Palestine Polytechnic University

College of Engineering and Technology

Mechanical Engineering Department

Air conditioning and Refrigeration Engineering

Project Title

Design of Mechanical System of Diamond Hotel

Project Team

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June 2017

Dedication

To our parents and families ··· For their support

To our Teachers ··· For help us until the end

To our friends ··· Who give us positive sentiment

To our great Palestine

To everyone has supported us to reach

To our supervisor

Eng. Mohammad Awad

Mohammad Sabri Daraghma

Ahmad Ali Faqeh

Alaa Shaker Aqel

Acknowledgment

Our thanks firstly to our supervisor Eng.Mohammad Awad. He guides and support until made this work possible.

Our wishes and thanks to Dr. Ishaq Sider, And Eng Kazem Osaily, And this work would not exist without their inspiration.

And finally, our ultimate thanks to all lecturers, doctors, engineers, and edifice of science, (Palestine Polytechnic University), for the effort and guidance which helped building characters to become successful engineers.

Abstract

المشروع عبارة عن فندق عام في منطقة بيت لحم يتضمن العديد من الأنشطة الإدارية والفندقية بالإضافة إلى عنصر الترفيه، حيث يتكون الفندق من ثمانية طوابق وثلاث طوابق تسوية بمساحة إجمالية تبلغ ($8000\ m^2$).

ويقوم المشروع على عمل الخدمات الميكانيكية وشبكات المياه والصرف الصحي ونظام تكييف الهواء، ويشمل أيضا على تصميم نظام إخماد الحريق، وتصميم برك السباحة .

The aim of the project is to design a complete mechanical system for a hotel which is located in Bethlehem city. This building consists of Eighth floors and three basement with an area of 8000 m^2 . These services are certainly designed to verify human comfort. The project is going to provide an integrating service to that building in regard to the air conditioning, firefighting and plumbing systems ,In this project, air conditioning system type (VRF) is used since it is efficient and economical.

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Chapter four:

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CHAPTER ONE

INTRODUCTION

1.1 Project outline:

Chapter one:

Includes an overview about project, project benefits and objectives.

Chapter two:

Includes an overview about the cooling and heating systems, and how to calculate cooling load from all sources.

Chapter three:

Includes an overview about plumbing systems, water distribution system (cold and hot water), separation and treatment of gray water.

Chapter four:

Includes an overview about the fire fighting system.

Chapter five:

Includes an overview about the swimming pool.

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1.2 Scope of project:

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

1.Design the mechanical systems inside the hotel building.

2.Theoretical calculations and design of HVAC system.

3.Theoretical calculations and design of plumbing system.

4.Theoretical calculations and design of swimming pool system.

5.To be familiar with the mechanical drawings for different mechanical systems.

1.3 Project objectives:

The main objective of the project is to develop mechanical services design in diamond hotel , and the aim objectives are:

1. Design the air conditioning system for all floors.

2. To calculate and design the plumbing system including water supply and waste water systems for the hotel.

3. To select the required equipment of the systems.

4.Design the fire fighting system for hotel.

5. To prepare suitable bill of quantities for the relevant systems.

1.4 Project benefits:

1-The main benefit is to fulfill the graduation requirements of Palestine Polytechnic University, And be familiar with all mechanical design of system installed in hotel to be ready in working in this field after graduation.

2- To be familiar with all mechanical calculation and design of system installed in residential building.

3- To be familiar with the different mechanical drawings.

4- To be familiar with solar cells design.

1.5 Key words:

HVAC: Heating Ventilation and Air Conditioning.

VRF: Variable Refrigeration flow.

WSFU: is water supply fixture unit it used to calculate the portable maximum water demand for the building.

Dfu: Drainage fixture unit it used to calculate the provision of drainage system.

1.6 Time table:

In this section the tasks and time tables it shown below:

Table 1.1: Tasks description

Objective	Week #															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Set and review goals of project	■	■														
Design plumbing system			■	■	■											
Design VRF system				■	■	■	■									
Design firefighting system							■	■	■	■	■					
Design ventilation system										■	■	■	■			
Design gas system												■	■	■		
Design swimming pool														■	■	
Writing report				■	■	■	■	■	■	■	■	■	■	■	■	
Presentation																■
Printing															■	■

CHAPTER 2

HEATING AND COOLING LOADS

2.1 Overview:

The main objective of the air conditioning is comfort so vital for a guest's good night sleep , the hotel have always VRF system provides exceptional dehumidification and temperature control by rapidly adapting to changing loads In selecting a suitable air conditioning system for a particular application, consideration should also be known as following:

1) System constraints: cooling load, zoning requirements, heating and ventilation.
2) Architectural constraints : size and appearance of terminal devices, acceptable noise level, space available to house equipment and its location relative to the conditioned space , acceptability of components obtruding into the conditioned space.
3) Financial constraints: capital cost, operating cost, maintenance cost.

2.2 Heating and cooling load:

Heating load: it is in winter and it is the rate at which heat must be added to the space in order to maintain the desired conditions in the space.

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

The inside and outside conditions are obtained from Palestinian code for Bethlehem city ,as shown in the following table as shown in Table (2.1).

we choose the design month to be July (in summer) and January (in winter).

Table (2.1): Inside and outside design conditions

Property	Inside Design Condition		Outside Design Condition	
	Summer	Winter	Summer	Winter
Temperature (˚C)	24	24	29.5	4.7
Relative Humidity (%)	50%	50%	53%	71%
Wind Speed (m/s*)*	....	....	1.4	1.4

2.3 Cooling load source :

The cooling loads for a given space consist of the following heat gains:

1) Heat gains that transmitted through building structures such as walls, floors and ceiling that are adjacent to unconditioned spaces. The heat transmitted is caused by temperature difference that exists on both sides of structures.

2) Heat gain due to solar effect which includes:

   a. Solar radiation transmitted through the glass and absorbed by inside surfaces and furniture.
   b. Solar radiation absorbed by walls, glass windows, glass doors and roofs that are exposed to solar radiation.

3) Sensible and latent heat gains brought in to the space.

4) Sensible heat produced in space by lights, appliances, motor and other miscellaneous heat gains.

5) latent heat produced from cooking, hot baths.

6) Sensible and latent heat produced by occupants.

The heating load sources that affect the air conditioning system design can be made-up of many components, including the follow:

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

2.4 Overall heat transfer coefficient:

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:

$$\boldsymbol{U} = \frac{1}{\frac{1}{h_{fin}}+\sum\frac{\Delta x}{k_m}+\frac{1}{h_{fout}}} \qquad (2.1)$$

Where:

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

K: conduction heat transfer coefficient ($W/m.K$).

Δx: layer thickness (m).

h_{fin}:Indoor convection heat transfer coefficient ($W/m^2.K$).

h_{fout}: Outdoor convection heat transfer coefficient ($W/m^2.K$).

2.5 Heating load calculation:

2.5.1 Overview:

Heating load is the rate at which heat energy must be supplied to a space to maintain a given inside design condition.

The heating load of a building consists of the following components:

1) Heat loss through all exposed walls, ceiling, floor, windows, doors, and walls between a heated space and an unheated space (partition walls).

2) Heat load required to warm outside cold air infiltrated to heated space through cracks (clearances) of windows and doors, and outside cold air infiltrated due to opening and closing of doors.

3) Domestic hot water load .

4) Miscellaneous loads such as emergency heating loads and safety factor heating load.

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2.5.2 Heating load calculation:

The general procedure for calculating the total heating load is:

1) Compute the overall heat transfer coefficients for all exposed surfaces of the building through which heat losses are to be calculated.

2) Determine all surface areas through which heat is lost.

3) Compute the heat loss for each type of walls, floor, ceiling or roof, doors, windows, etc. by using this equation:

$$Q = UA(Tin\text{-}Tout) \tag{2.2}$$

Where:

Q: rate of heat transfer (W).

U:overall heat transfer coefficient ($W/m^2.^\circ C$).

A: heat transfer area (m^2).

Tin: inside design temperature (˚C).

Tout: outside design temperature (˚C).

4) Compute heat loss from bellow-grade walls and floor, if any.
5) Calculate the infiltration air rate and compute the resulting heating load due to infiltration.
6) Assume a safety factor value of 10 to 15% to account for emergency loads.
7) The sum of all the above heat losses for all rooms represents the total heating load of the building.

2.5.3 Heat loss through walls (Q_w):

Area for the Window= 1.2 * 2 =2.4 m^2.

Area for the door =2.2*0.9 =1.98 m^2.

$Q_{Wall\ out}$= UA (Tin-Tout)

= 0.89 * ((3.85*2.83)-2.4) *19.3

=0.14592 kW

$Q_{Wall\ in}$= UA (Tin-Tout)

= 2.95 *((3.85*2.83) -1.98) * 7

= 0.1841 kW

$Q_{\text{wall for room 6}} = Q_{\text{Wall out}} + Q_{\text{Wall in}} + Q_{\text{celling}} + Q_{\text{floor}}$

$= 0.14592 + 0.1841 + 0 + 0$

$= 0.33002$ kW

$Q_{\text{Window}} = UA\ (Tin\text{-}Tout)$

$= 5.6 * 2.4 * (24 - 4.7)$

$= 0.25939$ kW

$Q_{\text{door}} = UA\ (Tin\text{-}Tout)$

$= 3.6 * 1.98 * (24 – 17)$

$= 0.049896$ kW

2.5.4 Heat gain due to infiltration (Q_f):

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

$$Q_{inf,g} = \dot{V}_f / v_0 * (h_o - h_i) \qquad (2.3)$$

Where:

h_i: Inside enthalpy of infiltrated air in (kJ/kg).

h_o: Outside enthalpy of infiltrated air in (kJ/kg).

$\dot{V}_f$: The volumetric flow rate of infiltrated air in (m^3/s).

v_o: Specifics volume in (m^3/kg).

$$\dot{V}_f = K * L\,[0.613(S1S2V_0)^2]^{2/3} \qquad (2.4)$$

Where:

K : the infiltration air coefficient.

L: the crack length in meter.

S1: factor that depends on the topography of the location of the building.

S2: coefficients that depends on the height of the building.

Vo: measured wind speed (m/s).

The values of K,S1 andS2 are obtained from Tables A (6-2), A(6-3) and A(6-4) respectively:

K=0.43 , S1=0.9 , S2=0.75

Vo =1.4 (m/s) from Palestinian code.

$\mathbf{Q}_{\textbf{Tot for room \# 6}} = Q_{\text{Wall out}} + Q_{\text{Wall in}} + Q_{\text{Celling}} + Q_{\text{Floor}} + Q_{\text{Window}} + Q_{\text{Door}} + Q_{\text{inf ,window}} + Q_{\text{inf ,door}}$

= 0.14592 + 0.1841 + 0 + 0 + 0.25939 + 0.049896 + 0.0255 + 0.008537

= **0.67334 KW**

Floor	Heating Load (kW)
Basement # - 3	28.37
Basement # - 2	5.413
Basement # - 1	19.25
Ground Floor	27.54
First Floor	24.67
Second Floor	24.67
Third Floor	24.67
Fourth Floor	24.67
Fifth Floor	24.67
Sixth Floor	24.67
Roof Floor	34.86

2.6 Cooling load calculation:

Cooling load is the rate at which heat energy must be removed from a space in order to maintain a given inside design condition. Figure 2.4 shows the sources of cooling load.

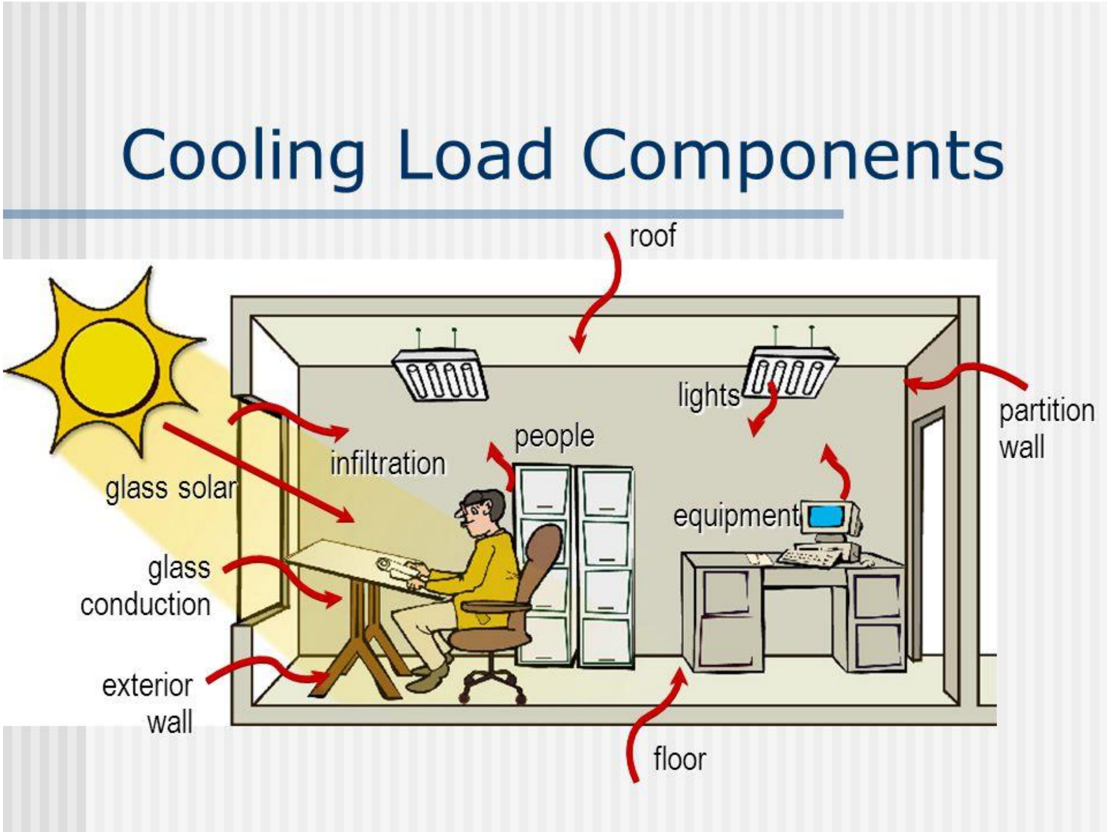

Figure 2.1: Source of cooling load

2.6.1 Cooling load sources:

The cooling load for a given space consists of the following heat gains:

1) Heat gains that transmitted through building structures such as walls, floors and ceiling that are adjacent to unconditioned spaces. The heat transmitted is caused by temperature difference that exists on both sides of structures.

2) Heat gain due to solar effect which include:

a) Solar radiation transmitted through the glass and absorbed by inside surfaces and furniture.
b) Solar radiation absorbed by walls, glass windows, glass doors and roofs that are exposed to solar radiation.

3) Sensible and latent heat gains brought into the space .

4) Sensible heat produced in space by lights, appliances, motor and other miscellaneous heat gains.

5) Latent heat produced from cooking, hot baths.

6) Sensible and latent produced by occupants.

2.6.2 Solar radiation:

Solar radiation received at the earth's surface on a plane perpendicular to the sun rays may reach at hourly value 900W/m^2on a clear day. This value of solar radiation intensity occurs when the sun is directly over head. Solar radiation intensity decreases as the suns angle of altitude decreases. The altitude angle is the angle that the sun rays make with horizontal line in a vertical plane.

Time of day and altitude of the location are also factors that affect the direct radiation.

2.6.3 Heat gain through sunlit walls and roofs:

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

The calculation of this type of heat gain can be obtained by using the following relation for the heat transmission through the walls.

$$U = \frac{1}{\sum Rth} \quad (2.5)$$

Where:

R_{th}: are the thermal resistances of the various materials ($m^2.℃/W$).

The transmitted heating load can be calculated from the relation:

$$Q = U*A*\Delta T \quad (2.6)$$

Where:

Q: Heat flow through the walls, ceiling, floor, by conduction (W).

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

A: is the effective area that heat transmitted through it (m^2).

ΔT: The total equivalent temperature difference which take in consideration the increase of wall temperature due to absorption of solar radiation.

The value of CLTD extracted from Table (A-1)needs to be corrected, so that the actual value is found for different cases, and hence it will be called corrected CLTD and can be calculated from the following equation:

$$(CLTD)corr = (CLTD+LM)K + (25.5-T_i) + (T_{o,m} - 29.4)f \quad (2.7)$$

Where:

LM: latitude correction factor which can obtain from Table (A-2) from reference for horizontal and vertical surfaces.

K: Color adjustment factor such that K=1.0 for dark colored roof, and K=0.5 for permanently light colored roofs.

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

($T_{o,m}$-29.4): A correction factor for outdoor mean temperature .

It is related to the outdoor design temperature to, according to the relation :

$$T_{o,m}= To-DR/2 \qquad (2.8)$$

Where:

DR: The daily temperature range which equal to the difference between the average maximum and average minimum temperature for the hottest month of the summer season.

F: Roof fan factor such that f=0 if there is no attic or roof fan and f=1 if there is an attic or roof fan.

Overall heat transfer coefficient depends on the layers which the building is consist of and the indoor and outdoor convection heat transfer coefficient.

2.6.4 Heat transfer through 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 is absorbed by the glass depending on the absorptive value of glass.

3) Reflected component.

