Design Of the Mechanical System For Palestine Hotel in Ramallah

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In partial fulfilment of the requirements for the

Bachelor degree in refrigeration and air condition Engineering

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Abstract

This project aims to design the mechanical systems for Palestine Hotel which is located in Ramallah city. This Hotel consist of eleven floors with total area of 10321 m^2.

The design of this project include making the calculations, drawings, equipment selection and determine the table of quantity for the air conditioning system, ventilation system, water system, drainage system, the firefighting system. The calculation and the design processes are to be done using Revit Software. A Revit reports, table of quantities for all of the previous systems will also be included

الملخص :

يهدف هذا المشروع الى تصميم الانظمه الميكانيكيه الخاصه بفندق فلسطين الواقع في مدينة رام الله ، يتكون المبنى من احد عشر طابقا بمساحه اجماليه تقدر ب 10321 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 ،عمليات الحساب و التصميم واخراج جداول الكميات لهذه الانظمة ستتم باستخدام برنامج (Revit).

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Chapter 1: Introduction

1.1 Introduction

Throughout the ages, the human beings tried to improve their lives to be easier and more comfortable, and as the Wisdom says: “The necessity is the mother of invention” the engineers always try to meet the needs of humans to achieve the welfare of their lives. So, HVAC engineers developed the mechanical services systems and technologies to achieve the comfort, which the humans need in the buildings.

1.2 Project overview

Since old time human was looking for comfort conditions, at this time, human has designed mechanical systems to improve the comfort conditions that human need. Thus, to achieve these conditions of comfort the four relative atmospheric parameter should be maintained and controlled according:

1) Temperature of the inside space.
2) Humidity contents of the air.
3) Purity and quality of the inside air.
4) Air velocity and air circulation within the space.

In this project, will design mechanical systems that provide the conditions for the human comfort of the Palestine Hotel in Ramallah, through the use of the Rivet design program. This hotel includes 12 floors, with total area 10321 m^2 including one basement floor, the floors from 3^{rd} to 7^{th} floor are single rooms, the floors from 8^{th} to 10th are sweets and the 11^{th} and 12^{th} floors are also single rooms. The first three floors are for services, gymnasiums, theater, bank and restaurants.

1.3 Project objectives

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

1) Design the mechanical systems inside the hotel building.
2) Theoretical calculations for outside and inside conditions, heating and cooling load for the hotel.
3) Theoretical calculations and design of plumping system.
4) To be familiar with the mechanical drawings for all mechanical systems.
5) Firefighting, hot & cold water system.

1.4 Project choice and justification

1) This project will create sufficient experiences for the students, which would assist them to have an employment opportunity after graduation.
2) Such projects provide the opportunity to review what have been studied in the last four years in college of engineering.

1.5 Symbols

- HVAC: Heating Ventilation and Air Conditioning.
- VRV: Variable Refrigeration Flow.
- WSFU: Water supply fixture unit, it’s used to calculate the portable maximum water demand for the building.
- GPM: gallon per minute.

1.6 Time Table

Table 1.1: 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 design information															
Search for previous projects															
Start learning Revit software															
Start the editing of the architectural file															
Starting a manual sample calculating’s of the loads															
Starting calculating the loads Using Revit															
Project Documentation															
Project Printing															

Table 1.2: Time table

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:

The main objective of the air conditioning is to maintain the environment in enclosed spaces at conditions that induced the feeling of comfort to all occupants of the space. This feeling of comfort is influenced by a number of main related parameters which are the inside temperature, the humidity and the outside design condition.

2.2 Human comfort

2.2.1 Introduction of 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 (hidden) heat energy that is absorbed or released when the phase of a substance is changed. For example, when liquid water is converted to steam, or when Steam is converted to liquid water.

The necessity for comfort air conditioning system 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.

2.2.2 Factors affecting human comfort

1) Dry Air: air that has air that has no any water vapor.
2) Moist Air: air that is a mixture of dry air and any amount of water vapor generally, air with a high relative humidity.
3) Humidity: is the amount of water vapor in the air.
4) Saturation: the state of being saturated or the action of saturating.
5) Dry Bulb Temperature: temperature that is usually thought of as air temperature.
6) Wet Bulb Temperature: is the temperature a parcel of air would have if it were cooled to saturation (100% relative humidity) by the evaporation of water into it.
7) Dew-Point Temperature: the temperature at which water vapor starts to condense out of the air (the temperature at which air becomes completely saturated). Above this temperature the moisture will stay in the air.

2.3 Calculations of overall heat transfer coefficient U:

The overall heat transfer coefficient depends on the layers that the walls, floor and roof consist of and the inside and outside convection heat transfer coefficients. So the overall heat transfer coefficient can be calculated by applying the following equation:

$$\mathrm{U} = \frac{1}{R_{th}} = \frac{1}{\frac{1}{\mathrm{h_i}}+\frac{\Delta \mathrm{x}_1}{\mathrm{k}_1}+\frac{\Delta \mathrm{x}_2}{\mathrm{k}_2}+\cdots+1/\mathrm{h}_0} \quad \mathbf{(2.1)}$$

Where:

U: is the overall coefficient [$W/m^2.c^0$]

Δx: the thickness of the wall. [m].

h_i : Convection heat transfer coefficient (surface conductance) for inside air ($h_i = 9.37\ W/m^2.C^0$) from the Palestinian code.

h_0 : Convection heat transfer coefficient (surface conductance) for outside air ($h_0 = 22.7\, W/m^2.C^0$) From the Palestinian code A: flat plane surface area [m^2]

2.3.1 The Overall heat transfer coefficient (U):

Calculation of overall heat transfer coefficient for walls, ceiling, floor, glass and door

1) For external wall

Table 2.1: construction of external walls

	Materiel	Δx(m)	k (W/m.ºC)
1	Stone	0.05	2.2
2	concrete	0.15	1.75
3	Polyurethane	0.05	0.03
4	Cement brick	0.1	0.9
5	Plaster	0.02	1.4

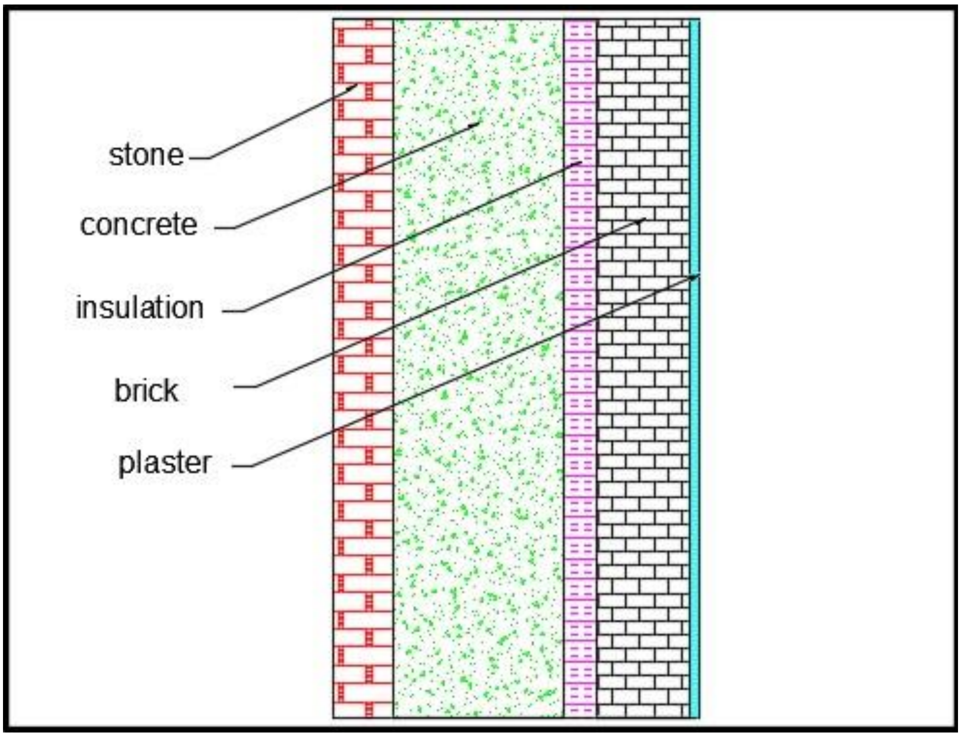


Figure 2.1: External wall construction

R_{in} and R_{out} for the external walls as 0.12 and 0.04(m^2/W.°C), respectively from table (A-27) .

$$Uout = \frac{1}{Rin + \frac{\Delta x_{st.}}{k_{st.}} + \frac{\Delta x_{con.}}{k_{con.}} + \frac{\Delta x_{poly.}}{k_{poly.}} + \frac{\Delta x_{Brick}}{k_{Brick}} + \frac{\Delta x_{plaster}}{k_{plaster}} + Rout} \quad \textbf{(2.2)}$$

$$U = \frac{1}{0.12 + \frac{0.05}{2.20} + \frac{0.15}{1.75} + \frac{0.05}{0.03} + \frac{0..1}{0.9} + \frac{0.02}{1.4} + 0.04}$$

U= 0.85 W/m^2 °C

2) For Internal Wall:

Table 2.2: Construction of internal wall

	Materiel	Δx(m)	k (W/m.ºC)
1	Plaster	0.02	1.4
2	brick	0.1	0.9
3	Plaster	0.02	1.4

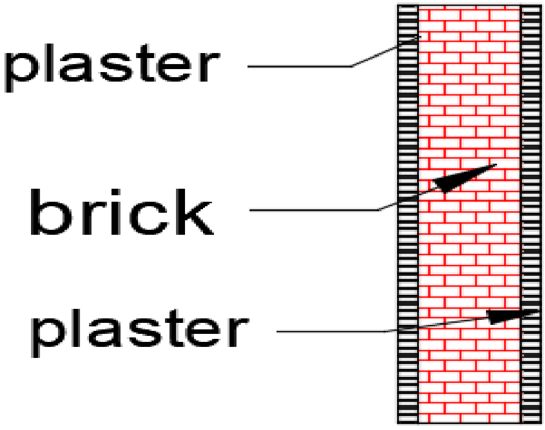


Figure 2.2: internal wall construction

$$Uin = \frac{1}{2\ Rin\ + \frac{\Delta x_{Brick}}{k_{Brick}} + 2*(\frac{\Delta x_{plaster}}{k_{plaster}})} \quad (2.3)$$

$$= \frac{1}{0.12 + \frac{0.1}{1} + 2*(\frac{0.02}{1.4}) + 0.12}$$

$$= 2.6(W/m^2.°C).$$

3) For Ceiling:

Table 2.3: Construction of celling

	Materiel	Δx(m)	k (W/m.ºC)
1	Asphalt mix	0.02	0.8
2	Concrete	0.05	1.75
3	polystyrene	0.03	0.03
4	Reinforced concrete	0.03	1.75
5	Brick	0.14	0.9
6	Plaster	0.02	1.4

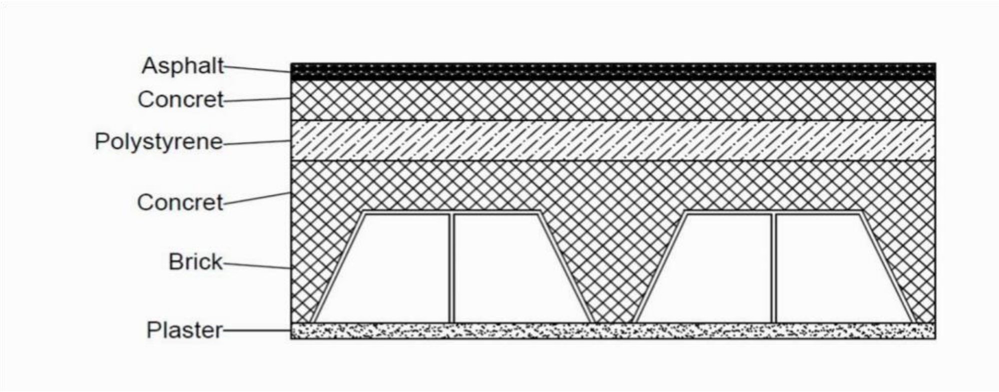


Figure 2.3: Ceiling construction

Because of its construction, the ceiling is divided into two overall heat transfer coefficient one with brick and the other without.

R_{in} and R_{out} for the ceiling are 0.1 and 0.04($W/m^2.°C$), respectively from Table (A-27)

$$U_1 = \frac{1}{Rin+\frac{\Delta x_{asph.}}{k_{asph.}}+\frac{\Delta x_{conc.}}{k_{conc.}}+\frac{\Delta x_{poly.}}{k_{poly.}}+\frac{\Delta x_{conc.}}{k_{conc.}}+\frac{\Delta x_{Brick}}{k_{Brick}}+\frac{\Delta x_{Plaster}}{k_{Plaster}}+Rout} \qquad \textbf{(2.4)}$$

$$= \frac{1}{0.1+\frac{0.02}{0.70}+\frac{0.05}{1.75}+\frac{0.03}{0.04}+\frac{0..05}{1.75}+\frac{0.2}{0.95}+\frac{0.02}{1.4}+0.04}$$

$= 0.832\ (W/m^2.°C)$.

Similarly, $U_2 = 1.01(W/m^2.°C)$

4) For floor:

Table 2.4: Construction of floor

	Materiel	Δx(m)	k (W/m.ºC)
1	Reinforced concrete	0.15	1.75
2	Aggregates	0.10	1.05
3	Mortar	0.02	0.16
4	Ceramic tiles	0.02	1.2

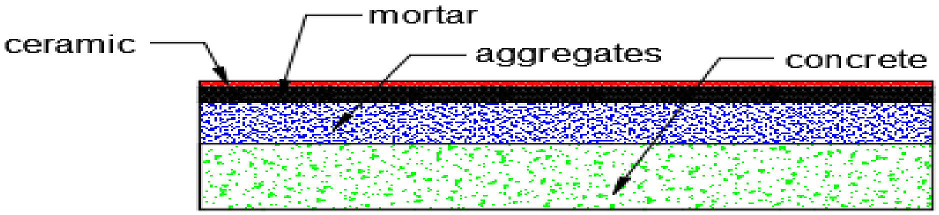


Figure 2.3: Floor construction

$R_{in} = 0.15(W/m^2.°C)$, from Table (A-27)

$$U = \frac{1}{Rin + \frac{\Delta x_{conc.}}{k_{conc.}} + \frac{\Delta x_{Aggregates.}}{k_{Aggregates.}} + \frac{\Delta x_{Mortar}}{k_{Mortar}} + \frac{\Delta x_{Ceramic\ tiles}}{k_{Ceramic\ tiles}}} \quad \textbf{(2.5)}$$

$$= \frac{1}{0.15 + \frac{0.15}{1.75} + \frac{0.1}{1.054} + \frac{0.02}{0.16} + \frac{0.02}{1.2}}$$

$$= 1.9\ (W/m^2.°C).$$

5) For glass from Table (A-28), $Uglass = 3.2(W/m^2.°C)$for double glass aluminum frame.
6) For door from Table (A-29), $Udoor = 3.6(W/m^2.°C)$ for wood door type.

2.4 Outdoor and indoor design conditions:

These conditions include the dry bulb temperature, relative humidity, and the average air speed. These values were obtained from the Palestinian code and the psychometric chart in Ramallah whether.

