DESIGN AND DOCUEMNTAION OF A MECHANICAL SERVICE SYSTEMS FOR HEALTH CARE CENTER AND AN OLYMPIC SWIMMING POOL IN HEBRON CITY

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According to the project supervisor and according to the agreement of the Testing Committee Members, this project is submitted to the Department of Mechanical Engineering at College of Engineering and Technology in partial fulfilments of the requirements of (B.SC) degree.

Supervisor Signature

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Committee signature

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Department Headmaster Signature

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Dedication

To The Souls of Our Ancestors

Who Left With Rivers Of Benevolence

To Our Parents Those Who Were Mentors, Teachers and Friends

Who Were Guidance with Their Endless Giving

To Our Teachers

Who Were Candles, Lighting Our Path to Excellence

To Our Beloved University

Where Our Hearts Will Remain

To All Those

We Promise…

The Promise of the Blood of Martyrs

The Promise of Hungry Prisoners

That We Shall Forever Be Loyal Servants

To Our Glorious Palestine

Acknowledgment

Our thanks go first to our advisor Dr. Ishaq Sider. His guidance and support made this work possible. His constant encouragement, intuitive wisdom, and resolute leadership were instrumental in completing this work.

And finally, ultimate thanks go to our families and to all lectures, engineers, doctors, and laboratories' supervisors. Their efforts and their nice dealing with us improved our characters to become successful engineers in the future.

Abstract

يهدف هذا المشروع إلى تصميم الخدمات الميكانيكية لمركز صحي و تصميم بركة سباحة أولمبية في مدينة الخليل. يتكون المركز من ٣ طوابق بمساحة إجمالية مع المساحات الخارجية تقدر ب ٨,٣٠٠ متر مربع و يشمل هذا المشروع تصميم شبكات المياه و شبكات الصرف الصحي و نظام تكيف الهواء, واعطاء تصميم كامل لبركة السباحة الاوليمبية ..

This project aim to design and document a mechanical service systems for health care centre and an Olympic swimming pool in Hebron city, this centre consist of 3 floors, and the total area of centre about 8.300 m^2, the design include water networks, sewage system, air conditioning system, fire fighting system and a full design for an Olympic swimming pool.

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CHAPTER ONE

INTRODUCTION

1.1 Project overview

Throughout the ages the man worked on improving his life to be easier and more comfortable, and as the wisdom says: “The necessity is the mother of invention” .Engineers were always the pioneers to meet the needs of humans achieving welfare and prosperity.

HVAC engineers developed and still the mechanical service systems and technologies to provide HVAC engineering solutions for any building.

The aim of this project is to design and document a mechanical services system for a health and an Olympic swimming pool located in Hebron-Palestine.

1.2 Project Scope

The scope of this project is to design an Olympic swimming pool and the mechanical service systems for a health care centre in Hebron city. This project can create a bridge between the engineering study and what the local labour market needs.

1.3 Project Objectives and Goals

The aim of this project is summarized by the following points:

1. Design an Olympic swimming pool according to the international standards of (FINA).
2. Design a Variable Refrigeration Temperature (VRT) air conditioning system.
3. Design a Firefighting system for the building.
4. Design a supply water system and waste water system for the building.
5. Draw all the last mechanical services systems on AutoCAD program in details.

1.4 Project Choice Justification

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

1.5 Key Words

- HVAC: Heating Ventilation and Air Conditioning.
- VRT: Variable Refrigeration Temperature.
- FINA: is the International Federation (IF) recognized by the International Olympic Committee (IOC) for administering international competition in Aquatics.

1.6 Time Table

Table 1.1 The time table for the first semester

Activity / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Selection of the project															
Search about information															
Cooling Load Calculations															
Olympic pool Calculations															
WSFU Calculations															
Studding the Fire Fighting Systems															
Preparing a sample of B.O.Q															
Project Documentation															
Project Printing															

The Time table for the second semester time (week)

Table1.2 The Time for the second semester

Activity / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Design The Mechanical Services System for The Building															
Calculate the pipe sizing for the water supply and the drainage systems															
Selecting The Pumps and Other Equipment's needed in our Systems															
Project Documentation															
Project Printing															

CHAPTER TWO

Variable Refrigerant Temperature (VRT) System

2.1 Introduction

Variable refrigerant Temperature (VRT) is an air-conditioning system configuration where there is one outdoor condensing unit and multiple indoor units. The term variable refrigerant Temperature refers to the ability of the system to control the temperature of the refrigerant that inters the indoor units and to control the amount of refrigerant flowing to the multiple evaporators (indoor units), enabling the use of many evaporators of differint 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 VRT technology/system was developed and designed by Daikin Industries, Japan who named and protected the term variable refrigerant Temperature (VRV IV or VRT) system.