This component is reflected by glass to the outside of the building. About 8% of the solar energy is reflected back by the glass.

The amount of solar radiation that can be transmitted through glass depends upon the following factor:

1) Type of glass (Single, double or insulation glass).

2) Availability of shading (such as drapes, venetian blinds, construction overhang, wing wall, etc).

3) Time of the day.

4) Orientation of glass area (north, northeast, east orientation, etc).

5) Solar radiation intensity and incident angle.

6) Latitude angle of the location.

2.6.5 Transmission heat gain:

The transmitted cooling load can be calculated from the relation:

$$Qtr = A(SHG)(SC)(CLF) \qquad (2.9)$$

Where:

SHG: Solar heat factor

Is a factor represents the amount of solar energy from Table (A-3).

SC: Shading coefficient:

This factor accounts for different shading effects of the glass wall or widow and can be extracted from special tables for single and double glass without inside shading or for single and double glass as well as for insulating glass with internal shading form Table (A-4-2).

CLF: Cooling load factor

Represent effect of the internal walls, floor, and furniture on the instantaneous cooling load, we find it from Table (A-5-1) for glass, and from Table(A-6-1), (A-6-2) for lights and occupants respectively .

2.6.6 Convection heat gain:

The value of the convection heat gain by the glass can be calculated from the equation:

$$Q_{conv} = U*A*(CLTD)corr \qquad (2.10)$$

Where:

CLTD: is the temperature difference for the glass and can be extracted from Table (A-7)its designed for inside room temperature of 25.5˚C and outside mean temperature of 29.4˚C.If Ti and To,m are different from 25.5˚C and 29.4˚C, then a correction must be added to the value of CLTD.

2.6.7 Heating gain due to equipment:

Sensible and latent heat loads arising from various equipment and appliances that are installed in a conditioned space. The indicated heat dissipation rates from such equipments and appliances should be inclined when the cooling load is estimated. Care must be taken when considering such dissipation rates all sensible or latent or partly sensible and partly latent.

2.6.8 Heating gain due to lights:

Heat gains due to lights are sensible loads. Such loads must be carefully analyzed specially for supermarkets, department stores and other commercial applications that are usually brightly illuminated. The peak lighting heat gains for some applications such as hospitals, restaurants and office will not occur simultaneously with the peak heat gain from other source. This fact should be considered when calculating the peak load for certain application.

The heat gain due to fluorescent lamps is obtained by multiplying the rated voltage of lamp by 1.2 while that for ordinary lamp is obtained from its rated voltage directly.

Lighting intensity differs from one application to another. It ranges from 10 to 30 W/m^2 of floor area for apartments, hospitals, hotels etc. and from 30 to 60 W/m^2 for class rooms, offices, barbershop and similar application.These lighting intensities can be used to estimate the heat gain from lights if the exact lighting power is not known.The heat gain from lights it's not an instantaneous load on the air conditioning equipment. The radiant energy from lights is first observed by walls, floor and furniture of the space causing there temperature to increase with time. As time passes, heat is converted from these surfaces.

This result in a time delay between turning the light on and the energy from the light to have an effect on the cooling load. To accommodate for this fact, the following equation can be used to calculate the heat gain due to the lights.

$$Q_{Lt} = P_{Lt} * A * (F_u * F_b)\ (CLF)_{Lt} \qquad (2.11)$$

Where:

P_{Lt}: the lamp rated power in watts per $m^2 (60 W/m^2)$.

A: Area of zone.

F_u: the fraction of lamps that are in use (F_u=1) .

F_b: the ballast factor that equals to 1.2 for fluorescent lamps and equals to 1.0 for ordinary lamps, (F_b=1.2).

$(CLF)_{Lt}$: the light cooling load factor from Table (A-6-1)10 hours turned on and 10 hours of operation, CLF=0.85.

2.6.9 Heat and human comfort:

The indoor design requirement are chosen to meet human body needs, so human body feeling with relax under known condition of temperature and relative humidity, in order to know these conditions of comfort it is very essential to understand the principle of heat transfer and body temperature.

The normal body temperature is 37.2˚C which is mostly higher than ambient temperature thus heat is transferred from the human body to ambient air by the difference in temperature. For reaching equilibrium the human body must generate heat equal to the heat loss by the body, the following equation describes the heat balance:

$$M-P = E+R+C+S \tag{2.12}$$

Where:

M: metabolic rate.

P: mechanical work done by the body.

E: rate of total evaporation loss.

R: is the rate of heat dissipated by radiation from the body.

C: is the rate of heat dissipated by convection from the body.

S: rate of heat storage of human body.

The amount of heat generated by the body depends on the type of personals activity, this heat is produced by metabolizing the food we eat, the process is known as metabolism, 1met = seated quiet person (100 W if body surface area is 1.7m^2).

Sample calculation for Floor No. 7:

Inside Design Condition: T_i =24˚C ,φ =50%

Outside Design Condition: T_o=30˚C,φ =53 %

Figure 2.2: Sample calculation for Floor No. 7

Table(2.2): Area for sample room

	Area (m^2)	U ($W/m^2.C$)	($T_i – T_o$) C	Q_{Loss} (kW)
Walls				
S-Wall	35.658	0.89	6	0.1904
	24.23	2.95	4	0.2859
E-Wall	58.64	0.89	6	0.3131
W-Wall	33.2	0.89	6	0.3472
N-Wall	41.14	0.89	6	0.2196
	35.092	0.88	4	0.123523
Ceiling				
Ceiling	518.9646	1.8	6	5.604
Floor				
	518.9646	1.8	0	0
Windows				
S	0	5.6	6	0
E	43.38	5.6	6	1.457
W	28.82	5.6	6	0.9717
N	0	5.6	6	0
Doors				
South	1.6	3.6	4	0.02304
	0.8	3.6	4	0.01152
	0.8	3.6	4	0.01152
North	1.25	3.6	4	0.018
			Q_{total}=	9.6065

Calculation of the value of (CLTD) corrected

Table(2.3): The value of (CLTD) corrected

Surface	U ($W/m^2.°C$).	Area (m^2)	CLTD (C)	LM	$CLTD_{corr.}$ (c)	Q (conv) (kW)
E-wall	0.89	58.64	15	0	4.5	0.2348
W-wall	0.89	33.2	17	0	5.5	0.1625
N-wall	0.89	41.14	8	0.5	1.25	0.0457
S-wall	0.89	35.658	12	-1.6	2.2	0.0698
E-Glass	5.6	43.38	7	0	0.5	0.1214
W-Glass	5.6	28.82	7	0	0.5	0.0806
N-Glass	5.6	0	7	0.5	0.75	0
S-Glass	5.6	0	7	-1.6	-0.3	0

	Total=	0.71436

Calculation of transmitted heat gains:

Table (2.4): transmitted heat gains

Surface	**Area (m^2)**	**SHG**	**SC**	**CLF**	**Q_{Loss}(tr) (kW)**	**Q_{Loss}** Tot (tr+conv) **(kW)**
N-Glass	0	126	0.57	0.86	0	0
S-Glass	0	227	0.57	0.68	0	0
E-Glass	43.38	678	0.57	0.22	3.688	3.8094
W-Glass	28.82	678	0.57	0.53	5.903	5.9836
				Total=	9.591	9.793

2.6.10 Cooling load from occupancy:

There is latent heat and sensible heat from people:

For each person from Table (A-8)

Q_s per person = 70 W/person.

Q_L per person = 44 W/person

1) Sensible heat gain:

$$Q_S = \text{No. of person} * Q_s \text{ per person} * CLF_{occ} \qquad (2.13)$$

CLF_{occ}: Cooling factor for occupants from Table (A-6-2).

CLF_{occ}= 0.87

Q_S = 128*70*0.87

=7795.2 W

2) Latent heat gain:

$$Q_L = \text{No. of person} * QL \text{ per person} \tag{2.14}$$

Q_L = 128*44

= 5632 W

Total heat gain from people (latent heat and sensible heat):

$Q_{Tot} = Q_S + Q_L$

=7795.2 + 5632 = 13427.2 W

= 13.4272 KW

2.6.11 Cooling load from ventilation (Infiltration) :

$$Q = \frac{N \times V \times \Delta h}{3600 \times v_o} \tag{2.15}$$

When:

N: number of room air change per hour.

V: volume of room.

v_o:Specific volume for outside air.

T_o = 30 C T_i= 24 C

φ_o = 53.7% φ_i = 50%

From psychometric chart:

h_{in} = 47 kJ/kg dry air

h_{out} = 67.7 kJ/kg dry air

v_{in}= 0.866 m^3/kg dry air

v_o= 0.878 m^3/kg dry air

$Q=\frac{15\times1613.1\times(67.7-47)}{3600\times0.878}$

= 0.1584 kW

2.6.12 Heat gain due to lights (Q_{Lt}):

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

$$Q_{Lt} = \text{light intensity} \times A \times (CLF)_{Lt} \quad (2.16)$$

Where:

light intensity : 10-30 W/m^2 for apartment, so we will take 25 m^2

A: floor area

$(CLF)_{Lt}$: cooling load factor for lights.

$(CLF)_{Lt}$ = 0.85 from Table A(6.1) .

The area = 570 m^2

Q_{Lt} = 25 * 570 * 0.85

= 12.1125 kW

2.6.13 Cooling load from infiltration:

$$Q_{inf, g} = \dot{V}_f / v_0 * (h_o - h_i) \quad (2.17)$$

$$\dot{V}_f = K * L[0.613(S1S2V_0)^2]^{2/3} \quad (2.18)$$

K = 0.43,S1 = 0.9 and S2 = 0.75

Vo= 1.4 (m/s) from Palestinian code.

L_{Window} = 8.25 m

Vf , window = 0.43 * 8.25 (0.613 (0.9 * 0.75 * 1.4) ^{2})$^{2/3}$

= 2.37395 m^3 / h

= 2.37395 / 3600

= 6.59430 * 10^{-4} m^3 / s

$Q_{inf ,window}$ = (6.0747 * 10^{-4} / 0.878) * 20.7

= 0.01432 kw

$Q_{inf , for all window}$ = 14 * 0.01432

= 0.20048 kw

L_{door} =9.8 m

Vf , door = 0.43 * 9.8 (0.613 (0.9 * 0.75 * 1.4) ^{2})$^{2/3}$

= 2.8199 m^3 / h

= 2.8199 / 3600

$= 7.8332 * 10^{-4}\ m^3 / s$

$Q_{inf,door} = (4.955 * 10^{-4} / 0.87) * (13)$

$= 0.007404\ kw$

$Q_{inf,all\ door} = 2 * 0.007404 = 0.014808\ kw$

$Q_{Tot} = Q_{Roof} + Q_{Wall} + Q_{un} + Q_{Glass} + Q_{Lt} + Q_f + Q_{oc} + Q_{vn}$

= **69.041**KW

Table (2.5): Total Cooling load calculated

Floor	Cooling Load (kW)
Basement # - 3	**40.405**
Basement # - 2	**11.404**
Basement # - 1	**29.464**
Ground Floor	**54.561**
First Floor	**48.852**
Second Floor	**48.852**
Third Floor	**48.852**
Fourth Floor	**48.852**
Fifth Floor	**48.852**
Sixth Floor	**48.852**

Roof Floor	**69.041**

2.7 Variable Refrigerant Flow System :

2.7.1 Overview:

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

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

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

2.7.2 VRV benefits:

1) Installation advantages:.

Chillers often require cranes for installation, but VRF systems are light weight and modular. Each module can be transported easily and fits into a standard elevator.

Multiples of these modules can be used to achieve cooling capacities of hundreds of tons. Each module (or set of two) is an independent refrigerant loop, but they are controlled by a common control system.

An additional installation advantage is that the piping connections between outdoor and indoor unit have total length of (1000 m), which is make the system applicable in large and higher buildings, and the number of indoor unit that connected to one outdoor unit reaches to (64).

2) Maintenance and commissioning:

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

Because they are DX systems, maintenance costs for a VRV should be lower than for water-cooled, chillers, so water treatment issues are avoided. Normal maintenance for a VRV, similar to that of any DX system, consists mainly of changing filters and cleaning coils.

3) Comfort:

Many zones are possible, each with individual set point control. Because VRF systems use variable speed compressors with wide capacity modulations capability, they can maintain precise temperature control, generally within ± 1 ºF

(± 0.06 ºC), according to manufactures' literature.

4) Energy efficiency:

The energy efficiency of VRV systems derives from several factors. The VRV essentially eliminates duct losses, which are often estimated to be between 10% to 20% of total airflow on a ducted system. VRV systems typically include two to three compressors, one of each 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, because HVAC systems typically spend most of their operating hours in the range of 40% to 80% of maximum capacity, so through using inverter technology and control of each zone separately the operating cost be lower with using modulating valve that control the amount of flowing refrigerant with changing load.

2.7.3 Applications:

VRV systems are generally best suited to buildings with diverse, multiple zones requiring individual control, such as office building, hospitals, or hotels a VRV system does not compete well with roof top systems in a large low-rise building such as a big box retail store. Although VRF heat pumps operate at ambient temperatures as low as 0 ºF (-18 ºC), as in all heat pumps, their efficiency drops off considerably at low temperatures, so they are less cost effective compared to gas heating in very cold climates.

2.7.4 Calculation:

2.7.4.1 Selection indoor unit:

Table (2.6): Selection indoor unit for typical floor

Unit type	No. of model	QTY	Cooling capacity (kW)	Total cooling capacity (kW)
Ceiling unit	FXSQ20P	48	2.4	2.3
Ceiling unit	FXSQ25P	42	3.1	3
Ceiling unit	FXSQ32P	12	4.1	3.7
Ceiling duct type	FXMQ07P	6	8.3	8.2

Table (2.7): Selection indoor unit for seventh floor

Unit type	No. of model	QTY	Cooling capacity (kW)	Total cooling capacity (kW)
Ceiling unit	FXSQ80P	7	10	9.4

Table (2.8): Selection indoor unit for ground floor

Unit type	No. of model	QTY	Cooling capacity (kW)	Total cooling capacity (kW)
Round flow cassete	FXFQ20A	9	2.2	2.5
Ceiling duct type	FXMQ07P	2	8.3	8.2

Table (2.9): Selection indoor unit for first basement floor

Unit type	No. of model	QTY	Cooling capacity (kW)	Total cooling capacity (kW)
Ceiling duct type	FXMQ07P	5	8.3	8.2

Table (2.10): Selection indoor unit for second basement floor

Unit type	No. of model	QTY	Cooling capacity (kW)	Total cooling capacity (kW)
Ceiling duct type	FXMQ07P	5	8.3	8.2

2.7.4.2 Selection outdoor unit:

Table (2.11): Selection outdoor unit

Unit type	No. of model	QTY	capacity (kW)	Refrigerant
Heat pump combination	RXYQ54P	1	150	R410A
Heat pump combination	RXYQ48P	1	132	R410A
Heat pump combination	RXYQ38P	1	124	R410A

Table (2.12): Selection outdoor unit

No. of model	Combination	Weight (kg)	Dimensions (mm)
RXYQ54P	RXYQ18P RXYQ18P RXYQ18P	341 341 341	1650*1240*765
RXYQ48P	RXYQ18P RXYQ18P RXYQ12P	341 341 285	1650*1240*765 1680*1240*765
RXYQ38P	RXYQ18P RXYQ12P	341 285 205	1650*1240*765 1680*1240*765 1680*930*765

	RXYQ8P		

2.7.5 Pipe size:

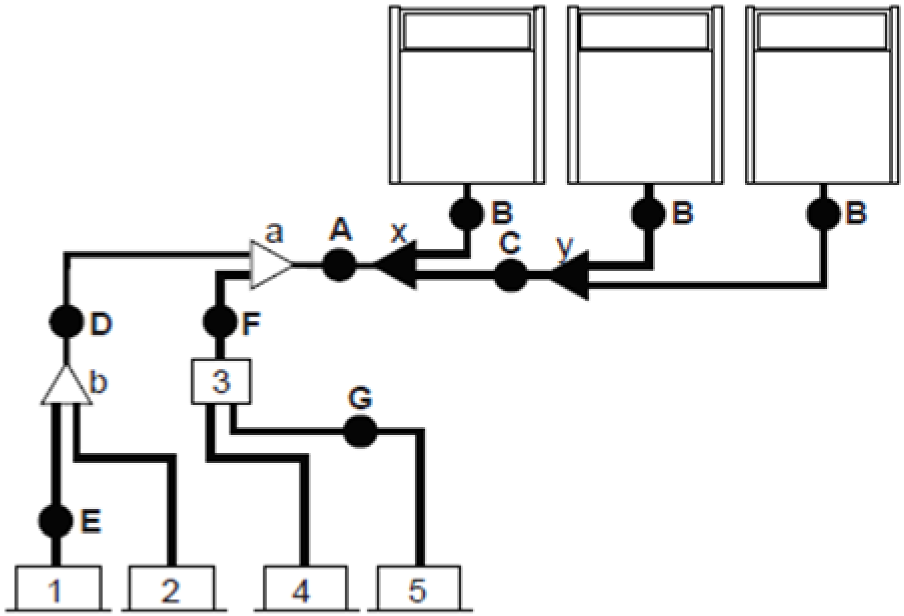

Figure 2.3: To select the pipe sizing

To select the piping size

A , B , C piping between outdoor unit and (first) refrigerant branch kit.