Table 2.5: Design condition

Design Property	Inside Design		Outside Design	
	Summer	Winter	Summer	Winter
Temp (°C)	23	22	35	1
R.H (%)	55	55	45	80
Wind Speed (m/s)	-	-	1.4	1.4

2.4.1 Heat loss calculations:

The main resources of heat loss come from the walls, floor, ceiling, doors, and windows and comes from the infiltration. To calculate each one of them the following equations are to be use:

$$Q = A \times U \times \Delta T \tag{2.6}$$

Where:

Q : Is the heat transfer rate. [kW]

A: Is the area of the plane wall perpendicular to the heat flow. [m^2]

ΔT: Is the difference between the inside and outside temperatures [℃]

U: Is the overall heat transfer coefficient. [$W/m^2.$℃]

2.4.2 Total heat load calculations

Total heat load calculations for the sample room:

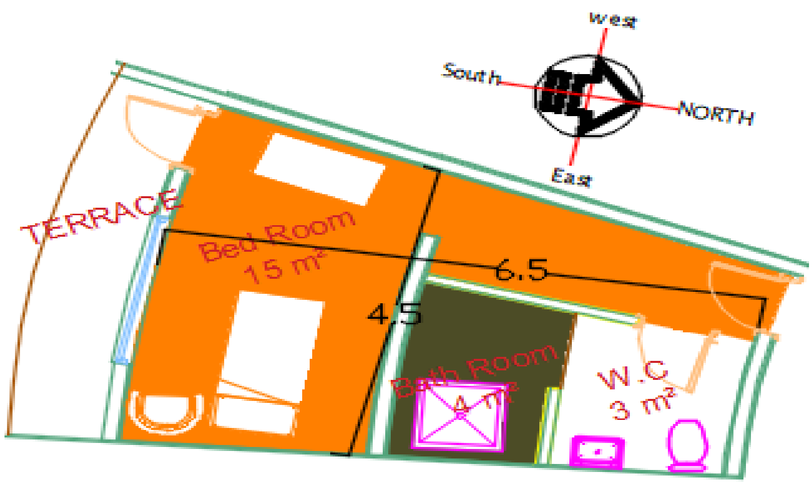


Figure 2.4: Sample room

Heat loss through ceiling ($\dot{Q}c$):

Because of its construction, the ceiling is divided into two areas.

$\dot{Q}_c = U_c A_c (T_i - T_o)$ **(2.7)**

$= (U_1A_1 + U_2A_2) (Ti - T_o)$

$\dot{Q}_c = (0.82 \times 0.8 \times 4.5 \times 6.5 + 1.01 \times 0.2 \times 4.5 \times 6.5) (22-1)$

$\dot{Q}_c = 527$ W

Heat loss through walls ($\dot{Q}_w$):

The external wall area is

A east wall = 6.5×4 =26 m^2

A north wall =4.5 × 4 =18 m^2

The heat loss from external wall

$\dot{Q}_{w,ex} = (U_{w,ex} A_{w,ex})(T_i - T_o)$

= 0.85 × (26+18)(21) = 785.5 W

There is one space beside the guest room, which is unconditioned, so heat loss from unconditioned walls:

The unconditioned temperature is calculate by equation (2.3)

T_{un}= 0.5 (Ti - To) **(2.8)**

= 0.5 (22 - 1) = 10.5 °C

There is one internal wall and the area of internal wall is :

Aw, in1= 4.5 × 4= 18 -2 = 16 m^2

Where: Aw is the area of the wall.

The heat loss from internal walls

$\dot{Q}_{w,un.} = Uun_{.} \times A_{w,un.}(Ti - T_{un.})$

= 2.6 × 16 × (21 - 10.5)

= 470 W

Heat loss through windows ($\dot{Q}glass$):

$\dot{Q}glass$ = Ug Ag (Ti - To)

= (2.9) (2 ×1.5) (22-1) = 180 W

Heat loss through external door

$\dot{Q}door$**:** = Ud Ad (Ti - Tun.)

= (3.6) (2) (22-10.5) = 82.8 W

Heat loss through infiltration ($\dot{Q}_{inf}$):

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 and the outside wind velocity or the pressure difference between the outside and inside of the room.

The total heat load due to infiltration is given by the equation:

$$Q_{inf} = \frac{1250}{3600} * V_f * \Delta T \quad \textbf{(2.9)}$$

Where:

T_{in}: inside design temperature (°C).

T_{out}: outside design temperature (°C)

Vf: The volumetric flow rate of infiltrated air in (m^3/h)

$$Vf = k*L\,[0.613(S1*S2*v_0)^2]^{2/3} \quad \textbf{(2.10)}$$

Where:

K: the infiltration air coefficient

L: the crack length in meter.

S_1: Factor that depends on the topography of the location of the building

S_2: Coefficient that depends on the height of the building.

V_o: measured wind speed (m/s)

The value of K, S_1 and S_2 is obtained from Tables (A-13), (A-19) and (A-20) Respectively.

K =0.43, S1=0.9, S_2= 0.94.

V_O = 1.4 (m/s) from Palestinian code and Length= 2Width + 2Hieght for door

L_{door} = 6 m

Length = 2 Width + 3 Height   for double sliding window

L_W = 8.5m

L_{total} = 14.5

Therefor V_f door = $0.43*6\ [0.613(0.9*0.94*1.4)^2]^{2/3} = 2.3\ m^3/h$

$Vf_w = 0.43*8.5\ [0.613(0.9*0.94*1.4)^2]^{2/3} = 3.31\ m^3/h$

$Qinf_w = \frac{1250}{3600} * Vf_d * \Delta T = 0.347 * 2.3 * 11.5 = 9.18$ W

$Qinf_w = \frac{1250}{3600} * Vf_w * \Delta T = = 0.347 * 3.31 * 11.5 = 13.21$

$Qinf = Qinf_d + Qinf_w = 22.4$ W

Heat gain due to ventilation

The ventilation is used for maintaining a healthy indoor air by introducing a fresh air from outside of the building. And this kind of heat gain can be calculated by using the Following equations:

$Q_{vent.} = \dot{m} \times (ho - hi)$

ṁ: Mass flow rate of ventilation air (kg/s).

$$\dot{m} = \frac{\text{Rate of ventilation air}}{\text{vo}}$$

Rate of ventilation = NO.of people × Required outside ventilation air

Where

vo :specific volume of the outside air

ṁ = mass flow rate of the ventilation air

Vo: volumetric flow rate of the ventilation air .

vo=0.895 m3/kg

Vo = 8 ×2 = 16 L/s = 0.016 m^3 /s.

$\dot{m}$ = 0.016/ 0.895

= 0.017 kg/s.

Q_{vent}.= 0.017 × 1000 × (73-49) =408 W

The total heating load for the sample room is

Q_{tot} = 2497W

The total heating load for the entire project is

Table 2.6: Heating load for each floor

Floor	$\dot{Q}$ (kW)
Ground	156
First	40
Second	112
Third	32
Forth	46
fifth	35
sixth	35
seventh	22
eighth	22
ninth	21.3
tenth	21.3
eleventh	16
twelfth	16.5
Total	544

Chapter 3: Cooling Load Calculation

3.1 Introduction

The cooling load is defined as the rate at which heat energy must be removed from a space in order to maintain a given inside design condition.

To achieve the human comfort conditions it is needed to do some calculation to select the proper equipment to have the conditions that it is needed and the cooling load is the most important load that can helps in selecting the equipment that needed correctly.

3.2 Cooling load

The total cooling load of a structure involves:

1) Sensible heat gain through walls, floors and roof.
2) Sensible heat gain through windows.
3) Sensible heat and latent heat gain from ventilation.
4) Sensible and latent heat due occupancy.
5) Sensible heat gain from the equipment.

3.2.1 Cooling load calculations:

Total cooling load calculations for the sample room:

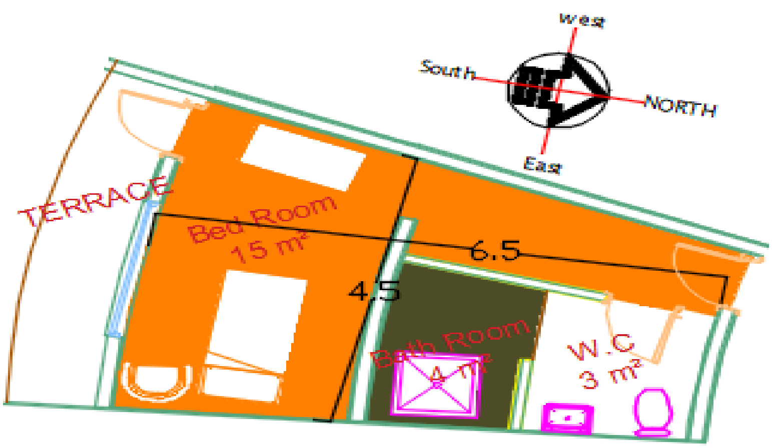


Figure 3.1: Sample room

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

The heat transfer rate through sunlit walls or sunlit roofs is calculated from the following equation:

$$Q = U.A. (CLTD)_{corrected} \quad \textbf{(3.1)}$$

Where:

$(CLTD)_{correct.}$ Corrected cooling load temperature difference, ˚

$$(CLTD)_{correct.} = (CLTD + LM)\,k + (25.5 - Tin) + (T_{o,m} - 29.4)\,f \quad \textbf{(3.2)}$$

Where:

CLTD: cooling load temperature difference, ˚, from Table (A-3)
LM: latitude correction factor, from Table (A-25)

K: color adjustment factor.

Tin: inside comfort design temperature, ˚

f: attic or roof fan factor.

Tom: outdoor mean temperature, ˚

$$Tom = (Tmax + Tmin)/2 \quad \textbf{(3.3)}$$

Where:

Tmax: maximum average daily temperature, ˚

Tmin: minimum average daily temperature, ˚

Tmax = 35 ˚ and Tmin = 29 ˚ are obtained from Palestinian code for August

Applying these values in equation (3.3) to obtain the outdoor mean temperature

$T_{o,m}$ = 32 ˚ .

3.3 Sample calculation

Calculation the heat gain from the Guest room in the last floor as a sample:

Heat gain through sunlit roof ($Q°_{Roof}$):

C LTD = 15˚ from Table A (7)

LM = 1

k = 0.5 for permanently light colored roofs.

f = 1 there is no attic or roof fan.

$(CLTD)_{corr.}$ = (15+ 1) 0.5 + (25.5 - 22) + (32 - 29.4) 1=14.1

$\dot{Q}_{Roof} = U_c\ A_c\ CLTD_{corr}$

$= (U_1A_1 + U_2A_2)\ CLTD_{corr}$

$\dot{Q}_r$ = (0.82 ×0.8 ×4.5 ×6.5 + 1.01×0.2×4.5 ×6.5)14.1

$\dot{Q}_r$ = 362 W

Heat gain through sunlit walls (Q_{Wall}):

East Wall:

CLTD =9 c

LM =0

F = 1

k = 0.5 for permanent medium color walls.

(CLTD) corr.E, = (9+0) 0.5+ (25.5-22) + (32-29.4) × 1 =14.1°

South Wall:

CLTD = 8 c°

LM = -1

k = 0.5 for permanent medium color walls.

F = 1

$(CLTD)_{corr.}$E, = (8- 1) 0.5+ (25.5-22) + (32-29.4) × 1 = 10.4 °

Q˙east Wall = U* A* CLTD corr

= 0.85*6.5*4*11.4

= 251.94 W

Q sw = U* A* CLTD corr

$= 0.85*4.5*4*10.4 = 159.12W$

$Q^{\cdot}$ internal Wall = U* A* ΔT

$\dot{Q}_{w,un.} = U_{un.} \times A_{w,un.}(Ti - T_{un.})$

$= 2.6 \times 16 \times (21 - 10.5)$

= 470

$Q^{\cdot}_{Wall} = 881.02$ W

Heat gain due to glass (Q Glass):

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

1) Transmitted component: it represents the largest component, which is transmitted directly into the interior of the building or the space. This component represents about 42% to 87% of incident solar radiation, depending on the glass transmissibility value.
2) Absorbed component: this component is absorbed by the glass itself and raises its temperature. About 5 to 50% of solar radiation it absorbed by the glass, depending on the absorptive value of the glass
3) Reflected component: this component is reflected by the glass to the outside of the building. About 8% of the solar energy is reflected back by the glass.

The amount of solar radiation depends upon the following factors:

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

The maximum cooling load due to the glass window Q Glass, consists of transmitted (Q tr.), and convicted (Q conv.) cooling loads as follows:

$$Q\ Glass = Q\ tr. + Q\ conv. \qquad \textbf{(3.4)}$$

Where:

Qtr.: transmission heat gain, W

Qconv.: convection heat gain, W

SHG: Solar heat gain factor: this factor represents the amount of solar energy that would be received by floor, furniture and the inside walls of the room and can be extracted, from Table (A-12)

SC: Shading coefficient: this factor accounts for different shading effects of the glass wall or window and can be extracted from Table (A-10) for single and double glass without interior shading or from Table (A-11) for single and double glass as well as for insulating glass with internal shading.

CLF: Cooling load factor: which Represent the effect of the internal walls, floor, and furniture on the instantaneous cooling load, and extracted from Table (A-8), and (A-9) for glass, and from Table (A-5) and (A-6), for lights and occupants respectively.

The transmitted cooling load is calculated as follows:

Q tr. = A (SHG) (SC) (CLF) **(3.5)**

SHG in W/m2 … from Table (A-12)

A = 3 m2

SHG = 350 W/m m

SC = 0.83… reflective double from Table A (2.14)

CLF = 0.42 … from Table A (2.16)

Qtr. N = 3 × 350 × 0.83 × 0.42

= 366 W

Q conv. = UA (CLTD) corr. **(3.6)**

Where:

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

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

$(CLTD)_{corr.}$: is calculated as the same of walls and roofs and the CLTD value for Glass is obtained from Table (A-7)

C LTD = 11 ˚ at 14:00 o'clock

k = 1 for glass

f = 1 for glass

Q conv. = U× A× CLTD

= 2.9×3×11

= 96 W

Q Glass = Q tr. + Q conv.

= 96+366 =462W

Heat gain due to lights ($\dot{Q}$ Lt.):

Heat gains due to lights are sensible loads and are calculated by the following equation:

$\dot{Q}$ Lt. = light intensity × A × (CLF) Lt. **(3.7)**

Where:

Light intensity = 10-30 W/ m^2 for apartment, so we will take 20W/ m^2

A: floor area = 29.25 m^2

(CLF)Lt.: cooling load factor for lights.

(CLF)Lt. = 0.82 … from Table (A-5) for 8 hours

Q Lt. = 20 × 29.25 × 0.82

= 479.7 W

Heat gain due to infiltration (Q f):

As the same way in heating load so the total infiltrated load is:

$Qinf = Qinf_d + Qinf_w = 22.4$ W

Heat gain due to occupants (Qoc.):

Sensible and latent heat gains from occupants must be removed from the conditioned space. The heat gain due to occupants is the following:

Q oc. = Q sensible + Q latent

(3.11) Q sensible = heat gain sensible × No. of people × (CLF) oc.

(3.12) where: (CLF) oc.: cooling load factor due to occupants.

Heat gain sensible = 70 very light work … from Table A (2.18)

No. of people = 2

(CLF) oc. = 0.84 at 9 hours after each entry into space is obtained from Table (A-21)

Q sensible = 70 × 2× 0.84 =117.6

Q latent = heat gain latent × No. of people **(3.8)**

Heat gain latent = 44… very light work from Table (A-21)

Q latent = 44 × 2 =88W

Q oc. = 117.6 + 88 = 205.6 W

Heat gain due to ventilation (Qvn.):

As the same way in heating load so the total ventilation load is

Q_{vent}.= 0.017 × 1000 × (73-49) = 408 W

The total heat loss from Sample Room is:

QTot = Q Roof + QWall + Q Glass + Q Lt + Qf + Q oc. + Q vn.