2.2 Overview of VRT system

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 Temperature (VRT) systems.

VRT systems operate on the direct expansion (DX) principle meaning that heat is transferred to or from the space directly by circulating refrigerant to evaporators located near or within the conditioned space. Refrigerant Temperature control is the key to many advantages as well as the major technical challenge of VRT systems.

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

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

In this technology you need to provide all the indoor units with a refrigerant pipe from the outdoor unit as you can see in the following figure.

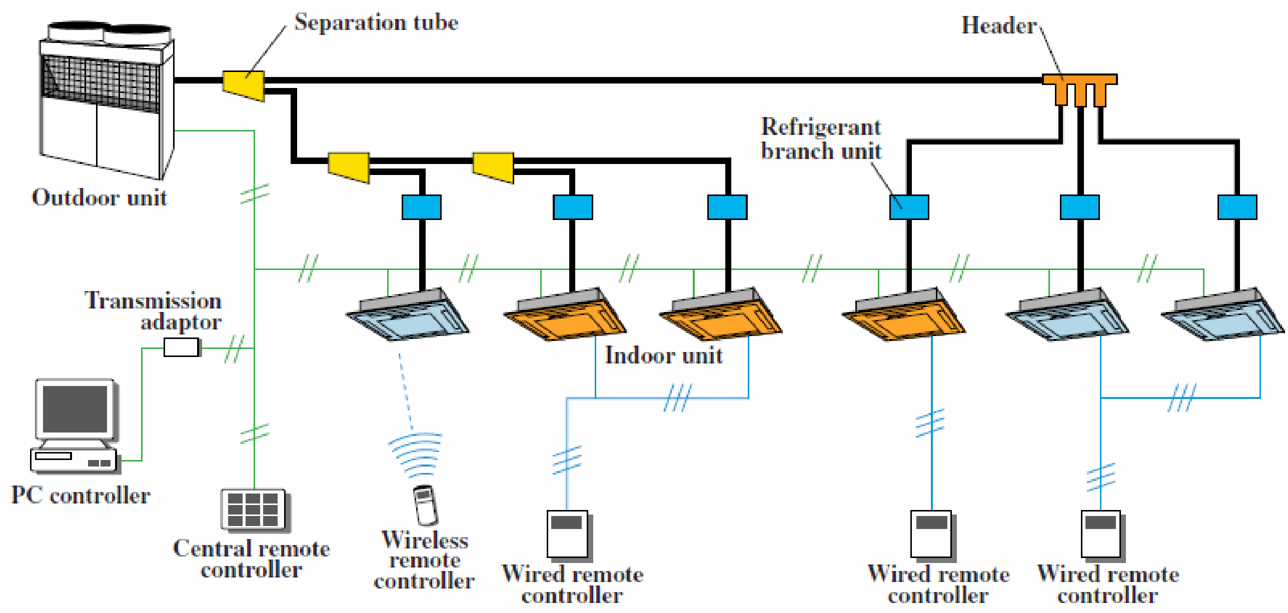


Figure 2.1 VRT Piping System

And we can provide the refrigerant using the separation tubes and the headers with different pipe diameters according to the indoor unit needs of refrigerant.