Choose from the following table (B-7) accordance with the outdoor unit total capacity type.

D: piping between refrigerant branch kit and indoor unit .

Choose from the following table (B-8) accordance with the indoor unit total capacity type.

To select refrigerant branch kit (refnets joints), when using refnets joints at the first branch counted from the outdoor unit, choose from the following table (B-9) in accordance with the capacity of the outdoor unit.

We select refnets joints between outdoor unit & main branch is type

KHRQ22M75

To select refrigerant branch kit (refnets joints)

Select the proper branch kit model based on the total capacity index of all indoor unit connected after the refrigerant branch, choose from the following table (B-10)

We select refnets joints between indoor unit & main branch is types:

KHRQ22M64T

KHRQ22M20T

KHRQ22M29T

2.7.6 indoor selection:

Table (2.13): Selection indoor unit for roof floor

The contents of the floor	No. of floor	Area	Heating load (kW)	Cooling load (kW)	Actual Capacity (kW)	Nominal Capacity (kW)	Type

RESTAURANT	ROOFFLOOR	500	34.865	69.041	15.5	10.1	FXSQ-80P

Table (2.14): Selection indoor unit for typical floor

No. of floor	The contents of the floor	Heating load (kW)	Cooling load (kW)	Actual Cooling Capacity	Nominal Cooling capacity	Actual Heating Capacity	Nominal Heating Capacity	Type
TYPICAL FLOOR	Room F101	1.01	2.313	2.4	1.9	2.2	1.9	FXSQ-20P
	Room F102	1.01	2.313	2.4	1.9	2.2	1.9	FXSQ-20P
	Room F103	1.01	2.313	2.4	1.9	2.2	1.9	FXSQ-20P
	Room F104	1.01	2.313	2.4	1.9	2.2	1.9	FXSQ-20P
	Room F105	1.01	2.313	2.4	1.9	2.2	1.9	FXSQ-20P
	Room F106	1.01	2.313	2.4	1.9	2.2	1.9	FXSQ-20P
	Room F107	1.01	2.313	2.4	1.9	2.2	1.9	FXSQ-20P
	Room F108	1.01	2.313	2.4	1.9	2.2	1.9	FXSQ-20P
	Room F109	1.38	3.162	4	2.8	2.2	2.8	FXSQ-32P
	Room F110	1.39	3.171	4	2.8	2.2	2.8	FXSQ-32P
	Room F111	1.08	2.472	3.1	2.2	2.2	2.2	FXSQ-25P
	Room F112	1.08	2.471	3.1	2.2	2.2	2.2	FXSQ-25P
	Room F113	1.08	2.471	3.1	2.2	2.2	2.2	FXSQ-25P
	Room F114	1.08	2.471	3.1	2.2	2.2	2.2	FXSQ-25P
	Room F115	1.08	2.471	3.1	2.2	2.2	2.2	FXSQ-25P
	Room F116	1.08	2.471	3.1	2.2	2.2	2.2	FXSQ-25P
	Room F117	1.08	2.471	3.1	2.2	2.2	2.2	FXSQ-25P
	Corridor	5.93	5.93	6.2	4.2	5.5	4.2	FXMQ-07P
TOTAL		24.67	48.852					

2.7.7 Type of indoor unit:

Indoor unit we selected

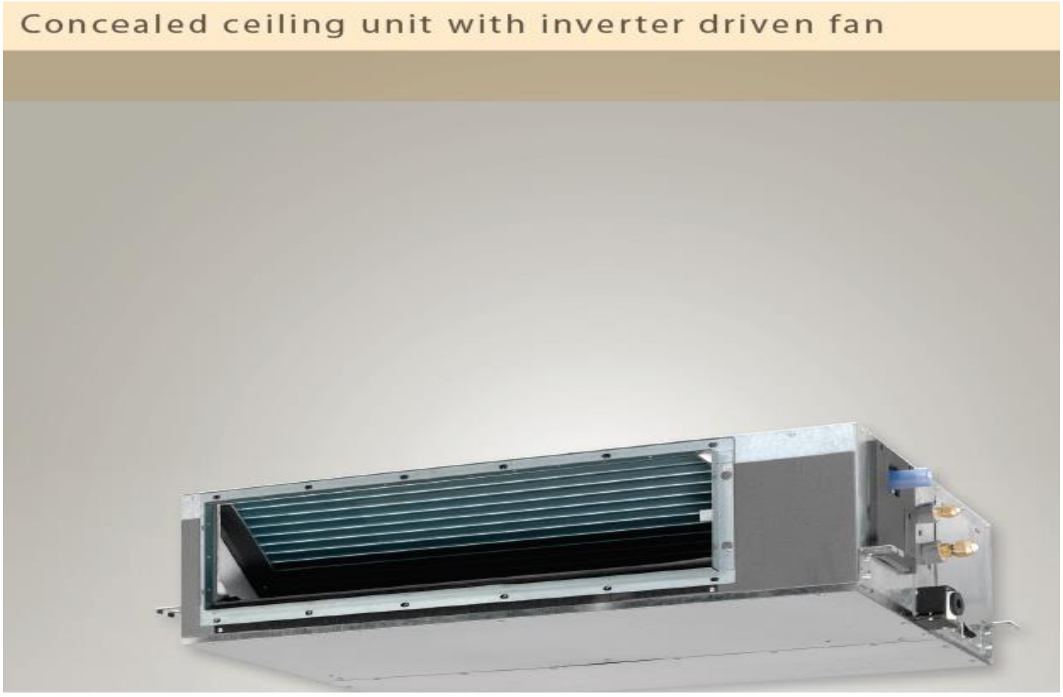

Figure 2.4: FXSQ – P Ceiling unit with inverter fan

Figure 2.5: FXMQ _ A Round flow cassette unit

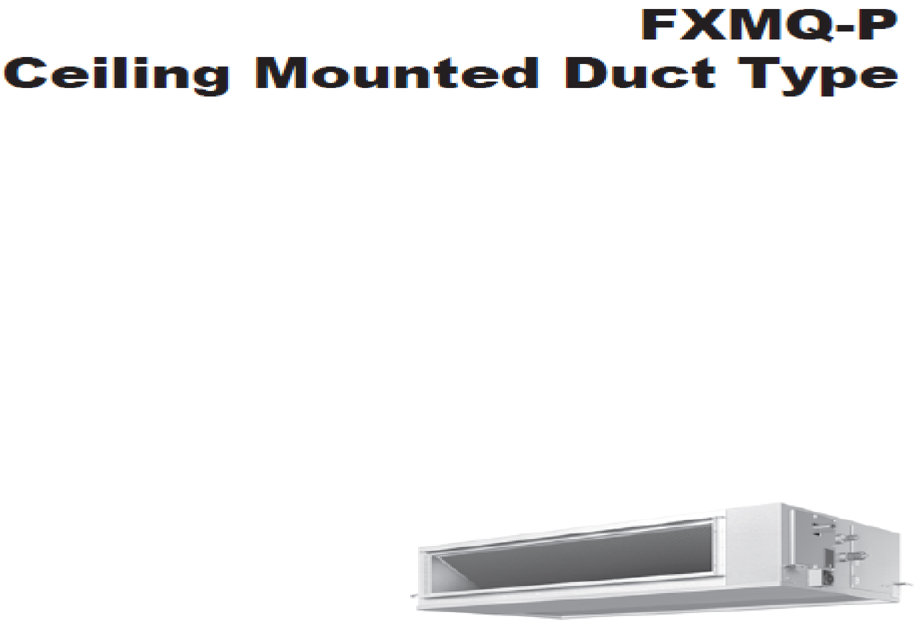

Figure 2.6: FXMQ _ P Duct type unit

Figure 2.7: FXHQ _ M ceiling suspended type

2.7.8 Grills selection :

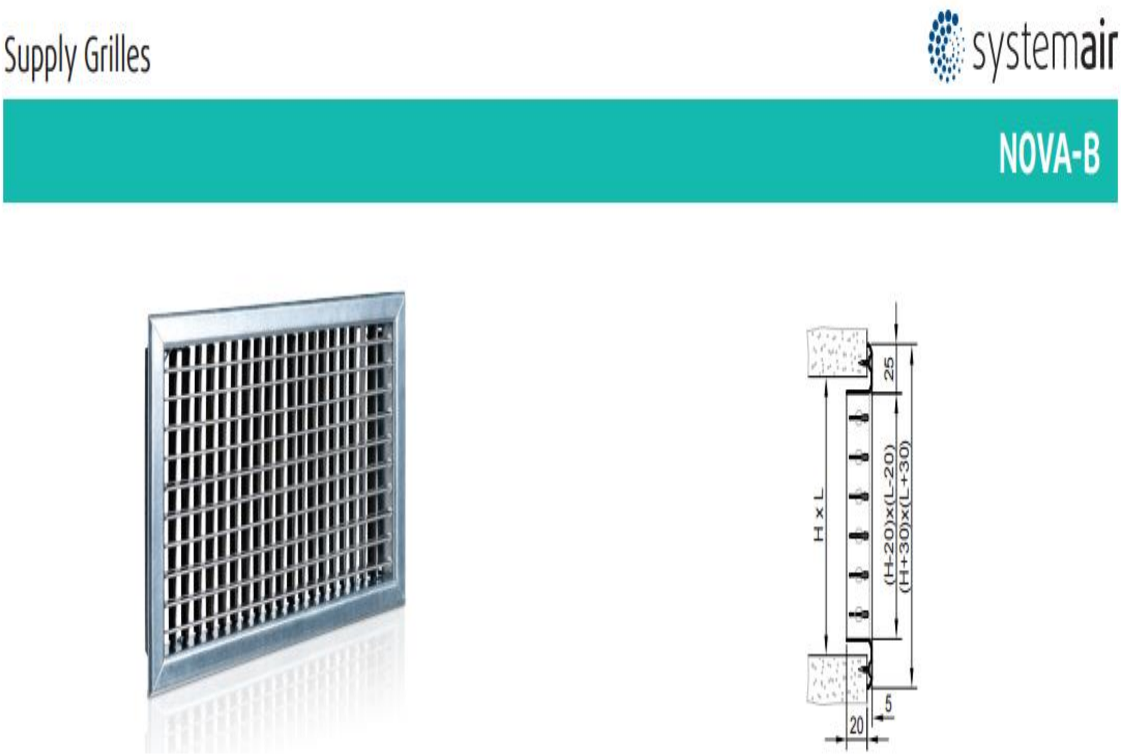

Figure 2.8: Linear bar supply grill

We used this type in typical floor & 7th floor direct with indoor unit

FXSQ 20-25-32-63P

We selected linear bar supply grills (800*100) mm, choose from the following table (B-11).

CHAPTER 3

Plumbing system

3.1 Overview:

Plumbing is the art of installing in buildings the pipes, fixtures and other apparatus for bringing in the water supply and removing liquid and water-carried wastes.

Plumbing fixtures are receptacles intended to receive and discharge water, liquid or water carried wastes into a drainage system with which they are connected.

Minimum plumbing facilities:

All codes state the minimum plumbing facilities that are required in each building types.

Hydraulics is study of the physical principals that govern behavior of liquid at rest and motion there are two separate and distinct types of liquid flows with which were concerned:

1) Flow in closed pressurized system: a system that is now here open to the atmosphere and operates above atmospheric pressure. This is the type of flow that occurs in domestic water systems:

1- Cold water system.

2- Hot water system.

2) Flow occurs in all drainage systems (gravity flow) :

1- Sanitary drainage system.

2- Storm drainage system.

This type of flow (gravity flow) is caused simply by the slope of pipe containing the liquid These systems are open to the atmospheric the pipes containing the liquid in gravity flow almost always run only partially full (as compared to completely full in pressurized systems).

Static pressure is caused by the weight of water above any point the system.

$$P = F/A = W/A \qquad (3.1)$$

When:

W: weight.

A: area.

3.2 Plumbing materials:

The knowledge of plumbing materials is necessary for the proper design of efficient safe, reliable and economical plumbing systems. All materials used in plumbing systems should meet the requirements of at least one of the standard related to this topic.

Piping materials and standard fittings:

1) Ferrous metal pipe (iron steel).

2) Nonferrous metallic pipe (copper, brass).

3) Plastic pipe:

    1-ABS (acrylonitrile butadiene system).
    2- PE (poly ethylene).
    3-PVC (polyvinyl chloride).
    4-CPVC (chlorinated polyvinyl chloride).

4) Nonmetallic pipe other than plastic:

    1-Vitrified clay (term cotta).
    2-Asbestos cement.
    3-Concrete pipe.

5) Joints between dissimilar.

3.2.1 Thermal expansion:

For hot water and stream piping, the problem of thermal expansion is important especially in high rise building or in structures with long horizontal runs due to temperature difference, the length of pipe expands depends on the pipe type, expansion joints and loops are installed every soft depending on pipe size lusts the expansion coefficients and typical expansions for common piping materials.

3.3 Water supply distribution:

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

1) Up feed distribution system.

2) Down feed distribution system.

- Up feed distribution system:

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

1) The supply of water for the building is received from a public street main (usually 35 psi for residential structures, and about 50 psi for other buildings).

2) Private water supply enters into a pneumatic tank (pressurized tank) and is pressurized from approximately 35 to 60 psi.

In both systems the height of the building is directly proportional to the pressure water.

- Down feed distribution system:

The water from the gravity tank on the roof serves the floors below by down feed distribution (gravity) system. Minimum press required on the top floor is usually is 15 psi (for flues valve), and max press on the lowest floor should not exceed 50 psi, otherwise pressure-reading values are used to reduce the pressure.

3.3.1 Zoning multistory building:

In a multistory building it is logical and economical to limit the height of the water zone to 15 stories each, for example a 45 story building can be divided into three zones.

3.3.2 Flow pressure:

The pressure available at the fixtures when the outlet is wide open it must be equal or exceed the minimum fixture pressure.

In adequate pressure the pressure is the said to be inadequate when the city main pressure is insufficient to provide the required minimum flow pressure. In this case a pressurized (pneumatic) tank or and over roof tank (gravity tank) is to used.

For the flow condition :

$$\text{Main pressure} = \text{static head} + \text{friction head} + \text{flow pressure} \quad (3.2)$$

3.3.3 Water service sizing:

WSFU: water supply fixture unit it is used to calculate the probable maximum water demand (max requirement of water for building). This WSFU technique is used and becomes more accurate as the number of fixture increase because the system is based on diversity between fixture in use.

WSFU technique should never be applied installations with only a few fixture, because in such installations, the additional use of single fixture can drastically change the total usage pattern. In this case, i.e. for small installation such as residences and small stores use the unite of bathroom groups and converted to gpm plus individual fixture flow rates (in gpm).

3.3.4 Water pipe sizing:

1) By friction head loss.

2) By velocity limitation.

3.3.4.1 Water pipe sizing by friction head loss:

The procedure is as follows:

-Step 1: draw rise (plumbing section). On this riser show:

1) Floor to floor heights.

2) Run out distance to farthest fixture on each floor.

3) Lengths of piping from service point to the floor take off points.

-Step 2: show the wsfu for each fixture and fixture unit total on each pipe run out. Use separate fixture units for hot and cold water where applicable.

-Step 3: total fixture units in each branch of the system, show both hot and cold water fixture units. (It is understood that hot water pipe sizing will require a separate diagram and calculation), add the continuous water loads.

-Step 4: show source pressure (minimum) and the minimum flow pressure requires of the most remote outlets.

-Step 5: determine the pressure available for friction head loss from the service point to the final outlet.

-Step 6: determine the required pipe size in each section using the friction head loss data calculated in step 5 and friction head charts. Section is normally based on uniform friction head loss per foot throughout and maximum water velocity – usually 8fps, except that branches feeding quick closing devices such as flush values should be limited about 4 fps to avoid water hammer.

3.3.4.2 Water pipe sizing by velocity limitation:

As said before the water velocity in the piping system in building is not preferred to exceed 8fps. Outside building it may exceed 8 fps.

Velocity of water for sudden open (flush values, etc…)<4 fps for building where available water pressure is more than adequate to supply all the fixture, where exists a simplified pipe sizing method based on water velocity considerations.

This method is normally applicable to all private residences, multiple residences and commercial and industrial building up to three stories in height.

To determine the method applicability, a rapid pressure calculation is made. If this calculation shows that pressure is adequate, use the following procedure:

-Step 1: prepare a building riser diagram show all fixture loads in wsfu and gpm in each pipe section include all continuous loads in gpm figures.

-Step 2: identify all branch piping that feeds quick-closing devices such as flush values, solenoid values (as in clothes washers) and self-closing faucets, the velocity in these branch pipes must be limited to 4 fps to avoid water hammer.

-Step 3: size all individual fixture branches according to the code minimum requirements.

-Step 4: size all other parts of the piping system in accordance with water velocity limitation for the type of piping selected.

3.4 Domestic hot water:

Almost all plumbing fixture except flush-type unit (closet bowls and urinals) require hot water as well as cold.

The usual point of use temperatures are:

1) Lavatories, showers and tubes: (35-40 ℃)

2) Residential dishwashing and laundry: (50-60 ℃).

3) Commercial and institutional kitchens: (60 ℃).

4) Commercial and institutional laundries: (80 ℃).

5) Sanitizing use.