= 2820.76 W

Cooling Load Summary is listed in the following table:

Table 3.1: Cooling load for each floor

Floor	**Q(kW)**
Ground	**167.1**
First	**156.6**
Second	**148.5**
Third	**109.7**
Forth	**72.1**
fifth	**60.26**
sixth	**60.43**
seventh	**36.7**
eighth	**36.2**
ninth	**36.2**
tenth	**36.2**
eleventh	**21**
twelfth	**21**
Total	**1000.4**

Chapter 4: Plumbing system

4.1Introduction

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

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

Water supply system, there are two basic types of water distribution systems for building:

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

in this project up feed distribution system is to be used , the domestic water for the hotel is supplied from a well , Usually the water pressure at the supply point of the municipality be between (35-50) psi, this water enters the well of the hotel and then by using pump which pumping the water to the floors.

Minimum pressure required in the top floor is usually (8) psi and maximum pressure on the lowest floor should not exceed (80) psi otherwise pressure reducing valves are used to reduce the pressure.

4.2 Water Supply system:

The main objective of water supply system is to provide the building with the needed amount of water for daily use, such as drinking, cooking, washing and flushing, bathing, and irrigation.

4.2.1 The design procedure:

Step1: Determine if the suitable system is up-feed or down-feed.

Step2: Determine the number of risers needed and their location.

Step3: Calculate the total water supply fixture unit (WSFU), and then convert to gallon per minute (gpm).

Step4: Determine the minimum flow pressure for the critical fixture unit (fu).

Step5: Calculate the total static head.

Step6: Calculate the pipe friction and equivalent length of the system.

Step7: Use the chart to determine the recommended pipe size.

4.2.2 Calculations of the hot and cold water demand:

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

This technique gives each plumbing fixture a number of wsfu these numbers are to be added to each other for the whole building and then converted to gallons per minutes of water

In case of separating cold and hot water , to calculate the cold water demand the wsfu of the fixture is to be multiplied by 0.75 and to calculate the hot water demand the same way is followed but only with plumbing fixtures that contain hot water

The technique is followed and the following table contains the number of fixtures in each floor, the summation of wsfu for each floor, the cold water fixture unit in each floor converted from the wsfu and the hot water fixture unit converted from wsfu for those fixtures contains hot water.

The following Table shows the water supply fixture unit for all floor plans:

Table4.1: water supply fixture unit

Floor	Number of fixtures		Water fixture unit	Cold water fixture unit	Hot water fixture unit
parking	12		27	21	3
Ground floor	31		61	44	7
First floor	30		62	41	12
Second floor	13		28	19	4
Third floor	10		21	14	3
Fourth floor	29		59	38	13
Fifth floor	46		91	39	23
Sixth floor	46		91	39	23
Seventh floor	20		40	24	13
Eighth floor	20		40	24	13
Ninth floor	20		40	24	13
Tenth floor	20		40	24	13
Eleventh floor	24		52	30	12
Twelfth floor	24		52	30	12
Total	345		704	407	164

4.3 Pipe sizing calculations

The system is divided to two risers for cold water and one riser for hot water.

4.3.1 First riser:

This riser carries the total amount of water needed for the hotel from the water well in case of problems in the main water supply from the municipality, supplies the first four floors with cold water demand and feeds a second pump which distributes the water for the rest floors also will supply water for the hot water boiler which located in fourth floor.

- **Pipe sizing:**

In order to calculate the size of each pipe in the water supply system, friction head , static head minimum flow pressure are to be calculated by using the up-feed distribution system equation and For the network the water velocity is not to exceed 8 f/s.

UP-Feed distribution system equation:

Main pressure (pump pressure) = Static head + Pipe friction + Flow pressure

Where:
Static head: is the level difference between the water source and the critical fixture unit outlet.

Pipe friction: the friction head comes from the friction between water and pipes.

Flow pressure: is the minimum flow pressure required at the faucet outlet = 8psi.

Static head = distance from basement to fourth floor + sink faucet outlet height.
= 22 + 1 = 23 m and equals to 75ft
Then the static pressure = static head * 0.433 psi/ft. = 75 * 0.433 = 32 psi.

- **Pipe friction:**

Suppose that the head of the pump for this riser is 50 psi
Pipe friction = pump head – static head – flow pressure = 50 – 32 – 8 = 10 psi
Friction head loss coefficient = Friction Head / Total Equivalent Length of the pipe.

Total Length is the pipe length from the water source to the farthest fixture and equals to 50 m= 165ft. while,
Total Equivalent Length (TEL) = Total Length * 1.5 = 247.5 ft.

Then, Friction head loss coefficient = 10 / 248 = 0.0403 psi /ft. = 4.03 psi/100ft.

So this number 4.03 psi/100ft. is to be used to determine the pipe sizes throw the network.

The water flow in this riser is obtained by converting WSFU to gallons per minutes
Then and by using interpolation from table 9.4 the required flow is
Hot and cold water = 157 gpm.

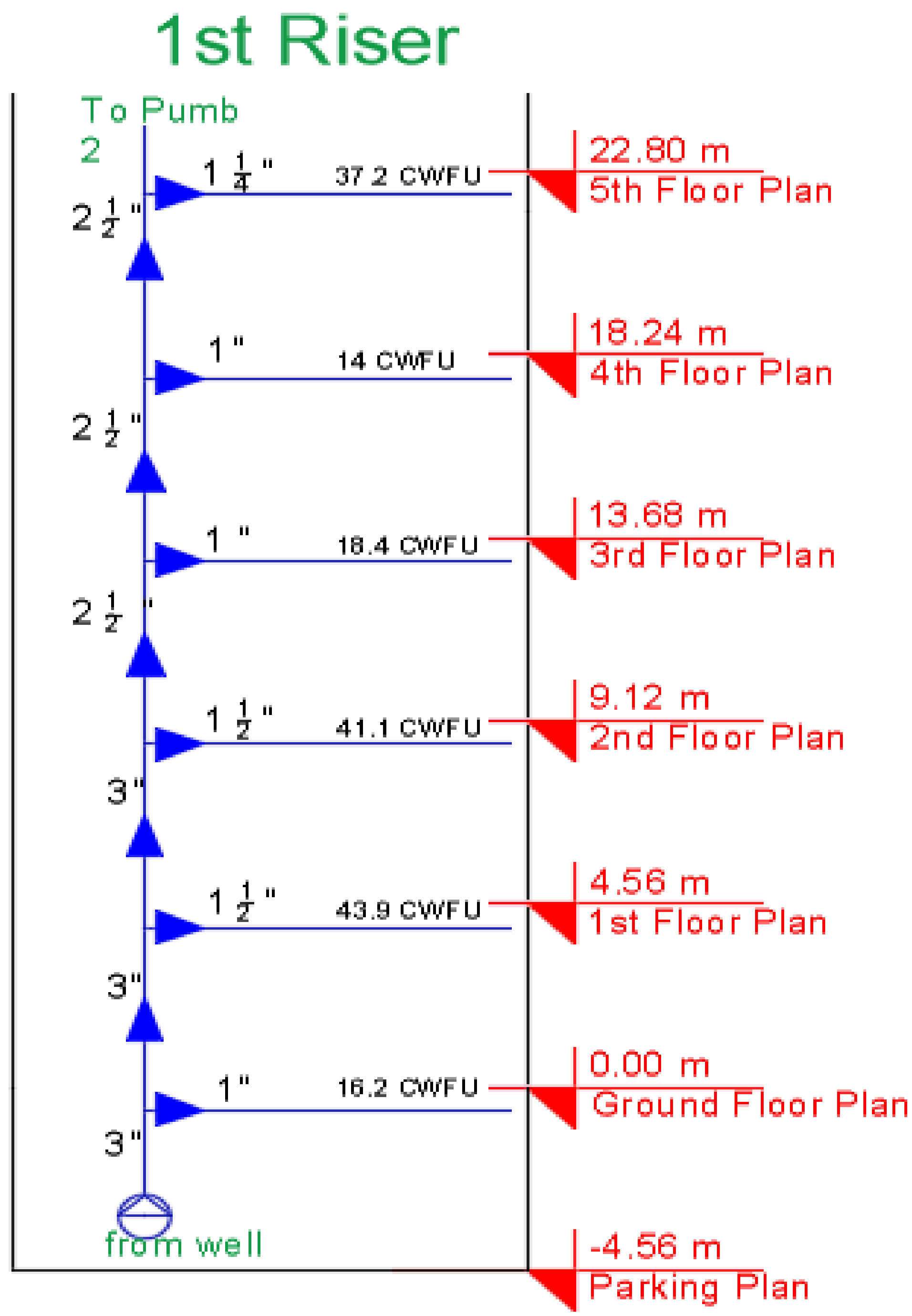


Figure 4.1: First riser

- **Selection for the first pump**

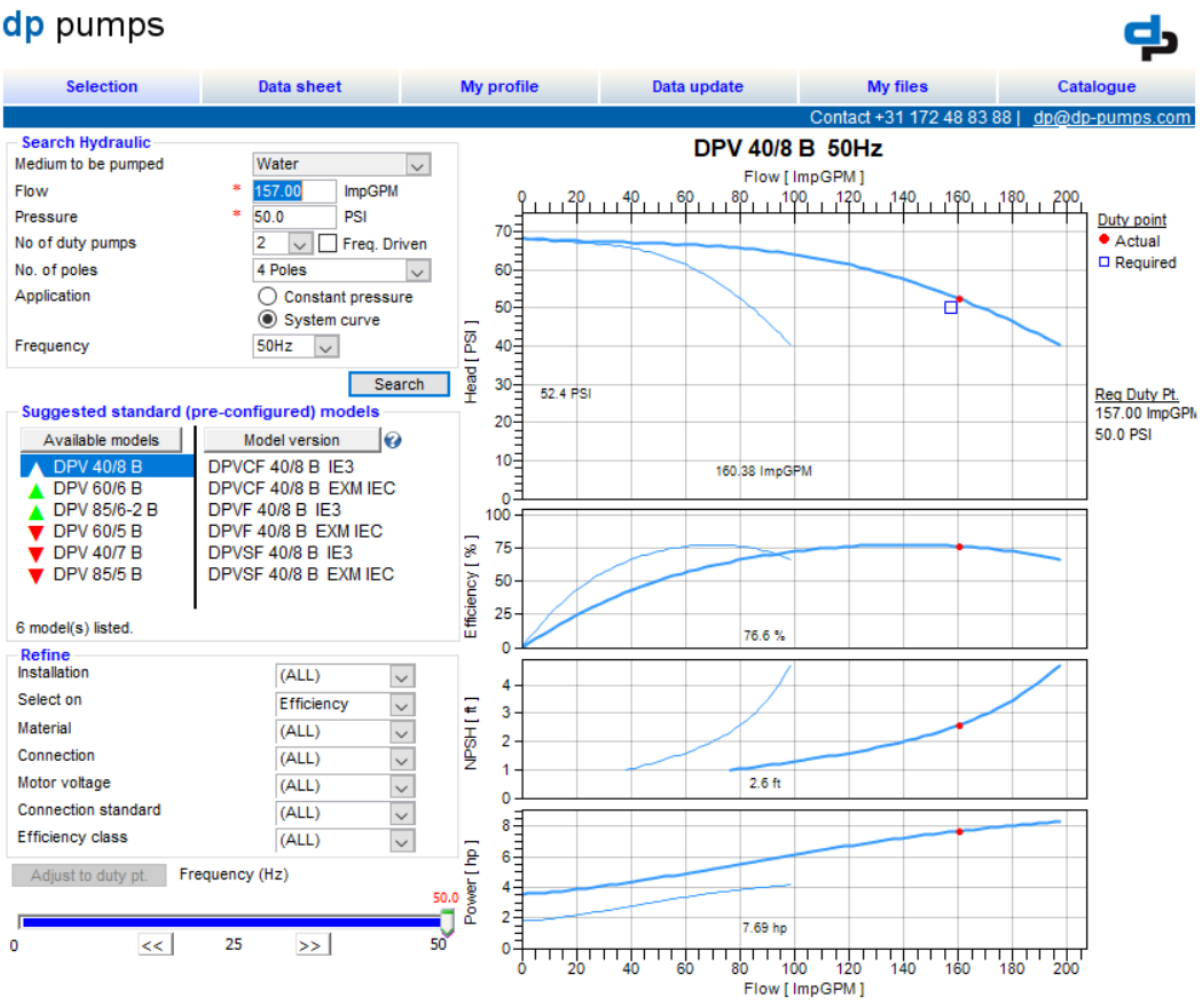


Figure 4.2: Selection for the first pump

4.3.2 Second riser

This riser will receive the water from the first pump or from the municipality line and by another pump it will distribute cold water for floors from fifth to twelfth. And by making the same calculation procedure for the first riser.

Main pressure (pump pressure) = Static head + Pipe friction + Flow pressure.

Static head = distance from fourth floor to twelfth floor + sink faucet outlet height
= 37 +1 = 38 m = 123.34 ft.
then the static pressure = 55.3 psi.
Total length = 196.8 ft.so TEL = 196.8 * 1.5 = 295.2 ft.
Friction loss = friction loss coefficient * TEL = 295.2 * 0.0403 = 11.8 psi.

Then 2nd pump pressure = 55.3 + 11.8 + 8 = 75.1 psi.

The water flow in this riser is cold water demand for floors from 4th to 12th and obtained by converting WSFU to gallons per minutes then and by using interpolation from table 9.4 the required flow is 72 gpm.