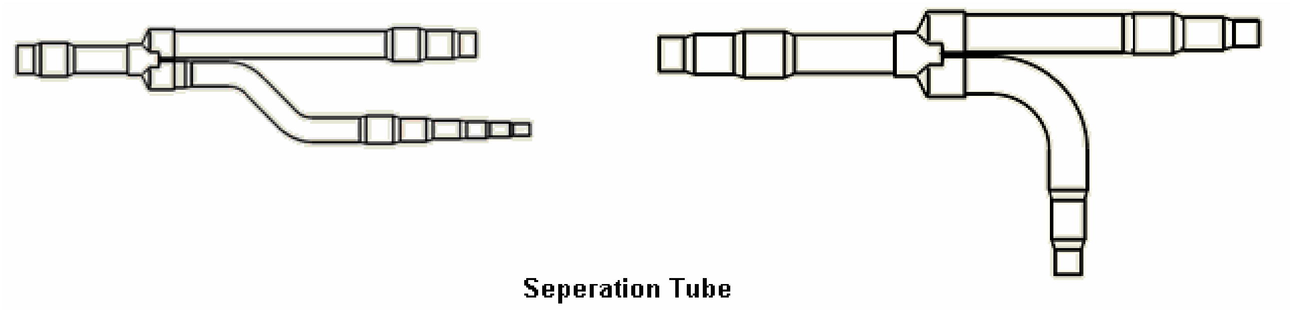


Figure 2.2 The Separation Tubes

2.3 Types of VRT System

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

- **VRT heat pump systems**

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

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

- **<u>Heat Recovery VRT system (VRT-HR)</u>**

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

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

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

2.4 Selecting of the VRT Devices

In our project we decided to select the Daikin VRT-HR system , So for our selections for the indoors and outdoors units and the hydroboxs you can see the cataluges and the AutoCAD drawings in the appendix .

2.5 Cooling load

The cooling load is defined as the rate at which heat energy must be removed from a space in order to maintain a given inside design condition. This load can be expressed in units of Watt (Joule per second) or in refrigeration ton (T.R) where 1 T.R =3.517 kW.

The calculation of a building's total cooling loads is required to be able to design an adequate and efficient cooling system .This calculations, which involves determining all of the building's heat gain components is much more complex than the heat loss calculations and this is for two reasons:

- There are many more factors involved in heat gain than the heat loss.
- Heat gain various sharply during the day .This makes it necessary often ,in nonresidential work to do hour by hour calculations.

The total cooling load of a structure involves:

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

2.5.1 Heat Gain through Sunlit Walls and Roofs:

The heat gain that results from walls and roofs that exposed to the sun is because of the absorption of the radiations by this walls and roofs which is lead to increase the temperature of this surfaces .The amount of radiation absorbed by the walls and roofs depends on the time of the day ,building orientation ,type of wall construction and the 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 .

$$Q = UA\Delta T \tag{2.1}$$

Where:

U: The overall heat transfer coefficient [W/m^2.K].

A: The area of the surface [m^2].

ΔT: The temperature deference between the outside temperature and the inside temperature .

but the value of ΔT also called the cooling load temperature deference (CLTD) , the value of CLTD is need to be corrected so the actual value is found for different cases and hence it will be called the corrected CLTD and it can be calculated from the following relation :

$$(CLTD)corr = (\mathrm{CLTD} + \mathrm{LM})\,\mathrm{K} + (25.5 + \mathrm{Ti}) + (\mathrm{To,m} - 29.4)\,\mathrm{f} \tag{2.2}$$

Where:

LM: Latitude correction factor.

K: Color adjusting factor such that K=1 for dark colored roof ,and K=0.5 for permanently light colored roofs.

Ti: The inside room temperature.

f: Attic or roof fan factor such that f=1 if there is no attic or roof fan , f=0.75 if there is an attic or roof fan.

And:

$$To, m = To - DR / 2 \tag{2.3}$$

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

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

$$U = \frac{1}{\frac{1}{hfin} + \sum \frac{\Delta x}{k} + \frac{1}{hfout}} \tag{2.4}$$

Where:

h_{fin}: The inside convection heat transfer coefficient[W/m^2.K].

h_{fout}:The outside conviction heat transfer coefficient[W/m^2.K].

x: The layer thickness[m^2].

k: The conduction heat transfer coefficient [W/m.K] .