Note 1:

That these are fixture water temperatures depending on the design and length of the supply piping from the hot water heater, the water heater outlet temperature will be 5 to 20 F higher than fixture temperature to compensate for temperature loss in the supply piping.

Note 2:

Water heating system is designed to provide hot water at the minimum required temperature because:

1) Lower the heat loss in piping.

2) Slower scale formation in piping.

3.5 Types of hot water heaters:

1) Instantaneous water heater:
   a- Atmore.
   b- Gas boiler.

2) Tank type water heater

3.5.1 Instantaneous water heater:

When hot water faucet opens or other fixture demands hot water they are referred to as tank less heaters because they do not use any sort of storage tank, should be large enough to provide maximum hot water demand immediately at required temperature.

3.5.2 Tank type water heaters:

Are the most common used units, their advantages are they makes or provide large quantity of heated water available up on demand.

Circulating system are usually provided when the piping run is about 100 ft long:

1- Thermos phone circulation system (the taller the building the better the thermo siphon).
2- Forced circulation system (low and long building).

3.6 Sizing of hot water heaters:

To determine the required size of a hot water heater for specified facility is not a simple tank.

The calculation involves knowledge of:

1) Daily consumption of hot water .

2) Peak load.

3) The duration of this peak load.

With these data, a balance must be made between heating capacity and storage, the larger the burner, the smaller the required storage, and vice versa.

- For building with long periods of uniform demand (hotels and laundries) a long capacity bummer (rapid recovery) with small storage is indicated, because peaks are mall.

- For building with large but in frequent peak loads, such as dormitories and gyms, a small bummer (low recovery node) and a large storage tank are chosen, with this arrangement, the hot water in the tank can supply the large peak load, and the small bummer then has a long period in which to heat the (cool) water in the tank.

- For residences, apartments: use the following:
  a) 50l/person/day for the first two persons in family.
  b) 30 l/person/day for other persons of the family.

3.7 Plumbing calculation:

3.7.1 The WFSU of bathroom:

Table (3.1): The WFSU of bathroom

Fixture unit	No. of unit	WSFU	Total of WFSU for cold water	Total of WFSU for hot water	Total of WFSU for cold water &hot water
Lavatory (private)	1	3/4 * 1	3/4	3/4	1
Shower head (private)	1	3/4 * 2	1.5	1.5	2
Water closet flush valve (private)	1	1*6	6	---------	6
---------			∑WSFU= 8.25	∑WSFU= 2.25	∑WSFU= 9

3.7.2 The WFSU of ground floor :

Table (3.2): The WFSU of ground floor

Fixture unit	No. of unit	WSFU	Total of WFSU for cold water	Total of WFSU for hot water	Total of WFSU for cold water &hot water
Lavatory (general)	6	3/4 * 2	1.5*6 =9	9	12
Shower head (general)	2	3/4 *4	6	6	8
Water closet flush valve (general)	6	1*10	60	---------	60
---------			∑WSFU= 75	∑WSFU= 15	∑WSFU= 80

3.7.3 The WFSU of typical floor (1st, 2nd, 3rd, 4th, 5th, 6th):

Table (3.3): The WFSU of typical floor (1st, 2nd, 3rd, 4th, 5th, 6th)

Fixture unit	No. of unit	WSFU	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU for cold water &hot water
Lavatory (private)	17	3/4 * 1	3.4*17 = 12.75	12.75	17
Shower head (private)	17	3/4 * 2	1.5*17 = 25.5	25.5	34
Water closet flush valve (private)	17	1*6	6*17= 102	---------	102
---------			WSFU= ∑140.25	∑WSFU= 43.25	∑WSFU=153

The total of WFSU = No. of total WSFU* No. of typical floor

= 153 * 6

= 918 WSFU

3.7.4 The WFSU of seventh floor:

Table (3.4): The WFSU of seventh floor

Fixture unit	No. of unit	WSFU	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU for cold water &hot water
Lavatory (general)	7	3/4 * 2	1.5*7= 10.5	10.5	14
Kitchen sink (general)	1	3/4 * 4	4	4	14
Water closet flush valve (general)	7	1*6	6*7= 42	---------	42
---------			∑WSFU= 56.5	∑WSFU= 14.5	∑WSFU=70

3.7.5 The WFSU of first basement floor:

Table (3.5): The WFSU of first basement floor

Fixture unit	No. of unit	WSFU	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU for cold water &hot water
Lavatory (general)	10	3/4 * 2	1.5*10= 15	15	20
Kitchen sink (general)	3	3/4 * 4	9	9	12
Water closet flush valve (general)	11	1*6	11*6 = 66	---------	66
Shower head (general)	2	3/4 * 4	3*2 = 6	6	8
---------			∑WSFU= 96	∑WSFU= 30	∑WSFU=106

3.7.6 The WFSU of the second basement floor:

Table (3.6): The WFSU of the second basement floor

Fixture unit	No. of unit	WSFU	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU for cold water &hot water
Lavatory (general)	4	3/4 * 2	1.5*4= 6	6	8
Water closet flush valve (general)	4	1*6	24	------	24
------	-------	--------	∑WSFU= 30	∑WSFU=6	∑WSFU=32

3.7.7 The WFSU of the third basement floor:

Table (3.7): The WFSU of the third basement floor

Fixture unit	No. of unit	WSFU	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU for cold water &hot water
Lavatory (general)	6	3/4 * 2	1.5*6= 9	9	12
Water closet flush valve (general)	7	1*6	42	------	42
Shower head (general)	8	3/4 * 4	24	24	32
------	-------	--------	∑WSFU= 75	∑WSFU= 33	∑WSFU=86

Table (3.8): Total of GPM for cold water &hot water

No of floor	Total of WSFU for cold water	Total of WSFU for hot water	Total of WSFU for cold water &hot water	Total of GPM for cold water	Total of GPM for hot water	Total of GPM for cold water &hot water
Ground floor	75	15	80	60.25	31	62
1st floor	140.25	43.25	153	78.1	48.3	81.25
2nd floor	140.25	43.25	153	78.1	48.3	81.25
3rd floor	140.25	43.25	153	78.1	48.3	81.25
4th floor	140.25	43.25	153	78.1	48.3	81.25
5th floor	140.25	43.25	153	78.1	48.3	81.25
6th floor	140.25	43.25	153	78.1	48.3	81.25
7th floor	56.5	14.5	70	53.6	30.6	58.5
Basement (-1)	96	30	106	66.8	41	69.8
Basement (-2)	30	6	32	41	16.2	42.2
Basement (-3)	75	33	86	60.25	42.8	63.8
------	------	------	------	∑GPM =750.5	∑GPM = 451.4	∑GPM = 783.8

3.8 Pipe size calculations:

By using, the up feed distribution system in which the water is supplied to the building
From water reservoir in basement (-3) floor.

Before we calculations we should now some information:

- By using appendix the minimum flow pressure can be determined for the critically fixture unit shower by 8 psi.

- The pump pressure is equal 40 psi.
- The friction loss through the water meter equal 6.6 psi by equation.
- The total equivalent length of riser 1 from the source to critically _fixture unit is 78.75 meter and equal 258.3 feet.
- The total equivalent length of riser 2 from the source to critically _fixture unit is 74.75 meter and equal 245.18 feet.
- The static pressure equal 44.40-meter equal 145.6 feet and equal63.24 psi the shown below explains how calculate it.

Main pressure = Static pressure + Friction head loss + Flow pressure (3.1)

Static pressure = 44.40* 0.433/0.304 = 63.24 psi

40 = 63.24 + Friction head loss + 8

Then the friction head loss = -31.24 refuse

Main pressure + head pump = Static pressure + Friction head loss + Flow pressure (3.2)

40 + head pump = 63.24 + 31.24 + 8

Then the head pump = 62.24 psi

Head pump = 62.24*1.5 = 93.36 psi= main pressure

Hint: 1.5 is factor of safety

Main pressure = Static pressure + Friction head loss + Flow pressure

93.36 = 63.24 + Friction head loss + 8

Then: Friction head loss =22.12 psi

Riser1: Equivalent length 1 = (71.6*1.5)/0.304 = 235 feet

Riser2: Equivalent length 2= (79.6*1.5)/0.304 = 261.1 feet

Riser3: Equivalent length 3 = (52.67*1.5)/0.304 = 172.8 feet

Riser4: Equivalent length 4 = (33.2*1.5)/0.304 = 109 feet

Uniform design friction loss =available head loss/ Equivalent length (3.3)

Uniform design friction loss1= (22.12*100)/235 = 6.27 psi/100ft

Uniform design friction loss2= (22.12*100)/261.1 =5.64 psi/100ft

Uniform design friction loss1= (22.12*100)/172.8 = 8.53 psi/100ft

Uniform design friction loss2= (22.12*100)/109 =13.53 psi/100ft

The total water supply fixture unit for all risers after going back to the tables to find The total amount of water required which is 750.25 (GPM) for cold water and 451.4 (GPM) for hot water.

Table (3.9): Properties of cold-water riser

No of riser	Total WFSU	Total (GPM)	Diameter (inches)	Velocity (fps)
1st riser	561	148.4	3	4
2nd riser	337.2	115.55	3	4
3ed riser	180.6	87	2.5	6
4thriser	96.25	67.5	2	6

Table (3.10): Properties of hot water riser

No of riser	Total WFSU	Total (GPM)	Diameter (inches)	Velocity (fps)
1st riser	173.1	85	2.5	6
2nd riser	101	68	2.5	6
3ed riser	54	52	2	6
4thriser	30	41	1.5	6

3.9 Pump selection:

Pumps selection depends on two main properties and these properties are head (H) and flow rate (Q). Starting selection with:

3.9.1 Cold water pump:

This pump rising the water from well to all floor.

Total flow rate =80 m3 /h

Head = 50.18psi (Height of the building = 35m) add 2 psi from fitting = 52.18 psi.

Using the special software of DP pump program selection company it appears that the required pump is from type: DPVCF 60/6 B 60Hz IEC7.5kW.

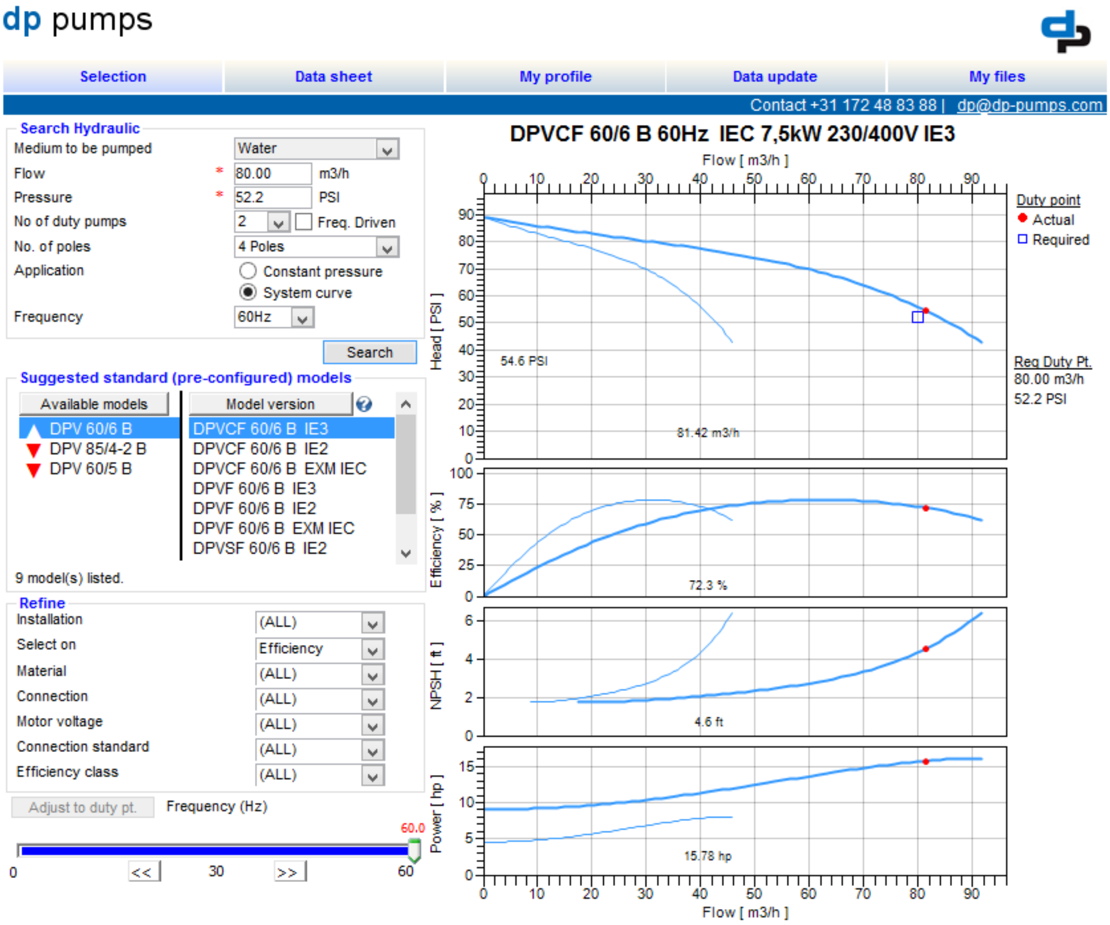

Figure 3.1: Pump characteristic curve

3.9.2 Softener Coldwater pump:

This pump rising the water from tank to kitchen and Landry room and boiler and Solar plan.

Using the special software of DP pump program selection company it appears that the required pump is from type: DPV 15/10 B 60Hz IEC2.2kW.

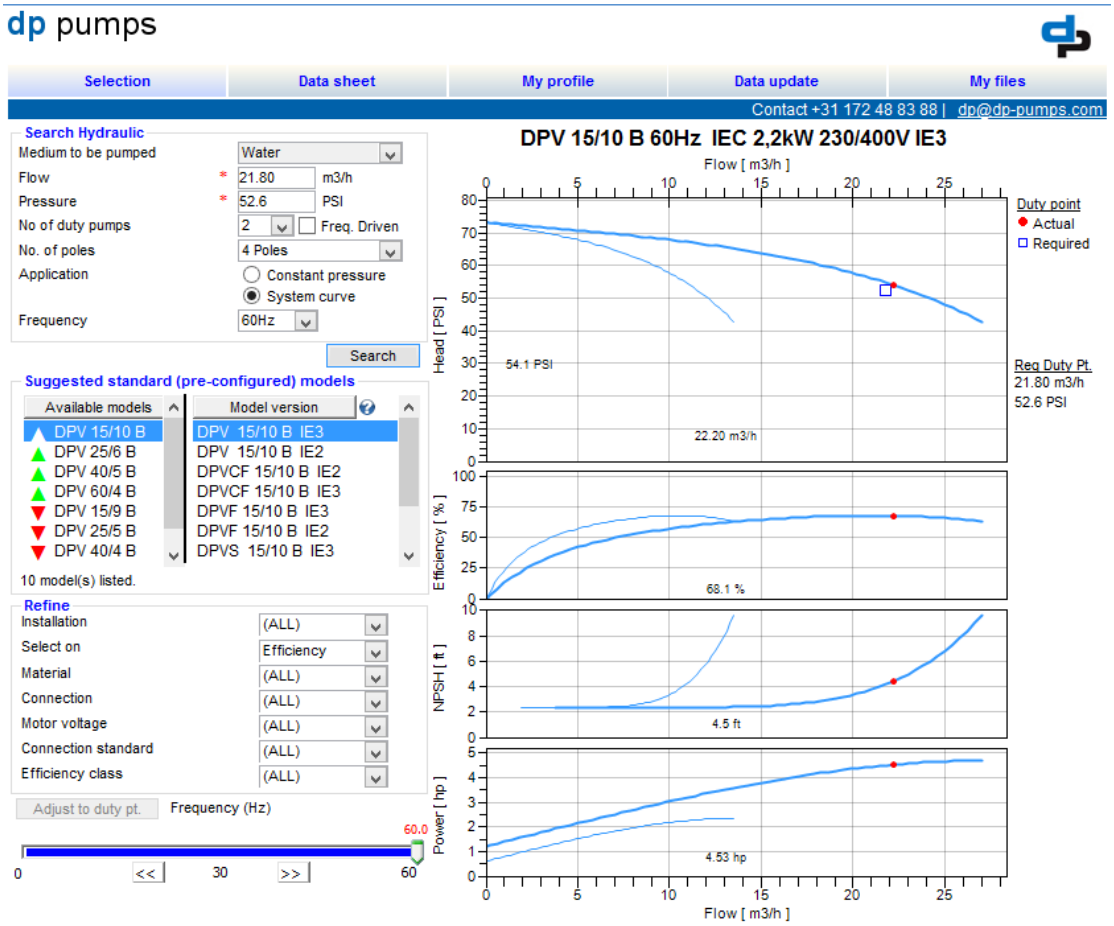

Figure 3.2: Softener water pump characteristic curve

3.9.3 Hot water pump:

From hot water riser 1:

Using the special software of DP pump program selection company it appears that the required pump is from type: DPVCF 25/11 B 60Hz IEC 3kW.