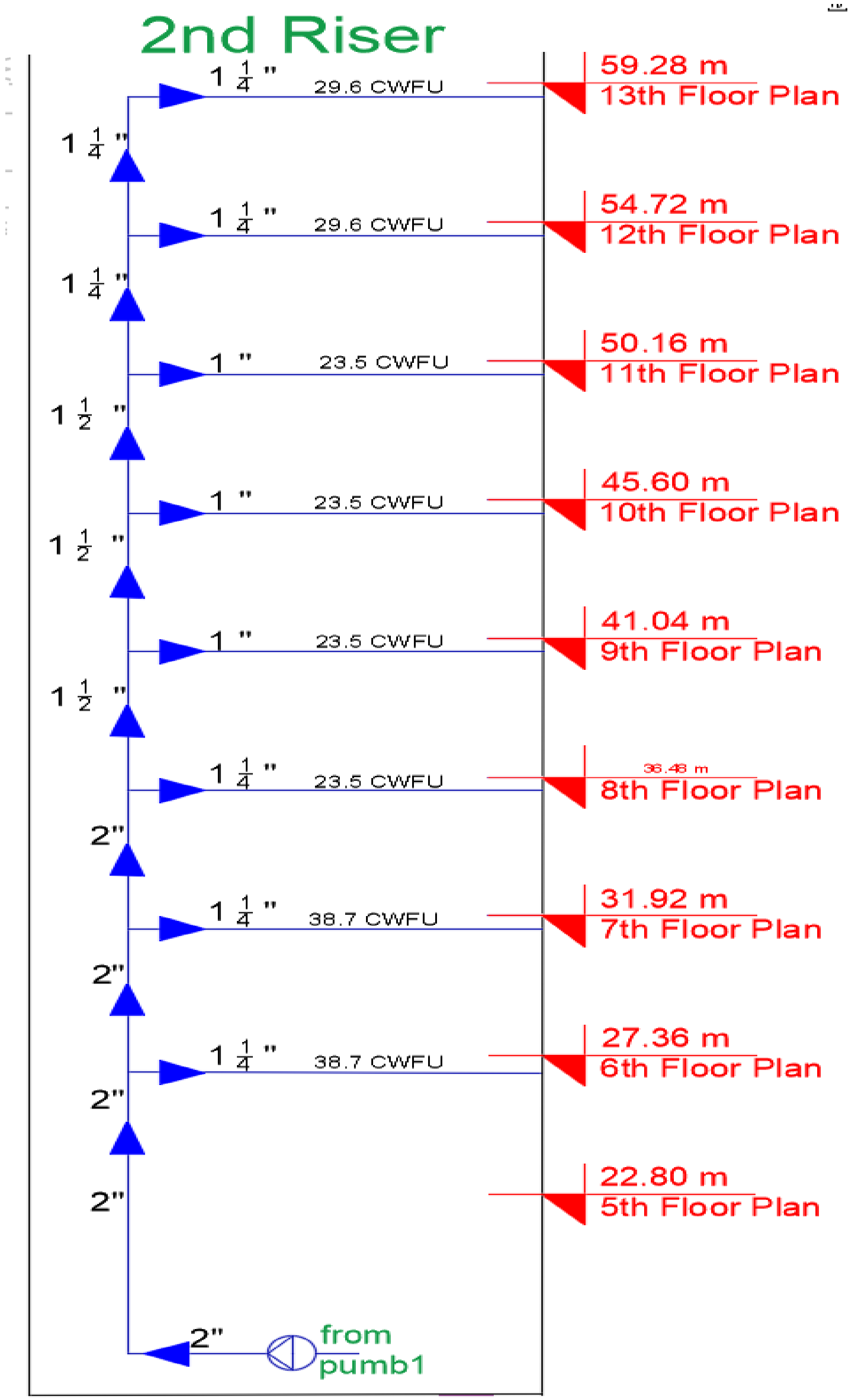


Figure 4.2: Second riser

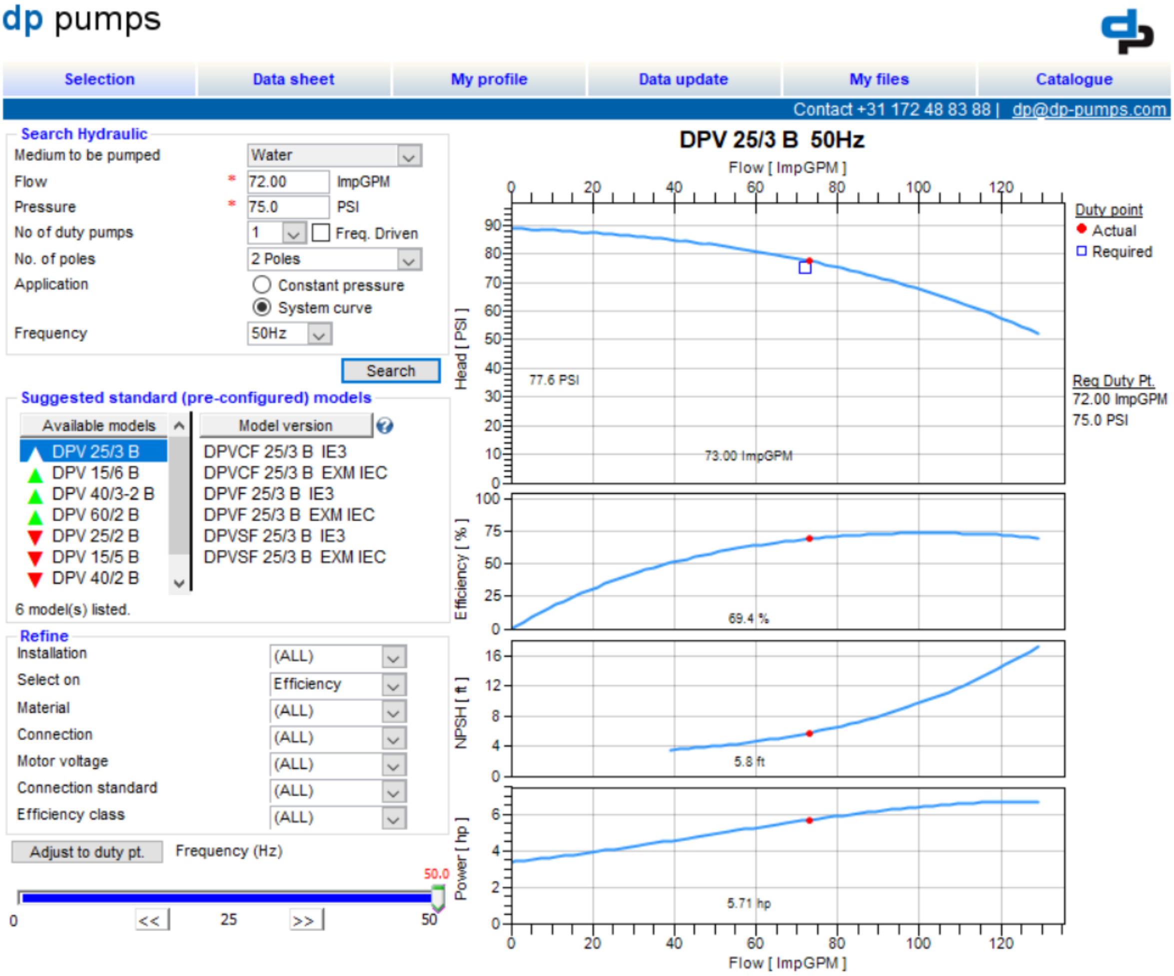


Figure 4.3: Selection for the Second pump

4.4 Hot Water Riser

Hot water is supplied to the hotel by this riser which carries the hot water from a hot water boiler located in a void in fourth floor, a pump is used to supply water to floors from third to twelfth, floors (first , ground , second and parking) is supplied using down feed distribution system.

The hot water flow throw this riser is the total hot water demand for the building and to be obtained by converting the hot water fixture unit to gallons per minutes of hot water.

So by using table 9.4 the required hot water flow is 57 gpm.

The static head, minimum flow pressure, friction head for this riser is the same as riser two, then the head of the hot water pump is equals to the head of pump two and equals 75.1 psi.

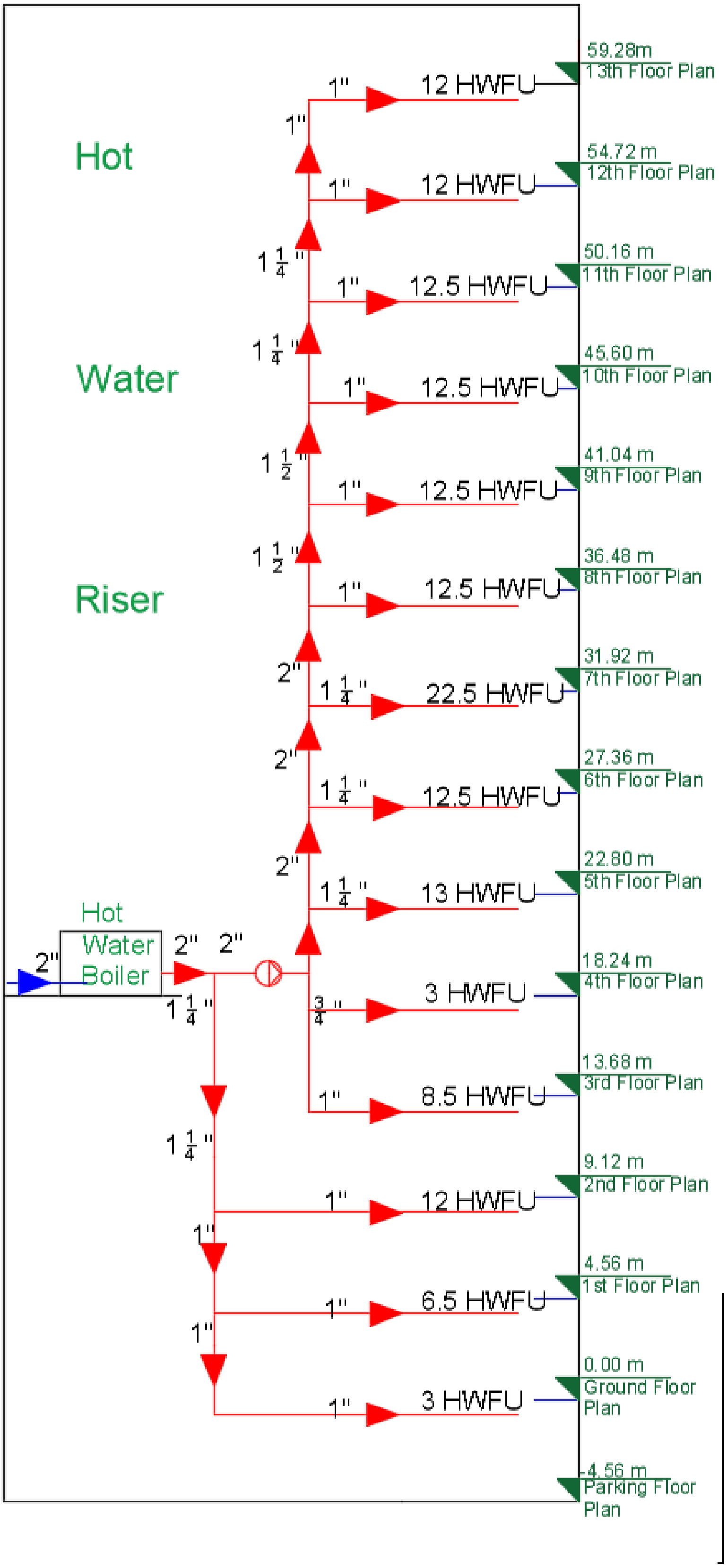


Figure 4.3: Hot Water Riser

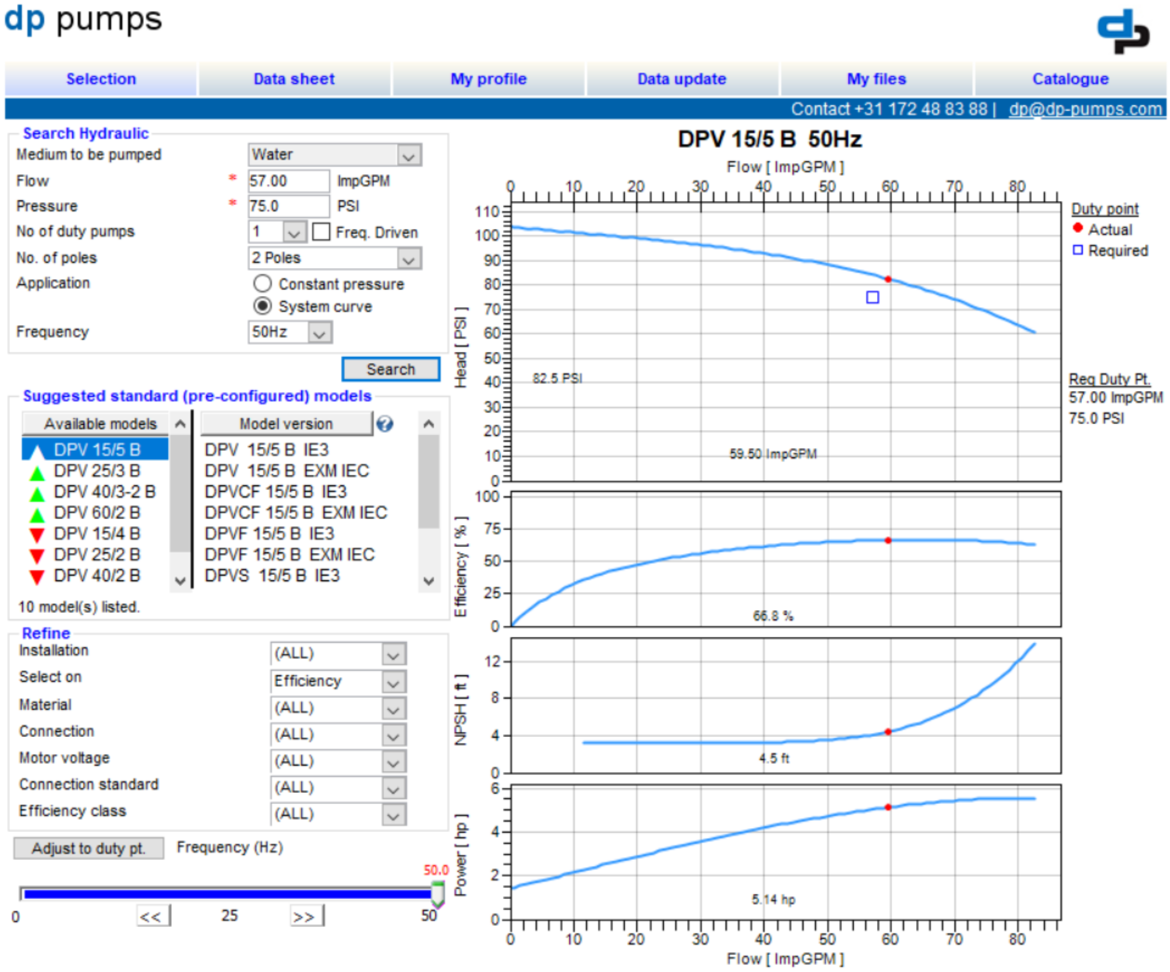


Figure 4.3: Selection for the hot water pump

4.5 Drainage system:

The main objective of drainage system is to carry the waste water out of the Hotel by moving it from the fixture units to manholes and from the manholes to the municipal sewage system.

4.5.1 Drainage system components:

The main components of the Hotel drainage system are:

1) Fixture units.
2) Traps.
3) Clean outs.
4) Drainage pipes.
5) Main Stacks and vent pipes.
6) Manholes.
7) Municipal sewage system.

4.5.2 Design procedure and pipe sizing:

Pipe size is calculated by using a concept of fixture units (DFU) technique. This technique 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.

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%)

Design procedure:

1) Calculation of the number of DFU for each branch by using Table.
2) Calculation of the number of DFU for each stack.
3) Choosing the branch pipe diameter by using Table.
4) Choosing the stack pipe diameter by using Table.
5) Comparing the stack pipe diameter with branch diameter.
6) Choosing the building drain pipe diameter.

The Hotel has three main stacks to collect the drainage water from all the plumbing fixtures in the building; each stuck has a fixed number of branches from all floors.

The next tables shows the number of branches, the fixture unit connected to each branch and the dfu for each branch for the three stacks.

Table4.2: Drainage fixture unit (dfu) for the first stack:

Floor	Plumbing Fixture type	Number of fixtures	dfu per fixture	Total dfu
Ground floor	Water closet	6	4	24
	Lavatory	6	1	6
First floor	Water closet	4	4	16
	Lavatory	4	1	4
	Shower	4	2	8
	Kitchen sink	5	4	20
Second floor	Lavatory	4	1	4
	Water closet	3	4	12
Third floor	0	0	0	0
Fourth floor	Bathtub group	7	6	42
Fifth floor and sixth floor	Bathtub group	7	6	42*2=84
	Lavatory	3	1	3*2=6
	Water closet	3	4	12*2=24
Seventh floor to tenth floor	Bathtub group	1	6	6*4=24
	Lavatory	1	1	1*4 = 4
Eleventh & twelfth	Bathtub group	4	6	24*2=48
Total				309

Table4.3: Drainage fixture unit (dfu) for the second stack.

Floor	Plumbing Fixture type	Number of fixtures	dfu per fixture	Total dfu
Ground floor	Water closet	8	4	32
	Lavatory	9	1	9
First floor	Water closet	5	4	20
	Lavatory	5	1	5
Second floor	Lavatory	9	1	9
	Water closet	4	4	16
Third floor	Lavatory	3	1	3
	Water closet	2	4	8
Fourth floor	Bathtub group	1	6	42
	Lavatory	4	1	4
	Water closet	3	4	12
Fifth floor	Bathtub group	5	6	30*2=60

and sixth floor				
Seventh floor to tenth floor	Bathtub group	3	6	18*4=72
	Lavatory	3	1	3*4 = 12
Eleventh & twelfth	Bathtub group	4	6	24*2=48
Total				352

Table4.4: Drainage fixture unit (dfu) for the third stack.

