doors	Single Swing	Vestibule Swinging Doors	Revolving Doors
300	4.757	3.540	1.359	3.115	2.350	0.850
500	4.757	3.540	1.303	3.115	2.350	0.821
700	4.757	3.540	1.218	3.115	2.322	0.765
900	4.757	3.540	1.104	3.087	2.322	0.708
1,100	4.757	3.540	0.935	3.087	2.322	0.651
1,200	4.757	3.540	0.850	3.058	2.322	0.595
1,300	4.757	3.540	0.793	3.058	2.322	0.538
1,400	4.757	3.540	0.708	3.058	2.294	0.510
1,500	4.757	3.540	0.651	3.058	2.294	0.481
1,600	4.729	3.540	0.595	3.058	2.294	0.453
1,700	4.616	3.511	0.538	3.030	2.294	0.425
1,800	4.502	3.455	0.510	2.973	2.265	0.396
1,900	4.418	3.398	0.481	2.945	2.265	0.368
2,000	4.304	3.341	0.453	3.832	2.237	0.340

A-15: Table for estimating demand

Table (P-1): Table for Estimating Demand

Supply Systems Predominantly for Flush Tanks		*Supply Systems Predominantly for Flushometers*	
Load, WSFU[a]	*Demand, gpm*	*Load, WSFU*[a]	*Demand, gpm*
6	5	—	—
10	8	10	27
15	11	15	31
20	14	20	35
25	17	25	38
30	20	30	41
40	25	40	47
50	29	50	51
60	33	60	55
80	39	80	62
100	44	100	68
120	49	120	74
140	53	140	78
160	57	160	83
180	61	180	87
200	65	200	91
225	70	225	95
250	75	250	100
300	85	300	110
400	105	400	125
500	125	500	140
750	170	750	175
1000	210	1000	218
1250	240	1250	240
1500	270	1500	270
1750	300	1750	300
2000	325	2000	325
2500	380	2500	380
3000	435	3000	435
4000	525	4000	525
5000	600	5000	600
6000	650	6000	650
7000	700	7000	700
8000	730	8000	730
9000	760	9000	760
10000	790	10000	790

A-16: fixture units

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

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

A-17: Approximate discharge rates and velocities in sloping drains flowing half full

Table (P-3) Approximate Discharge Rates and Velocities[a] in Sloping Drains Flowing Half Full[b]

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

[a] Computed from the Manning Formula for 1/2-full pipe, $n = 0.015$.
[b] Half full means filled to a depth equal to one-half the inside diameter.

Note: For 1/4 full, multiply discharge by 0.274 and multiply velocity by 0.701. For 1/3 full, multiply discharge by 0.44 and multiply velocity by 0.80. For 3/4 full, multiply discharge by 1.82 and multiply velocity by 1.13. For full, multiply discharge by 2.00 and multiply velocity by 1.00. For smoother pipe, multiply discharge and velocity by 0.015 and divide by n value of smoother pipe.

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A-18: Horizontal fixture branches and stacks

Table (P-3) Horizontal Fixture Branches and Stacks

Diameter of Pipe, in.	Maximum Number of Fixture Units That May Be Connected to			
	Any Horizontal Fixture Branch,[a] dfu	One Stack of Three Branch Intervals or Less, dfu	Stacks with More Than Three Branch Intervals: Total for Stack, dfu	Stacks with More Than Three Branch Intervals: Total at One Branch Interval, dfu
1 1/2	3	4	8	2
2	6	10	24	6
2 1/2	12	20	42	9
3	20[b]	48[b]	72[b]	20[b]
4	160	240	500	90
5	360	540	1100	200
6	620	960	1900	350
8	1400	2200	3600	600
10	2500	3800	5600	1000
12	3900	6000	8400	1500
15	7000			

[a] Does not include branches of the building drain.
[b] Not more than two water closets or bathroom groups within each branch interval nor more than six water closets or bathroom groups on the stack.

Note: Stacks shall be sized according to the total accumulated connected load at each story or branch interval and may be reduced in size as this load decreases to a minimum diameter of half of the largest size required.

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A-19: Values of the factor S1

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

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

A-20: Values of the factor S2

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

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

A-21: Instantaneous heat gain from occupants

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

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

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

A-22: Minimum pressure required by typical plumbing fixtures

Table 9.1 Minimum Pressure Required by Typical Plumbing Fixtures

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

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

Table 9.2 Recommended Flow Rates for Typical Plumbing Fixtures

Fixture Type	*Flow, gpm*
Lavatory	3
Sink	4.5
Bathtub	6
Laundry tray	5
Shower	3–10
Water closets	
tank type	3
flush valve*	15–40
Urinal flush valve	15
Garden hose	
½-in. sill cock	3⅓
¾-in. sill cock	5
Drinking fountain	¾

Source. Data extracted from various sources.

*Wide range of flows; depends on flow pressure.

Table 9.5 Demand at Individual Water Outlets

Type of Outlet	*Demand, gpm*
Ordinary lavatory faucet	2.0
Self-closing lavatory faucet	2.5
Sink faucet, ⅜ or ½ in.	4.5
Sink faucet, ¾ in.	6.0
Bath faucet, ½ in.	5.0
Shower head, ½ in.	5.0
Laundry faucet, ½ in.	5.0
Ballcock in water closet flush tank	3.0
1-in. flush valve (25-psi flow pressure)	35.0
1-in. flush valve (15-psi flow pressure)	27.0
¾-in. flush valve (15-psi flow pressure)	15.0
Drinking fountain jet	0.75
Dishwashing machine (domestic)	4.0
Laundry machine (8 or 16 lb)	4.0
Aspirator (operating room or laboratory)	2.5
Hose bibb or sill cock (½ in.)	5.0

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Table 9.4 Table for Estimating Demand

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

*Water Supply Fixture Units

Source. Reproduced with permission from The National Standard Plumbing Code, published by The Na-

A-23: Drainage fixture unit values for various plumping fixtures

Table 10.2 Drainage Fixture Unit Values for Various Plumbing Fixtures

Type of Fixture or Group of Fixtures	*Drainage Fixture Unit Value, dfu*
Automatic clothes washer (2-in. standpipe and trap required, direct connection)	3
Bathtub group consisting of a water closet; lavatory and bathtub or shower stall:	6
Bathtub (with or without overhead shower)[a]	2
Bidet	1
Clinic sink	6
Clothes washer	2
Combination sink-and-tray with food waste grinder	4
Combination sink-and-tray with one 1-in. trap	2
Combination sink-and-tray with separate 1-in. trap	3
Dental unit of cuspidor	1
Dental lavatory	1
Drinking fountain	½
Dishwasher, domestic	2
Floor drains with 2-in. waste	3
Kitchen sink, domestic, with one 1-in. trap	2
Kitchen sink, domestic, with food waste grinder	2
Kitchen sink, domestic, with food waste grinder and dishwasher 1-in. trap	3
Kitchen sink, domestic, with dishwasher 1-in trap	3
Lavatory with 1-in. waste	1
Laundry tray (1 or 2 compartments)	2
Shower stall, domestic	2
Showers (group) per head	2
Sinks	
surgeon's	3
flushing rim (with valve)	6
service (trap standard)	3
service (P trap)	2
pot, scullery, etc.	4
Urinal, syphon jet blowout	6
Urinal, wall lip	4
Wash sink (circular or multiple) each set of faucets	2
Water closet, private	4
Water closet, general use	6
Fixtures not already listed	
trap size 1¼ in. or less	1
trap size 1½ in.	2
trap size 2 in.	3
trap size 2½ in.	4
trap size 3 in.	5
trap size 4 in.	6

[a]A shower head over a bathtub does not increase the fixture unit value.

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Table 10.3 Minimum Size of Nonintegral Traps

Plumbing Fixture	*Trap Size, in.*
Bathtub (with or without overhead shower)	1½
Bidet	1¼
Clothes washing machine standpipe	2
Combination sink and wash (laundry) tray	1½
Combination sink and wash (laundry) tray with food waste grinder unit[a]	1½
Combination kitchen sink, domestic, dishwasher, and food waste grinder	1½
Dental unit or cuspidor	1¼
Dental lavatory	1¼
Drinking fountain	1¼
Dishwasher, commercial	2
Dishwasher, domestic (nonintegral trap)	1½
Floor drain	2
Food waste grinder, commercial	2
Food waster grinder, domestic	1½
Kitchen sink, domestic, with food waste grinder unit	1½
Kitchen sink, domestic	1½
Kitchen sink, domestic, with dishwasher	1½
Lavatory, common	1¼
Lavatory (barber shop, beauty parlor or surgeon's)	1½
Lavatory, multiple type (wash fountain or wash sink)	1½
Laundry tray (1 or 2 compartments)	1½
Shower stall or drain	2
Sink (surgeon's)	1½
Sink flushing rim type (flush valve supplied)	3
Sink (service type with floor outlet trap standard)	3
Sink (service trap with P trap)	2
Sink, commercial (pot, scullery, or similar type)	2
Sink, commercial (with food grinder unit)	2

[a]Separate trap required for wash tray and separate trap required for sink compartment with food waste grinder unit.

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A-24: Horizontal fixture branches and stacks, building drains and sewers

Table 10.4 Horizontal Fixture Branches and Stacks

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

[a]Does not include branches of the building drain.

[b]Not more than two water closets or bathroom groups within each branch interval nor more than six water closets or bathroom groups on the stack.

Note: Stacks shall be sized according to the total accumulated connected load at each story or branch interval and may be reduced in size as this load decreases to a minimum diameter of half of the largest size required.

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Table 10.5 Building Drains and Sewers[a]

Diameter of Pipe, in.	*Maximum Number of Fixture Units That May Be Connected to Any Portion of the Building Drain or the Building Sewer* — *Slope per Foot* — 1/16 in.	1/8 in.	1/4 in.	1/2 in.
2			21	26
2½			24	31
3			42[b]	50[b]
4		180	216	250
5		390	480	575
6		700	840	1000
8	1400	1600	1920	2300
10	2500	2900	3500	4200
12	2900	4600	5600	6700
15	7000	8300	10,000	12,000

[a]On site sewers that serve more than one building may be sized according to the current standards and specifications of the Administrative Authority for public sewers.

[b]Not over two water closets or two bathroom groups, except that in single family dwellings, not over three water closets or three bathroom groups may be installed.

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A-25: Latitude- month correction factor LM

Table (A-2) Latitude-Month correction factor LM, as applied to walls and horizontal roofs, north latitudes.