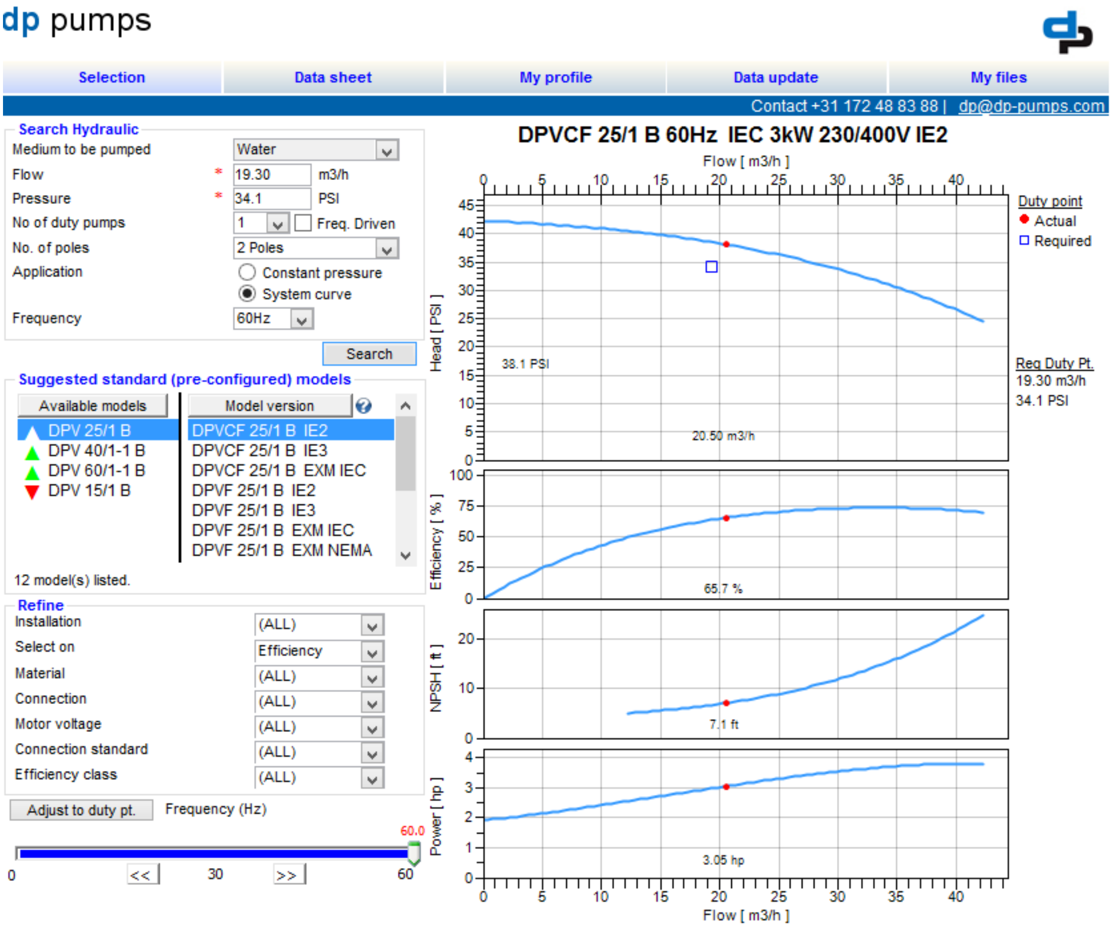

Figure 3.3: Hot water pump characteristic curve

From hot water riser 2:

Using the special software of DP pump program selection company it appears that the required pump is from type: DPV 15/2 B 60Hz IEC 3kW.

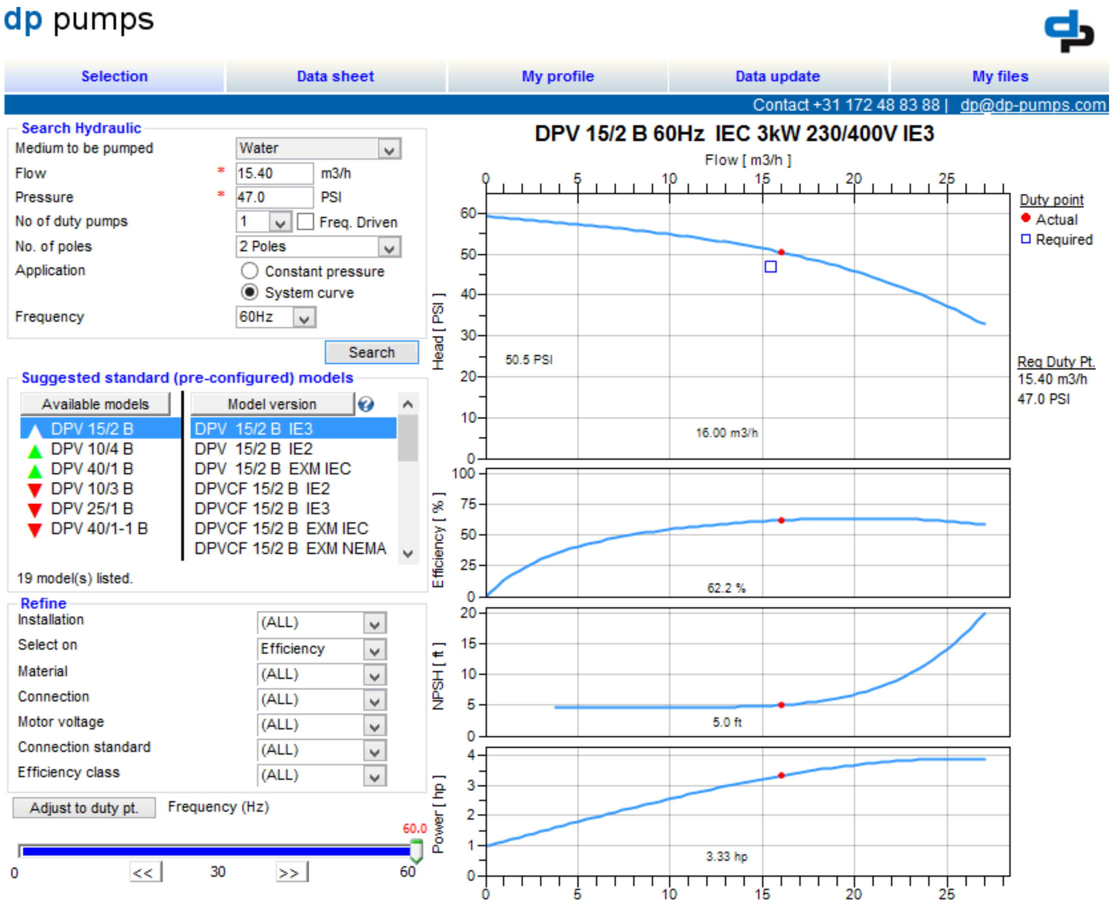

Figure 3.4: Hot water pump characteristic curve

From hot water riser 3:

Using the special software of DP pump program selection company it appears that the required pump is from type: DPV 10/1 B 60Hz IEC 0.75kW.

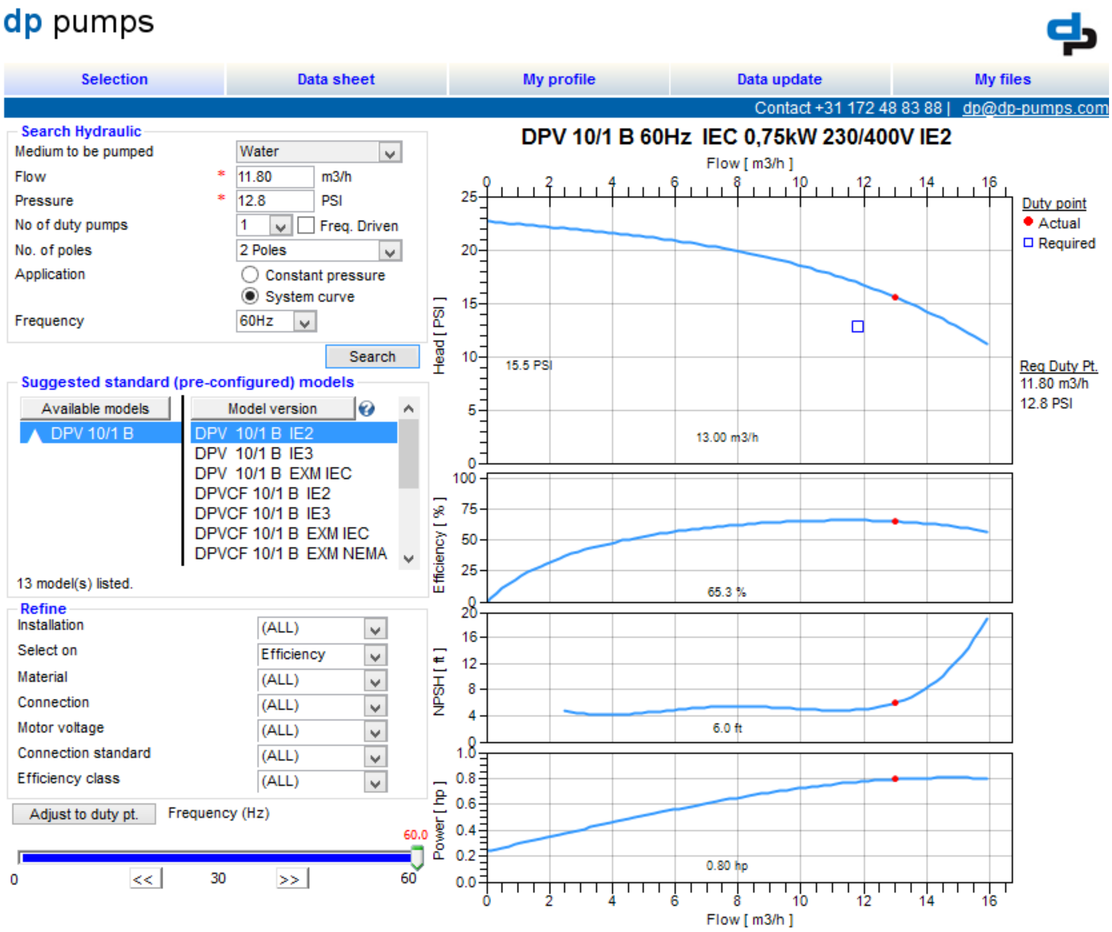

Figure 3.5: Hot water pump characteristic curve

From hot water riser 4:

Using the special software of DP pump program selection company it appears that the required pump is from type: DPVCF6/1 B 60Hz.

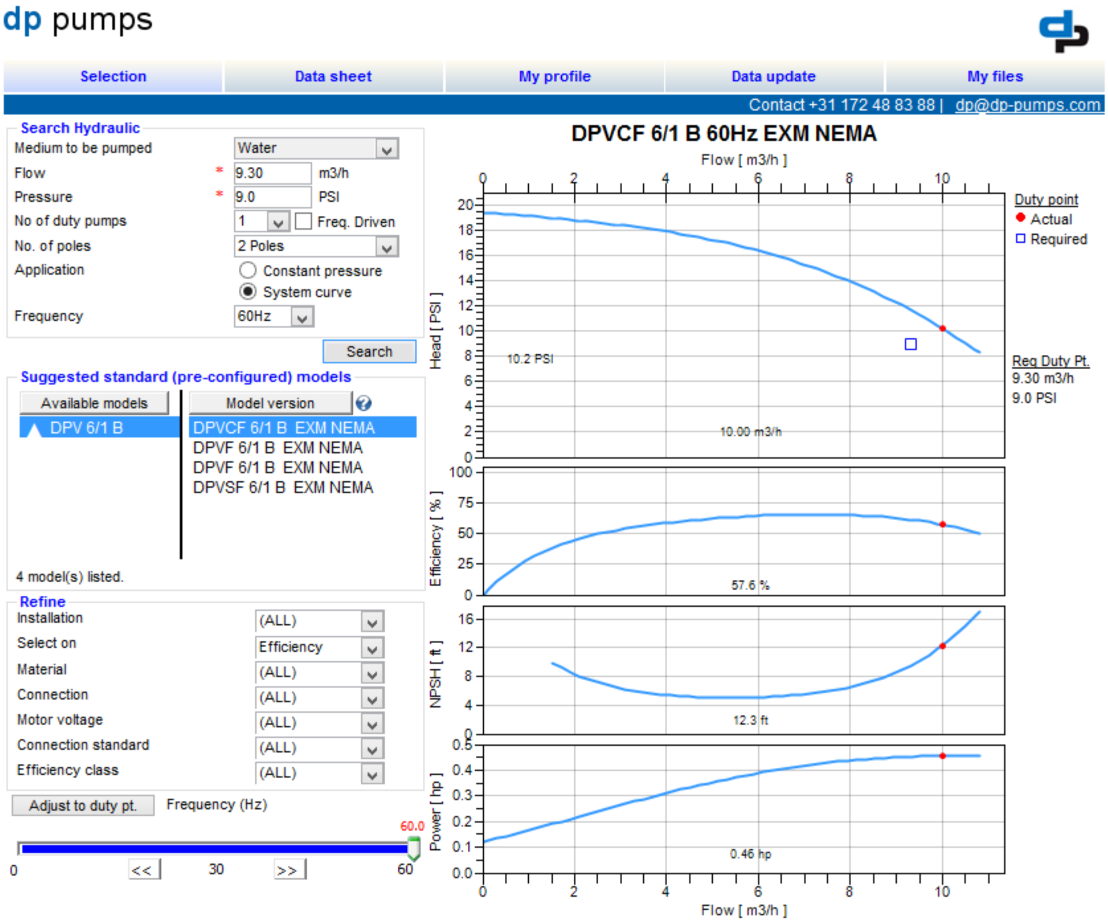

Figure 3.6: Hot water pump characteristic curve

3.9.4 Selection for boiler:

According to the previews calculation and equation estimation, the total flow rate for the (1.2.3.4) risers is 246 gpm, so by

$$Q = Cp \times m \times DT \qquad (3.4)$$

kW = gph (gallons per hour) x delta T (as expressed in ˚F) divided by 410 (3.5)

Where:

Q: boiler capacity. [KW]

m: mass flow rate from data sheet [GPH)]

DT: hot water temperature [˚F]

kW= gph x delta T/410

= (246*60) x 20/410

=295200/410

= 720

The boiler select from viessmann boiler company from data sheet in appendix we selected CR3B boiler at 60-80 C.
Boiler water capacity 1470L.

Gas condensing boiler Vitocrossal 300, type CR3B

Rated heating output 50/30 °C	kW	787	978	1100	1400
Rated heating output 80/60 °C	kW	720	895	1006	1280
Dimensions (overall)					
Length	mm	3021	3221	3338	3688
Width incl. thermal insulation	mm	1114	1114	1296	1296
Width incl. control unit	mm	1281	1281	1463	1463
Height	mm	1550	1550	1550	1550
Total weight (boiler incl. thermal insulation and boiler control unit)	kg	1553	1635	1980	2185
Boiler water capacity	l	1407	1552	1558	1833

Figure 3.7: Selection for boiler

3.10 Drainage system components:

The main components of drainage system are:

- Fixture units.
- Trap.
- Clean out.
- Drainage pipe.
- Stack and vent pipes.
- Manholes.
- Septic tank or municipal sewage system.
- Accessories.

This project deals with two types of waste water which is grey and black water, the separation of waste water will rationalize consumption of water and reuse it in irrigation and in using water closets.

3.10.1 Sanitary drainage:

Design procedure and pipe sizing:

Pipe size is calculated by using a concept of _fixture units (DFU) instead of using gpm of drainage water. This unit takes into account not only the _fixtures water use but also its frequency of use, which is the DFU has a built in diversity factor. This enables us, exactly as for water supply to add DFU of various fixtures to obtain the maximum Expected drainage flow. Drainage pipes sized for a particular number of drainage fixture units, according to Tables (10.1, 10.2, 10.4, 10.5).

Factors, which are:

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

The recommended velocity for drainage piping:

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

Velocity of water flow through drainage piping depends on:

- Pipe diameter
- Slope

Minimum slope requirements for horizontal drainage piping:

- For pipes of diameter $\leq$3" the minimum slope is (2%)
- For pipes of diameter $\geq$4" the minimum slope is (4%)

To achieve the recommended velocities which are 3 fps in building drain, it will be chosen the slope and flow velocity in building drain .

3.10.2 Selection water trench drainage :

The following figure and tables shows the sizing of stacks:

Table (3.11): The piping size**:**

No. of stack	Stack Diameter(inch)	branch Diameter(inch)	Total dfu	Slop % (in/ft)	Velocity (fps)
Stack 1	6"	4"	180	2%	2.73
Stack 2	6"	4"	180	2%	2.73
Stack 3	6"	4"	180	2%	2.73
Stack 4	6"	4"	180	2%	2.73
Stack 5	6"	4"	180	2%	2.73
Stack 6	6"	4"	180	2%	2.73
Stack 7	6"	4"	180	2%	2.73
Stack 8	6"	4"	180	2%	2.73
Stack 9	6"	4"	180	2%	2.73
Stack 10	6"	4"	180	2%	2.73
Stack 11	6"	4"	180	2%	2.73
Stack 12	6"	4"	180	2%	2.73

3.10.3 Selection pump for septic tank:

Selected sumpmersible pump (15 m^3 / h) and (30 m) head.