Floor	Plumbing Fixture type	Number of fixtures	dfu per fixture	Total dfu
Ground floor	Water closet	3	4	12
	Lavatory	3	1	3
	Kitchen sink	6	4	24
First floor	Water closet	4	4	16
	Lavatory	4	1	4
Second floor	0	0	0	0
Third floor	Lavatory	3	1	3
	Water closet	3	4	12
Fourth floor	0	0	0	0
Fifth floor and sixth floor	Bathtub group	3	6	18*2=36
	Lavatory	3	1	3*2=6
	Water closet	4	4	16*2=32
Seventh floor to tenth floor	Bathtub group	1	6	6*4=24
	lavatory	1	1	1*4 = 4
Eleventh & twelfth	0	0	0	0
Total				176

For the three stacks the diameter of them are selected to be 4” along them.

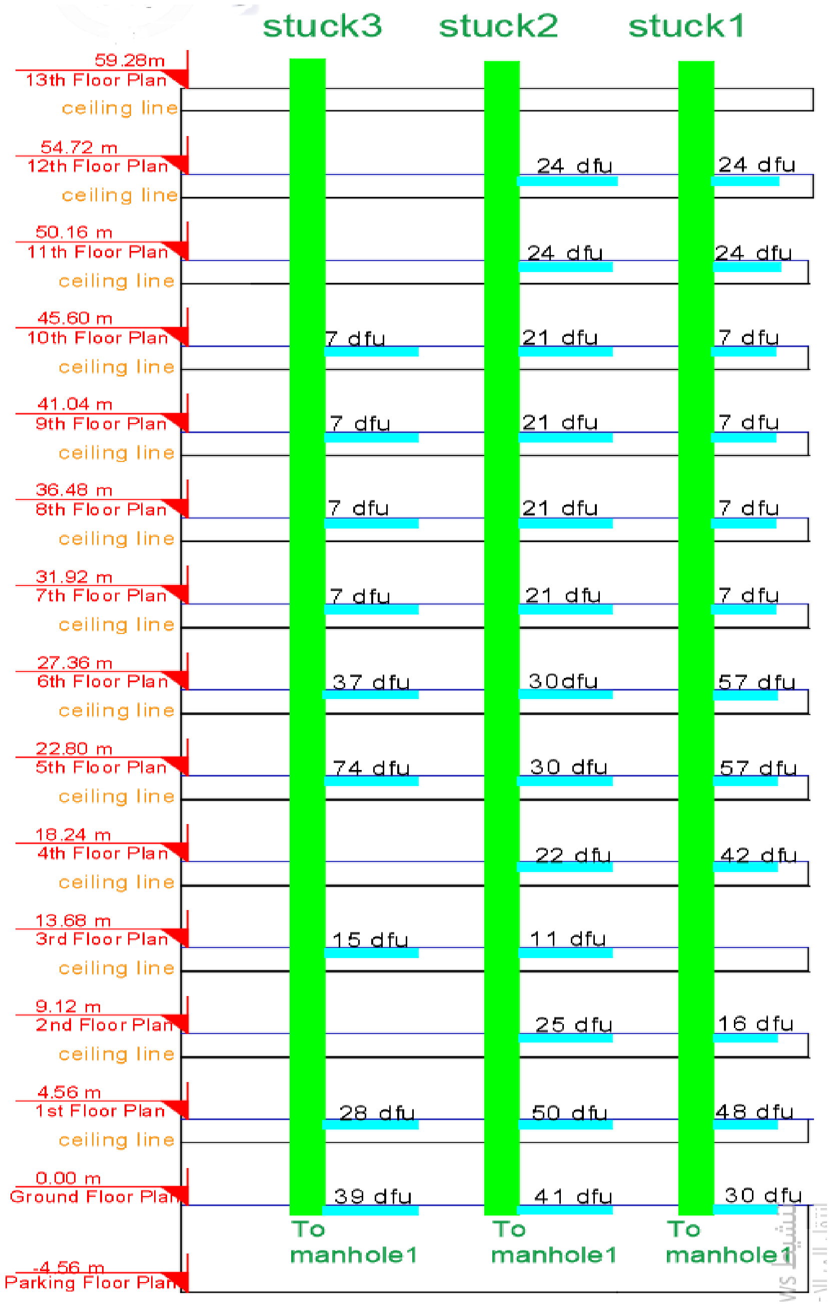

stuck3
stuck2
stuck1
59.28m
13th Floor Plan
ceiling line
54.72 m
12th Floor Plan
ceiling line
24 dfu
24 dfu
50.16 m
11th Floor Plan
ceiling line
24 dfu
24 dfu
45.60 m
10th Floor Plan
ceiling line
7 dfu
21 dfu
7 dfu
41.04 m
9th Floor Plan
ceiling line
7 dfu
21 dfu
7 dfu
36.48 m
8th Floor Plan
ceiling line
7 dfu
21 dfu
7 dfu
31.92 m
7th Floor Plan
ceiling line
7 dfu
21 dfu
7 dfu
27.36 m
6th Floor Plan
ceiling line
37 dfu
30dfu
57 dfu
22.80 m
5th Floor Plan
ceiling line
74 dfu
30 dfu
57 dfu
18.24 m
4th Floor Plan
ceiling line
22 dfu
42 dfu
13.68 m
3rd Floor Plan
ceiling line
15 dfu
11 dfu
9.12 m
2nd Floor Plan
ceiling line
25 dfu
16 dfu
4.56 m
1st Floor Plan
ceiling line
28 dfu
50 dfu
48 dfu
0.00 m
Ground Floor Plan
39 dfu
41 dfu
30 dfu
To manhole1
To manhole1
To manhole1
-4.56 m
Parking Floor Plan

Figure 4.4: s

Chapter 5: VRF System

5.1 introduction:

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 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. This arrangement provides an individualized comfort control, and simultaneous heating and cooling in different zones. VRF systems operate on the direct expansion (DX) principle meaning that heat is transferred to or from the space directly by circulating refrigerant to evaporators located near or within the conditioned space. Refrigerant flow control is the key to many advantages as well as the major technical challenge of VRF systems.

5.2 Main Components of VRF System:

1) Outdoors units.

2) Indoors units.

3) Piping connection

- **Outdoors units:**

The outdoor unit contains a heat pump, A heat pump is a machine that by reversing its Refrigeration cycle can provide heating instead of cooling. Because a heat pump uses refrigerant It can upgrade the heat in air at even -15ºC to a usable heat source to heat buildings.

- **Indoor Units:**

The indoor units were developed to be highly efficient, compact, low noise, and to have user Friendly operation. Care was also taken with the design to make that go well with the interior Decoration and tube easy to install and maintain. Further, a variety of options are available to Achieve an air conditioning environment that is more desirable from the user's perspective

- **Expansion valve:**

Thermostatic Expansion Valves (TXV) is very important part to control the flow in vrv System As the thermostatic expansion valve regulates the rate at which liquid refrigerant flows

Into the evaporator, it maintains a proper supply of refrigerant by matching this flow rate against How quickly the refrigerant evaporates (boils off) in the evaporator coil.

5.3 Advantages of VRF System:

- **Comfort:**

Comfort by providing "even" cooling or heating when and where it is required. Multiple Types of fan coils and sizes provides design flexibility for different applications. Design software Simplifies selecting and piping design.

- **Installation Advantages:**

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

- **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.

- **Maintenance and Commissioning:**

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

- **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.

5.4 Design Procedure for the cooling and heating systems:

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. 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 feeding 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.

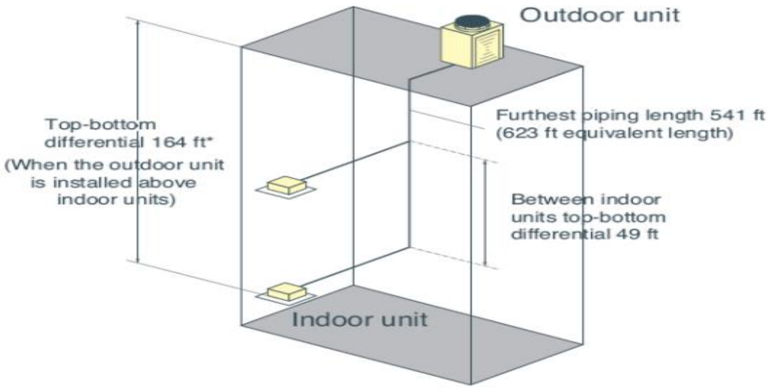


Figure 5.1:

5.5 The three pipe system

Which are configured with a heating pipe, a cooling pipe, and a return pipe (see Figure 5.1). Branch selectors are used with three-pipe systems to perform the same functions as two-pipe systems with the exception of separators

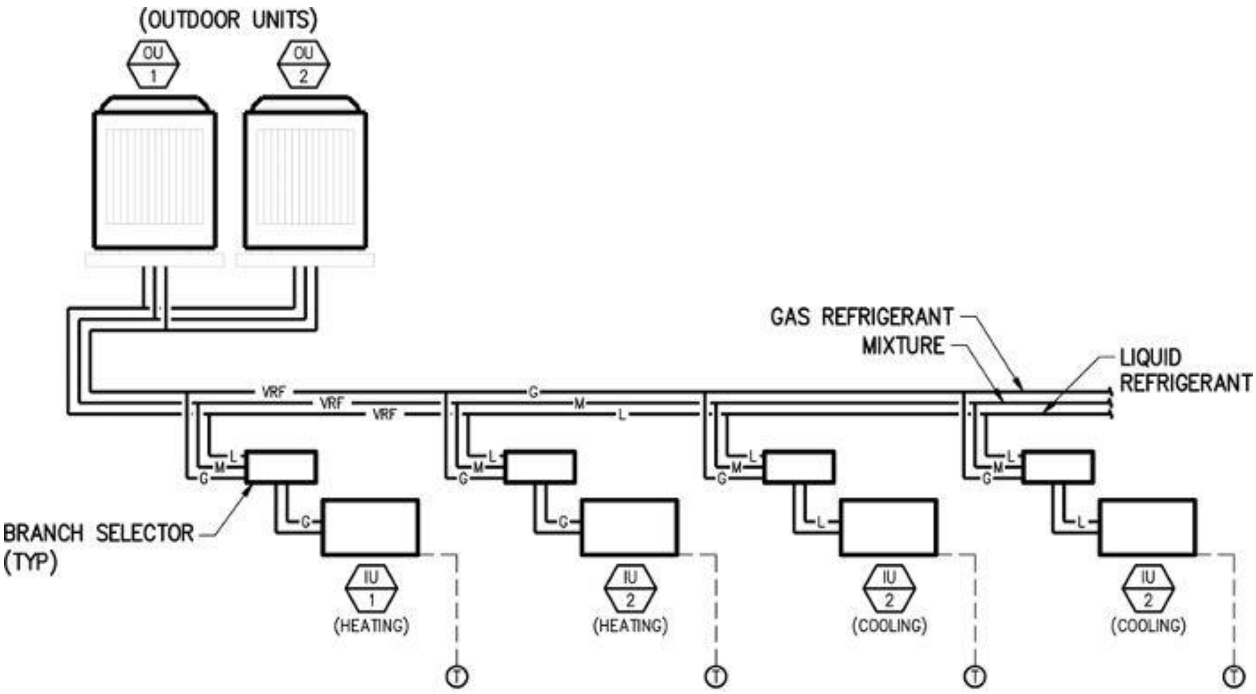


Figure 5.2 Three pipe system

And this system is to be used in the hotel to ensure that the system works in both cooling and heating modes at the same time

5.6 Selection of the indoor and outdoor units:

1- **Indoor units:**
   The selection of the indoor units depends on the cooling and heating capacity of the space. After calculation of the loads and selecting the type of the indoor unit (wall mounted, cassette …) the actual capacities of the unit is to be the same as the heating and cooling loads of the space. The actual capacity is different from the nominal capacity of the unit and that depend on the design condition of the system.

5.6.1 Sample selection of one of the indoor units:

For one of the bedrooms and from the technical catalog for Samsung the selected unit is wall mounted the actual and nominal capacities are shown below:

Table5.1: Sample selection of one of the indoor units

A3050

Type				AR5000	AR5000	AR5000
Model				AM015JNVDKH/EU	AM022JNVDKH/EU	AM028JNVDKH/EU
Power Supply			Ø, #, V, Hz	1,2,220-240,50/60	1,2,220-240,50/60	1,2,220-240,50/60
Mode			-	HP/HR	HP/HR	HP/HR
Performance	Capacity (Nominal)	Cooling	kW	1.50	2.20	2.80
			Btu/h	5,100	7,500	9,600
		Heating	kW	1.70	2.50	3.20
			Btu/h	5,800	8,500	10,900

Table5.2: Sample selection of one of the outdoor units

Cooling TC : Total Capacity, SHC : Sensible Heat Capacity

Model	Outdoor temperature (°C, DB)	Indoor temperature (°C, WB)													
		14.0		16.0		18.0		19.0		20.0		22.0		24.0	
		TC	SHC	TC	SHC	TC	SHC	TC	SHC	TC	SHC	TC	SHC	TC	SHC
		kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW
1.50	10	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.70	1.10	1.80	1.00
	12	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.70	1.10	1.80	1.00
	14	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.70	1.10	1.80	1.00
	16	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.80	1.00
	18	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.80	1.00
	20	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.80	1.00
	21	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.80	1.00
	23	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.80	1.00
	25	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.80	1.00
	27	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.80	1.00
	29	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.80	1.00
	31	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.80	1.00
	33	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.80	1.00
	35	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.80	1.00
	37	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.80	1.00
	39	1.00	0.90	1.20	1.00	1.40	1.00	1.50	1.00	1.60	1.00	1.60	1.00	1.70	0.90
2.20	10	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.50	1.60	2.60	1.40
	12	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.50	1.60	2.60	1.40
	14	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.50	1.60	2.60	1.40
	16	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.60	1.40
	18	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.60	1.40
	20	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.60	1.40
	21	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.60	1.40
	23	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.60	1.40
	25	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.60	1.40
	27	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.60	1.40
	29	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.60	1.40
	31	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.60	1.40
	33	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.60	1.40
	35	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.60	1.40
	37	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.60	1.40
	39	1.50	1.30	1.80	1.50	2.10	1.50	2.20	1.50	2.30	1.50	2.40	1.50	2.50	1.30
2.80	10	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.40	1.90
	12	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80
	14	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80
	16	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80
	18	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80
	20	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80
	21	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80
	23	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80
	25	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80
	27	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80
	29	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80
	31	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80
	33	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80
	35	1.90	1.60	2.30	1.80	2.60	2.00	2.80	1.90	2.90	1.90	3.10	1.90	3.30	1.80

For the room with required Q cooling = 2.5 Kw this unit with actual cooling load = 2.6 Kw at the design conditions is proper. The heating actual capacity is done by the same way. The selection for all in door units is done using the same way.

2- Outdoor units :

The selection of the outdoor unit depends on the cooling and heating capacity of all the related indoor units. After selecting all the indoor units and adding the actual capacities then choosing capacity ratio = 1.3 for the system. The Outdoor capacity = summation of indoor capacities / 1.3.
The outdoor capacity is to be converted to electrical horse power then from the technical catalog the unit is chosen.