Lat.	Month	N	NNE NNW	NE NW	ENE WNW	E W	ESE WSW	SE SW	SSE SSW	S	Horizontal Roofs
16	December	−2.2	−3.3	−4.4	−4.4	−2.2	−0.5	2.2	5.0	7.2	−5.0
	Jan./Nov.	−2.2	−3.3	−3.8	−3.8	−2.2	−0.5	2.2	4.4	6.6	−3.8
	Feb./Oct.	−1.6	−2.7	−2.7	−2.2	−1.1	0.0	1.1	2.7	3.8	−2.2
	Mar/Sept.	−1.6	−1.6	−1.1	−1.1	−0.5	−0.5	0.0	0.0	0.0	−0.5
	Apr./Aug.	−0.5	0.0	−0.5	−0.5	−0.5	−1.6	−1.6	−2.7	−3.3	0.0
	May/July	2.2	1.6	1.6	0.0	−0.5	−2.2	−2.7	−3.8	−3.8	0.0
	June	3.3	2.2	2.2	0.5	−0.5	−2.2	−3.3	−4.4	−3.8	0.0
24	December	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	1.1	5.0	6.6	−9.4
	Jan./Nov.	−2.2	−3.3	−4.4	−5.0	−3.3	−1.6	−1.6	5.0	7.2	−6.1
	Feb./Oct.	−2.2	−2.7	−3.3	−3.3	−1.6	−0.5	1.6	3.8	5.5	−3.8
	Mar/Sept.	−1.6	−2.2	−1.6	−1.6	−0.5	−0.5	0.5	1.1	2.2	−1.6
	Apr./Aug.	−1.1	−0.5	0.0	−0.5	−0.5	−1.1	−0.5	−1.1	−1.6	0.0
	May/July	0.5	1.1	1.1	0.0	0.0	−1.6	−1.6	−2.7	−3.3	0.5
	June.	1.6	1.6	1.6	0.5	0.0	−1.6	−2.2	−3.3	−3.3	0.5
32	December	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	1.1	5.0	6.6	−9.4
	Jan./Nov.	−2.7	−3.8	−5.0	−6.1	−4.4	−2.2	1.1	5.0	6.6	−8.3
	Feb./Oct.	−2.2	−3.3	−3.8	−4.4	−2.2	−1.1	2.2	4.4	6.1	−5.5
	Mar/Sept.	−1.6	−2.2	−2.2	−2.2	−1.1	−0.5	1.6	2.7	3.8	−2.7
	Apr./Aug.	−1.1	−1.1	−0.5	−1.1	0.0	−0.5	0.0	5.0	0.5	−0.5
	May/July	0.5	0.5	0.5	0.0	0.0	−0.5	−0.5	−1.6	−1.6	0.5
	June	0.5	1.1	1.1	0.5	0.0	−1.1	−1.1	−2.2	−2.2	1.1
40	December	−3.3	−4.4	−5.5	−7.2	−5.5	−3.8	0.0	3.8	5.5	−11.6
	Jan./Nov.	−2.7	−3.8	−5.5	−6.6	−5.0	−3.3	0.5	4.4	6.1	−10.5
	Feb./Oct.	−2.7	−3.8	−4.4	−5.0	−3.3	−1.6	1.6	4.4	6.6	−7.7
	Mar/Sept.	−2.2	−2.7	−2.7	−3.3	−1.6	0.5	2.2	3.8	5.5	−4.4
	Apr./Aug.	−1.1	−1.6	−1.6	−1.1	0.0	0.0	1.1	1.6	2.2	1.6
	May/July	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5
	June	0.5	0.5	0.5	0.5	0.0	0.5	0.0	0.0	−0.5	1.1
48	December	−3.3	−4.4	−6.1	−7.7	−7.2	−5.5	−1.6	1.1	3.3	−13.8
	Jan./Nov.	−3.3	−4.4	−6.1	−7.2	−6.1	−4.4	−0.5	2.7	4.4	−13.3
	Feb./Oct.	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	0.5	4.4	6.1	−10.0
	Mar/Sept.	−2.2	−3.3	−3.3	−3.8	−2.2	−0.5	2.2	4.4	6.1	−6.1
	Apr./Aug.	−1.6	−1.6	−1.6	−1.6	−0.5	0.0	2.2	3.3	3.8	−2.7
	May/July	0.0	−0.5	0.0	0.0	0.5	0.5	1.6	1.6	2.2	0.0
	June	0.5	0.5	1.1	0.5	1.1	0.5	1.1	1.1	1.6	1.1

A-26: mechanical ventilation

TABLE A(2.20) Minimum outside air requirements for mechanical ventilation

Application	Maximum Occupancy Per 100 m²	Ventilation Air Requirements	
		L/s/Person	L/s/m²
Bath, toilets[3]	—	10.0	—
Hotels and motels:			
Bedrooms	—	—	7.5-15 L/s/room
Living rooms	—	—	5-10 L/s/room
Bathes	—	—	15-25 L/s/room
Lobbies	30	2.5-7.5	—
Conference rooms	50	3.5-17.5	—
Assembly rooms	120	3.5-17.5	—
Dormitory sleeping areas	20	8.0	—
Gambling casinos	120	15.0	—

A-27: inside & outside film resistance

Table A(2.2) Inside film resistance, R_i.

Element	Heat Direction	Material Type	R_i m²·°C/W
Walls	Horizontal	Construction materials	0.12
		Metals	0.31
Ceilings and floors	Upward	Construction materials	0.10
		Metals	0.21
	Downward	Construction materials	0.15

Table A(2.3) Outside film resistance, R_o.

Element	Wind Speed / Material Type	Less than 0.5 m/s	0.5 - 5.0 m/s	More than 5.0 m/s
		Outside Resistance R_o, m²·°C/W		
Walls	Construction materials	0.08	0.06	0.03
	Metals	0.10	0.07	0.03
Ceilings	Construction materials	0.07	0.04	0.02
	Metals	0.09	0.05	0.02
Exposed floors	Construction materials	0.09	—	—

A-28: overall heat coefficient for windows

TABLE A(2.4) Overall Heat Transfer Coefficient for Windows, W/m².°C

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

A-29: overall heat coefficient for wood and metals door

TABLE A(2.5) Overall heat transfer coefficients for wood and metal doors, W/m².°C.

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

Palestinian code

جدول رقم (3/ 1): القيم التصميمية الخارجية للمناطق المناخية المختلفة

القيم التصميمية الخارجية		المنطقة المناخية*						
		الضفة الغربية					قطاع غزة	
		الأولى	الثانية	الثالثة	الرابعة	الخامسة	الثالثة	السادسة
درجة الحرارة (°C)	شتاءً	7	7	5	4	8	5	9
	صيفاً	39	39	32	30	34	32	31
الرطوبة النسبية (%) شتاءً:	ادنى	60	60	60	62	63	60	62
	اقصى	70	70	72	72	78	72	69
صيفاً:	ادنى	43	43	49	44	55	49	65
	اقصى	54	54	67	57	66	67	77
سرعة الرياح (m/s)		1	1	1.5	1.4	1.1	1.5	2.8
شدة الاشعاع الشمسي (W/m²)		تعتبر قيم شدة الاشعاع القصوى للاتجاهات المختلفة في الجـدولين (3/ 18) و (3/ 19) قيماً تصميمية لكافة المناطق المناخية						
درجة يوم تسخين (°C.day)		لا تتوفر معلومات عن هذه القيم حالياً						
درجة يوم تبريـد (°C.day)								

* المناطق المناخية للأراضي الفلسطينية مبينة في الملحق (هـ)

جدول رقم (1/ 10) معدل سرعة الرياح للمحطات المناخية في الضفة الغربية.

المحطة	1	2	3	4	5	6	7	8	9	10	11	12
القدس	16.3	18.0	18.4	18.5	18.0	19.4	20.4	18.6	17.0	13.0	14.1	16.0
نابلس	8.7	9.5	10.0	10.2	10.7	12.0	12.4	11.7	10.3	7.7	7.8	7.7
جنين	7.5	7.9	7.9	7.9	9.0	9.4	9.7	8.6	7.2	5.4	6.1	7.5
طولكرم	4.3	4.1	3.8	3.4	3.3	2.9	2.9	2.7	2.6	2.9	3.8	4.0
أريحا	8.9	10.4	13.1	16.2	15.8	15.3	16.0	14.8	12.5	9.4	7.9	7.6
الخليل	12.4	12.8	12.6	11.5	9.3	9.3	9.2	8.7	8.1	8.0	8.8	10.1
العروب	8.6	10.1	10.8	9.7	6.5	5.1	5.1	5.4	5.1	5.8	5.8	7.9
الفارعة	4.6	6.5	6.1	3.6	3.3	3.6	6.8	6.5	5.0	2.5	2.5	2.1

Appendix – B

- Cooling load Calculation
- Heating load Calculation
- VRF System selection

Room No.	Room Area	Heating Load	Cooling Load	Nominal Capacity	Actual Cooling Capacity	Actual Heating Capacity	Space Name	Unit type	Unit code
Bs 01	139	10300.7	15014.09	Ventilation			Mechanical Room	------------	
Bs 02	Water Tank								
Bs 03	37.5	2778.965	4050.565	Ventilation			Medical Gas	------------	
Bs 04	23.2	0	0	Ventilation			Air Comp. Room	------------	
Bs 05	13.7	1015.249	1479.806	**Refrigerator**			Ref. Body Store Room	------------	
Bs 06	14.9	1104.176	1609.424	Ventilation			Body Wash	------------	
Bs 07	15.3	1133.818	1652.63	2.2	2.1	2.2	Yellow Bag Holding	Vivace Wall mounted	AVXWVH022E
Bs 08	15.3	1133.818	1652.63	2.2	2.1	2.2	Red Bag Holding	Vivace Wall mounted	AVXWVH022E
Bs 09	4.5	333.4758	486.0678	Ventilation			Morgue	------------	
Bs 10	5.6	414.9922	604.8843				Soiled Utility		
Bs 11	7.7	570.6142	831.7159				Cart Wach		
Bs 12	337.6	25018.1	36465.88				Parking		
Bs 13	45	0	0				Electrical Room		
Bs 14	19	1408.009	2052.286				Female Visitor Toilet		
Bs 15	20.7	1533.989	2235.912	2.2	2.1	2.2	Ortho Cons Exam	Vivace Wall mounted	AVXWVH022E
Bs 16	12	889.2689	1296.181	2.2	2.1	2.2	Ortho Treatmen Plastering	Vivace Wall mounted	AVXWVH022E
Bs 17	2.7	200.0855	291.6407	Ventilation			Plastering	------------	
Bs 18	17	1259.798	1836.256	2.2	2.1	2.2	Eyes Clinic	Vivace Wall mounted	AVXWVH022E
Bs 19	2.6	192.6749	280.8391	Ventilation			Elec. R.	------------	
Bs 20	23.4	1734.074	2527.552	2.8	2.6	2.7	Treatment / Procedure Room	Vivace Wall mounted	AVXWVH028E

Bs 21	2.7	200.0855	291.6407	Ventilation			Store	------------	
Bs 22	17	1259.798	1836.256	2.2	2.1	2.2	Cons Exam	Vivace Wall mounted	AVXWVH022E
Bs 23	17	1259.798	1836.256	2.2	2.1	2.2	Cons Exam	Vivace Wall mounted	AVXWVH022E
Bs 24	17	1259.798	1836.256	2.2	2.1	2.2	Ob&Gyn	Vivace Wall mounted	AVXWVH022E
Bs 25	17	1259.798	1836.256	2.2	2.1	2.2	Ob&Gyn	Vivace Wall mounted	AVXWVH022E
Bs 26	64	4742.768	6912.964	9	8.4	8.4	Store	4 way cassette	AVXC4H090E
Bs 27	14.6	1081.944	1577.02	2.2	2.1	2.2	Immunization	Vivace Wall mounted	AVXWVH022E
Bs 28	19	1408.009	2052.286	2.2	2.1	2.2	Pediatric	Vivace Wall mounted	AVXWVH022E
Bs 29	24.7	1830.412	2667.972	Ventilation			Dry Store Area	------------	
Bs 30	29.4			**Refrigerator**			Refrigerator	------------	
Bs 31							Refrigerator		
Bs 32							Refrigerator		
Bs 33	25.7	1904.518	2775.987	Ventilation			Backing	------------	
Bs 34	29.6	2193.53	3197.246				Cold Area		
Bs 35	57.4	4253.67	6200.064				Dirty Area		
Bs 36	9.2	681.7728	993.7385	2.2	2.1	2.2	Control Office	Vivace Wall mounted	AVXWVH022E
Bs 37	4.4	0	0	Ventilation			Toilet	------------	
Bs 38	24.7	1830.412	2667.972	Ventilation			Dish Store	------------	
Bs 39	17.8	1319.082	1922.668				H-Dishwashing Area		
Bs 40	2	148.2115	216.0301				Cold Garbage room		
Bs 41	7	518.7402	756.1054				Electrical		
Bs 42	30.6	2267.636	3305.261				Central Changing Female		
Bs 43	31.2	2312.099	3370.07				Central Changing Male		
Bs 44	19	1408.009	2052.286				Checkin Area , Fish Area		