Figure 3.8: sumpmersible pump

Chapter 4

Firefighting system

4.1 Overview:

4.1.1 General 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 extinguishers

2) Fire hose cabinet

3) Fire hydrant systems

4) Automatic sprinkler systems

4.2 Fire Extinguishers:

Fire extinguishers are provided for a 'first attack' Fire Fighting measure generally undertaken by the occupants of the building before the fire service arrive. It is important that occupants are familiar with which extinguisher type to use on which fire.

Most fires start as a small fire and may be extinguished if the correct type and amount of extinguishing agent is applied whilst the fire is small and controllable.

4.2.1 The principle of fire extinguisher types currently available include:

Table (4.1): 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)

Fire extinguisher locations must be clearly identified. Extinguishers are color coded according to the extinguishing agent.

It is the policy of the Community Safety Department that fire extinguishers be logically grouped at exits from the building, so that occupants first go to the exit and then return to fight the fire, knowing that a safe exit lies behind them, away from the fire. In some instances this will be at odds with the prescriptive requirements of Australian Standard AS2444 Portable fire extinguishers and fire blankets - Selection and location which simply specifies a distance of travel to a fire extinguisher rather than their location in relation to escape paths. Blind compliance with the standard has the potential to place the fire between the occupant and the safe escape path.

Figure 4.1: Fire extinguishers

4.3 Fire Hose cabinet:

Fire hose cabinet are provided for use by occupants as a 'first attack' firefighting measure but may, in some instances, also be used by firefighters.

When stowing a fire hose cabinet, it is important to first attach the nozzle end to the hose cabinet valve, then close the hose reel valve, then open the nozzle to relieve any pressure in the wound hose, then close the nozzle. This achieves two principle objectives:

1) A depressurized hose and hose reel seal will last longer than if permanently pressurized .

2) When the hose reel is next used, the operator will be forced to turn on the isolating valve, thus charging the hose reel with pressurized water supply, before being able to drag the hose to the fire. A potential danger exists if the operator reaches the fire and finds no water is available because the hose reel valve is still closed.

Because hose cabinet are generally located next to an exit, in an emergency it is possible to reach a safe place simply by following the hose.

.

Figure 4.2: Fire Hose cabinet

4.4 Fire Hydrant systems:

Fire hydrant systems are installed in buildings to help firefighters quickly attack the fire. Essentially, a hydrant system is a water reticulation system used to transport water in order to limit the amount of hose that firefighters have to lay; thus speeding up the Fire Fighting process.

Fire hydrants are for the sole use of trained firefighters (which includes factory firefighting teams). Because of the high pressures available serious injury can occur if untrained persons attempt to operate the equipment connected to such installations.

Fire hydrant systems sometimes include ancillary parts essential to their effective operation such as pumps, tanks and fire service booster connections. These systems must be maintained and regularly tested if they are to be effective when needed.

The placement of such equipment needs to closely interface with fire service operational procedure; simply complying with deemed to satisfy code provisions is a potential recipe for disaster.

Figure 4.3: Fire Hydrant systems

4.5 Automatic Sprinkler Systems:

Time is essential in the control of fire. Automatic sprinkler systems are one of the most reliable methods available for controlling fires. Today's automatic fire sprinkler systems offer state of the art protection of life and property from the effects of fire. Sprinkler heads are now available which are twenty times more sensitive to fire than they were ten years ago.

A sprinkler head is really an automatic (open once only) tap. The sprinkler head is connected to a pressurized water system. When the fire heats up the sprinkler head, it opens at a preset temperature, thus allowing pressurized water to be sprayed both down onto the fire and also up to cool the hot smoky layer and the building structure above the fire. This spray also wets combustible material in the vicinity of the fire, making it difficult to ignite, thereby slowing down or preventing fire spread and growth.

When a sprinkler head operates, the water pressure in the system drops, activating an alarm which often automatically calls the fire brigade via a telephone connection.

Some people say sprinklers cause a lot of water damage. As has been explained, only those sprinkler heads heated by the fire operate; all sprinklers in a building do not operate at once. Usually non-fire water damage only occurs if the occupants carelessly damage the system. Firefighters use much more water than a sprinkler system. The combined damage from a fire and the water used by firefighters dramatically exceeds that likely from a properly installed sprinkler system.

Because, historically, complete extinguishment of fires has not been achieved, it is traditional to consider that sprinklers only control fire growth until intervention occurs by the fire brigade. Today, some sprinkler systems are designed for early suppression and are considered to have failed if they do not extinguish the fire.

Sprinkler systems are usually installed in high or large buildings and high fire hazard occupancies. Statistics show that in a majority of cases where sprinklers are installed the fire has been controlled by one sprinkler head alone.

Figure 4.4: Automatic Sprinkler Systems

4.6 Select the most effective type:

After the identification of the fire systems now the best performance for the hotel is hose cabinet and extinguisher and we use the Automatic Sprinkler Systems in the parking.

The number of hose cabinet to be used in hotel is 23 firehouse cabinet for all floors most fire hose is designed to be stored flat to minimize the storage space required.

4.7 Pipe size calculation:

The fire hose cabinet system is to be used, so the pipe size for this system will be calculated as follows:

The minimum flow rate for single cabinet = 23 (l/min)

Then:

The total flow rate = min. flow rate X No. of cabinet (4.1)

=23 *23

=529 (l/min)

Then the table (B-1) is to be used to calculate the pipe size by follow the next procedure. First, the total flow rate is determined which is 529 l/min for our calculation sample. Then the total distance of piping from farthest outlet is to be chosen. Finally, the intersection between the two values in table 42 will give the size of pipe supply, which is equal to 4".

Then to determine the outlet pipe size from pipe supply to hose connection For this building. The selection diameter is (2") hose stations to supply water for use primarily by the building occupants or by the fire department during initial response.

4.8 Fire firefighting pumps:

Continuous water and pumping station supply should always be available and ready to fight fire, the following three pumps should be connected to a suction header (from water tank), and discharge header (to fire fighting network).

Pumping should be included :

1) Electrical fire fighting pump.

2) Diesel Fire fighting Pump,(Stand-by pump).

Diesel pump works if:

- The electrical pump is out of service, or if there is a lack of electricity.
- The electrical pump is working but can't satisfy system water requirements.

3) Jockey Pump: work to make up the system pressure in case of leakage or during the first seconds of fire.

4.9 Selection firefighting pumps:

By calculation electrical fire water pump 30 m^3 / h and the jockey 5 m^3 / h and the diesel pump 30 m^3 / h.

Pump that used in hotel made by PEERLESS PUMP Company.

Mode: Peerless-J-J65F.

CHAPTER 5

Swimming pool

5.1: Overview

A swimming pool, swimming bath, wading pool, or paddling pool is a structure designed to hold water to enable swimming or other leisure activities. Pools can be built into the ground (in ground pools) or built above ground (as a freestanding construction or as part of a building or other larger structure), and are also a standard feature aboard and cruise ships. In-ground pools are most commonly constructed from materials such as concrete, natural stone, metal, plastic or fiberglass, and can be of a custom size and shape or built to a standard size, the largest of which is the Olympic-size swimming pool.

Many health clubs, fitness centers and private clubs, such as the YMCA, have pools used mostly for exercise or recreation. Many towns and cities provide public pools. Many hotels have pools available for their guests to use at their leisure. Educational facilities such as schools and universities occasionally have pools for physical education classes, recreational activities, leisure or competitive athletics such as swimming teams. Hot tubs and spas are pools filled with hot water, used for relaxation or hydrotherapy, and are common in homes, hotels, and health clubs. Special swimming pools are also used for diving specialized water sports, physical therapy as well as for the training of lifeguards and astronauts. Swimming pools may be heated or unheated.

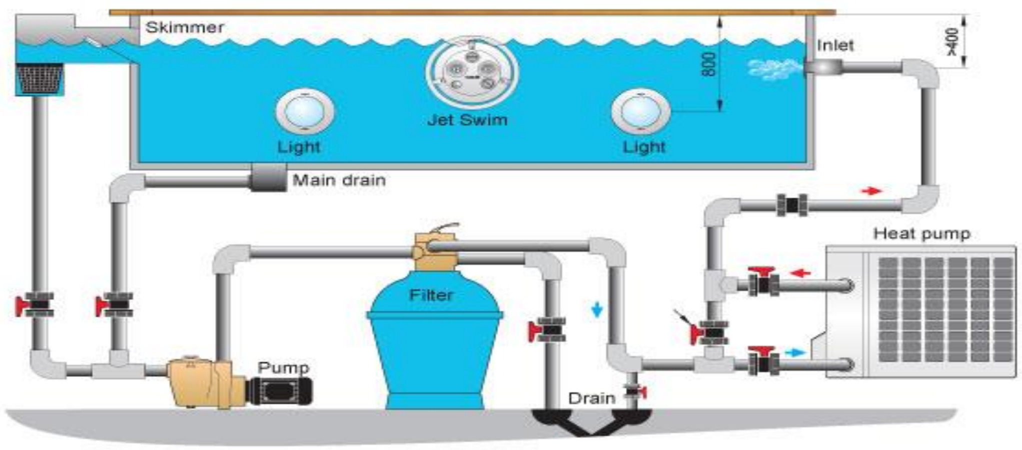

Figure 5.1: Swimming pool

5.2: Types of swimming pools:

1-Private pools.

2-pools Children’s.

3- public pools.

4- competition pools.

5- exercise pools.

6- hot tube & spa pools .

7- ocean pools.

8- infinity pools.

9- natural pools & ponds.

10-zero – entry swimming pools.

11- general pools

5.3: Components of swimming pools:

1) Filters (chlorine filter ,astral aster filter):

Proper sanitation is needed to maintain the visual clarity of water and to prevent the transmission of infectious waterborne diseases and to remove pollutants, disinfection to kill infectious microorganisms, swimmer hygiene to minimize the introduction of contaminants into pool water, and regular testing of pool water, including chlorine and pH levels Guidelines.

We selected astral aster 750_2" filter and chloride filter feeder 5 kg.

Figure 5.2: Astral Aster filter

2) Pipes, valve and accessories (fittings):

In a pool plumbing system, there are pipes that bring water from the pool (suction pipes), and one or more pipes that take water back to the pool (return pipes). Valves are used to control the direction of water flow, to and from the pool, and in and out of equipment. In between our suction pipes and the return pipe are the pool pump and filter, and maybe a heater.

Figure 5.3: fittings

3) Pumps:

An electrically operated water pump is the prime motivator in recirculation the water from the pool. Water is forced through a filter and then returned to the pool. Using a water pump by itself is often not sufficient to completely sanitize a pool. Commercial and public pool pumps usually run 24 hours a day for the entire operating season of the pool. Residential pool pumps are typical run for 4 hours per day in winter (when the pool is not in use) and up to 24 hours in summer. To save electricity costs, most pools run water pumps for between 6 hours and 12 hours in summer with the pump being controlled by an electronic timer.

Most pool pumps available today incorporate a small filter basket as the last effort to avoid leaf or hair contamination reaching the close-tolerance impeller section of the pump.

We selected Victoria pump 1.5 hp and wolf type pump for hot water line

Figure 5.4: Victoria Pump

4) Return inlets:

Installed around the edge of the pool, will boost skimming performance so leaves and debris are easily flushed away.

Flow rate = $2m^3/hr$

Figure 5.5: Return inlets

5) Main drain:

The main drains are usually located on the lowest point in the pool, so the entire pool surface slants toward them. Most of the dirt and debris that sinks exits the pool through these drains.

Figure 5.5: main drain

6) Skimmer:

The skimmer in your pool is the thing that looks like a mini mouth in the side of your pool, near the top of the water Depending on the size of your pool, you could have 1, 2, or even more skimmers installed.

Figure 5.6: skimmer

8) Boiler :

Selection boiler

Flow rate = 13.3375 m^3/hr = 58.8 gpm

gph (gallon per hour) = 58.8 * 60 = 3528 gph

kw = (gph * difference temperature in F)/410

kw = (3528*20)/410 = 172 kw

We selected gas boiler type CT3B

Gas condensing boiler Vitocrossal 300, type CT3B

Rated heating output 50/30 °C	kW	187	248
Rated heating output 80/60 °C	kW	170	225
Dimensions (overall)			
Length	mm	1636	1714
Width	mm	1889*	1967*
Height	mm	1959	2009
Total weight (boiler incl. burner, thermal insulation and boiler control unit)	kg	608	660
Boiler water capacity	l	240	265

* with MatriX radiant burner

Figure 5.7: boiler

5.4: Swimming pools design:

Swimming pools capacity = 1/3 base capacity + 1/3 safety of factor + 1/3 surge

Note : when design the swimming pools we calculated base capacity after that

Swimming pools capacity = 3* base capacity

5.4.1: In design swimming pools :

20% flow rate from floor drain

80% flow rate from skimmer or cutter

5.4.2: Volume of swimming pools :

Average depth= (high rise + low rise)/2 (5.1)

=(2.05+1.25)/2 = 1.65m

Area =(length * width) (5.2)

=9.70*5.0 = 48.5 m^2

Volume of water = area* average depth (5.3)

= 48.5*1.65 = 80.025 m^3

Volumetric flow rate = volume / time (5.4)

usually (time 3-6 hours)

We choose time = 6 hours

= 80.025/ 6 = 13.3375 m^3/hr

Volumetric flow rate = velocity * area of filter usually (velocity =20-40 m^3/hr/m^2) (5.5)

We choose velocity = 30 m^3/hr/m^2

13.3375 = 30 * area of filter

Area of filter = 0.44 m^2

Floor drain = 20% * volumetric flow rate (5.6)

= 0.20* 13.3375

= 2.66 m^2/hr

The recommended flow rate is 1m^3/hr

No. of floor drain needed = 3 floor drain

skimmer = 80% * volumetric flow rate (5.7)

= 0.80* 13.3375

= 10.67 m^3/hr

The recommended flow rate is 1.5-2.5 m^3/hr

10.67/2.5 = 5.335 = 4 skimmer

Filtration rate = pool capacity / turn over time

The recommended Turn over time is (1 – 12) hr

The best turn over time in hotel swimming pool 6 hr

Filtration rate = pool capacity / turn over time (m^3/hr) (5.8)

= 80.025/ 6 = 13.3375 m^3/hr

Filtration rate = pump capacity

Because water leave in filter the same volume of water in suction line of pump

No of return inlet = filtration flowrate / flowrate for one inlet (5.9)

13.3375 m^3/hr/ 2 m^3/hr = 6 return inlet

Pipe size :

Filtration rate = area * velocity (5.10)

The recommended velocity in pipe is (0.5- 1.5) m/s

We choose 0.70 m/s

13.3375= area * 0.70

Area = 19 m^2

But Area = $\pi/_4\, d^2$

19 = $3.14/_4\, d^2$

19 = 0.785 d^2

24.27 =d^2

d = 4.92 cm = 5cm = 50 mm = 2''

Refrances:

1- Heating And Air Conditioning For Residential Building . Fourth Edition, 2007.

2- ASHRAE.1999.HVAC application.USA.

3-Energy Efficient Building Cod,2004.