5.6.2 Sample selection of one of the outdoor units:

For one of the systems and the total cooling load of the indoor capacities = 7 * 2.6 = 18.2 Kw

Q outdoor = 18.2 / 1.3 = 14 Kw.

Table5.3: Sample selection of one of the outdoor units

AM060FXMDEH/EU

Cooling TC : Total Capacity, PI : Power Input

Combination, % (Capacityy index)	Outdoor temperature (°C, DB)	Indoor temperature (°C, WB) 14		16		18		19		20		22		24	
		TC	PI	TC	PI	TC	PI	TC	PI	TC	PI	TC	PI	TC	PI
		kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW
130	10	13.80	1.98	16.40	2.43	19.10	2.89	20.50	3.12	20.70	3.06	21.20	2.93	21.70	2.79
	12	13.80	2.02	16.40	2.47	19.10	2.94	20.20	3.10	20.40	3.04	20.90	2.91	21.40	2.86
	14	13.80	2.06	16.40	2.52	19.00	3.00	19.90	3.09	20.20	3.02	20.70	3.00	21.20	3.02
	16	13.80	2.10	16.40	2.58	19.00	3.06	19.60	3.11	19.80	3.13	20.30	3.16	20.90	3.19
	18	13.80	2.14	16.40	2.62	19.00	3.26	19.30	3.28	19.50	3.29	20.00	3.32	20.50	3.35
	20	13.70	2.18	16.40	2.79	18.80	3.42	19.00	3.43	19.30	3.45	19.80	3.49	20.30	3.52
	21	13.70	2.25	16.40	2.89	18.70	3.50	18.90	3.52	19.20	3.53	19.60	3.56	20.10	3.60
	23	13.70	2.40	16.30	3.10	18.40	3.66	18.60	3.68	18.90	3.70	19.40	3.73	19.90	3.76
	25	13.70	2.57	16.30	3.32	18.00	3.82	18.30	3.84	18.50	3.85	19.00	3.89	19.50	3.93
	27	13.70	2.75	16.30	3.55	17.80	3.98	18.00	4.00	18.30	4.02	18.80	4.05	19.20	4.10
	29	13.70	2.93	16.30	3.80	17.50	4.14	17.80	4.16	18.00	4.18	18.50	4.23	19.00	4.26
	31	13.70	3.12	16.30	4.05	17.30	4.30	17.50	4.32	17.70	4.35	18.20	4.39	18.70	4.44
	33	13.60	3.33	16.30	4.33	17.00	4.47	17.20	4.48	17.50	4.51	18.00	4.56	18.50	4.60
	35	13.60	3.54	16.10	4.57	16.80	4.63	16.90	4.65	17.10	4.68	17.60	4.73	18.10	4.78
	37	13.20	3.59	15.40	4.50	15.90	4.55	16.10	4.57	16.40	4.60	16.80	4.65	17.30	4.70
	39	12.90	3.62	14.80	4.41	15.30	4.46	15.50	4.49	15.80	4.51	16.30	4.56	16.70	4.61
	42	12.90	3.83	14.50	4.56	15.00	4.61	15.20	4.64	15.50	4.67	16.10	4.72	16.50	4.77
	44	12.90	4.04	14.30	4.71	14.70	4.76	14.90	4.80	15.20	4.82	15.90	4.87	16.30	4.92
	46	12.90	4.26	14.00	4.86	14.40	4.91	14.60	4.96	14.90	4.98	15.70	5.03	16.20	5.08

Note: The outdoor unit is selected from the technical catalog.

5.7 System piping:

The piping system is depend on the amount of refrigerant passing throw the pipe. And that depend on the actual load of the unit connected to the pipe. The previous selected indoor unit has to be connected of these sizes to pipes.
Liquid pipe diameter = 9.52 mm, and gas pipe diameter = 15.88 mm.
The next table shows the details of three system and the rest of the systems in the hotel have been selected in the same way.

Table5.4: First system indoor units

System NO	Indoor units						
First system	Type	No	Code	Nominal heating capacity	Actual heating capacity	Nominal cooling capacity	Actual cooling capacity
	Wall mounted	7	AM028JNADKH/EU	3.2 kW	2.9 kW	2.8 kW	2.6 kW

Table5.6: First system outdoor units

System NO	Outdoor units			
First system	Code	Nominal capacity	Actual capacity	hp.
	AM060FXMDEH/EU	17 kW	16.6 kW	6

Table5.7: Eighth system indoor units

System NO	Indoor units						
Eighth system	Type	No	Code	Nominal heating capacity	Actual heating capacity	Nominal cooling capacity	Actual cooling capacity
	Cassate unit	4	AM140FN4DEH	16 kW	15 kW	14 kW	13.1 kW
	Cassate unit	2	AM056FN4DEH	6.3 kW	6 kW	5.6 kW	5.3 kW
		6		76.6 kW	72 kW	67.2 kW	63 kW

Table5.8: Eighth system outdoor units

System NO	Outdoor units			
eighth system	Code	Nominal capacity	Actual capacity	hp.
	AM240JXVHGR1EU	67 kW	63 kW	24

Table5.9: Ninth system indoor units

System NO	Indoor units						
ninth system	Type	No	Code	Nominal heating capacity	Actual heating capacity	Nominal cooling capacity	Actual cooling capacity
	HS Duct	2	AM280FNHDEH	31.5 kW	29 kW	28 kW	26.5 kW

Table5.10: Ninth system outdoor units

System NO	Outdoor units			
ninth system	Code	Nominal capacity	Actual capacity	hp.
	AM120JXVHGH1EU/EU	33 kW	33 kW	12

Table5.11: All systems specifications

floor	Number Of systems	Outdoor unit		Indoor unit	
		code	hp.	type	number
Ground floor	1	AM160JXVHGH	16	Ducted unit	2
	2	AM080JXVHGH	8	Cassete type	4
	3	AM080JXVHGH	8	Cassete type	4
	4	AM100JXVHGH	10	Wall mounted	9
	5	AM160JXVHGH	16	Casete&wallm	7
First floor	1	AM240HXVAGH	24	Ducted units &wall mounted	9
	2	AM160JXVHGH	16	cassete	6
	3	AM180JXVHGH	18	Ducted unit	2
Second floor	1	AM300JXVHGH1EU	30	Ducted unit	4
	2	AM240HXVAGH	24	Ducted unit	2
Third floor	1	AM200JXVHGH	20	casset	4
	2	AM200JXVHGH	20	Ducted unit	3
Fourth floor	1	AM100JXVHGH/EU	10	Wall mounted	7
Fifth&sixth floor	1	AM100JXVHGH/EU	10*2	Wall mounted	7*2
	2	AM120JXVHGH/EU	12*2	Wall mounted	8*2
Seven,8,9&10	1	M080JXVHGH/EU	8*4	Wall mounted	5*4
	2	AM080JXVHGH/	8*4	Wall mounted	5*4
Eleventh& 12 floor	1	AM100JXVHGH/EU	10*2	Wall mounted	8*2

5.8 Ventilation system:

In addition to air conditioning and to meet the comfort requirements Automatic ventilation is needed in many spaces in the hotel such like theater, gyms, and restaurant kitchens. So many fans of different types have been installed in the drawings and their location and specifications are as follows.

The air flow of the fans is calculated after getting the amount of fresh air needed to each space from ASHRAE code.

Table5.12: Automatic Ventilation System Fans

floor	space	Space area m^2	Volume m^3	No of air change per hour	Fan no	type	Air flow (cfm)
Parking	parking	980	3925	7	14	exhaust	1000
first floor	Restaurant kitchen	25	72	16	1	exhaust	882
					1	supply	882
Second floor	Male gym	290	871	3	6	exhaust	240
					6	supply	240
	Female gym	400	1193	3	4	exhaust	475
					4	supply	475
Third floor	theater	250	765	7	5	exhaust	600
					5	supply	600

Chapter 6 : Firefighting System

6.1Overview

6.1.1Firefighting triangles

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 (6.1) Fire Triangle

6.1.2Classifications of Fire:

Not all fires are the same. Per NFPA 10, burning may be classified into one or more of the following fire classes and the firefighting system depends on the type of the fire

Class A

Class A fires are fires in ordinary combustibles such as wood, paper, cloth, rubber, and many plastics.

Class B

Class B fires are fires in flammable liquids such as gasoline, petroleum greases, tars, oils, oil-based paints, solvents, alcohols. Class B fires also include flammable gases such as propane and butane. Class B fires do not include fires involving cooking oils and grease.

Class C

Class C fires are fires involving energized electrical equipment such as computers, servers, motors, transformers, and appliances. Remove the power and the Class C fire becomes one of the other classes of fire.

Class D

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

Class K

Class K fires are fires in cooking oils and greases such as animal and vegetable fats.

6.1.3Classifications of Hazard

In accordance with NFPA, areas are typically classified as being light (low) hazard, ordinary (moderate) hazard, or extra (high) hazard.

Light (low) hazard areas are locations where the quantity and combustibility of Class A combustibles and Class B flammables is low. In these areas, expected fires have relatively low rates of heat release. Light hazard areas may include offices, classrooms, meeting rooms etc.

Ordinary (moderate) hazard areas are locations where the quantity and combustibility of Class A combustible materials and Class B flammables is moderate. Fires with moderate rates of heat release are expected in these areas. Ordinary hazard locations could be offices, malls, light manufacturing or research operations, parking garages, workshops, or maintenance/service areas.

Extra (high) hazard areas are locations where the quantity and combustibility of Class A combustible material is high or where high amounts of Class B flammables are present. Quickly developing fires with high rates of heat release are expected. These locations could be sites for cars repair, aircraft and boat servicing, painting, dipping, and coating, storage areas (tanks, containers etc.).

6.2General Firefighting Equipment:

Firefighting systems and equipment vary depending on the age, size, use and type of building construction. A building may contain some or all of the following features:

1) Fire hose cabinet

2) Fire extinguishers

3) Fire hydrant systems

4) Automatic sprinkler systems

6.2.1Fire hose cabinet:

Fire hose cabinet are provided for use by occupants of the Hotel as a 'first attack' firefighting measure but may, in some instances, also be used by firefighters.It is distributed through the floors according to the NFPA code and starting by the exit of the stairs and the next cabinet is after 30m distance from the previous one and that depends on the length of the hose.

The selected type of cabinets is combined with fire extinguisher in the same cabinet as follows

Figure (6.2) Fire Hose cabinet & extinguisher

6.2.2Fire Extinguishers:

Is an active fire protection device used to extinguish or control small fires, often in emergency situations. It is not intended for use on an out-of-control fire, such as one which has reached the ceiling.

The main types of fire extinguishers

Table (6.1) Fire extinguisher types

Extinguishing Agent	Principle Use
Water	wood and paper fires - not electrical
Foam	flammable liquid fires - not electrical
Carbon dioxide	electrical fires
Dry Chemical	flammable liquids and electrical fires
Wet chemical	fat fires - not electrical
Special Purpose	various (e.g. metal fires)

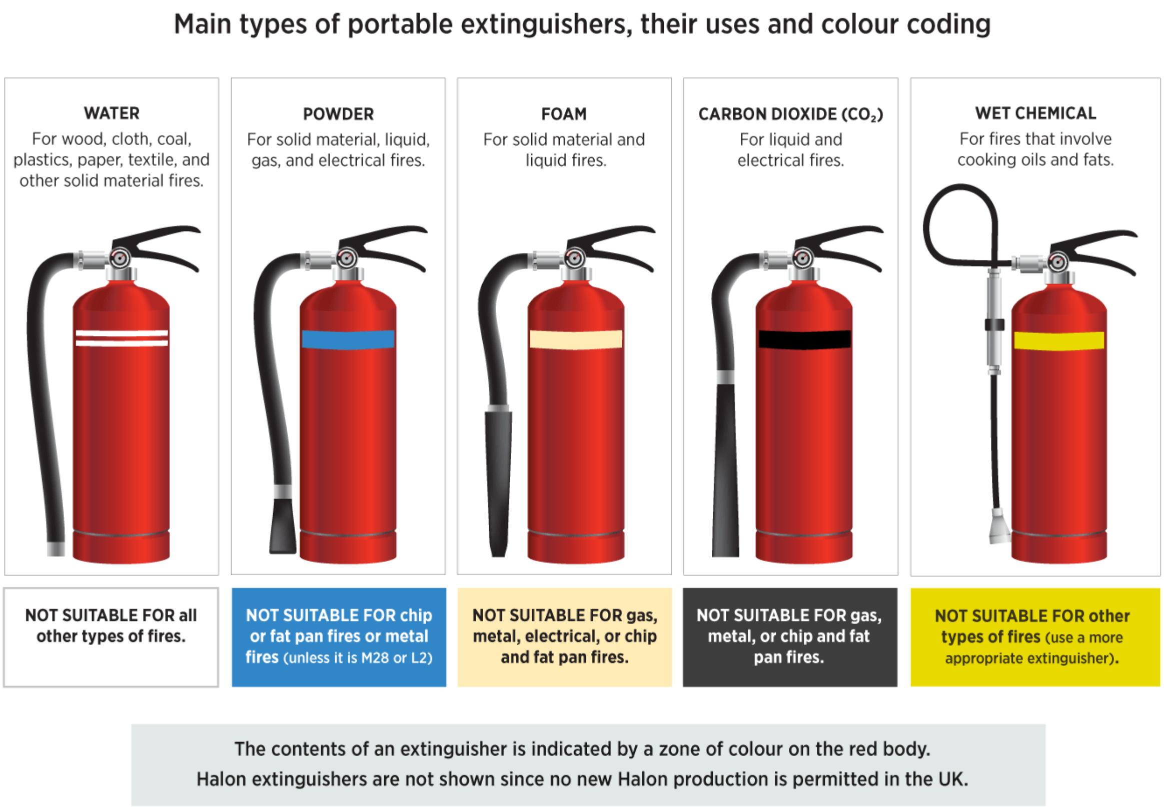


Figure (6.3) Fire extinguisher types

The Fire Extinguisher used in the Hotel and combined with the Hose in the same cabinet like the previous Figure (6.2) shows

6.2.3 Fire Hydrant systems:

Is connection point in the street at front of the Hotel by which firefighters connect into a water supply to use it in the firefighting process.

It is connected to the firefighting network of the hotel and have a water flow of 250 gpm

Figure (6.4) Fire Hydrant

6.2.4 Automatic sprinkler systems

Automatic sprinkler systems are considered to be the most effective and economical way to apply water to suppress a fire. And there are four basic types of sprinkler systems:

1- A wet pipe system is by far the most common type of sprinkler system. It consists of a network of piping containing water under pressure. Automatic sprinklers are connected to the piping such that each sprinkler protects an assigned building area. The application of heat to any sprinkler will cause that single sprinkler to operate, permitting water to discharge over its area of protection.
2- A dry pipe system is similar to a wet system, except that water is held back from the piping network by a special dry pipe valve. The valve is kept closed by air or nitrogen pressure maintained in the piping. The operation of one or more sprinklers will allow the air pressure to escape, causing operation of the dry valve, which then permits water to flow into the piping to suppress the fire. Dry systems are used where the water in the piping would be subject to freezing.
3- A deluge system is one that does not use automatic sprinklers, but rather open sprinklers. A special deluge valve holds back the water from the piping, and is activated by a separate fire detection system. When activated, the deluge valve admits water to the piping network,

and water flows simultaneously from all of the open sprinklers. Deluge systems are used for protection against rapidly spreading, high hazard fires.

4- A pre-action system is similar to a deluge system except that automatic sprinklers are used, and a small air pressure is usually maintained in the piping network to ensure that the system is air tight. As with a deluge system, a separate detection system is used to activate a deluge valve, admitting water to the piping. However, because automatic sprinklers are used, the water is usually stopped from flowing unless heat from the fire has also activated one or more sprinklers.