Bs 45	16.7	1237.566	1803.851	2.2	2.1	2.2	Service Area	Vivace Wall mounted	AVXWVH022E
Bs 46	95.5	7077.099	10315.44	11.2	10.5	10.6	Cafeteria	4 way cassette	AVXC4H112E
Bs 47	4.3	0	0	Ventilation			Bathroom	------------	
Bs 48	4.3	0	0				Bathroom		
Bs 49	20.2	1496.936	2181.904				Pastry Area		
Bs 50	74.3	0	0				Cooking Area		
Bs 51	29.8	0	0				Vegetable & Meat Area		
Bs 52	15.5	1148.639	1674.233				Corridor		
Bs 53	9	666.9517	972.1355	2.2	2.1	2.2	Super Visor	Vivace Wall mounted	AVXWVH022E
Bs 54	1.3	96.33747	140.4196	Ventilation			Toilet	------------	
Bs 55	8.6	637.3094	928.9295				Flammable Material Storage		
Bs 56	21.9	1622.916	2365.53				Goods Receiving Unpaching Area		
Bs 57	7.7	570.6142	831.7159				Storing		
Bs 58	10.7	792.9315	1155.761	2.2	2.1	2.2	Dispatch & Control	Vivace Wall mounted	V
Bs 59	29.9	2215.762	3229.65	Ventilation			Wash Dirty Trolly	------------	
Bs 60	7.5	555.7931	810.1129	Cold Room					
Bs 61	34.8	2578.88	3758.924	4.5	4.2	4.2	Central Store Mecical Supplues	4 way cassette	AVXC4H045E
Bs 62	23.3	1726.664	2516.751	Ventilation			Enerale Store Clean Linen	------------	
Bs 63	7.3	540.9719	788.5099	2.2	2.1	2.2	Supervisor Office	Vivace Wall mounted	AVXWVH022E
Bs 64	1.9	140.8009	205.2286	Ventilation			Toilet	------------	
Bs 65	2.2	163.0326	237.6331				Jan Clos		
Bs 66	4.5	333.4758	486.0678				Washing Material		
Bs 67	10.4	770.6997	1123.357				Folding Assembling And Backing		

Bs 68	20.2	1496.936	2181.904	Ventilation			Laundry	------------	
Bs 69	41.1	3045.746	4439.419				Plastic Packaging		
Bs 70	11.4	844.8055	1231.372	2.2	2.1	2.2	Rest Room	Vivace Wall mounted	AVXWVH022E
Bs 71	28.4	2104.603	3067.628	Ventilation			Hall	------------	
Bs 72	11.8	874.4478	1274.578	2.2	2.1	2.2	Reception	Vivace Wall mounted	AVXWVH022E
Bs 73 Bs123	6.6	822.4979	1198.959	2.2	2.1	2.2	Records &Director Office	Vivace Wall mounted	AVXWVH022E
Bs 74	6.4	474.2768	691.2964	Ventilation			Store Equipment	------------	
Bs 75	6.5	481.6873	702.0979	2.2	2.1	2.2	Technicians Office	Vivace Wall mounted	AVXWVH022E
Bs 76	150.8	11175.15	16288.67	(2)9	8.4	8.4	Corridor	2 (4 way cassette)	AVXC4H045E
Bs 77	6.7	496.5085	723.7009	Ventilation			D.U	------------	
Bs 78	6.7	496.5085	723.7009				C.U		
Bs 79	37.7	2793.787	4072.168	4.5	4.2	4.2	Pharmacy	4 way cassette	AVXC4H045E
Bs 80	7.8	578.0248	842.5174	Ventilation			Housekeeping Supervisors Office	------------	
Bs 81	15.8	0	0				Female Toilets Changing		
Bs 82	8.2	607.6671	885.7235				Housekeeing		
Bs 83	13.7	0	0				Male Toilets Changing		
Bs 84	35.7	2645.575	3856.137				Housekeeping Main Storage		
Bs 85	31.2	2312.099	3370.07				Dirty Linen		
Bs 86	45.4	3364.401	4903.884				Production Area		
Bs 87 Bs110	16.6	2712.27	3953.05	4.5	4.2	4.2	Maintenace	4 way cassette	AVXC4H045E
Bs 88	16.6	0	0	Ventilation			Male Visitor Toilet	------------	
Bs 89	10.4	770.6997	1123.357	2.2	2.1	2.2	Echo Cardiogrpahy	Vivace Wall mounted	AVXWVH022E

Bs 90	10.4	770.6997	1123.357	2.2	2.1	2.2	Stress Test	Vivace Wall mounted	AVXWVH022E
Bs 91	20	1482.115	2160.301	2.2	2.1	2.2	Cons Exam	Vivace Wall mounted	AVXWVH022E
Bs 92	19.6	1452.473	2117.095	2.2	2.1	2.2	Dental Surgery	Vivace Wall mounted	AVXWVH022E
Bs 93	24.6	1823.001	2657.17	3.6	3.4	3.4	Dental Surgery	Vivace Wall mounted	AVXWVH036E
Bs 94	5	370.5287	540.0753	Ventilation			Store	------------	
Bs 95	9.4	696.594	1015.342	2.2	2.1	2.2	Work Area	Vivace Wall mounted	AVXWVH022E
Bs 96	20.6	1526.578	2225.11	2.8	2.6	2.7	Ent Consult Exam	Vivace Wall mounted	AVXWVH028E
Bs 97	19.6	1452.473	2117.095	2.2	2.1	2.2	Intrarnal Medicine Cons Exam	Vivace Wall mounted	AVXWVH022E
Bs 98	141	10448.91	15230.12	(2)7.1	6.7	6.8	Corridor	2(4 way cassette)	AVXC4H071E
Bs 99	14	1037.48	1512.211	2.2	2.1	2.2	Vital Signs	Vivace Wall mounted	AVXWVH022E
Bs 100	14.6	1081.944	1577.02	2.2	2.1	2.2	Emg	Vivace Wall mounted	AVXWVH022E
Bs 101	19.4	1437.651	2095.492	2.2	2.1	2.2	Clinic	Vivace Wall mounted	AVXWVH022E
Bs 102	69.5	Water Tank							
Bs 103	62.8	4653.841	6783.346	9	8.4	8.4	Blood Bank	4 way cassette	AVXC4H090E
Bs 104	53.8	0	0	Ventilation			Elec. Transf. Room	------------	
Bs 105	7	518.7402	756.1054	2.2	2.1	2.2	Engineering Office	Vivace Wall mounted	AVXWVH022E
Bs 106	7	518.7402	756.1054	2.2	2.1	2.2	Engineering Office	Vivace Wall mounted	AVXWVH022E
Bs 107	2.2	0	0	Ventilation			Toilet	------------	
Bs 108	2.2	0	0				Toilet		
Bs 109	7.8	578.0248	842.5174	2.2	2.1	2.2	Workshop Store	Vivace Wall mounted	AVXWVH022E
Bs 111	23.5	2176.856	3172.942	3.6	3.4	3.4	Security	Vivace Wall mounted	AVXWVH036E
Bs 112		0	0	Ventilation			Toilet	------------	
Bs 113	2	148.2115	216.0301				Security		
Bs 114	30	2223.172	3240.452				Central Store General Supplues		
Bs 115	20	1482.115	2160.301				Store		

Bs 116	19.6	1452.473	2117.095	Ventilation			Corridor	------------	
Bs 117	9.5	704.0046	1026.143				Corridor		
Bs 118	89.2	6610.232	9634.943	11.2	10.5	10.6	Corridor	4 way cassette	AVXC4H112E
Bs 119	10	741.0574	1080.151	Ventilation			Corridor	------------	
Bs 120	5.3	392.7604	572.4798				Corridor		
Bs 121	12	889.2689	1296.181				Corridor		
Bs 122	10.3	763.2892	1112.555				Corridor		
Bs 124	30	0	0				Ups R(!)		
Bs 125	26	1926.749	2808.391	3.6	3.4	3.4	Reception	Vivace Wall mounted	AVXC4H036E
Bs 126	40.6	3008.693	4385.411	5.6	5.3	5.3	Waiting Area	4 way cassette	AVXC4H056E
Bs 127	5.7	422.4027	615.6858	Ventilation			T.F	------------	
Bs 129	4	296.423	432.0602				T.Staff		
Bs 130	2	148.2115	216.0301				T.M		

room no.	room area	HEATING LOAD	COOLING LOAD	NOMINAL CAPACITY	ACTUAL COOLING CAPACITY	ACTUAL HEATING CAPACITY	SPACE NAME	Unit type	Unit code
gr 01	27.6	2556.648	3726.519	4.5	4.2	4.2	plainx-ray	4 way cassette	AVXC4H045E
gr 02	4.3	398.3184	580.581	Ventilation			changing	-----	-----
gr 03	28.3	2621.491	3821.033	4.5	4.2	4.2	fluoroscopy	4 way cassette	AVXC4H045E
gr 04	3.5	324.2126	472.5659	Ventilation			chang&t	-----	-----
gr 05	38.6	3575.602	5211.726	5.6	5.3	5.3	MRI rom	MP wall mounted	AVXWBH056E
gr 06	7.5	694.7414	1012.641	*1			control rom		
gr 07	10.5	972.6379	1417.698				elec equipment room		
gr 08	9	833.6896	1215.169				mammography		
gr 09	4.2	389.0552	567.079	Ventilation			t	-----	-----
gr 10	13.3	1232.008	1795.75	2.2	2.1	2.2	patient prep	Slim 1 way cassette	AVXCSH022E
gr 11	8.6	796.6367	1161.162	2.2	2.1	2.2	corredor	Slim 1 way cassette	AVXCSH022E
gr 12	10.8	1000.428	1458.203	2.2	2.1	2.2	control room	Slim 1 way cassette	AVXCSH022E
gr 13	30.2	2797.492	4077.568	4.5	4.2	4.2	CT-ROOm	4 way cassette	AVXC4H045E
gr 14	3	277.8965	405.0565	Ventilation			t	-----	-----
gr 15	9.5	880.0057	1282.679	2.2	2.1	2.2	staff room	Neo fort wall mounted	AVXWNH022E
gr 16	7.3	676.2149	985.6374	2.8	2.6	2.7	sp. Test	Slim duct	AVXDSH028E
gr 17	5	463.1609	675.0941				blood bank store		
gr 18	3.8	352.0023	513.0715				safty store		
gr 19	7.6	704.0046	1026.143	*2			unit head		
gr 20	3	277.8965	405.0565	Ventilation			t	-----	-----

gr 21	2.2	203.7908	297.0414	Ventilation			t	-----	-----
gr 22	2.7	250.1069	364.5508	Ventilation			t	-----	-----
gr 23	3.6	333.4758	486.0678	*2			VENIPUNCTURE CUBICLE		
gr 24	4.5	416.8448	607.5847				VENIPUNCTURE CUBICLE		
gr 25	3.1	287.1598	418.5583	Ventilation			t	-----	-----
gr 26	2.4	222.3172	324.0452	Ventilation			shower	-----	-----
gr 27	21	1945.276	2835.395	3.6	3.4	3.4	Medical manager office	Nea fort wall mounted	AVXWNH036E
gr 28	14.2	1315.377	1917.267	*3			serology		
gr 29	19.1	1769.275	2578.859				hormon lab		
gr 30	18.4	1704.432	2484.346				routine lab		
gr 31	7.2	-----					entrance	-----	-----
gr 32	5.5	509.477	742.6035	*4			preparation room		
gr 33	7.8	722.531	1053.147				CHEF RAD-IOLOGIST HEADOF UNIT OFFICE		
gr 34	19.8	1834.117	2673.373	2.8	2.6	2.7	treatment room	Nea fort wall mounted	AVXWNH028E
gr 35	6.3	583.5827	850.6186	*4			CU		
gr 36	7.7	713.2678	1039.645				DU		
gr 37	15.4	1426.536	2079.29	2.2	2.1	2.2	resuscitiation &screen	Nea fort wall mounted	AVXWNH022E
gr 38	16.4	1519.168	2214.309	2.8	2.6	2.7	ultrasound	Mini 4 way cassette	AVXCMH028E
gr 39	6.7	620.6356	904.6261	Ventilation			DU	-----	-----