In our project the roofs construction is as follows in the figure bellow:

Asphalt Mix	0.028	0.02 m
Concrete	0.029	0.05 m
Insulation	0.500	0.02 m
Reinforced Concrete	0.034	0.06 m
Cement Block	0.189	0.18 m
Plaster	0.017	0.02 m

***U* = 1.08**

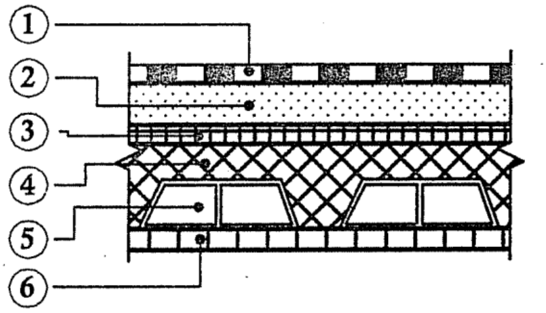


Figure 2.3 The roofs constructions

And the outside walls construction as follows:

Stone	0.041	0.07 m
Concrete	0.114	0.20 m
Insulation	0.750	0.03 m
Cement Brick	0.078	0.07 m
Plaster	0.025	0.03 m

***U* = 0.86**

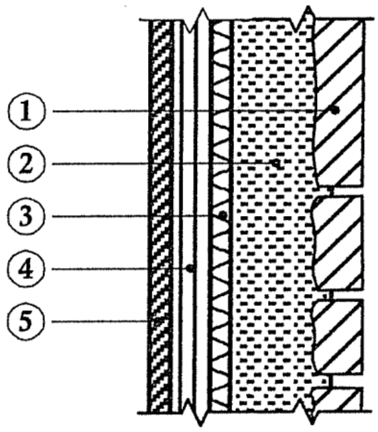


Figure 2.4 The outside walls construction

And the inside walls construction as follows:

Plaster	0.017	0.02 m
Cement Brick	0.222	0.20 m
Insulation	0.500	0.02 m
Plaster	0.025	0.03 m
***U* = 1.09**		

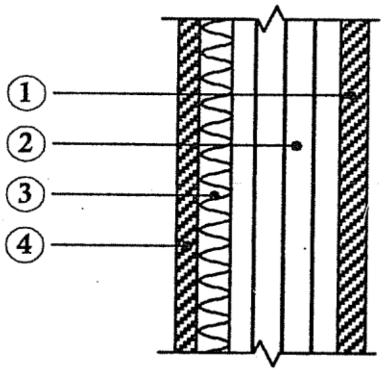


Figure 2.5 The inside walls constructions

And the overall heat transfer coefficient for the floor, doors and windows:

U_{floor} =1.15 W/m^2.K .

U_{win} =3.2 W/m^2.K.

U_{doors} Which it consist from wood = 3.1 W/m^2.K .

2.5.2 Heat Gain through Glass

This component of the building's heat gain consist of two parts :direct solar radiation heat gain through unshaded glass exposed to the sun and conductive heat gain through shaded glass and glass not exposed to the sun. Shaded glass is treated the same as the north-facing glass, that is like glass not exposed to the sun .The glass heat gain factor is frequently the largest heat gain of a building and must be accurately calculated .

2.5.3 Transmission Heat Gain

Heat gain due to solar transmission through glass windows and glass doors is estimated by using the following equation:

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

Where:

A: The area of the glasses window or glasses door.

SHG: This factor represents the amount of the solar energy that would be received by floor, furniture and inside walls of the room.

SC: Is the shading coefficient which is defined as the ratio of the solar heat gain of glass window of the space to the solar heat gain of double strength glass.

CLF: The cooling load factor represents the effect of the internal walls, floor and furniture on the instantaneous cooling load.

In our project the windows is reflective coated insulation glass, venetian blinds light SC=0.19.

2.5.4 Convection Heat Gain

The convicted cooling load by the glass is calculated from the following equation

$$Q_{con} = AU(CLTD)corr \qquad (2.6)$$

Where the $CLTD_{corr}$ is calculated by the equation (2.2)

2.5.5 Heat Gain Due To Lights

Heat gain due to lights is sensible load. And can be found by using the following equation

$$Q_{light} = P_{lt}(F_u * F_b) * CLF_{light} \qquad (2.7)$$

Where:

P_{lt} is the lamp rated power [W].

Fu is the fraction of lamp that is in use.

Fb is the ballast factor.