Internet:

http://oasisdesign.net/greywater/laundry/

http://www.understandconstruction.com/understand-fire-fighting-systems.html

http://www.crystalpools.com.au/types-of-swimming-pools/

Bill No. (1): MECHANICAL WORKS

Item No.	Description	Unit	Qty.	Unit Rate	Amount
1.1	**VRF System** Supply and installation testing and commissioning of the following indoor units, complete with electrical connections, PVC drained pipe, indoor/ outdoor hanging supports and insulated copper pipes with necessary accessories. As per drawings and related codes and all this under the specification and direction of supervisor engineer.				
1.1.1	**Indoor Units** Round flow Cassette type, Suspended type, Duct type, Ceiling with inverter driven fan type, and temperature set and display. Indoor design Conditions 24 C dry. According to the following:				
A.	Round flow cassette type FXFQ20A	No.	9		
B.	Suspended type FXHQ12M	No.	4		
C.	Duct type FXMQ07P	No.	22		
D.	Ceiling with inverter driven fan type FXSQ20P	No.	48		
E.	Ceiling with inverter driven fan type FXSQ25P	No.	42		
F.	Ceiling with inverter driven fan type FXSQ32P	No.	12		
1.1.2	**Outdoor Unit** Variable refrigerant flow outdoor unit, scroll compressor, refrigerant R 410 A, Outdoor design conditions 24C summer indoor temperature, 29.5C summer outdoor temperature.				
A.	Heat pump outdoor unit combination RXYQ54P	No.	1		
B.	Heat pump outdoor unit combination RXYQ48P	No.	1		

C.	Heat pump outdoor unit combination RXYQ38P	No.	1		
1.1.3	**<u>Copper piping network</u>** Supply, install & commissioning copper pipes for refrigerant R410a between indoor units and outdoor unit.				
A.	outdoor unit connection pipe (T joint)	No.	6		
B.	Refrigerant Kit Refnet joint(KHRQ22M75T)	No.	121		
C.	Refrigerant Kit Refnet joint(KHRQ22M20T)	No.	1		
D.	Refrigerant Kit Refnet joint(KHRQ22M29T)	No.	3		
G.	**Copper piping connection**	No.			
G.1	**<u>Gas pipe</u>**				
G.1.1	Gas pipe 1.25"	ML	77		
G.1.2	Gas pipe 1 3/8"	ML	150		
G.1.3	Gas pipe 1 5/8"	ML	105		
G.1.4	Gas pipe 1"	ML	50		
G.1.5	Gas pipe 5/8"	ML	60		
G.1.6	Gas pipe 3/4"	ML	40		
G.1.7	Gas pipe 1/2"	ML	250		
G.2	**<u>Liquid pipe</u>**				
G.2.1	Liquid pipe 5/8"	ML	12		
G.2.2	Liquid pipe 6/8"	ML	120		
G.2.3	Liquid pipe 1/4"	ML	200		
G.2.4	Liquid pipe 1/2"	ML	100		
1.2	**<u>Ventilation</u>**				
1.2.1	**<u>Exhaust Fans</u>** Supply, install, and connect, testing and commissioning g of, wall mounted exhaust fans	NO			
A.	Gravity shutter & Exhaust fan volume flow rat 371 cfm.	NO	6		
B.	Gravity shutter & Exhaust fan volume flow rat 60 cfm	NO	16		
C.	Gravity shutter & Exhaust fan volume flow rat 400 cfm	NO	2		

D.	Centrifugal Ventilators Fan model : 5DDD12CA Flow : 1137 CFM Static Pressure in Inches wg 1" Speed : 1694 rpm	NO	2		
E.	EXF PARKING Fan model(5BDD18) with Flow 4000 CFM and Static Pressure in Inches wg 0.8" with Speed 1383 rpm.	NO	1		
F.	Max-Fan 8" Fan model 8" Inch with Flow 863 CFM and Speed 3288 rpm.	NO	2		
G.	Max-Fan 10" Fan model 10" Inch with Flow 1019 CFM and Speed 2990 rpm.				
1.3	**Water Supply System** .				
1.3.1	**Water Supply Pump Set** Supply, install, test and commission water supply pump set (factory assembled), The unit price shall include pressure vessel, electric control panel, electrical wiring, galvanized steel frame, inertia base, vibration isolators, Concrete base and all required valves and fittings as detailed on the drawings and all this under the specification and direction of supervisor engineer.				
A.	Cold dually water pump Pump type: DPVCF 60/6 B 60Hz IEC7.5Kw	NO	1		
B.	Cold one duty, one stand-by, water pump. Pump type: DPV 15/10 B 60Hz IEC2.2kW.	NO	1		
C.	Hot water pump.	NO			
C.1	DPVCF 25/11 B 60Hz IEC 3kW.	NO	1		
C.2	DPV 15/2 B 60Hz IEC 3kW.	NO	1		
C.3	DPV 10/1 B 60Hz IEC 0.75kW	NO	1		
C.4	DPVCF 6/1 B 60Hz.	NO	1		

1.3.2	**<u>Galvanized Steel Pipes & Fittings</u>** Supply, install, test and commission galvanized steel pipe work to ASTM - A53 grade "A". Schedule (40) for the domestic hot and cold water supply pipe work up to the water outlet. The unit price shall include valves, expansion joints, pressure regulators, air vents, fittings and all accessories and works required to complete the work as shown on drawings, Specifications and instructions and all this under the specification and direction of supervisor engineer.				
A.	Diameter 3”	ML	78		
B.	Diameter 2.5”	ML	92		
C.	Diameter 2”	ML	336		
D.	Diameter 1. 5 "	ML	136		
E.	Diameter 1.25 "	ML	97		
1.3.3	**<u>Cross-Linked Polyethylene (PEX) Distribution Pipes</u>** Supply, install, test and commission Cross-linked polyethylene (PEX) pipes to DIN 16892/3, 20 bar working pressure, for cold and hot water distribution from metal water pipes to sanitary fixtures, complete with sleeves and service valve for each connection. The unit price shall seal, brass Elbow/adapter inside PVC termination box built in wall for connection with the sanitary fixtures, dielectric unions, excavation, bedding, chasing in wall and all works required as shown on drawings, specifications and P.M. instructions. 16 mm O.D. x 2.2mm thick, sleeve 25 mm diameter and all this under the specification and direction of supervisor engineer.	ML	2720		

1.3.4	**Water Meter** Supply, install, test and commission water meter with totalizer, 2" diameter, including air vent, check valve, strainer, two gate valves, connection to municipality's potable water supply network, fittings, and all accessories and works required to complete the work as shown on the drawings and as per the preamble, Specifications and all this under the specification and direction of supervisor engineer.	NO	1		
1.3.5	**Hot Water Tanks** Supply, install, test and commission hot water tanks, vertical shell & tube storage type, 8 bar working pressure, Hydrostatically tested for 1-1/2 times the working pressure. The unit price shall include a thermometer, an ASME rated pressure and temperature. Relief valve, isolating valves, drain valves, check valve on cold-water make-up line, automatic air vent, support.	NO	2		
1.3.7	**Expansion Tank:** Supply, install, test and commission expansion tank, 2" diameter, including air vent, check valve, strainer, two gate valves, water meter manhole 50x50 cm , connection to municipality's potable water supply network, fittings, and all accessories and works required to complete the work as shown on the drawings and as per the preamble, specifications and the supervision engineer's requirements.	NO	4		
1.3.8	**Water Collector** Supply and install hot and cold water collector's type GIACOMINI or E.A.				
A.	1.25 ” Copper collector	NO	9		
B.	1” Copper collector	NO	12		
C.	0.75 ” Copper collector	NO	66		

1.4	**Waste and Drainage System**				
1.4.1	**Vertical and Horizontal PVC Pipe** Supply, install UPVC pipes and fittings similar to local made P.S SN 8. The rate shall include all needed connections and all types of fittings caps, all done according to drawings, specifications.				
A.	Diameter 2"	ML	215		
B.	Diameter 4"	ML	176		
C.	Diameter 6"	ML	264		
1.4.2	**Floor Drain** Supply, install, testing and commissioning of, 4"chrome plated threaded 15x15cm cast brass cover, multi inlet adjustable with trap floor drain. Including, floor clean out plug, HDPE siphon or equivalent and necessary accessories, connections with fixtures and main drain pipes. As per drawings, specifications and related codes.	NO	113		
1.4.3	**Clean Out** Supply, install, testing and commissioning of the following, HDPE siphon or equivalent , non-adjustable 15x15 cm stainless steel cover, out with gas and water tightness ABS plug and necessary accessories as per drawings, specifications and related codes. (Ø 4")	NO	132		
1.4.4	**Roof Drainage Pipes And Fittings:** Supply, install, test and commission HDPE pipes of 10 bars working pressure to DIN 8062 for the storm water drainage. The unit price shall include all fittings, joints, chasing in wall all accessories and works required to complete the work as shown on drawings, specifications and instructions.	NO	12		

	<u>Manholes</u> Supply and install PRE-CAST concrete manholes of 15 cm thick walls and base with heavy duty cast iron covers and frames of 25 tons load strength with all necessary excavation back filling as specified to the required depth. With connecting it to main city manholes as shown in drawing and in accordance to specifications and approval engineers.				
A.	Size 50X50cm	NO	5		
B.	Size 60X60cm	2			
C.	Size 80X80cm	4			
D.	Size 100X100cm	2			
1.4.6	**<u>polyester chimney:</u>** polyester chimney 14", the price includes all flue sections in room, concrete base fittings, supports, hangers, cleanout, etc…., plus the horizontal pipes is height of 38 m from the second basement as specified and as shown on drawings. Height up to 1.5m above roof parapet, the all of stacks is royal made.	ML	36		
1.5	**<u>Sanitary Fixture and Their Accessories</u>**				
1.5.1	**<u>Lavatory</u>** Supply and installation of porcelain wash basin glazed white(from creavit or equivalent) with chrome plated mixer adoption of the supervising engineer) half leg measuring 56 × 45 cm and isolate it from the wall using the Sika Anti-gray, The price includes valves angle 13mm chrome holder soap of the finest varieties mirror 60 × 45 cm with aluminum frame and providing sink series and rubber stopper and all necessary for installation, operation and drainage to the nearest packet assembly floor drain , according to the specifications and plans .	NO	153		

1.5.2	**<u>Shower Basin – Ground Mounted:</u>** Supply, install and test wash basin including Chrome plated basin faucet mixer , connection to domestic hot & cold water supply, drainage network and all fittings and works required to complete the work as -Shower Basin (100X100cm), semi pedestal complete with concealed steel support and siphon.	NO	127		
1.5.3	**<u>Dish Washer:</u>** Supply, install and test wash basin including Chrome plated basin Dish Washer, connection to domestic hot & cold water supply, drainage network and works required to complete the work as shown on drawings and supervision engineer's requirements	NO	12		
1.5.4	**<u>Kitchen Sink</u>** Supply and installation of porcelain kitchen sink basin glazed white (from cravat or equivalent) with chrome plated mixer adoption of the supervising Engineer) half leg measuring 56 × 45 cm and isolate it from the wall using the Sikh according to the supervising engineer adoption). The price include all necessary for installation, operation and drainage to the nearest packet assembly floor drain , according to the specifications of the Supervising engineer.	NO	12		

1.5.5	**GAS water boiler.** Supply, install, test and commission gas water boiler, capacity 720KW,horizontal shell & tube storage type(chapped, bidders),8 bar working pressure, hydrostatically tested for 1-1/2 times the working pressure. The unit price shall include a thermometer, an ASME rated pressure and temperature relief valve, isolating valves, drain valves, check valve on cold water make-up line, automatic air vent, support, insulation with 1-1/2" foam insulation and protected with 0.7mm aluminum cladding, boiler capacity 1407L, all as per drawings and Instructions according to the specifications of the Supervising engineer.	NO	1		
1.5.6	**Solar water heating system** Supplying, lifting and installing a solar heater of the best quality according to the Palestinian specifications. It consists of two sizes of 90 cm x 190 cm x 10 cm, and is insulated with 3 cm thick. The price includes all the necessary pieces of valves and joints and the connection with the pipe network on the surface according to the drawings, specifications and approval. Supervising engineer.	NO	30		

1.5.7	**Water Closet** Supply, install, testing and commissioning of, floor mounted, white color, Porcelain, siphon jet water closet/toilet with an elongated bowl, seat with open front and check hinge, and carrier. or equivalent including necessary accessories, 9-lt capacity cistern, valves, fittings, 13mm stop angle valves, chrome plated 13mm hose, heavy duty side l m length 13mm Chrome plated hand shower, connection to drainage and water systems as per drawings, specifications and related codes.	NO	164		
1.5.8	**Sink (General)** Supply, install, testing and commissioning of glazed porcelain basin sink white size 20 × 40 × 60 cm excellent water mixer chrome the price shall include plastic Siphon and the drain to the nearest floor drain and all that is required for installation and installation according to plans and specifications and instructions of the supervising engineer.	NO	25		
1.5.9	**Plastic Water Tanks** Supply and install plastic water tanks made in Palestine each one has a capacity 1500L. The price shall include stand with heavy duty, valves and all fittings needed according to drawings.	NO	2		

1.6	**Fire Fighting** Supply and install galvanized steel pipes to ASTM-A53 grade "A" schedule-40 for firefighting system pipework, inside building. The unit price shall include valves, fittings, and all accessories and works required to complete the work and as per preambles, specifications, and the supervision of engineer's requirements.				
A.	Diameter 4”	ML	15		
B.	Diameter 3”	ML	37		
C.	Diameter 2”	ML	109		
D.	Diameter 1.5”	ML	30		
E.	Diameter 1.25”	ML	36		
1.6.1	**Fire Fighting Pump Set** Supply, install, test and commission firefighting pump set(factory assembled), composed of one electric on duty pump, one Stand-by electrical pump, jockey pump, diesel pump, and automatic control panel. The unit price shall include pressure vessel, electric control panel, electrical wiring, galvanized steel frame, inertia base, vibration isolators, concrete base, piping from water reservoir to delivery header outlet complete with test lines, and all required valves and fittings as detailed on the drawings, specifications and instructions.	NO	3		
1.6.2	**Fire Extinguisher** Supply and install Portable Fire Extinguisher of 6 Kg. Co2 capacity each in Location as decided by the Engineer. The installation shall be complete with brackets and it should be in accordance with the Civil Defense specification.	NO	25		

1.6.3	**Fire Hose Cabinets** Supply, install, test and commission fire hose reel cabinets to, complete with 30 Meters long 1 ½” diameter rubber hose of 16 bar working pressure. The unit price shall include hose cabinet, pressure reducing valve, globe valve and automatic swinging recessed type cabinet as detailed on drawings and as per the specifications and the supervision engineer's requirements.	NO	23		
1.7	**Swimming pool** Test the supply, installation and installation of the swimming pool system and all components of the swimming pool in addition to all the parts that complement the valves and pipes, clean the swimming pool and return to the swimming pool.				
1.7.1	**Filters (chlorine filter ,astral aster filter)** Supply, install, test and commission filter, All the complete parts connected to the filter such as pipes, valves, and all accessories We selected astral aster 750_2" filter and chloride filter feeder 5 kg	NO	2		
1.7.2	**Pump** Supply, install, test and commission water supply pump set (factory assembled), The unit price shall include pressure vessel, electric control panel, electrical wiring, galvanized steel frame, inertia base, vibration isolators, Concrete base and all required valves and fittings as detailed on the drawings and all this under the specification and direction of supervisor engineer. We selected Victoria pump 1.5 hp and wolo type pump for hot water line.	NO	2		

1.7.3	**<u>Main drain:</u>** Supply, install, testing and commissioning of, multi inlet adjustable accessories, connections with fixtures and main drain pipes. As per drawings, specifications MODEL # SP1048AVH,dimensions 6.5" L X 3" W X 1.5" D	NO	3		
1.7.4	**<u>Skimmer:</u>** Supply, install, testing and commissioning of 2 in PVC skimmer. White, black colors. Optional equalizer valve.	NO	6		
1.7.5	**<u>GAS water boiler.</u>** Supply, install, test and commission gas water boiler, capacity 170KW,horizontal shell & tube storage type(chapped, bidders),8 bar working pressure, hydrostatically tested for 1-1/2 times the working pressure. The unit price shall include a thermometer, an ASME rated pressure and temperature relief valve, isolating valves, drain valves, check valve on cold water make-up line, automatic air vent, support, insulation with 1-1/2" foam insulation and protected with 0.7mm aluminum cladding, boiler capacity 240L, all as per drawings and Instructions according to the specifications of the Supervising engineer.	NO	1		

Table (A-9)

درجات حرارة المنطقة الرابعة(س°)

الشهر	1	2	3	4	5	6	7	8	9	10	11	12
المتوسط الشهري	8.3	8.2	9.5	17.4	19.9	21.7	23.6	24	22.3	20.1	16	10.8
المتوسط الشهري للدرجة القصوى	11.2	11.8	13.6	20.8	25.3	27.5	29.3	30	27.4	21.2	19.3	13.7
المتوسط الشهري للدرجة الدنيا	5.3	4.7	5.4	13.9	14.5	15.8	17.9	18	17	15.9	12.6	7.9
المدى	5.9	7.2	8.3	6.9	10.8	11.7	11.4	12	10.4	8.3	6.7	5.8
الدرجة القصوى	14.3	19.7	19.7	34.1	33.2	33.2	35.8	36.1	36.1	32.9	28.6	25.3
الدرجة الدنيا	-2	1.2	-1.3	4.4	7	10.9	13.8	13.7	14.7	14	11.9	6.6

درجة الحرارة التصمية للمنطقة الرابعة.
صيفاً: 30 س°
شتاءً: 4.7 س°

Table (A-10)

قيم الرطوبة النسبية التصميمية (بالمائة)

	صيفاً		شتاءً	
	ادنى	اقصى	ادنى	اقصى
المنطقة الاولى	44	49	65.7	69.3
المنطقة الثانية	44	49	65.7	69.3
المنطقة الثالثة	55.5	61.9	68	69.7
المنطقة الرابعة	49.7	53.7	68	71.7
المنطقة الخامسة	61.5	65.2	65.9	73.7
المنطقة السادسة - غزة	75	77	62	69
المنطقة السابعة- غزة	55.5	61.9	68	69.7

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

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

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

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

TABLE 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

Table (A-1) Cooling load temperature differences (CLTD) for various construction groups of sunlit walls, °C.