gr 40	2.7	250.1069	364.5508	Ventilation			record reception	-----	-----
gr 41	2	185.2644	270.0376	Ventilation			t	-----	-----
gr 42	2	185.2644	270.0376	Ventilation			t	-----	-----
gr 43	7.8	722.531	1053.147	2.2	2.1	2.2	NS	Slim 1 way cassette	AVXCSH022E
gr 44	6.6	611.3724	891.1242	2.2	2.1	2.2	CU	Slim 1 way cassette	AVXCSH022E
gr 45	44.8	4149.922	6048.843	*5			waiting		
gr 46	6	555.7931	810.1129	*4			laser imagers printers		
gr 47	4	370.5287	540.0753	Ventilation			t	-----	-----
gr 48	20.2	1871.17	2727.38	3.6	3.4	3.4	speciment reception	Mini 4 way cassette	AVXCMH036E
gr 49	8.7	805.9	1174.664	*2			blood recovery		
gr 50	8.7	805.9	1174.664				blood donation		
gr 51	8.2	759.5839	1107.154	*6			bacteriology lab		
gr 52	5.1	472.4241	688.596				media preparation		
gr 53	15	1389.483	2025.282	*3			hematology lab		
gr 54	19.6	1815.591	2646.369				chemoistry lab		
gr 55	7.5	694.7414	1012.641	*7			PCR		
gr 56	6.3	583.5827	850.6186				PCR		
gr 57	6.1	565.0563	823.6148				GROSSE		
gr 58	11.2	1037.48	1512.211				pathology lab		
gr 59	6.7	620.6356	904.6261				pathologist		
gr 60	28	2593.701	3780.527	4.5	4.2	4.2	waiting	4 way cassette	AVXC4H045E
gr 61	5.6	518.7402	756.1054	Ventilation			trolley parking	-----	-----

gr 62	31.3	2899.387	4226.089	*8			waiting area		
gr 63	8.2	759.5839	1107.154				Waiting area		
gr 64	6.7	620.6356	904.6261				cashier		
gr 65	3.5	324.2126	472.5659	Ventilation			t	-----	-----
gr 66	3.2	296.423	432.0602	Ventilation			t	-----	-----
gr 67	7.1	657.6885	958.6336	*5			reception		
gr 68	1.8	166.7379	243.0339	Ventilation			UPS	-----	-----
gr 69	4.2	389.0552	567.079	Ventilation			patients toliet spesimen	-----	-----
gr 70	10.1	935.585	1363.69	2.2	2.1	2.2	plastering store	Slim 1 way cassette	AVXCSH022E
gr 71	28.4	2630.754	3834.534	Ventilation			patients toilet speciment	-----	-----
gr 72	11.8	1093.06	1593.222	Ventilation			JAN	-----	-----
gr 73	6.6	611.3724	891.1242	2.2	2.1	2.2	doctor office	Vivaccce wall mounted	AVXWVH022E
gr 74	66.8	6187	9019.26	11.2	10.5	10.6	Treatment observation	4 way cassette	AVXC4H112E
gr 75	46.13	4273.12	6228.42	7.1	6.7	6.8	drug store	4 way cassette	AVXC4H071E
gr 76	14.4	1333.9	1944.27	2.2	2.1	2.2	spare room	Neo fort wall mounted	AVXWNH022E
gr 77	6.7	620.6356	904.6261	2.2	2.1	2.2	KITCHEN	Neo fort wall mounted	AVXWNH022E
gr 78	6.7	620.6356	904.6261	2.2	2.1	2.2	MAIL room	Vivace wall mounted	AVXWVH022E
gr 79	11.1	1028.217	1498.709	2.2	2.1	2.2	non medical services director	Vivace wall mounted	AVXWVH022E
gr 80	4.3	398.3184	580.5809	Ventilation			FEMALE T	-----	-----
gr 81	4.2	389.0552	567.079	Ventilation			MALE T	-----	-----
gr 82	2.4	222.3172	324.0452	Ventilation			PANTRY	-----	-----

gr 83	31.3	2899.387	4226.089	4.5	4.2	4.2	reception counter	4 way cassette	AVXC4H045E
gr 84	26.9	2491.806	3632.006	3.6	3.4	3.4	secretary pool	Mini 4 way cassette	AVXCMH036E
gr 85	11.1	1028.217	1498.709	2.2	2.1	2.2	head nurse office	Vivace wall mounted	AVXWVH022E
gr 86	12.4	1148.639	1674.233	2.2	2.1	2.2	head finance	Vivace wall mounted	AVXWVH022E
gr 87	13.8	1278.324	1863.26	2.2	2.1	2.2	office	Vivace wall mounted	AVXWVH022E
gr 88	14.2	1315.377	1917.267	2.2	2.1	2.2	store	Neo fort wall mounted	AVXWNH022E
gr 89	26.1	2417.7	3523.991	4.5	4.2	4.2	general maneger	4 way cassette	AVXCMH045E
gr 90	40.8	3779.393	5508.768	6	5.6	5.9	meeting room	Mini 4 way cassette	AVXCMH060E
gr 91	8.8	815.1632	1188.166	2.2	2.1	2.2	secretary	Vivace wall mounted	AVXWVH022E
gr 92	3.4	314.9494	459.064	Ventilation			T	-----	-----
gr 93	44.6	4131.395	6021.839	7.1	6.7	6.8	praying room	Slim duct	AVXDSH071E
gr 94							gifts shop		
gr 95	20.7	1917.486	2794.89	3.6	3.4	3.4	head accountant	Mini 4 way cassette	AVXCMH036E
gr 96	28.3	2621.491	3821.033	4.5	4.2	4.2	accountant	4 way cassette	AVXC4H045E
gr 97	Outside						terrace		
gr 98	15	1389.483	2025.282	2.2	2.1	2.2	waiting	Neo fort wall mounted	AVXWNH022E
gr 99	8.4	778.1103	1134.158	2.2	2.1	2.2	archive	Neo fort wall mounted	AVXWNH022E
gr 100	18	1667.379	2430.339	2.8	2.6	2.7	corridor	Mini 4 way cassette	AVXCMH028E
gr 101	19.4	1797.064	2619.365	2.8	2.6	2.7	RECEPTION	Mini 4 way cassette	AVXCMH028E
gr 102	69.5	6437.937	9383.808	11.2	10.5	10.6	corridor	MSP duct	AVXDUH112E

gr 103	456.6	42295.85	61649.59	5*14	13.1	13.5	hall	Slim duct	AVXDSH140E
gr 104	20.7	1917.486	2794.89	Ventilation			MALE T	-----	-----
gr 105	21.4	1982.329	2889.403	Ventilation			FEMALE T	-----	-----
gr 106	78.2	7243.836	10558.47	11.2	10.5	10.6	CAFATERIA	4 way cassette	AVXC4H112E
gr 107	Outside						TERACE		
gr 108	Outside						TERRACE		
gr 109	3.7	342.7391	499.5696	Ventilation			Electrical room	-----	-----
gr 110	20.7	1917.486	2794.89	3.6	3.4	3.4	SECURITY ROOM	Mini 4 way cassette	AVXCMH036E
gr 111	42.7	3955.394	5765.304	*5			corridor		
gr 112	76.2	7058.572	10288.43	11.2	10.5	10.6	corridor	4 way cassette	AVXC4H112E
gr 113	Not exist								
gr 114	18	1667.379	2430.339	2.8	2.6	2.7	corridor	Mini 4 way cassette	AVXCMH028E
gr 115	3	277.8965	405.0565	Ventilation				-----	-----
gr 116	Refrigerator								
gr 117	16	1482.115	2160.301	Ventilation			UPS R(2)	-----	-----

	Rooms name	NOMINAL CAPACITY	ACTUAL COOLING CAPACITY	ACTUAL HEATING CAPACITY	Unit type	Unit code
*1	Gr(06,07,08)	4.5	4.2	4.2	Slim duct	AVXDSH045E
*2	Gr (19,23,24,49,50)	5.6	5.3	5.3	MSP duct	AVXDUH056E
*3	Gr(28,29,30,53,54)	12.8	12	11.7	MSP duct	2.7
*4	Gr(32,33,35,36,46)	5.6	5.3	5.3	MSP Duct	AVXDUH056E
*5	Gr(45,67,111)	14	13.1	13.5	4 way cassette	AVXC4H140E
*6	Gr(51,52)	2.2	2.1	2.2	Slim duct	AVXDSH022E
*7	Gr(55,56,57,58,59)	5.6	5.3	5.3	MSP duct	AVXDUH056E
*8	Gr(62,63,64)	7.1	6.7	6.8	MSP duct	AVXDUH071E

room no.	room area	HEATING LOAD	COOLING LOAD	NOMINAL CAPACITY	ACTUAL COOLING CAPACITY	ACTUAL HEATING CAPACITY	SPACE NAME	Unit type	Unit code
I1 01	29.1	2929.992	4384.992	5.6	5.3	5.3	staff residence3	Vivace Wall mounted	AVXWVH056E
I1 02	3.5	352.4045	527.4045				T		
I1 03	19.7	3066.305	4051.305	4.5	4.2	4.2	staff residence2	4 way cassette	AVXC4H045E
I1 04	3.7	372.5419	557.5419				T		
I1 05	17.8	2770.57	3660.57	4.5	4.2	4.2	staff residence1	4 way cassette	AVXC4H045E
I1 06	5.2	523.5724	783.5724				corridor		
I1 07	18.4	1852.641	2772.641	3.6	3.4	3.4	MALE lounge	Vivace Wall mounted	AVXWVH036E
I1 08	4	402.748	602.748				T		
I1 09	29.3	2950.129	4415.129	5.6	5.3	5.3	endoscopic investigation	Vivace Wall mounted	AVXWVH056E
I1 10	5.6	563.8472	843.8472				scoop washing and storage		
I1 11	6	604.122	904.122				CU		
I1 12	32.2	5011.93	6621.93	7.1	6.7	6.8	recovery	Vivace Wall mounted	AVXC4H071E
I1 13	4.4	684.86	904.86				CU		
I1 14	4.4	443.0228	663.0228				DU		
I1 15	63.3	6373.487	9538.487	11.2	10.5	10.6	catherization laboratory	4 way cassette	AVXC4H112E
I1 16	26.1	4062.465	5367.465	6	5.6	5.9	laboratory		
I1 17	11.1	1117.626	1672.626	2.2	2.1	2.2	embryo transfer	Vivace Wall mounted	AVXWVH022E
I1 18	26.7	2688.343	4023.343	4.5	4.2	4.2	operating room(IVF)	4 way cassette	AVXC4H045E
I1 19	3.6	362.4732	542.4732				T		
I1 20	5.6	563.8472	843.8472				IMMEDIATe sterilization		
I1 21	30.4	3060.885	4580.885	5.6	5.3	5.3	scrub & corridor	Vivace Wall mounted	AVXWVH056E
I1 22		0	0						
I1 23	15.7	1580.786	2365.786	2.8	2.6	2.7	prep & recovery	Vivace Wall mounted	AVXWVH028E
I1 24	5.2	523.5724	783.5724				CU		
I1 25	4.6	463.1602	693.1602				DU		
I1 26	14.2	1429.755	2139.755	2.2	2.1	2.2	control room	Vivace Wall mounted	AVXWVH022E
I1 27	0	0	0						
I1 28	10.5	1057.214	1582.214	2.2	2.1	2.2	equioment area	Vivace Wall mounted	AVXWVH022E
I1 29	4.3	432.9541	647.9541				aperm sample		
I1 30	11.6	1167.969	1747.969	2.2	2.1	2.2	NS	Vivace Wall mounted	AVXWVH022E
I1 31	5.3	533.6411	798.6411						