The selected type in the hotel is the wet pipe system, because there is no possibility of water freezing in the pipes.

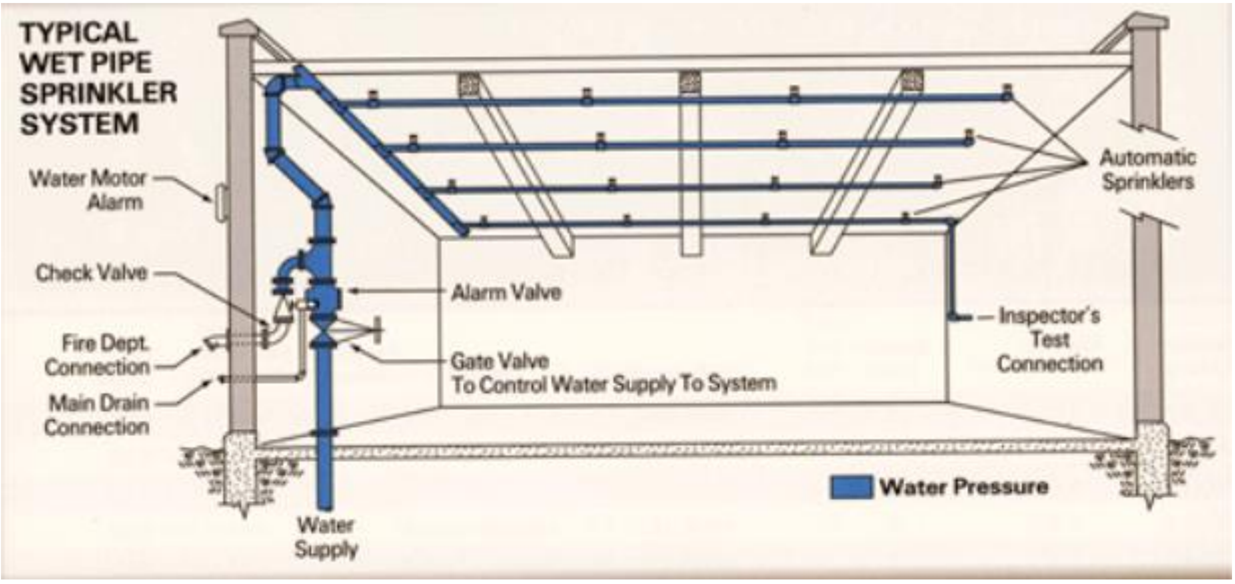


Figure (6.4) wet pipe system

6.2.5 Components of the system:

- **Sprinkler**

Wide range of sprinklers are available and there is two main classifications for them. The first one is the color classification. Every sprinkler bulb has a color and that color identifies the working temperature of the sprinkler. Once the temperature reaches that limit the bulb explode and the water is sprayed out of it and start attacking the fire.

The second classification is according to the location of the sprinkler and there is three main types of sprinkler. first one is pendent sprinkler which located in the false ceiling of the hotel the second type is upright which used in case of no ceiling in the place such like parking the third on its side wall sprinkler which used in case in the ceiling is more than 3 m high .

Operating Temperature Optional

Nozzle Nominal Working Temperature	Max Environment Temperature	Crystal Ball Color Code
57℃	27℃	Orange
68℃	38℃	Red
79℃	49℃	Yellow
93℃	63℃	Green
141℃	111℃	Blue

Figure (6.4) types of sprinkler

- **Piping system**

Piping system is a critical part of fire sprinkler system the type of the pipe, the coefficient of friction, diameter of the pipe, and distance between pipes all of these parameters has to be determined.

- **Pumps**

Firefighting pumps are special pumps and has to achieve several conditions and they are

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%.

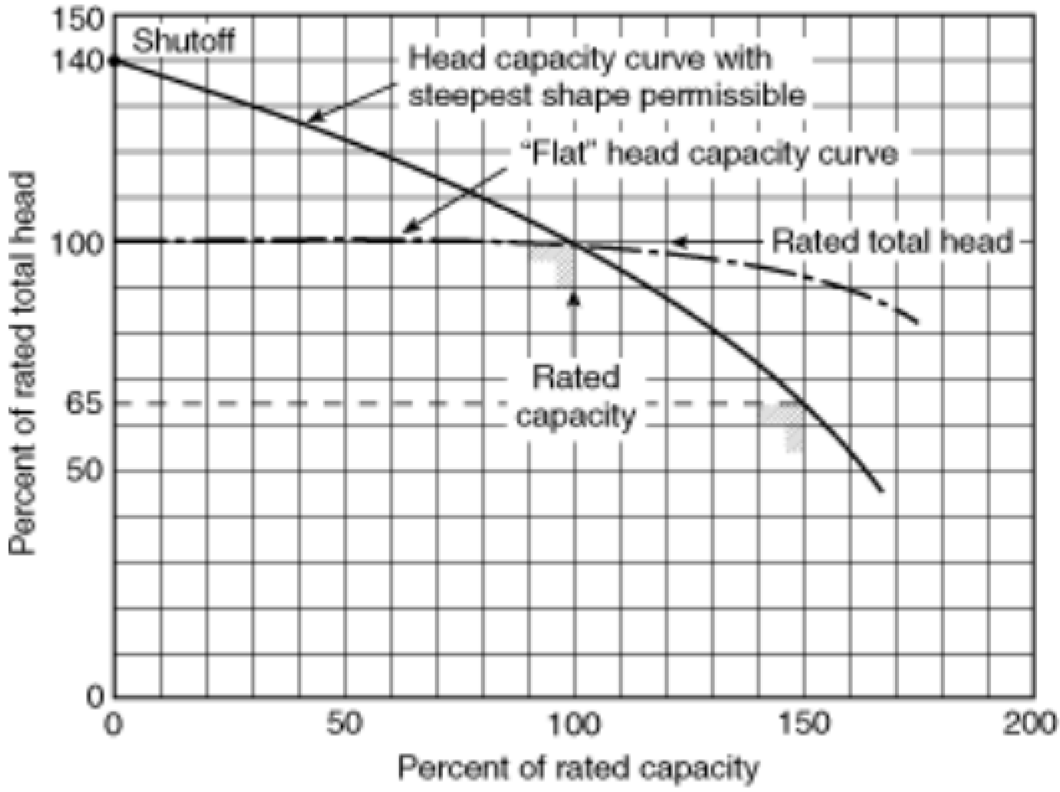


Figure (6.4) fire pump characteristic curve

6.3 Fire pump set

The set of fire pumps has three pumps

1. Main pump: it is electrical pump and has the same flow and head required for the system.
2. Stand by pump : has the same head and flow of the main pump but in most cases it is diesel driven
3. Jokey pump : this pump to insure that the piping network is well pressurized and in case of fire this pump is driven firs and has the same head of main pump but only 10%of the flow

Network valves

1. Non return valve: installed everywhere the water is allowed to flow in only one direction to prevent the pressurized water from flowing in opposite direction.
2. Pressure switch: to activate an electrical alarm in case of water flowing because of fire.
3. OS & Y gate valve: a flow control valve with less pressure drop from other gate valves installed in the network for the maintenance purpose.

4. Alarm check valve; in case of fire and a pressure difference happened before and after this valve. It allows the water to flow in a channel to activate a mechanical alarm

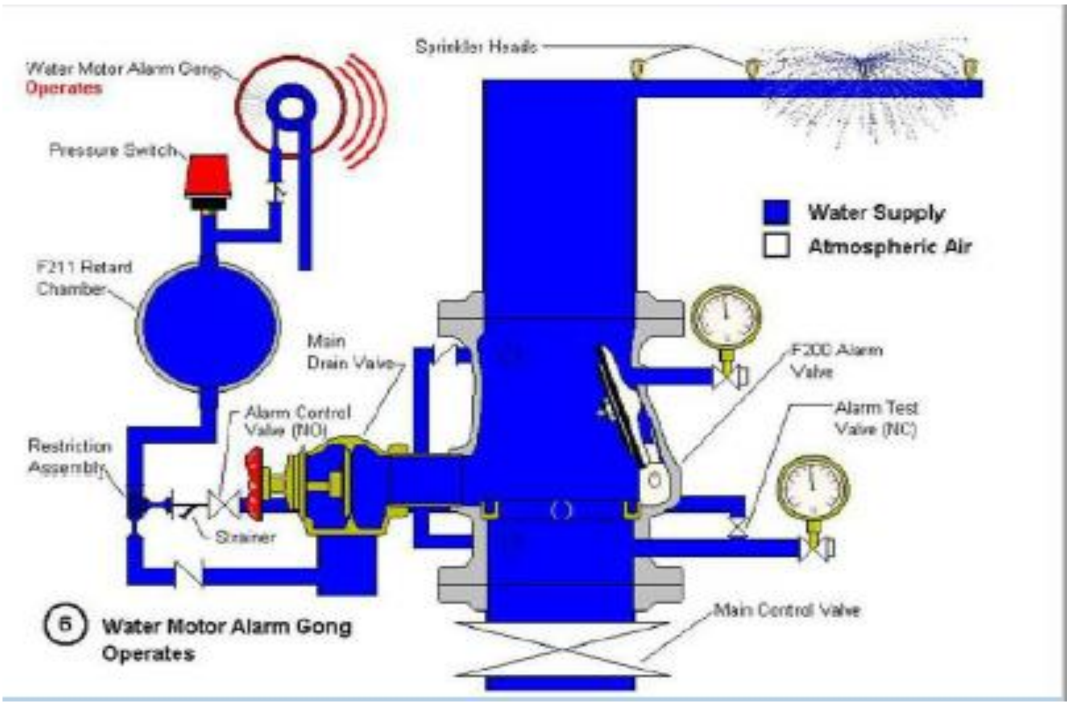


Figure (6.5)

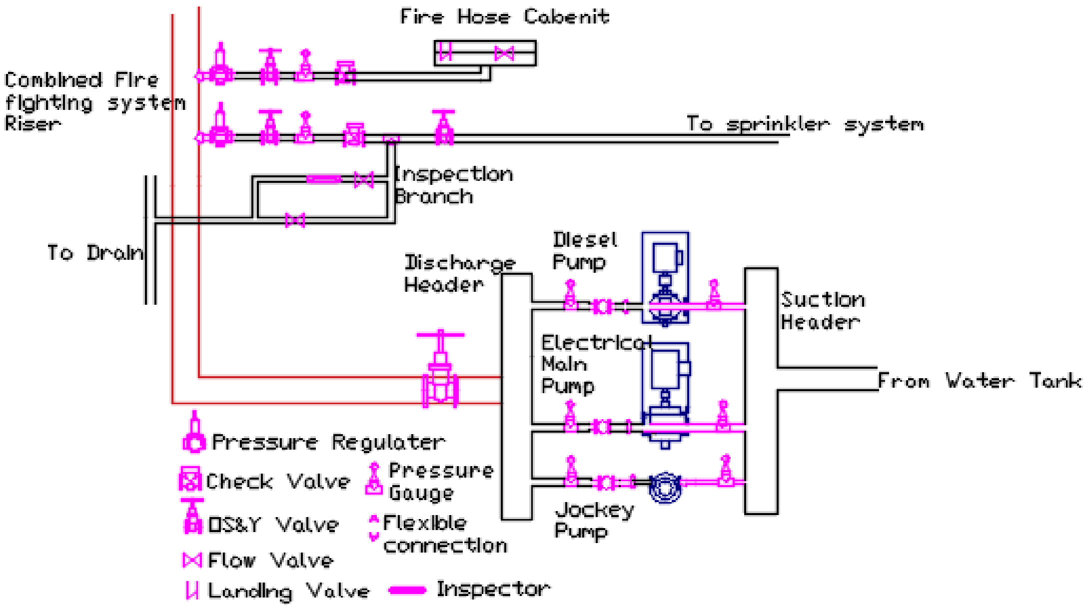


Figure (6.5)

6.4 Hydraulic calculations

6.4.1The design procedure

1- Identifies the hazard and it has been identifies for the hotel to be ordinary hazard

2- Identifies the sprinkler type and in the Hotel it is chosen to be pendent in all of the floors and upright in the parking

3- The sprinklers to be distributed in the building according to NFPA hazard table

4- Choose the design area. This is the area that has the most water demanding and the max possible head.

5- Calculate the flow and head from the design area

6- Add the flow of the hose and the landing valve to the total flow in case of combined system

7- Choose the pumps depending on the flow and the head

6.4.2 Design area

In the Hotel and according to NFPA It is the farthest 1500 ft^2=139m^2 from the pumps. So it is in the 12th floor

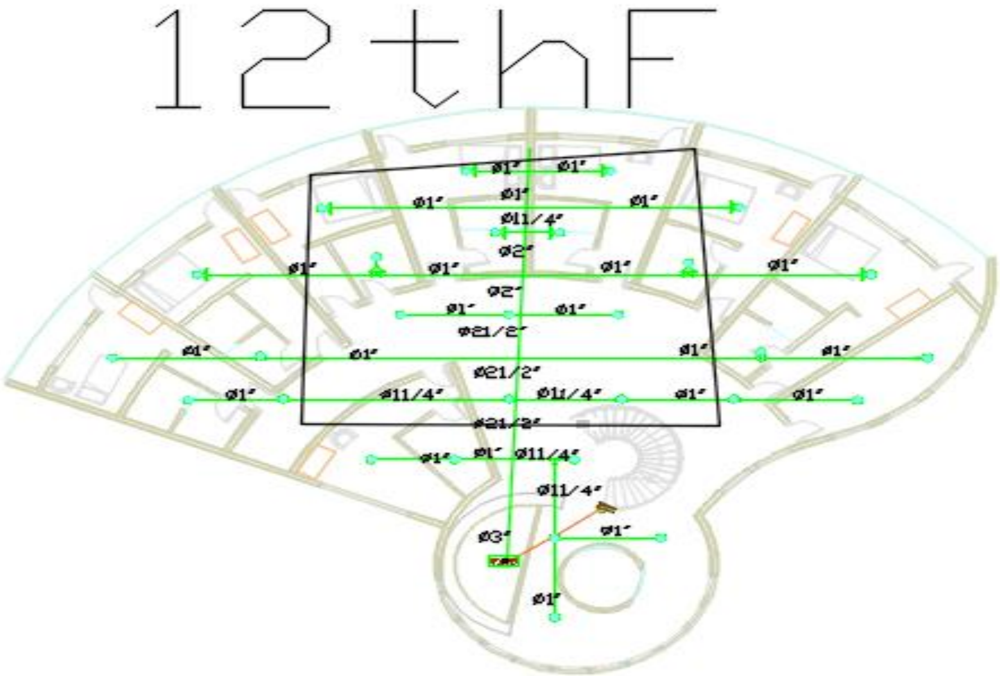


Figure (6.5)

6.4.3 Flow calculations

Number of sprinkler = Design Area / sprinkler area coverage

= 139 / 12 = 12 sprinkler.

Flow for the design area = flow per sprinkler * number of sprinklers

= 30 gpm * 12 = 360 gpm

The total flow = sprinkler flow + Hose flow + landing valve flow

= 360 + 250 + 250 = 860 gpm

6.4.4Head calculations:

Head at the design area = Static head + Residual head + Friction head

Static head = the level difference head between pumps and the farthest sprinkler

Residual head = the water pressure at the inlet of the sprinkler and depend on the sprinkler

Friction head = friction head throw the pipes and depend on the pipe type, diameter, flow.