$CLF_{light:}$ the cooling load factor for the light.

2.5.6 Heat Gain Due To Ventilation

Ventilation is required for places in which the inside air is polluted due to activities that take place in the space such as factories, restaurants.....etc. this type of load can be calculated by the following equation:

$$Q_{Vent} = (\frac{V * N}{3600}) * \rho * \text{Cp} * \Delta \text{T} \tag{2.8}$$

Where:

V: The volume of the room .

N: The number of air change per hour .

ρ: The density of air .

2.5.7 Heat Gain Due To Infiltration

Infiltration is the leakage of outside air through cracks or clearances around the windows and doors .It provides fresh outside air needed for living in comfort and healthy places .The amount of this infiltrated air depends mainly on the tightness of the windows and doors and on the outside wind speed and the pressure difference between the outside and inside of the room. This load can be calculated by this equation :

$$Q_{\text{t.inf}} = (\frac{V_{\text{inf}}}{v_o}) * (\text{h}_o - \text{h}_i) \tag{2.9}$$

Where:

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

v_o: The specific volume of the air [m^3/kg] .

h_o : The enthalpy of the outside air [kJ/kg] .

h_i : The enthalpy of the inside air [kJ/kg] .

2.6 calculating the value of (CLTD) corrected

The center which will be conditioned having a medium colored walls the glass window with interior shading windows is reflective coated insulation glass, and the latitude angle is (32), the inside design condition as: 24 C db & 50%RH, the outdoor mean temperature is (32C), CLTD corrected will be calculated for the parts that having heat gain due to solar effects so if we back to equation (2.2) we can see that we have an unknown parameter which is the CLTD , the following table shows the CLTD values for walls through their direction

Table 2.1 CLTD values for walls

Direction	CLTD Value
N	11
NE	14
E	18
SE	18
SW	16
S	21
W	23
NW	18
Roof	23

1. the value of (CLTD)corrected for north wall :

$$(CLTD)corr = (\mathrm{CLTD} + \mathrm{LM})\,\mathrm{K} + (25.5 + \mathrm{Ti}) + (\mathrm{To,m} - 29.4)\,\mathrm{f}$$

= (11+0.5)*0.83+(25.5+24)+(32-29.4)*1

= 13.6 C

Table 2.2 CLTDcorr values for walls

Wall Direction	N	NE	E	SE	S	SW	W	NW	Roof
CLTDcorrected [C]	13.6	16.1	19.4	19.4	17.8	19.4	23.6	19.4	23.6

2. Calculating the value of (CLTD)corrected for north glass :

The value of CLTD for glass taken from table [9-12] in Heating and Air Conditioning book

(mohammad A.Alsaad, Mahmoud A. Hammad).

$$(CLTD)corr = (\mathrm{CLTD} + \mathrm{LM})\,\mathrm{K} + (25.5 + \mathrm{Ti}) + (\mathrm{To,m} - 29.4)\,\mathrm{f}$$

= (8+0.5)*1+(25.5+24)+(32-29.4)

=12.6 C

There is so many factors that affect the heat gain due to glass as we mentioned before and this factors are different and it depends on the direction of the glass so the following table summarized the values of this factor according to the direction of the glass .

Table2.3 Factors which the glass depends on

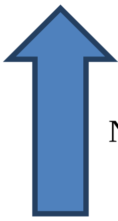
Glass Direction	SC	SHG	CLF
N	0.19	126	0.75
NE	0.19	527	0.2
NW	0.19	527	0.73
E	0.19	678	0.17
W	0.19	678	0.82
SE	0.19	473	0.22
SW	0.19	473	0.81
S	0.19	227	0.35
Horizontal	0.19	861	0.58

2.7 Sample of the Cooling Load Calculation

In this section we well take the office (B18) in the first floor as an example of the cooling load calculations:

1. Wall Gain load

South outside wall area for the room (A1):



North direction

$A1 = A_{wall} - A_{window}$

$= (7.5*3.5) - (3.7*2) =18.85\ m^2$

Q1 = U *A1*CLTDcorr south

=0.86*18.85*17.8

=288.5 W

West inside wall area for the room (A2):