l1 32	18.5	2879.525	3804.525	4.5	4.2	4.2		4 way cassette	AVXC4H045E
l1 33	3.4	342.3358	512.3358				staff residences		
l1 34	2.1	211.4427	316.4427						
l1 35	27	2718.549	4068.549	4.5	4.2	4.2	corridore	4 way cassette	AVXC4H045E
l1 36	9.1	916.2517	1371.252	2.2	2.1	2.2	patien prep recovery	Vivace Wall mounted	AVXWVH022E
l1 37	10	1006.87	1506.87	2.2	2.1	2.2	staff base	Vivace Wall mounted	AVXWVH022E
l1 38	3.2	322.1984	482.1984				DU		
l1 39	3.2	322.1984	482.1984				CU		
l1 40	2	201.374	301.374				WC		
l1 41	3.3	332.2671	497.2671				WC		
l1 42	2	201.374	301.374				WC		
l1 43	3.3	332.2671	497.2671				WC		
l1 44	2.2	221.5114	331.5114				T		
l1 45	2.1	211.4427	316.4427				T		
l1 46	31	3121.297	4671.297	5.6	5.3	5.3	waiting	Vivace Wall mounted	AVXWVH056E
l1 47	29	2919.923	4369.923	5.6	5.3	5.3	waiting	Vivace Wall mounted	AVXWVH056E
l1 48	6.7	674.6029	1009.603				consult		
l1 49	7.8	785.3586	1175.359	2.2	2.1	2.2	dr office	Vivace Wall mounted	AVXWVH022E
l1 50		0	0						
l1 51	2.2	221.5114	331.5114				T		
l1 52	2	201.374	301.374				T		
l1 53	9.8	986.7326	1476.733	2.2	2.1	2.2	wait	Vivace Wall mounted	AVXWVH022E
l1 54	10	1006.87	1506.87	2.2	2.1	2.2	consulting room	Vivace Wall mounted	AVXWVH022E
l1 55	7.8	785.3586	1175.359	2.2	2.1	2.2	staff change	Vivace Wall mounted	AVXWVH022E
l1 56	159	16009.23	23959.23	(2)14	13.1	13.5			
l1 57	3.1	312.1297	467.1297				T		
l1 58	19	2957.35	3907.35	4.5	4.2	4.2	staff residence5	4 way cassette	AVXC4H045E
l1 59	19	2957.35	3907.35	4.5	4.2	4.2	staff residence6	4 way cassette	AVXC4H045E
l1 60	4.1	412.8167	617.8167				t		
l1 61	6.4	644.3968	964.3968				corrodor		
l1 62	20	2013.74	3013.74	3.6	3.4	3.4	female lounge	Vivace Wall mounted	AVXWVH036E
l1 63	12.4	1248.519	1868.519	2.2	2.1	2.2	kitcen	Vivace Wall mounted	AVXWVH022E
l1 64	3.7	372.5419	557.5419				JAN		
l1 65	7.7	775.2899	1160.29	2.2	2.1	2.2	LINEN STORe	Vivace Wall mounted	AVXWVH022E
l1 66	25	3891.25	5141.25	5.6	5.3	5.3	staff residence7	Vivace Wall mounted	AVXWVH056E

l1 67	3.4	342.3358	512.3358				T		
l1 68	3.6	362.4732	542.4732				lockers f		
l1 69	2.4	241.6488	361.6488				WC		
l1 70	2.4	241.6488	361.6488				WC		
l1 71	3.6	362.4732	542.4732				LOCKERS m		
l1 72	5.7	573.9159	858.9159				trolley park		
l1 73	6.6	664.5342	994.5342				trolley wash		
l1 74	50	5034.35	7534.35	9	8.4	8.4	data center room	4 way cassette	AVXC4H090E
l1 75	7.4	745.0838	1115.084	2.2	2.1	2.2	T	Vivace Wall mounted	AVXWVH022E
l1 76	6.1	614.1907	919.1907				T		
l1 77	30.5	3070.954	4595.954	5.6	5.3	5.3	IT serveces	Vivace Wall mounted	AVXWVH056E
l1 78	4.1	412.8167	617.8167				elec. C		
l1 79	145	14599.62	21849.62	(2)12.8	12	11.7	conference	4 way cassette	AVXC4H128E
l1 80	5.2	523.5724	783.5724				translation		
l1 81	64.4	10023.86	13243.86	14	13.1	13.5	library	4 way cassette	AVXC4H140E
l1 82	0	0	0						
l1 83	39.8	5007.63	5997.343	7.1	6.7	6.8	medical records	Vivace Wall mounted	AVXC4H071E
l1 84	10.2	1027.007	1537.007	2.2	2.1	2.2	sterile good store	Vivace Wall mounted	AVXWVH022E
l1 85	10	1006.87	1506.87	2.2	2.1	2.2	issue/dispatch	Vivace Wall mounted	AVXWVH022E
l1 86	16	1610.992	2410.992	2.8	2.6	2.7	corridor	Vivace Wall mounted	AVXWVH028E
l1 87	21.1	2124.496	3179.496	3.6	3.4	3.4	washers decontaminators	Vivace Wall mounted	AVXWVH036E
l1 88	34	3423.358	5123.358				packing		
l1 89									
l1 90				5.6	5.3	5.3		Vivace Wall mounted	AVXWVH056E
l1 91	5	503.435	753.435				equioment store		
l1 92	5.7	573.9159	858.9159				changing		
l1 93	4.1	412.8167	617.8167				clean linen supply		
l1 94	6.8	684.6716	1024.672				supervisor office		
l1 95	15.3	2381.445	3146.445	3.6	3.4	3.4	autoclaves	Vivace Wall mounted	AVXWVH036E
l1 96	51.3	0	0				terrace		
l1 97	64.5	0	0				terrace		
l1 98	29.1	2929.992	4384.992	5.6	5.3	5.3	rest area	Vivace Wall mounted	AVXWVH056E
l1 99	360	56034	74034				rest area		
l1 100				(6)14	13.1	13.5		4 way cassette	AVXC4H140E

# of Room	Name	Area	Heating load	Cooling load	Act. cooling	Act.heating	Nominal Capacity	Unit type	Unit code
I2 01	SUITE	42.5		6847.175	6700		7.1	Vivace Wall mounted	AVXC4H 071E
I2 02	bathroom	5.5	611.105	886.105					
I2 03	R.single	28.2	3133.302	4543.302	4200	3400	4.5	4 way cassette	AVXC4H 045E
I2 04	bathroom	5.1	566.661	821.661					
I2 05	R.single	30.4	3377.744	4897.744	5300	3400	5.6	Vivace Wall mounted	AVXWVH 056E
I2 06	bathroom	5.7	633.327	918.327					
I2 07	R.single	32	3555.52	5155.52	5300	3400	5.6	Vivace Wall mounted	AVXWVH 056E
I2 08	bathroom	4.1	455.551	660.551					
I2 09	R.single	30.6	3399.966	4929.966	5300	3400	5.6	Vivace Wall mounted	AVXWVH 056E
I2 10	bathroom	4.4	488.884	708.884					
I2 11	SUITE	32.1	3566.631	5171.631	5300	3400	5.6	Vivace Wall mounted	AVXWVH 056E
I2 12	bathroom	5	555.55	805.55					
I2 13	R.single	21.5	2388.865	3463.865	3400	2700	3.6	Vivace Wall mounted	AVXWVH 036E
I2 14	bathroom	4.2	466.662	676.662					
I2 15	R.single	25	2777.75	4027.75	4200	2700	4.5	4 way cassette	AVXC4H 045E
I2 16	bathroom	4.6	511.106	741.106					
I2 17	R.single	23	2555.53	3705.53	4200	2700	4.5	4 way cassette	AVXC4H 045E
I2 18	bathroom	4.3	477.773	692.773					
I2 19	R.single	24	2666.64	3866.64	4200	2700	4.5	4 way cassette	AVXC4H 045E
I2 20	bathroom	6.1	677.771	982.771					
I2 21	R.double	26.7	2966.637	4301.637	4200	3400	4.5	4 way cassette	AVXC4H 045E
I2 22	bathroom	5.8	644.438	934.438					
I2 23	R.single	24.6	2733.306	3963.306	4200	2700	4.5	4 way cassette	AVXC4H 045E
I2 24	bathroom	4	444.44	644.44					
I2 25	R.double	24.2	2688.862	3898.862	4200	2700	4.5	4 way cassette	AVXC4H 045E
I2 26	bathroom	5.8	644.438	934.438					
I2 27	R.double	29.3	3255.523	4720.523	5300	3400	5.6	Vivace Wall	AVXWVH

								mounted	056E
l2 28	bathroom	4.4	488.884	708.884					
l2 29	Rest room	19	2111.09	3061.09	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 30	Space	26.1	2899.971	4204.971	4200	3400	4.5	4 way cassette	AVXCSH 045E
l2 31	Rest room	16.3	1811.093	2626.093	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 32	Ante room	10.1	1122.211	1627.211	2100	2200	2.2	Vivace Wall mounted	AVXWVH 022E
l2 33	Isolation room	18.1	2011.091	2916.091	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 34	bathroom	4	444.44	644.44					
l2 35	R.single	19	2111.09	3061.09	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 36	bathroom	4.1	455.551	660.551					
l2 37	R.single	21	2333.31	3383.31	3400	2700	3.6	Vivace Wall mounted	AVXWVH 036E
l2 38	bathroom	4.7	522.217	757.217					
l2 39	R.single	20.7	2299.977	3334.977	3400	2700	3.6	Vivace Wall mounted	AVXWVH 036E
l2 40	bathroom	5	555.55	805.55					
l2 41	R.single	21.6	2399.976	3479.976	3400	2700	3.6	Vivace Wall mounted	AVXWVH 036E
l2 42	bathroom	5	555.55	805.55					
l2 43	R.single	19.8	2199.978	3189.978	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 44	bathroom	4	444.44	644.44					
l2 45	R.single	20.7	2299.977	3334.977	3400	2700	3.6	Vivace Wall mounted	AVXWVH 036E
l2 46	bathroom	4.7	522.217	757.217					
l2 47	R.single	20.6	2288.866	3318.866	3400	2700	3.6	Vivace Wall mounted	AVXWVH 036E
l2 48	bathroom	4.4	488.884	708.884					
l2 49	R.single	20.7	2299.977	3334.977	3400	2700	3.6	Vivace Wall mounted	AVXWVH 036E
l2 50	bathroom	4.8	533.328	773.328					
l2 51	space	286.8	31866.35	46206.35	3*13100	3*10600	14	4 way cassette	AVXC4H140E
l2 52	N.S	17.2	621.8173	1481.817	2100		2.2	Vivace Wall mounted	AVXWVH 022E
l2 53	pantry	9.3	336.2152	801.2152					
l2 54	C.U	9.2	332.6	792.6					
l2 55	bathroom	3.5	126.5326	301.5326					
l2 56	Janitor	7.2	260.2956	620.2956					

	closet								
l2 57	D.U	6.3	227.7587	542.7587					
l2 58	bathroom	2.8	101.2261	241.2261					
l2 59	bathroom	2.8	101.2261	241.2261					
l2 60	VIP room	33.1	1196.637	2851.637	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 61	bathroom	5.5	198.8369	473.8369					
l2 62	secur	5.6	202.4522	482.4522					
l2 63	VIP room	33.3	1203.867	2868.867	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 64	bathroom	5.7	633.327	918.327					
l2 65	secur	5.5	611.105	886.105					
l2 66	VIP room	51.2	1850.991	4410.991	5300	2200	5.6	Vivace Wall mounted	AVXWVH 056E
l2 67	bathroom	6	216.913	516.913					
l2 68	secur	9.1	328.9847	783.9847					
l2 69	VIP room	34.2	1236.404	2946.404	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 70	bathroom	4.7	169.9152	404.9152					
l2 71	secur	8.5	307.2934	732.2934					
l2 72	VIP room	28.2	1019.491	2429.491	2600	2200	2.8	Vivace Wall mounted	AVXWVH 028E
l2 73	bathroom	4.8	533.328	773.328					
l2 74	secur	7.7	278.3717	663.3717					
l2 75	suite	29.2	1055.643	2515.643	2600	2200	2.8	Vivace Wall mounted	AVXWVH 028E
l2 76	bathroom	5.3	191.6065	456.6065					
l2 77	hall	60.7	6744.377	9779.377	10500	6800	11.2	4 way cassette	AVXC4H 112E
l2 78	corridor	250.1	27788.61	40293.61	4*10500	3*8400	11.2	4 way cassette	AVXC4H 112E
l2 79	void	11.9	1322.209	1917.209	2100	2200	2.2	Vivace Wall mounted	AVXWVH 022E
l2 80	Electric room	24.8	2755.528	3995.528	4200	2700	4.5	4 way cassette	AVXC4H 045E
l2 81	Trolly parking	6.7	242.2195	577.2195					
l2 82	R.doubl	19.8	2199.978	3189.978	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 83	bathroom	3	333.33	483.33					
l2 84	R.doubl	19.8	2199.978	3189.978	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 85	bathroom	3	333.33	483.33					
l2 86	R.single	20.2	2244.422	3254.422	3400	2700	3.6	Vivace Wall	AVXWVH