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

Continued Table (A-1)

North Latitude Wall Facing	Solar Time h																								Hour of Max. CLTD	Min. CLTD	Max. CLTD	Difference CLTD
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24				
NW	14	13	12	11	10	9	8	7	6	6	5	5	6	6	6	7	9	10	12	14	15	15	15	15	22	5	15	10
Group D Walls																												
N	8	7	7	6	5	4	3	3	3	3	4	4	5	6	6	7	8	9	10	11	11	10	10	9	21	3	11	8
NE	9	8	7	6	5	5	4	4	6	8	10	11	12	13	13	13	14	14	14	13	13	12	11	10	19	4	14	10
E	11	10	8	7	6	5	5	5	7	10	13	15	17	18	18	18	18	18	17	17	16	15	13	12	16	5	18	13
SE	11	10	9	7	6	5	5	5	5	7	10	12	14	16	17	18	18	18	17	17	16	15	14	12	17	5	18	13
S	11	10	8	7	6	5	4	4	3	3	4	5	7	9	11	13	15	16	16	16	15	14	13	12	19	3	16	13
SW	15	14	12	10	9	8	6	5	5	4	4	5	5	7	9	12	15	18	20	21	21	20	19	17	21	4	21	17
W	17	15	13	12	10	9	7	6	5	5	5	5	6	6	8	10	13	17	20	22	23	22	21	19	21	5	23	18
NW	14	12	11	9	8	7	6	5	4	4	4	4	5	6	7	8	10	12	15	17	18	17	16	15	22	4	18	14
Group E Walls																												
N	7	6	5	4	3	2	2	2	3	3	4	5	6	7	8	10	10	11	12	12	11	10	9	8	20	2	12	10
NE	7	6	5	4	3	2	3	5	8	11	13	14	14	14	14	14	15	14	14	13	12	11	9	8	16	2	15	13
E	8	7	6	5	4	3	3	6	10	15	18	20	21	21	20	19	18	18	17	15	14	12	11	9	13	3	21	18
SE	8	7	6	5	4	3	3	4	7	10	14	17	19	20	20	20	19	18	17	16	14	13	11	10	15	3	20	17
S	8	7	6	5	4	3	2	2	2	3	5	7	10	14	16	18	19	18	17	16	14	13	11	10	17	2	19	17
SW	12	10	8	7	6	4	4	3	3	3	4	5	7	10	14	18	21	24	25	24	22	19	17	14	19	3	25	22
W	14	12	10	8	6	5	4	3	3	4	4	5	6	8	11	15	20	24	27	27	25	22	19	16	20	3	27	24
NW	11	9	8	6	5	4	3	3	3	3	4	5	6	7	9	11	14	18	21	21	20	18	15	13	20	3	21	18
Group F Walls																												
N	5	4	3	2	1	1	1	2	3	4	5	6	8	9	11	12	12	13	13	13	11	9	7	6	19	1	13	12
NE	5	4	3	2	1	1	3	8	13	16	17	16	16	15	15	15	15	14	13	12	10	9	7	6	11	1	17	16
E	5	4	3	2	2	1	4	9	16	21	24	25	24	22	20	19	18	17	15	13	11	10	8	7	12	1	25	24
SE	5	4	3	2	2	1	2	6	10	15	20	23	24	23	22	20	19	17	16	14	12	10	8	7	13	1	24	23
S	5	4	3	2	2	1	1	1	2	4	7	11	15	19	21	22	21	19	17	15	12	10	8	7	16	1	22	21
SW	8	6	5	4	3	2	1	1	2	3	4	6	10	14	20	24	28	30	29	25	30	16	11	10	18	1	30	29
W	9	7	5	4	3	2	2	2	2	3	4	6	8	11	16	22	27	32	33	30	24	19	15	12	19	2	33	31
NW	8	6	4	3	2	2	1	1	2	3	4	6	7	9	12	15	19	24	26	24	20	16	12	10	19	1	26	25
Group G Walls																												
N	2	1	0	0	0	1	4	5	5	7	8	10	12	13	13	14	14	15	12	8	6	5	4	3	18	0	15	15
NE	2	1	1	0	0	5	15	20	22	20	16	15	15	15	15	15	14	12	10	8	6	5	4	3	9	0	22	22
E	2	1	1	0	0	6	17	26	30	31	28	22	19	17	17	16	15	13	11	8	7	5	4	3	10	0	31	31
SE	2	1	1	0	0	3	10	18	24	27	28	27	23	20	18	16	15	13	11	8	7	6	4	3	11	0	28	28
S	2	1	1	0	0	0	1	3	7	12	17	22	25	26	24	21	17	14	11	8	7	5	4	3	14	0	26	26
SW	3	2	2	1	0	0	1	3	4	6	9	14	21	28	33	35	34	29	20	13	10	7	6	4	16	0	35	35
W	4	3	2	1	1	1	1	3	5	6	8	10	15	23	31	37	40	37	21	16	11	8	6	5	17	1	40	39
NW	3	2	1	1	0	0	1	3	4	6	8	10	12	15	20	26	31	31	23	14	10	7	5	4	18	0	31	31

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

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

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·K	
			$h_o = 22.7$	$h_o = 17.0$
Single Glass				
Clear	3	0.84	1.00	1.00
	6	0.78	0.94	0.95
	10	0.72	0.90	0.92
	12	0.67	0.87	0.88
Heat absorbing	3	0.64	0.83	0.85
	6	0.46	0.69	0.73
	10	0.33	0.60	0.64
	12	0.42	0.53	0.58
Double Glass				
Regular	3	—	0.90	—
Plate	6	—	0.83	—
Reflective	6	—	0.20-0.40	—
Insulating Glass				
Clear	3	0.71	0.88	0.88
	6	0.61	0.81	0.82
Heat absorbing*	6	0.36	0.55	0.58

Table (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	—	—

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
	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
N	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
Shaded	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
	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
NNE	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
	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
NE	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
	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
ENE	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
	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
E	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
	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
ESE	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
	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
SE	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
	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
SSE	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
	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
S	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
	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
SSW	M	0.14	0.12	0.11	0.09	0.08	0.09	0.11	0.13	0.15	0.18	0.25	0.35	0.46	0.55	0.59	0.59	0.53
	H	0.15	0.14	0.13	0.12	0.11	0.12	0.14	0.16	0.18	0.21	0.27	0.37	0.46	0.53	0.57	0.55	0.49
	L	0.12	0.10	0.08	0.06	0.05	0.06	0.08	0.10	0.12	0.14	0.16	0.24	0.36	0.49	0.60	0.66	0.66
SW	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
	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
WSW	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

Continued Table (A-5-1)

Glass Facing	Building Construction	Solar Time, h																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
W	M	0.15	0.13	0.11	0.10	0.09	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.19	0.29	0.40	0.50	0.56
	H	0.14	0.13	0.12	0.11	0.10	0.11	0.12	0.13	0.14	0.14	0.15	0.16	0.21	0.30	0.40	0.49	0.54
WNW	L	0.12	0.10	0.08	0.06	0.05	0.06	0.07	0.09	0.10	0.12	0.13	0.15	0.17	0.26	0.40	0.53	0.63
	M	0.15	0.13	0.11	0.10	0.09	0.09	0.10	0.11	0.12	0.11	0.14	0.15	0.17	0.24	0.35	0.47	0.55
	H	0.14	0.13	0.12	0.11	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.25	0.36	0.46	0.53
NW	L	0.11	0.09	0.08	0.06	0.05	0.06	0.08	0.10	0.12	0.14	0.16	0.17	0.19	0.23	0.33	0.47	0.59
	M	0.14	0.12	0.11	0.09	0.08	0.09	0.10	0.11	0.13	0.14	0.16	0.17	0.18	0.21	0.30	0.42	0.51
	H	0.14	0.12	0.11	0.10	0.10	0.10	0.12	0.13	0.15	0.16	0.18	0.18	0.19	0.22	0.30	0.41	0.50
NNW	L	0.12	0.09	0.08	0.06	0.05	0.07	0.11	0.14	0.18	0.22	0.25	0.27	0.29	0.30	0.33	0.44	0.57
	M	0.15	0.13	0.11	0.10	0.09	0.10	0.12	0.15	0.18	0.21	0.23	0.26	0.27	0.28	0.31	0.39	0.51
	H	0.14	0.13	0.12	0.11	0.10	0.12	0.15	0.17	0.20	0.23	0.25	0.26	0.28	0.28	0.31	0.38	0.49
HORIZ.	L	0.11	0.09	0.07	0.06	0.05	0.07	0.14	0.24	0.16	0.48	0.58	0.66	0.72	0.74	0.73	0.67	0.59
	M	0.16	0.14	0.12	0.11	0.11	0.11	0.16	0.24	0.13	0.43	0.52	0.59	0.64	0.67	0.66	0.62	0.56
	H	0.17	0.16	0.15	0.14	0.13	0.15	0.20	0.28	0.16	0.45	0.52	0.59	0.62	0.64	0.62	0.58	0.51

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

Table (A-6-1) Cooling load factor $(CLF)_{Lt}$, for lights. [3]

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

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

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

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

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

Table (A-8) 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

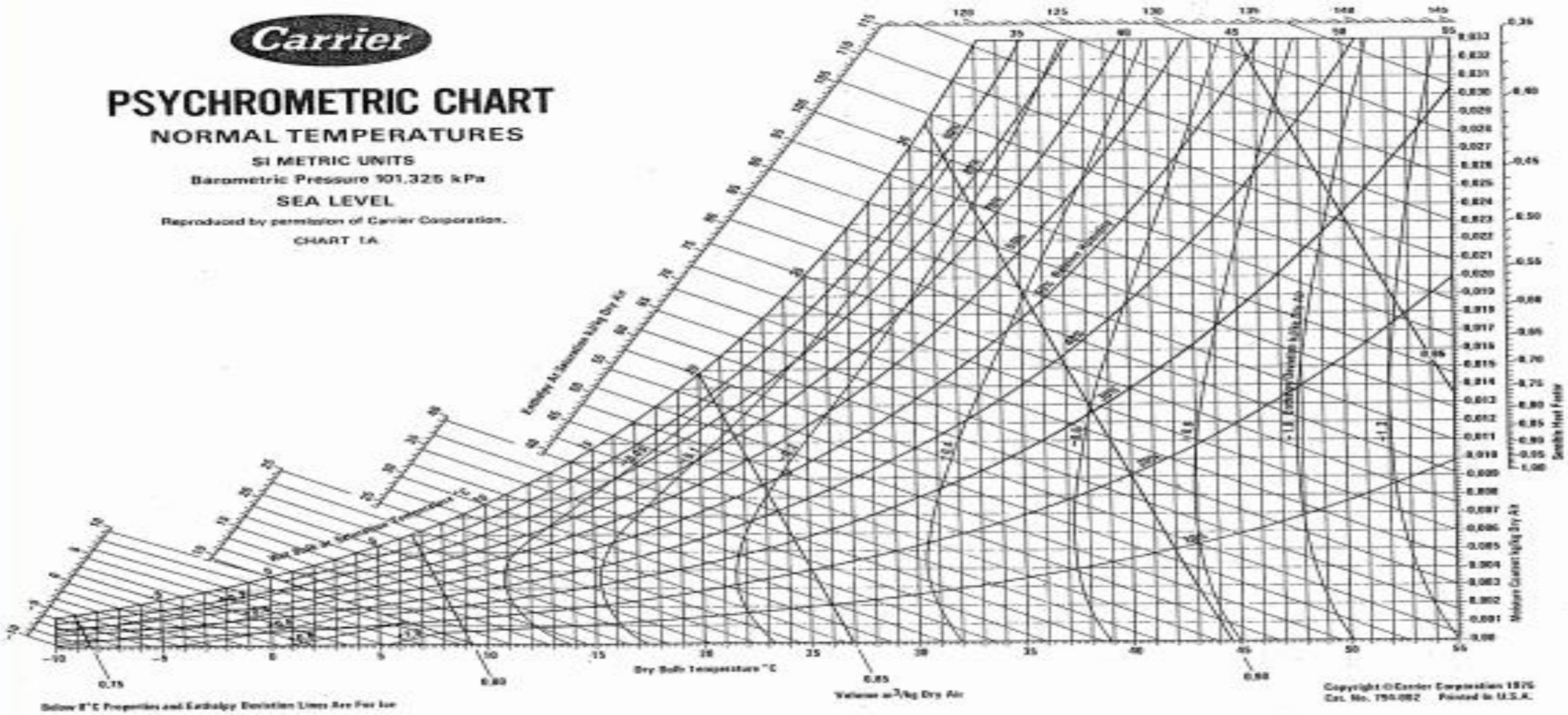

FIGURE 3–1 (a) Carrier psychrometric chart.

Table (B-1):Pipe schedule - standpipes and supply piping

Total Accumulated Flow		Total Distance of Piping from Farthest Outlet		
L/min	**gpm**	**<15.2 m (<50 ft)**	**15.2–30.5 m (50–100 ft)**	**>30.5 m (>100 ft)**
379	100	2	2½	3
382–1893	101–500	4	4	6
1896–2839	501–750	5	5	6
2843–4731	751–1250	6	6	6
4735	1251 and over	8	8	8

Note: For SI units, 3.785 L/min = 1 gpm; 0.3048 m = 1 ft.

Table (B-7)

Outdoor unit capacity type (HP)	Piping outer diameter size (mm)	
	Gas pipe	Liquid pipe
8	19.1	9.5
10	22.2	9.5
12~16	28.6	12.7
18~22	28.6	15.9
24	34.9	15.9
26~34	34.9	19.1
36~54	41.3	19.1

Table (B-8)

<table>
<tr><th rowspan="2">Indoor unit capacity index</th><th colspan="2">Piping outer diameter size (mm)</th></tr>
<tr><th>Gas pipe</th><th>Liquid pipe</th></tr>
<tr><td><150</td><td>15.9</td><td rowspan="3">9.5</td></tr>
<tr><td>150≤x<200</td><td>19.1</td></tr>
<tr><td>200≤x<290</td><td>22.2</td></tr>
<tr><td>290≤x<420</td><td rowspan="2">28.6</td><td>12.7</td></tr>
<tr><td>420≤x<640</td><td>15.9</td></tr>
<tr><td>640≤x<920</td><td>34.9</td><td rowspan="2">19.1</td></tr>
<tr><td>≥920</td><td>41.3</td></tr>
</table>

Table (B-9)

Outdoor unit capacity type (HP)	2 pipes
8~10	KHRQ22M29T9
12~22	KHRQ22M64T
24~54	KHRQ22M75T

Table (B-10)

Indoor unit capacity index	2 pipes
<200	KHRQ22M20T
200≤x<290	KHRQ22M29T9
290≤x<640	KHRQ22M64T
≥640	KHRQ22M75T

Table (B-11)

systemair

NOVA-A, -B

Dimensions, free area and weight for NOVA-A & NOVA-B

Dimensions		Free area		Weight NOVA-A		Weight NOVA-B	
L	H	A_{1V}	A_{2V}	m_1	m_2	m_1	m_2
mm		m^2		kg			
200	100	0,012	0,009	0,2	0,3	0,32	0,54
	150	0,019	0,016	0,25	0,4	0,45	0,77
	200	0,026	0,021	0,32	0,52	0,54	0,97
300	100	0,018	0,015	0,27	0,42	0,45	0,78
	150	0,03	0,024	0,34	0,57	0,64	1,11
	200	0,041	0,033	0,44	0,73	0,77	1,39
	300	0,064	0,051	0,6	1,04	1,08	2
400	100	0,025	0,02	0,34	0,54	0,58	1,02
	150	0,041	0,033	0,43	0,73	0,82	1,45
	200	0,055	0,045	0,55	0,95	0,99	1,82
	300	0,086	0,07	0,77	1,35	1,4	2,61
	400	0,117	0,095	0,98	1,75	1,8	3,4
500	100	0,031	0,025	0,41	0,67	0,72	1,26
	150	0,051	0,042	0,52	0,89	1,01	1,79
	200	0,07	0,057	0,67	1,16	1,21	2,24
	300	0,109	0,088	0,93	1,66	1,71	3,22
	400	0,148	0,12	1,19	2,16	2,21	4,2
	500	0,187	0,151	1,45	2,65	2,71	5,17
600	100	0,038	0,03	0,48	0,79	0,85	1,5
	150	0,062	0,05	0,61	1,05	1,2	2,13
	200	0,085	0,068	0,79	1,38	1,44	2,66
	300	0,132	0,107	1,1	1,97	2,03	3,83
	400	0,179	0,145	1,4	2,56	2,62	4,99
	500	0,226	0,183	1,71	3,15	3,21	6,15
800	100	0,051	0,041	0,63	1,03	1,11	1,98
	150	0,084	0,068	0,79	1,38	1,57	2,82
	200	0,114	0,092	1,03	1,81	1,89	3,51
	300	0,177	0,143	1,43	2,58	2,66	5,04

Table 13-3 Demand Weight of Fixtures, in Fixture Units

Fixture or Group	Occupancy	Type of Supply Control	Fixture Units		
			Hot	Cold	Total
Water closet	Public	Flush valve	—	10	10
Water closet	Public	Flush tank	—	5	5
Pedestal urinal	Public	Flush valve	—	10	10
Stall or wall urinal	Public	Flush valve	—	5	5
Stall or wall urinal	Public	Flush tank	—	3	3
Lavatory	Public	Faucet	1.5	1.5	2
Bathtub	Public	Faucet	3	3	4
Shower head	Public	Mixing valve	3	3	4
Service sink	Office, etc.	Faucet	3	3	4
Kitchen sink	Hotel or restaurant	Faucet	3	3	4
Water closet	Private	Flush valve	—	6	6
Water closet	Private	Flush tank	—	3	3
Lavatory	Private	Faucet	.75	.75	1
Bathtub	Private	Faucet	1.5	1.5	2
Shower head	Private	Mixing valve	1.5	1.5	2
Bathroom group	Private	Flush valve W.C.	2.25	6	8
Bathroom group	Private	Flush tank W.C.	2.25	4.5	6
Separate shower	Private	Mixing valve	1.5	1.5	2
Kitchen sink	Private	Faucet	1.5	1.5	2
Laundry tray	Private	Faucet	2	2	3
Combination fixture	Private	Faucet	2	2	3

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

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

Table (P-3) Horizontal Fixture Branches and Stacks

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

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

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

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

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Table (P-1): Table for Estimating Demand

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

Table (P-3) Horizontal Fixture Branches and Stacks

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

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

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

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

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