Static head = distance from basement to 12^{th} floor + distance from floor to sprinkler

= 60 + 3 = 63 m = 206.64 = 89 psi = 6.2 bar

Residual head: depends on the sprinkler and can be calculated from the next equation

Sprinkler flow = $K*\sqrt{head}$ while k is the sprinkler k factor and equals to 5.6

So, head = $(flow /K)^2$ = 28 psi

Friction head: Friction losses resulting from water flow through piping can be estimated by several engineering approaches, but NFPA 13 specifies the use of the Hazen Williams method. This approach is based on the formula developed empirically by Hazen and William

Hazen Williams's equation

$P/L = 4.52Q^{1.85}/c^{1.85}d^{4.87}$ where

P: friction loss per ft of pipe in psi
L=equivalent length
Q flow rate in gpm
d internal pipe diameter in inches
C Hazen-Williams coefficient and for steel pipes equals 120

Equivalent Length means to transfer every fitting in the piping system to its equivalent in straight pipe and that includes all the fittings from the pump to the last sprinkler and after substituting the related pipe diameter of the specified pipe section.

Elite software can do all of that and come out by the friction head. So the friction head loss in the Hotel network = 2 bars

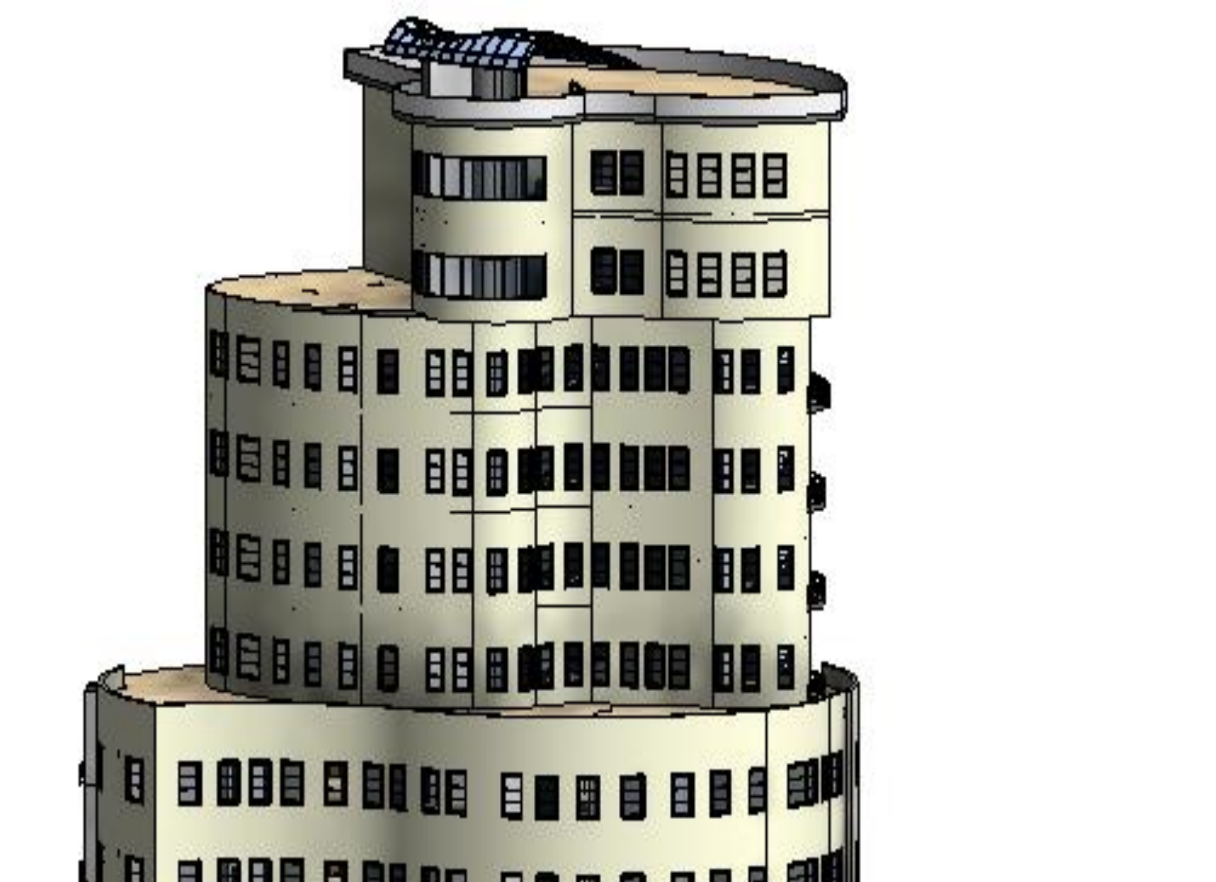
Total head = Static head + Residual head + Friction head
= 89 + 28 + 29 = 146 psi.

6.5 Pump Selection

The head and flow required for selection the pump set are

(860gpm, 146psi)

Revit summery



- For the sample room:

Space Summary - 42 Bed Room

Input Data	
Area (m^2)	15
Volume (m^3)	44.05
Wall Area (m^2)	46
Roof Area (m^2)	17
Door Area (m^2)	5
Partition Area (m^2)	0
Window Area (m^2)	4
Skylight Area (m^2)	0
Lighting Load (W)	220
Power Load (W)	147
Number of People	2
Sensible Heat Gain / Person (W)	75
Latent Heat Gain / Person (W)	75
Infiltration Airflow (L/s)	17.9
Space Type	Dormitory Bedroom
Calculated Results	
Peak Cooling Total Load (W)	**2,630**
Peak Cooling Sensible Load (W)	2,375
Peak Cooling Latent Load (W)	255
Peak Cooling Airflow (L/s)	142.1
Peak Heating Load (W)	**2,168**
Peak Heating Airflow (L/s)	185.9

Cooling Components	**Total (W)**	**Percentage**	North (W)	South (W)	East (W)	West (W)	Northeast (W)	Southeast (W)	Northwest (W)	Southwest (W)
Wall	437	16.60%	0	0	0	0	154	139	72	72
Window	337	12.82%	0	0	0	0	0	0	337	0
Door	83	3.14%	0	0	0	0	0	54	28	0
Roof	1,136	43.20%	-	-	-	-	-	-	-	-
Skylight	0	0.00%	-	-	-	-	-	-	-	-
Partition	0	0.00%	-	-	-	-	-	-	-	-
Infiltration	326	12.38%	-	-	-	-	-	-	-	-
Lighting	106	4.02%	-	-	-	-	-	-	-	-
Power	70	2.68%	-	-	-	-	-	-	-	-
People	135	5.15%	-	-	-	-	-	-	-	-
Plenum	0	0.00%	-	-	-	-	-	-	-	-
Total	**2,630**	**100%**	**0**	**0**	**0**	**0**	**154**	**193**	**438**	**72**
Heating Components	**Total (W)**	**Percentage**	North (W)	South (W)	East (W)	West (W)	Northeast (W)	Southeast (W)	Northwest (W)	Southwest (W)
Wall	826	29.58%	0	0	0	0	259	199	191	176
Window	234	8.37%	0	0	0	0	0	0	234	0
Door	157	5.61%	0	0	0	0	0	78	78	0
Roof	854	30.61%	-	-	-	-	-	-	-	-
Partition	0	0.00%	-	-	-	-	-	-	-	-
Skylight	0	0.00%	-	-	-	-	-	-	-	-
Infiltration	409	14.66%	-	-	-	-	-	-	-	-
Lighting	-106	-3.79%	-	-	-	-	-	-	-	-
Power	-70	-2.53%	-	-	-	-	-	-	-	-
People	-135	-4.85%	-	-	-	-	-	-	-	-
Total	**2,168**	**100%**	**0**	**0**	**0**	**0**	**259**	**277**	**503**	**176**

For the building

Project Summary

Location and Weather	
Project	Palestine Hotel
Address	Ramallah
Calculation Time	Monday, April 23, 2018 12:00 AM
Report Type	Detailed
Latitude	31.89°
Longitude	35.22°
Summer Dry Bulb	35 °C
Summer Wet Bulb	25 °C
Winter Dry Bulb	1 °C
Mean Daily Range	10 °C

Building Summary

Inputs	
Building Type	Hotel
Area (m^2)	6,877
Volume (m^3)	20,857.17
Calculated Results	
Peak Cooling Total Load (W)	**1,000,475**
Peak Cooling Month and Hour	July 5:00 PM
Peak Cooling Sensible Load (W)	1,025,279
Peak Cooling Latent Load (W)	447,196
Maximum Cooling Capacity (W)	1,485,371
Peak Cooling Airflow (L/s)	52,509.1
Peak Heating Load (W)	**544.34**
Peak Heating Airflow (L/s)	47,875.5
Checksums	
Cooling Load Density (W/m^2)	214.12
Cooling Flow Density ($L/(s \cdot m^2)$)	7.64
Cooling Flow / Load ($L/(s \cdot kW)$)	35.66
Cooling Area / Load (m^2/kW)	4.67
Heating Load Density (W/m^2)	94.23
Heating Flow Density ($L/(s \cdot m^2)$)	6.96

Appendix

A-1: Description of wall construction groups

TABLE 9-5 Description of wall construction groups.

Group No.	Description Of Construction	$U_{ov.}$ $W/m^2 \cdot {}^\circ C$
	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.

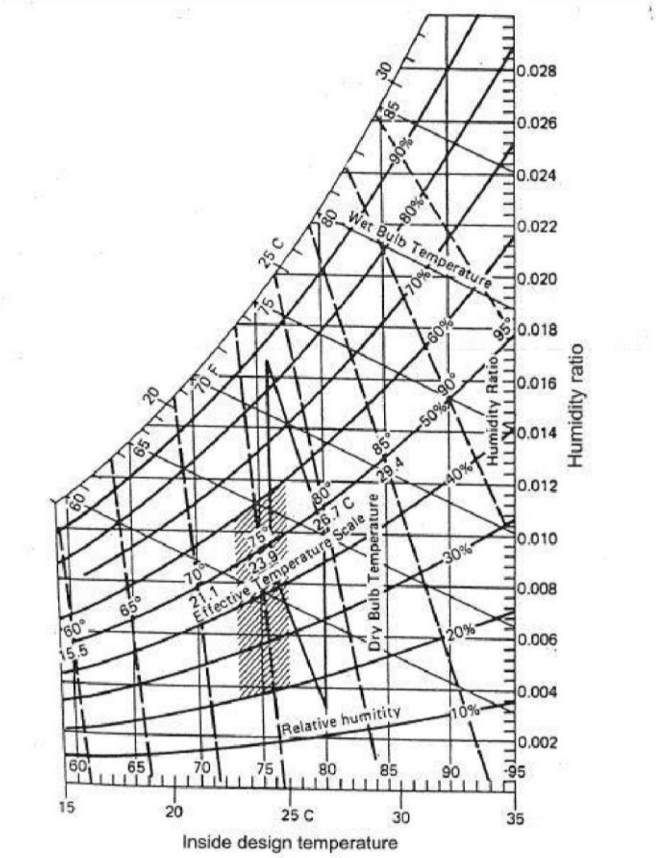
Solar Time	Wall construction											
	Light				Medium				Heavy			
	N	E	S	W	N	E	S	W	N	E	S	W
8:00	—	16	—	—	—	—	—	—	—	—	—	—
9:00	—	20	—	—	—	6	—	—	—	—	—	—
10:00	—	21	2	—	—	11	—	—	—	—	—	—
11:00	—	18	7	—	—	14	—	—	—	3	—	—
12:00	—	12	12	—	—	15	—	—	—	5	—	—
13:00	2	9	15	5	—	14	5	—	—	7	—	—
14:00	3	7	16	13	—	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)li , for lights. [3]

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

[3] Adapted from Stoecker and Jones, 1982, "*Refrigeration and Air Conditioning*", 2[nd] 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 Facing	Solar Time, *h* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
N	0.08	0.07	0.06	0.06	0.07	0.73	0.66	0.65	0.73	0.80	0.86	0.89	0.89	0.86	0.82	0.75	0.78
NNE	0.03	0.03	0.02	0.02	0.03	0.64	0.77	0.62	0.42	0.37	0.37	0.37	0.36	0.35	0.32	0.28	0.23
NE	0.03	0.02	0.02	0.02	0.02	0.56	0.76	0.74	0.58	0.37	0.29	0.27	0.26	0.24	0.22	0.20	0.16
ENE	0.03	0.02	0.02	0.02	0.02	0.52	0.76	0.80	0.71	0.52	0.31	0.26	0.24	0.22	0.20	0.18	0.15
E	0.03	0.02	0.02	0.02	0.02	0.47	0.72	0.80	0.76	0.62	0.41	0.27	0.24	0.22	0.20	0.17	0.14
ESE	0.03	0.03	0.02	0.02	0.02	0.41	0.67	0.79	0.80	0.72	0.54	0.34	0.27	0.24	0.21	0.19	0.15
SE	0.03	0.03	0.02	0.02	0.02	0.30	0.57	0.74	0.81	0.79	0.68	0.49	0.33	0.28	0.25	0.22	0.18
SSE	0.04	0.03	0.03	0.03	0.02	0.12	0.31	0.54	0.72	0.81	0.81	0.71	0.54	0.38	0.32	0.27	0.22
S	0.04	0.04	0.03	0.03	0.03	0.09	0.16	0.23	0.38	0.58	0.75	0.83	0.80	0.68	0.50	0.35	0.27
SSW	0.05	0.04	0.04	0.03	0.03	0.09	0.14	0.18	0.22	0.27	0.43	0.63	0.78	0.84	0.80	0.66	0.46
SW	0.05	0.05	0.04	0.04	0.03	0.07	0.11	0.14	0.16	0.19	0.22	0.38	0.59	0.75	0.83	0.81	0.69
WSW	0.05	0.05	0.04	0.04	0.03	0.07	0.10	0.12	0.14	0.16	0.17	0.23	0.44	0.64	0.78	0.84	0.78
W	0.05	0.05	0.04	0.04	0.03	0.06	0.09	0.11	0.13	0.15	0.16	0.17	0.31	0.53	0.72	0.82	0.81
WNW	0.05	0.05	0.04	0.03	0.03	0.07	0.10	0.12	0.14	0.16	0.17	0.18	0.22	0.43	0.65	0.80	0.84
NW	0.05	0.04	0.04	0.03	0.03	0.07	0.11	0.14	0.17	0.19	0.20	0.21	0.22	0.30	0.52	0.73	0.82
NNW	0.05	0.05	0.04	0.03	0.03	0.11	0.17	0.22	0.26	0.30	0.32	0.33	0.34	0.34	0.39	0.61	0.82
HORIZ.	0.06	0.05	0.04	0.04	0.03	0.12	0.27	0.44	0.59	0.72	0.81	0.85	0.85	0.81	0.71	0.58	0.42

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		Roller Shade: 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, m^3 per passage.[4]

№ of Passage per Hour	Doors in One Wall Only: Single Swing	Vestibule Swinging Doors	Revolving Doors	Doors in more than One Wall: 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-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-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 m^2	Ventilation Air Requirements	
		L/s/Person	L/s/m^2
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 $m^2 \cdot °C/W$
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.

Wind Speed		Less than 0.5 m/s	0.5 - 5.0 m/s	More than 5.0 m/s
Element	Material Type	Outside Resistance R_o, $m^2 \cdot °C/W$		
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/m^2.°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/m^2.°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	—	—

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/m^2)		تعتبر قيم شدة الاشعاع القصوى للاتجاهات المختلفة في الجدولين (3/18) و (3/19) قيماً تصميمية لكافة المناطق المناخية						
درجة يوم تسخين (˚C.day)		لا تتوفر معلومات عن هذه القيم حالياً						
درجة يوم تبريد (˚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