								mounted	036E
l2 87	R.single	18.5	2055.535	2980.535	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 88	bathroom	3.7	411.107	596.107					
l2 89	R.single	19	2111.09	3061.09	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 90	bathroom	3.7	411.107	596.107					
l2 91	R.single	19	2111.09	3061.09	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 92	bathroom	3.7	411.107	596.107					
l2 93	R.single	19	2111.09	3061.09	3400	2200	3.6	Vivace Wall mounted	AVXWVH 036E
l2 94	bathroom	3.8	422.218	612.218					
l2 95	Spare room store	4.7	522.217	757.217					
l2 96	suite	36	5951.88	7751.88	8400	5900	9	4 way cassette	AVXC4H 090E
l2 97	bathroom	8	888.88	1288.88	2100		2.2	Vivace Wall mounted	AVXWVH 022E
l2 98	suite	22.7	3752.991	4887.991	5300	4200	5.6	Vivace Wall mounted	AVXWVH 056E
l2 99	bathroom	5.5	611.105	886.105					
l2 100	suite	22.6	3736.458	4866.458	5300	4200	5.6	Vivace Wall mounted	AVXWVH 056E
l2 101	bathroom	5.5	611.105	886.105					
l2 102	Clean line trolly bay	4.1	455.551	660.551					
l2 103	suite	36.1	5968.413	7773.413	8400	5900	9	4 way cassette	AVXC4H 090E
l2 104	bathroom	7	777.77	1127.77	2100		2.2	Vivace Wall mounted	AVXWVH 022E
l2 105	elect	2.3	255.553	370.553					
l2 106	Ante room	8.3	922.213	1337.213	2100		2.2	Vivace Wall mounted	AVXWVH 022E
l2 107	Isolation room	15.2	1688.872	2448.872	2600	2200	2.8	Vivace Wall mounted	AVXWVH 028E
l2 108	bathroom	4	444.44	644.44					
l2 109	R.single	20	2222.2	3222.2	3400	2700	3.6	Vivace Wall mounted	AVXWVH 036E
l2 110	bathroom	3	333.33	483.33					
l2 111	R.single	20	2222.2	3222.2	3400	2700	3.6	Vivace Wall mounted	AVXWVH 036E
l2 112	bathroom	3	333.33	483.33					
l2 113	R.doubl	20	2222.2	3222.2	3400	2700	3.6	Vivace Wall	AVXWVH

								mounted	036E
I2 114	bathroom	3	333.33	483.33					
I2 115	R.doubl	20.1	2233.311	3238.311	3400	2700	3.6	Vivace Wall mounted	AVXWVH 036E
I2 116	bathroom	2.7	299.997	434.997					
I2 117	R.doubl	21	2333.31	3383.31	3400	2700	3.6	Vivace Wall mounted	AVXWVH 036E
I2 118	bathroom	2.7	299.997	434.997					
I2 119	Rest room	28.7	3188.857	4623.857	5300	3400	5.6	Vivace Wall mounted	AVXWVH 056E
I2 120	Rest & wating	13.8	1533.318	2223.318	2600	2200	2.8	Vivace Wall mounted	AVXWVH 028E
I2 121	N.S	15	1666.65	2416.65	2600	2200	2.8	Vivace Wall mounted	AVXWVH 028E
I2 122	pantry	6.7	744.437	1079.437	2100		2.2	Vivace Wall mounted	AVXWVH 022E
I2 123	C.U	8	888.88	1288.88	2100		2.2	Vivace Wall mounted	AVXWVH 022E
I2 124	D.U	7.5	833.325	1208.325	2100		2.2	Vivace Wall mounted	AVXWVH 022E
I2 125	Janitor closet	2.6	288.886	418.886					
I2 126	bathroom	2	222.22	322.22					
I2 127	bathroom	2	222.22	322.22					
I2 128	terace	0	0	0	0				
I2 129	bathroom	3	333.33	483.33					

Room No.	Room Area	Heating Load	Cooling Load	Nominal Capacity	ACTUAL COOLING CAPACITY	ACTUAL HEATING CAPACITY	**Space Name**	Unit Type	Unit Code
L3 01	42.5	4910.45	6610.45	7.1	6700	6800	**Suite**	Vivace Wall mounted	AVXWVH071E
L3 02	5.5	635.47	855.47	Ventilation			**Bathroom**	------------	
L3 03	28.2	3258.228	4386.228	5.6	5300	5300	**R.Single**	Vivace Wall mounted	AVXWVH056E
L3 04	5.1	589.254	793.254	Ventilation			**Bathroom**	------------	
L3 05	30.4	3512.416	4728.416	5.6	5300	5300	**R.Single**	Vivace Wall mounted	AVXWVH056E
L3 06	5.7	658.578	886.578	Ventilation			**Bathroom**	------------	
L3 07	32	3697.28	4977.28	5.6	5300	5300	**R.Single**	Vivace Wall mounted	AVXWVH056E
L3 08	4.1	473.714	637.714	Ventilation			**Bathroom**	------------	
L3 09	30.2	3489.308	4697.308	5.6	5300	5300	**R.Single**	Vivace Wall mounted	AVXWVH056E
L3 10	4.4	508.376	684.376	Ventilation			**Bathroom**	------------	
L3 11	32.5	3755.05	5055.05	5.6	5300	5300	**Suite**	Vivace Wall mounted	AVXWVH056E
L3 12	5	577.7	777.7	Ventilation			**Bathroom**	------------	
L3 13	21.5	2484.11	3344.11	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 14	4.2	485.268	653.268	Ventilation			**Bathroom**	------------	
L3 15	25	2888.5	3888.5	4.5	4200	4200	**R.Single**	Slim 1 way cassette	AVXCSH045E
L3 16	4.6	531.484	715.484	Ventilation			**Bathroom**	------------	
L3 17	23	2657.42	3577.42	4.5	4200	4200	**R.Single**	Slim 1 way cassette	AVXCSH045E
L3 18	4.3	496.822	668.822	Ventilation			**Bathroom**	------------	
L3 19	24	2772.96	3732.96	4.5	4200	4200	**R.Single**	4 way cassette	AVXC4H045E
L3 20	6.1	704.794	948.794	Ventilation			**Bathroom**	------------	
L3 21	26.7	3084.918	4152.918	4.5	4200	4200	**R.Double**	4 way cassette	AVXC4H045E
L3 22	5.8	670.132	902.132	Ventilation			**Bathroom**	------------	
L3 23	24.6	2842.284	3826.284	4.5	4200	4200	**R.Single**	Slim 1 way cassette	AVXCSH045E
L3 24	4	462.16	622.16	Ventilation			**Bathroom**	------------	

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L3 25	24.2	2796.068	3764.068	4.5	4200	4200	**R.Double**	4 way cassette	AVXC4H045E
L3 26	5.8	670.132	902.132	Ventilation			**Bathroom**	------------	
L3 27	29.3	3385.322	4557.322	5.6	5300	5300	**R.Double**	Vivace Wall mounted	AVXWVH056E
L3 28	4.4	508.376	684.376	Ventilation			**Bathroom**	------------	
L3 29	19	2195.26	2955.26	3.6	3400	3400	**Best Room**	Vivace Wall mounted	AVXWVH036E
L3 30	26	3004.04	4044.04	4.5	4200	4200	**Space**	4 way cassette	AVXC4H045E
L3 31	16.3	1883.302	2535.302	2.8	2600	2700	**Best Room**	Vivace Wall mounted	AVXWVH028E
L3 32	10.1	1166.954	1570.954	2.2	2100	2200	**Ante Room**	Vivace Wall mounted	AVXWVH022E
L3 33	18.1	2091.274	2815.274	3.6	3400	3400	**Isolation Room**	Vivace Wall mounted	AVXWVH036E
L3 34	4	462.16	622.16	Ventilation			**Bath Room**	------------	
L3 35	19	2195.26	2955.26	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 36	4.1	473.714	637.714	Ventilation			**Bath Room**	------------	
L3 37	21	2426.34	3266.34	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 38	4.7	543.038	731.038	Ventilation			**Bath Room**	------------	
L3 39	20.7	2391.678	3219.678	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 40	5	577.7	777.7	Ventilation			**Bath Room**	------------	
L3 41	22.1	2553.434	3437.434	4.5	4200	4200	**R.Single**	4 way cassette	AVXC4H045E
L3 42	4.6	531.484	715.484	Ventilation			**Bath Room**	------------	
L3 43	19.6	2264.584	3048.584	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 44	4	462.16	622.16	Ventilation			**Bath Room**	------------	
L3 45	20.7	2391.678	3219.678	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 46	4.7	543.038	731.038	Ventilation			**Bath Room**	------------	
L3 47	20.4	2357.016	3173.016	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 48	4.6	531.484	715.484	Ventilation			**Bath Room**	------------	
L3 49	20.5	2368.57	3188.57	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E

L3 50	5	577.7	777.7	Ventilation			**Bath Room**	------------	
L3 51	286.8	33136.87	44608.87	12.8	(4)12000	11700	**Space**	2(4 way cassette) 2 (M.S.P duct)	2(AVXC4H128E) 2(AVXDUH128E)
L3 52	17.2	733.4768	1421.477	2.2	2100	2200	**Office**	Vivace Wall mounted	AVXWVH036E
L3 53	9.3	396.5892	768.5892	Ventilation			**Pantry**	------------	
L3 54	9.2	392.3248	760.3248				**C.U**		
L3 55	3.5	149.254	289.254				**Bath Room**		
L3 56	7.2	307.0368	595.0368				**Janitor Closet**		
L3 57	6.3	268.6572	520.6572				**D.U**		
L3 58	2.8	119.4032	231.4032				**Bath Room**		
L3 59	2.8	119.4032	231.4032				**Bath Room**		
L3 60	33.1	1411.516	2735.516	3.6	3400	3400	**Vip Room**	4 way cassette	AVXC4H036E
L3 61	5.5	234.542	454.542	Ventilation			**Bath Room**	------------	
L3 62	5.6	238.8064	462.8064				**Secur**	------------	
L3 63	33.3	3847.482	5179.482	5.6	5300	5300	**Vip Room**	4 way cassetre	AVXC4H056E
L3 64	5.7	658.578	886.578	Ventilation			**Bath Room**	------------	
L3 65	5.5	635.47	855.47				**Secur**	------------	
L3 66	50.3	2144.993	4156.993	4.5	4200	4200	**Oxygen Chamber**	4 way cassetre	AVXC4H045E
L3 67	5.7	243.0708	471.0708	Ventilation			**Bath Room**	------------	
L3 68	9	383.796	743.796				**Entrance**	------------	
L3 69	34.2	1458.425	2826.425	3.6	3400	3400	**Vip Room**	Vivace Wall mounted	AVXWVH036E
L3 70	4.7	200.4268	388.4268	Ventilation			**Bath Room**	------------	
L3 71	8.5	362.474	702.474				**Secur**	------------	
L3 72	28.2	1202.561	2330.561	2.8	2600	2700	**Vip Room**	Vivace Wall mounted	AVXWVH028E
L3 73	4.8	204.6912	396.6912	Ventilation			**Bath Room**	------------	
L3 74	7.7	328.3588	636.3588				**Secur**	------------	
L3 75	30	1279.32	2479.32	2.8	2600	2700	**Suite**	4 way cassette	AVXC4H028E