$A2 = 10.5*3.5 = 36.75\ m^2$

Q2= U*A2*ΔT

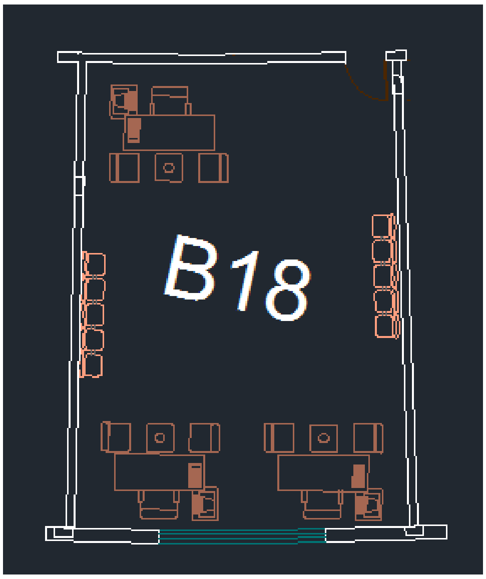


Figure 2.6 Office as sample of cooling load calculations

=1.09*36.75*7

=280.4 W

East inside wall area for the room (A3):

$A3=10.5*3.5 =36.75\ m^2$

Q3=U*A3*ΔT

=1.09*36.75*7

=280.4W

North inside wall area for the room (A4):

$A4 = A_{wall} - A_{door}$

$= (6.8*3.5) - (0.9*2.1)$

$= 21.9\ m^2$

$Q4 = U*A4*\Delta T$

$= 1.09*21.9*7$

$= 167.1\ W$

2. Roof and Floor Gain Load:

The roof area of the room (A5):

$A5 = 7.5*10.5$

$= 78.75\ m^2$

Q5=U*A5*CLTDcorr roof

$= 1.08*78.75*23.6$

$= 2007.2\ W$

The floor area for the room (A6):

$A6 = 10.5*7.5$

$= 78.75\ m^2$

$Q6 = U*A6*\Delta T$

$= 1.15*78.75*7$

$= 634\ W$

3. Heat Gain from Windows and Doors:

Q(south window) =Qtr + Qcon

Qtr = A_{win}(SHG)(SC)(CLF)

= (3.7*2)(227)(0.19)(0.35)

=111.7 W

Qcon=U*A_{win} *CLTDcorr south

=3.2*(3.7*2)*17.8

=421.5 W

Q (south window) =111.7+421.5 =533.2 W

Qdoor = U*A*ΔT

= 3.1*(0.9*2.1)*7

= 41 W

4.Heat Gain Through Lights:

Q_{lt} =P_{lt}*(Fu*Fb)*CLF_{lt}

But the lights intensity that we have is 30 [W/m^2] so we need to multiply the previous equation by the area of the room and it became as follow:

Q_{lt} =P_{lt}*(Fu*Fb)*CLF_{lt} *A

= 30 (1*1)*0.84*78.75

= 2000 W

5.Heat Loss Due to Infiltration :

$$Q_{t.\inf} = (\frac{V_{\inf}}{v_o}) * (\mathrm{h}_o - \mathrm{h}_i)$$

V_{inf} = No .of air change per hour * volume of the room /3600

= 1*(7.5*10.5*3.5)/3600

=0.07 m^3/s

ho, hi and Vo are obtained from the psychometric chart as :

ho = 70 kJ/kg at 32C and 50% RH.

hi = 48 kJ/kg at 24C and 50% RH.

Q_{inf} =(0.07/0.91)*(70-48)

=1.69 kW

6.Heat Gain Due to Ventilation :

$$Q_{Vent} = (\frac{V*N}{3600})*\rho*\mathrm{Cp}*\Delta \mathrm{T}$$

The Cp of air is 1.005 [kJ/kg] and ρ for air is 1.25 [kg/m^3] so :

Qvent= ((10.5*7.5*3.5)*1)/3600)*1.25*1.005*(32-22)

= 0.95 kW

Now the total load for our room (B18) is:

Qtot =∑Q *1.15.

Where is the other loads like machine loads.....etc.

So Qtot = 9.21*1.15

= 10.6 kW

2.8 Sample of heating load calculation:

In this section we will take the same room (B 18) that we take before in the cooling load calculations.

$$Qwalls = Qw.in + Qw.o + Qroof + Qfloor \tag{2.10}$$

$$Qw.in = Uw.in \times Ain \times \Delta Tin$$
$$Qw.in = (1.09) \times ((2(10.5 \times 3.5) + ((7.5 - 0.9) \times 3.5) \times (8)$$
$$Qw.in = 842.33W$$

$$Qw.o = Uw.o \times Ao \times \Delta To$$
$$Qw.o = (0.86) \times ((7.5 - 3.5) \times 3.5) \times (19)$$
$$Qw.o = 217.32W$$

$$Qroof = Uroof \times A \times \Delta Tin$$
$$Qroof = (1.08) \times (78.75) * (8)$$
$$Qroof = 680.4W$$

$$Qfloor = Ufloor \times A \times \Delta Tin$$
$$Qfloor = (1.15) \times (78.75) \times (8)$$
$$Qfloor = 724.5W$$

So the total load from walls is:

$$Qtot = 842.35 + 217.32 + 680.4 + 724.5$$
$$Qtot = 2464.5W$$

$$Qdoor = Udoor \times Adoor \times \Delta Tin$$
$$Qdoor = (3.1) \times (0.9 \times 2.1) \times (8)$$
$$Qdoor = 46.8W$$

$$Qwindow = Uwin \times Awin \times \Delta Tin$$
$$Qwindow = (3.2) * (7.4) * (19)$$
$$Qwindow = 450W$$

$$Qs.f = \rho \times V \times cp \times \Delta To$$

But:

V = (No of air change/h)*Volume of room

$$Qs.f = \frac{1250}{3600} \times (2.5 \times (10.5 \times 7.5 \times 3.5)) \times (19)$$
$$Qs.f = 4545.9W$$

$$Qheating = 4545.9 + 2464.5 + 46.8 + 450$$
$$Qheating = 7507W$$

$Q_{heating}$ =7507*1.15 =8633 W

Table 2.4 The Ground Floor Cooling and Heating Capacity

Room	Area [m^2]	Cooling load [kW]	Heating load [kW]
A1	340.1	49.6	48
A2	61.5	9	7.3
A3	55	8.02	6.3
A4	118	17.23	16.1
A5	220.1	32.1	30.1
A6	113.8	16.6	15.9
A7	79.5	11.6	10.2
A8	87.7	12.8	11.7
A9	76.1	10.2	8.3
A10	33	4.8	3.4

A11	282.5	41.2	40
A12	37	5.4	4.2
A13	31.4	4.5	3.1
A14	14.4	2.1	1.3
A15	10.3	1.6	0.9
A16	174.8	25.5	24.1
A17	70.6	9.7	8.6
A18	165.2	24.12	23
A19	127	19	17.8

Table 2.5 The First Floor Cooling and Heating Capacity

Room	Area [m^2]	Cooling load [kW]	Heating load [kW]
B1	340.1	49.6	48.2
B2	61.5	9	7.1
B3	55	8.02	6.3
B4	174.8	25.5	24
B5	16.8	2.5	1.1
B6	72.6	10.1	9.1
B7	55.5	8.1	6.6
B8	65.8	8.8	7.3
B9	65.8	8.8	7.4
B10	55.6	8.1	6.8
B11	95.3	14.1	12.6
B12	16.8	2.5	1.1
B13	137.1	20	18.6
B14	174.8	25.5	24

B15	372.3	54.3	52.6
B16	30.1	4.4	3
B17	26.7	3.9	2.2
B18	74.75	10.6	8.6
B19	170	24.8	23.3
B20	385.5	56.2	55
B21	28.8	4.2	2.9
B22	24	3.5	2.2
B23	58.2	8.5	7
B24	398.4	58.1	56

`

Table 2.6 The Second Floor Cooling and Heating Capacity

Room	Area [m^2]	Cooling load [kW]	Heating load [kW]
C1	133	19.4	18.3
C2	144	21	19.8
C3	377.1	55	53.5
C4	26.7	3.9	2.5
C5	30.1	4.4	3.5
C6	74.75	10.6	8.6
C7	85	12.4	10.4
C8	84	12.3	11
C9	384.7	56.1	55
C10	58.3	8.5	7.1
C11	29.4	4.3	3.1
C12	24	3.5	2
C13	205.7	30	28.6

CHAPTER THREE

SWIMMING POOL

3.1 Introduction

The world is full of recreational places like seas, lakes and water surfaces such as artificial pools, which are almost built far from seas and public recreational places.