L3 76	5.3	226.0132	438.0132	Ventilation			**Bath Room**	------------	
L3 77	60.7	7013.278	9441.278	11.2	10500	10600	**Hall**	4 way cassette	AVXC4H112E
L3 78	249.5	28827.23	38807.23	11.2	(4)10500	10600	**Corridor**	4(4 way cassette)	4(AVXC4H112E)
L3 79	24.5	2830.73	3810.73	Ventilation			**Electric**	------------	
L3 80				Ventilation			**Trolly Parking**	------------	
L3 81	9.7	1120.738	1508.738	2.2	2100	2200	**R.Double**	Vivace Wall mounted	AVXWVH022E
L3 82	2.8	323.512	435.512	Ventilation			**Bathroom**	------------	
L3 83	19.5	2253.03	3033.03	3.6	3400	3400	**R.Double**	Vivace Wall mounted	AVXWVH036E
L3 84	2.9	335.066	451.066	Ventilation			**Bathroom**	------------	
L3 85	19.7	2276.138	3064.138	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 86	3	346.62	466.62	Ventilation			**Bath Room**	------------	
L3 87	18.3	2114.382	2846.382	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 88	3.7	427.498	575.498	Ventilation			**Bathroom**	------------	
L3 89	18.6	2149.044	2893.044	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 90	3.7	427.498	575.498	Ventilation			**Bathroom**	------------	
L3 91	18.7	2160.598	2908.598	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 92	3.7	427.498	575.498	Ventilation			**Bathroom**	------------	
L3 93	18.5	2137.49	2877.49	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 94	3.8	439.052	591.052	Ventilation			**Bathroom**	------------	
L3 95	4.7	543.038	731.038				**Space Room Store**	------------	
L3 96	35.5	5746.634	7166.634	9	8400	8400	**Suite**	4 way cassette	AVXC4H090E
L3 97	7.6	878.104	1182.104	2.2	2100	2200	**Bathroom**	------------	
L3 98	22.7	3674.608	4582.608	5.6	5300	5300	**Suite**	Vivace Wall mounted	AVXWVH056E
L3 99	6	693.24	933.24	Ventilation			**Bathroom**	------------	
L3 100	22.6	3658.42	4562.42	5.6	5300	5300	**Suite**	Vivace Wall mounted	AVXWVH056E
L3 101	5.7	658.578	886.578	Ventilation			**Bathroom**	------------	
L3 102	4.1	473.714	637.714				**Clean Line Trolley Bay**	------------	

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L3 103	35.6	5762.821	7186.821	9	8400	8400	**Suite**	4 way cassette	AVXC4H090E
L3 104	7	808.78	1088.78	Ventilation			**Bathroom**	------------	
L3 105	2.3	265.742	357.742				**Elect**	------------	
L3 106	8.3	958.982	1290.982				**Ante Room**	------------	
L3 107	14.8	1709.992	2301.992	2.8	2600	2700	**Isolation Room**	Vivace Wall mounted	AVXWVH028E
L3 108	4	462.16	622.16	Ventilation			**Bathroom**	------------	
L3 109	19.6	2264.584	3048.584	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 110	3	346.62	466.62	Ventilation			**Bathroom**	------------	
L3 111	19.6	2264.584	3048.584	3.6	3400	3400	**R.Single**	Vivace Wall mounted	AVXWVH036E
L3 112	3	346.62	466.62	Ventilation			**Bathroom**	------------	
L3 113	19.7	2276.138	3064.138	3.6	3400	3400	**R.Double**	Vivace Wall mounted	AVXWVH036E
L3 114	3	346.62	466.62	Ventilation			**Bathroom**	------------	
L3 115	19.8	2287.692	3079.692	3.6	3400	3400	**R.Double**	Vivace Wall mounted	AVXWVH036E
L3 116	2.7	311.958	419.958	Ventilation			**Bathroom**	------------	
L3 117	20.5	2368.57	3188.57	3.6	3400	3400	**R.Double**	Vivace Wall mounted	AVXWVH036E
L3 118	2.7	311.958	419.958	Ventilation			**Bathroom**	------------	
L3 119	28.7	3315.998	4463.998	5.6	5300	5300	**Rest Room**	4 way cassette	AVXC4H056E
L3 120	12.7	1467.358	1975.358	2.2	2100	2200	**Rest And Waiting Area**	Slim 1 way cassette	AVXCSH022E
L3 121	15.5	1790.87	2410.87	2.8	2600	2700	**N.S**	Vivace Wall mounted	AVXWVH028E
L3 122	6.7	774.118	1042.118	Ventilation			**Pantry**	------------	
L3 123	8	924.32	1244.32				**C.U**	------------	
L3 124	7.5	866.55	1166.55				**D.U**	------------	
L3 125	2.6	300.404	404.404				**Janitor Closet**	------------	
L3 126	2	231.08	311.08				**Bathroom**	------------	
L3 127	2	231.08	311.08				**Bathroom**	------------	
L3 128	2.5	288.85	388.85	Ventilation			**Changing Room**	------------	

# of room	Name	space	Heating load	Cooling load	Actual cooling	Actual heating	Nominal Capacity	Unit type	Unit code
l4 01	Heart surgery	53.6	6515.991	9195.991	10500	6800	11.2	4 way cassette	AVXC4H112E
l4 02	Pump room	8.7	1057.633	1492.633	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
l4 03	Equipment store	5.8	705.0886	995.0886					
l4 04	Sterile instrument store	8	972.536	1372.536	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 05	Scrub	4.3	522.7381	737.7381					
l4 06	Cesarean	43	5227.381	7377.381	8400	5300	9	4 way cassette	AVXC4H090E
l4 07	Resusetation	27.3	4549.818	5914.818	5600	4200	6	4 way cassette	AVXC4H060E
l4 08	Resusetation	28	4666.48	6066.48	5600	5300	6	4 way cassette	AVXC4H060E
l4 09	Resusetation	28	4666.48	6066.48	5600	5300	6	4 way cassette	AVXC4H060E
l4 10	Bathroom	2.3	279.6041	394.6041					
l4 11	Bathroom	2	243.134	343.134					
l4 12	Labor	20	3333.2	4333.2	4200	3400	4.5	4 way cassette	AVXC4H045E
l4 13	Labor	21	2552.907	3602.907	6700	2700	7.1	Vivace Wall mounted	AVXWVH071E
l4 14	Preparation recovery	29	4833.14	6283.14	6700	5300	7.1	Vivace Wall mounted	AVXWVH071E
l4 15	D.U	7.1	863.1257	1218.126	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 16	Bathroom	3.4	413.3278	583.3278					
l4 17	C.U	4.2	510.5814	720.5814					
l4 18	Linen bay	2.3	279.6041	394.6041					
l4 19	Sub sterile	7.5	911.7525	1286.753	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 20	Scrub	8.1	984.6927	1389.693	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 21	Corridor	96	11670.43	16470.43	2*8400	11700	9	4 way cassette	AVXC4H090E
l4 22	Air lock	12.2	1483.117	2093.117	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
l4 23	Corridor	63	2967.111	6117.111	6700	3400	7.1	Vivace Wall mounted	AVXWVH071E
l4 24	Operation	37	4497.979	6347.979	6700	4200	7.1	Vivace Wall mounted	AVXWVH071E
l4 25	Store	4.2	197.8074	407.8074					
l4 26	Nurse office	4.2	197.8074	407.8074					
l4 27	Holding	22.2	1045.553	2155.553	2600	2200	2.8	Vivace Wall mounted	AVXWVH028E
l4 28	Disposal	8.2	386.1954	796.1954					
l4 29	Changing room	11.8	555.7446	1145.745	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 30	Bathroom	1.7	80.0649	165.0649					
l4 31	Bathroom	2.2	103.6134	213.6134					
l4 32	SH	1.7	80.0649	165.0649					
l4 33	Shower	2	94.194	194.194					
l4 34	Changing room	10.7	503.9379	1038.938	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 35	Doctor room	7.7	362.6469	747.6469					
l4 36	N.R	5.1	240.1947	495.1947					

l4 37	N.R	12.4	584.0028	1204.003	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 38	JAN	3.5	164.8395	339.8395					
l4 39	UPS	3.2	150.7104	310.7104					
l4 40	Bathroom	1.8	84.7746	174.7746	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 41	Female lockers	6.8	320.2596	660.2596					
l4 42	Bathroom	1.8	84.7746	174.7746					
l4 43	Male lockers	8.1	984.6927	1389.693	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 44	Bathroom	2.2	103.6134	213.6134					
l4 45	Bathroom	2.2	267.4474	377.4474					
l4 46	Reception	7	850.969	1200.969	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 47	Waiting	11	1337.237	1887.237	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
l4 48	Assessment	8.4	1021.163	1441.163	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
l4 49	Stretchers	14.2	1726.251	2436.251	2600	2200	2.8	Vivace Wall mounted	AVXWVH028E
l4 50	Sub sterile	6.3	765.8721	1080.872	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 51	Sub sterile	6.6	802.3422	1132.342	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 52	Scrub	7.5	911.7525	1286.753	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 53	Transfer area	21.2	2577.22	3637.22	4200	2700	4.5	4 way cassette	AVXC4H045E
l4 54	Corridor	83.6	10163	14343	13100	10600	14	4 way cassette	AVXC4H140E
l4 55	Stretchers	47.2	5737.962	8097.962	8400	5900	9	4 way cassette	AVXC4H090E
l4 56	Operation theater	37.2	4522.292	6382.292	6700	5300	7.1	Vivace Wall mounted	AVXWVH071E
l4 57	N.S	6.6	802.3422	1132.342	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 58	Recovery	34.8	4230.532	5970.532	5600	4200	6	4 way cassette	AVXC4H060E
l4 59	CU	4.5	547.0515	772.0515					
l4 60	DU	4.3	522.7381	737.7381					
l4 61	Bed area ccu 5	16.4	772.3908	1592.391	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 62	Bed area CCU 4	16.8	791.2296	1631.23	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 63	JANTOR CLOSET	4.7	221.3559	456.3559					
l4 64	UPS	4.8	226.0656	466.0656					
l4 65	Bathroom	2	94.194	194.194					
l4 66	Bathroom	2	94.194	194.194					
l4 67	Pantry	4.2	197.8074	407.8074					
l4 68	INCUBATORS	73.1	8886.548	12541.55	2100	8400	2.2	Vivace Wall mounted	AVXWVH022E
l4 69	Bed area ICU1	19.1	2321.93	3276.93	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
l4 70	Bed area ICU2	20	2431.34	3431.34	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
l4 71	ICU N.S	22	1036.134	2136.134	2600	2200	2.8	Vivace Wall mounted	AVXWVH028E
l4 72	C.U	5.6	263.7432	543.7432					
l4 73	D.U	5.2	632.1484	892.1484					
l4 74	SPACE	2	94.194	194.194					
l4 75	NURSE office	7.3	887.4391	1252.439	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 76	Staff lounge	7	850.969	1200.969	2100		2.2	Vivace Wall mounted	AVXWVH022E

I4 77	Doctors lounge	8.5	1416.61	1841.61	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I4 78	Store	1.4	170.1938	240.1938					
I4 79	Anesthesia workroom	9.6	1167.043	1647.043	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I4 80	Anesthesia office	7.1	1183.286	1538.286	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I4 81	UPS	8.4	1021.163	1441.163	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I4 82	Mobile X-ray bay	4.6	559.2082	789.2082					
I4 83	Pharmaceutical store	19.2	3199.872	4159.872	4200	3400	4.5	4 way cassette	AVXC4H045E
I4 84	Store	5.2	632.1484	892.1484					
I4 85	BATHROOM	2	243.134	343.134					
I4 86	Corridor	83.2	10114.37	14274.37	13100	11200	14	4 way cassette	AVXC4H140E
I4 87	BED AREA CCU 3	21	3499.86	4549.86	5300	3400	5.6	Vivace Wall mounted	AVXWVH056E
I4 88	BED AREA CCU 2	27.7	4616.482	6001.482	6700	5300	7.1	Vivace Wall mounted	AVXWVH071E
I4 89	BED AREA CCU1	29.4	4899.804	6369.804	6700	5300	7.1	Vivace Wall mounted	AVXWVH071E
I4 90	BATHROOM	3.2	389.0144	549.0144					
I4 91	BED AREA ICU 4	26.7	4449.822	5784.822	5600	4200	6	4 way cassette	AVXC4H060E
I4 92	BED AREA ICU 3	14.5	2416.57	3141.57	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
I4 93	ANTE ROOM	5.6	680.7752	960.7752					
I4 94	ISOLATION ROOM 32	19.4	3233.204	4203.204	4200	3400	3.6	Vivace Wall mounted	AVXWVH036E
I4 95	BATHROOM	3.1	376.8577	531.8577					
I4 96	BATHROOM	1.6	75.3552	155.3552					
I4 97	BATHROOM	2	94.194	194.194					
I4 98	SPACE	2	94.194	194.194					
I4 99	BATHROOM	2.8	131.8716	271.8716					
I4 100	NEWBORN NURSERY	27.5	3343.093	4718.093	5300	3400	3.6	Vivace Wall mounted	AVXWVH036E
I4 101	MILK PREPE RATION	8.8	1069.79	1509.79	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I4 102	NEWBORN NURSERY	5	607.835	857.835					
I4 103	HALL	60.7	7379.117	10414.12	10500	8400	11.2	4 way cassette	AVXC4H112E
I4 104	MILK PREPE RATION	3.1	376.8577	531.8577					
I4 105	ELECT	2.3	279.6041	394.6041					

l4 106	R.single	18.6	2261.146	3191.146	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
l4 107	Bathroom	3.7	449.7979	634.7979					
l4 108	R.single	18.7	2273.303	3208.303	3400	2200	3.6	Vivace Wall mounted	AVXWVH036E
l4 109	Bathroom	3.7	449.7979	634.7979					
l4 110	R.single	18.5	2248.99	3173.99	3400	2200	3.6	Vivace Wall mounted	AVXWVH036E
l4 111	Bathroom	3.8	461.9546	651.9546					
l4 112	Space room store	4.7	571.3649	806.3649					
l4 113	Suite	35.5	5916.43	7691.43	8400	5900	9	4 way cassette	AVXC4H090E
l4 114	bathroom	7.6	923.9092	1303.909	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 115	Suite	22.7	3783.182	4918.182	5300	4200	5.6	Vivace Wall mounted	AVXWVH056E
l4 116	Bathroom	6	729.402	1029.402	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 117	Suite	22.6	3766.516	4896.516	5300	4200	5.6	Vivace Wall mounted	AVXWVH056E
l4 118	Bathroom	5.7	692.9319	977.9319					
l4 119	Clean linen trolley bay	4.1	498.4247	703.4247					
l4 120	Suite	35.6	5933.096	7713.096	8400	5900	9	4 way cassette	AVXC4H090E
l4 121	Bathroom	7	850.969	1200.969	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 122	Ante room	8.3	1009.006	1424.006	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
l4 123	Isolation room	14.8	1799.192	2539.192	2600	2200	2.8	Vivace Wall mounted	AVXWVH028E
l4 124	Bathroom	4	486.268	686.268					
l4 125	R.double	19.7	2394.87	3379.87	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
l4 126	Bathroom	3	364.701	514.701					
l4 127	R.double	19.7	2394.87	3379.87	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
l4 128	Bathroom	3	364.701	514.701					
l4	R.double	19.7	2394.87	3379.87	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E

129									
l4 130	Bathroom	3	364.701	514.701					
l4 131	R.double	19.8	2407.027	3397.027	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
l4 132	Bathroom	2.7	328.2309	463.2309					
l4 133	R.double	20.6	2504.28	3534.28	4200	2700	4.5	4 way cassette	AVXC4H045E
l4 134	Bathroom	2.7	328.2309	463.2309					
l4 135	Rest room	28.7	3488.973	4923.973	5300	3400	5.6	Vivace Wall mounted	AVXWVH056E
l4 136	Corridor	249.5	30330.97	42805.97	3*13100	3*11200	14	4 way cassette	AVXC4H140E
l4 137	Rest and waiting area	12.7	1543.901	2178.901	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
l4 138	N.S	15.5	1884.289	2659.289	2600	2200	2.8	Vivace Wall mounted	AVXWVH028E
l4 139	Pantry	6.7	814.4989	1149.499	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 140	C.U	8	972.536	1372.536	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 141	D.U	7.5	911.7525	1286.753	2100		2.2	Vivace Wall mounted	AVXWVH022E
l4 142	Janitor Closet	2.6	316.0742	446.0742					
l4 143	Bathroom	2	243.134	343.134					
l4 144	Bathroom	2	94.194	194.194					
l4 145	corridor	9.6	1167.043	1647.043	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E

# of Room	Name	Area	Heating load	Cooling load	Act.cooling	Act.heating	Nominal Capcity	Unit type	Unit code
I5 01	HALL	174.5	22468.62	31193.62	3*10500	2*10500	11.2	4 way cassette	AVXC4H112E
I5 02	******	******	******	0	0				
I5 03	CARDIOLOGY SECTION	17.8	3027.246	3917.246	4200	3400	4.5	4 way cassette	AVXC4H045E
I5 04	GYM SECTION	77.5	13180.43	17055.43	2*8400	2*8400	9	4 way cassette	AVXC4H090E
I5 05	T.F	8	1030.08	1430.08	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I5 06	T.M	6.5	836.94	1161.94	2100		2.2	Vivace Wall mounted	AVXWVH022E
I5 07	PALAKONA	0	0	0	0				
I5 08	ROOM 1	18.4	2369.184	3289.184	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
I5 09	BATHROOM	4.5	579.42	804.42	2100				
I5 10	ROOM 2	20	2575.2	3575.2	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
I5 11	BATHROOM	4	515.04	715.04	2100				
I5 12	MIN. SURG	16.1	2073.036	2878.036	3400	2200	3.6	Vivace Wall mounted	AVXWVH036E
I5 13	LOCK F	4	515.04	715.04	2100				
I5 14	CLINIC 3	17.7	2279.052	3164.052	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
I5 15	LOCK M	5	643.8	893.8	2100				
I5 16	STORE	143	18412.68	25562.68	2*13100	2*8400	14	4 way cassette	AVXC4H140E
I5 17	T.M	3	386.28	536.28					
I5 18	ENGINEERS	68.3	8794.308	12209.31	12000	8400	12.8	4 way cassette	AVXC4H128E

I5 19	WORK SHOP	39.2	5047.392	7007.392	6700	5300	7.1	Vivace Wall mounted	AVXC4H071E
I5 20	BATHROOM	8.5	1094.46	1519.46	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
+I5 21	******	0	0	0	0				
I5 22	STOR	3.3	424.908	589.908	2100				
I5 23	CORRIDOR	8.2	1055.832	1465.832	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I5 24	CORRIDOR SERVICE	22.7	2922.852	4057.852	4200	3400	4.5	4 way cassette	AVXC4H045E
I5 25	CORRIDOR	6.3	811.188	1126.188	2100		2.2	Slim 1 way cassette	AVXCSH022E
I5 26	SPECIAL R FEMALE	19	2446.44	3396.44	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
I5 27	SPECIAL R MALE	18	2317.68	3217.68	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
I5 28	PHISOTHER APY MALE SECTION	33.4	4300.584	5970.584	5600	4200	6	Mini 4 way cassette	AVXC4H060E
I5 29	PHISOTHER APY FEMALE SECTION	33.3	5663.331	7328.331	8400	5900	9	4 way cassette	AVXC4H090E
I5 30	PEDIATRIC SECTION	51.2	8707.584	11267.58	12000	8400	9	4 way cassette	AVXC4H090E
I5 31	EMPLOYEE	12.7	1635.252	2270.252	2600	2200	2.8	Vivace Wall mounted	AVXWVH028E
I5 32	MANAGER	9.5	1223.22	1698.22	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I5 33	REGISTRATI ON	16.6	2137.416	2967.416	3400	2200	3.6	Vivace Wall mounted	AVXWVH036E
I5 34	KITCHEN	5	643.8	893.8					

I5 35	BATHROOM	5	643.8	893.8					
I5 36	STEAM SAUNA	4.7	605.172	840.172					
I5 37	SAUNA	4.7	605.172	840.172					
I5 38	SHOWER	3.8	489.288	679.288					
I5 39	R. SINGLE	31	3991.56	5541.56	5300	4200	5.6	4 way cassette	AVXC4H056E
I5 40	POOL	11.2	1442.112	2002.112	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I5 41	JACUZZI	7	901.32	1251.32	2100		2.2	Vivace Wall mounted	AVXWVH022E
I5 42	KITCHEN	13.7	1764.012	2449.012	2600	2200	2.8	Vivace Wall mounted	AVXWVH028E
I5 43	EXAM 3	8.2	1055.832	1465.832	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I5 44	CHANGING	4.1	527.916	732.916					
I5 45	DARK M.	2.3	296.148	411.148					
I5 46	DARK F.	2.5	321.9	446.9					
I5 47	LASIK THEATRE	26.6	3425.016	4755.016	5300	3400	5.6	4 way cassette	AVXC4H056E
I5 48	CORRIDOR	11.6	1493.616	2073.616	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I5 49	SUB WAITING LASIK	50.2	6463.752	8973.752	8400	6800	9	4 way cassette	AVXC4H090E
I5 50	REGISTRATI ON	7.2	927.072	1287.072	2100		2.2	Vivace Wall mounted	AVXWVH022E
I5 51	T.F	3	386.28	536.28					
I5 52	C.U	4.5	579.42	804.42					
I5 53	PANTRY	7	901.32	1251.32	2100		2.2	Vivace Wall mounted	AVXWVH022E
I5 54	CORRIDOR	2.2	283.272	393.272					
I5 55	WATING AREA	26.6	3425.016	4755.016	5300	3400	5.6	4 way cassette	AVXC4H056E
I5 56	REGISTRATI	6.3	811.188	1126.188	2100		2.2	Vivace	AVXWVH022E

	ON							Wall mounted	
I5 57	CORRIDOR	2.1	270.396	375.396					
I5 58	BATHROOM	2.2	283.272	393.272					
I5 59	T.F	3	386.28	536.28					
I5 60	SUB WAITING	58.1	7480.956	10385.96	10500	8400	11.2	4 way cassette	AVXC4H112E
I5 61	EXAM 1	4.1	527.916	732.916					
I5 62	EXAM 2	4.6	592.296	822.296					
I5 63	ARGON LAZER	4.6	592.296	822.296					
I5 64	VISUAL FEILD	4.6	592.296	822.296					
I5 65	FFA	4.6	592.296	822.296					
I5 66	OCT	4.6	592.296	822.296					
I5 67	MIN. SURG	10.8	1390.608	1930.608	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I5 68	AB SCAN	4.2	540.792	750.792					
I5 69	YAG LAZER	4.6	592.296	822.296					
I5 70	CLINIC1	18.4	2369.184	3289.184	3400	2700	3.6	Vivace Wall mounted	AVXWVH036E
I5 71	CLINIC2	16.4	2111.664	2931.664	3400	2200	3.6	Vivace Wall mounted	AVXWVH036E
I5 72	SUB WAITING	24.1	3103.116	4308.116	4200	3400	3.6	Vivace Wall mounted	AVXWVH036E
I5 73	STAFF TOI	3.7	476.412	661.412					
I5 74	BATHROOM	3	386.28	536.28					
I5 75	BATHROOM	3.6	463.536	643.536					
I5 76	CORRIDOR	11.7	1506.492	2091.492	2100	2200	2.2	Vivace Wall mounted	AVXWVH022E
I5 77	PENTA	4.6	592.296	822.296					
I5 78	JANITOR	4	515.04	715.04					
I5 79	STAFF	14.4	1854.144	2574.144	2600	2200	2.8	Vivace Wall mounted	AVXWVH022E