Swimming is a physical sport in which people can use and move most of body muscles, so that s/he can activate blood circulation and feel active. Calipha Omar bin Al-Khattab (God bless him) recommended fathers to teach their children how to swim because of its high importance to the body.

Human nature tends to joy and excitement which can be found in swimming because water has a refreshing touch especially in summer if it's cold and in winter if it's warm.

People after they finish building their houses, start to ornament the area that surrounds the house by planting roses, trees and gardens and building fountains and small swimming pools. Nowadays, there are increasing demand to build such pools and fountains to complement the beautiful coordinated sight-seeing in front of the houses. It is encouraging and pleasant to have such accessories of excitement in your own house.

Swimming pool means any basin, chamber or tank constructed of impervious material, located either indoors or outdoors containing an artificial body of water for swimming or recreational bathing and having a depth of 2 feet or more at any point. This includes any related equipment, structures, areas and enclosures that are intended for the use of persons using or operating the swimming pool such as equipment, dressing lockers, showers and toilet rooms.

Swimming pools are recreation; it's known that in summer and spring the temperatures rise much, which make people feeling they need to something joyful in order to relief themselves, that break the routines of life, work and to get out from their houses for recreation.

Swimming pools are environmental; The most beautiful sightseeing is to see a swimming pool surrounded by decorative and accessories like trees, flowers, fountains, waterfalls and cascades. Recently, hotel designer go to make the ground floor an inside park for people who live in this floor contains a big swimming pool, fountains, waterfalls, steam paths and comfortable cafeterias.

3.2 Swimming Pool

3.2.1 Basic mechanical components of swimming pools

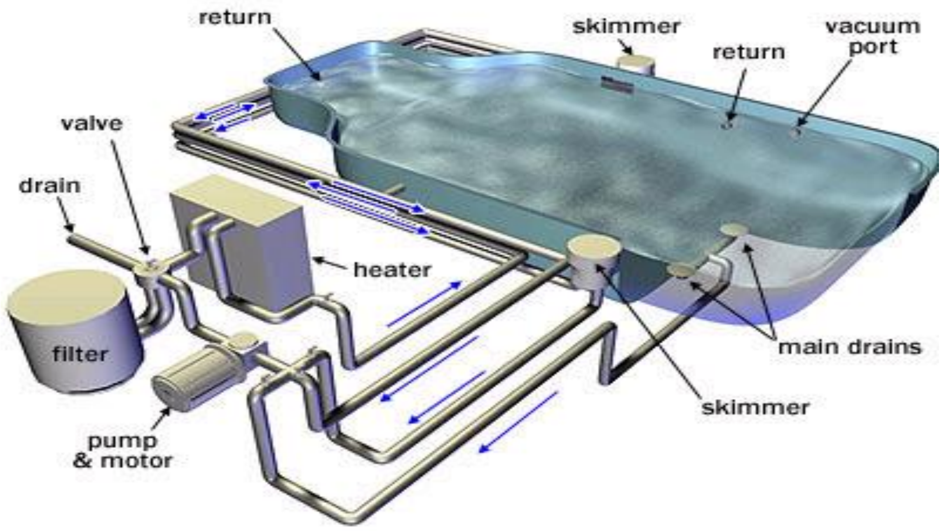


Figure 3.1 Basic component of swimming pool

The basic mechanical component of swimming pools:

1) Skimmers or Over flow gutters

Skimmer is mounted in the pool wall at water level, and connects to a branch of the suction piping from the filter pump.

Its purpose is to promote surface flow across the pool. Besides drawing in the water, which requires most treatment because of exposure to sun, wind, and rain, it also removes floating dust and debris, leaves~ and oil films before they can accumulate on floors and walls.

Over flow gutter: A trough in the wall of the pool which may be used for overflow and to skim the pool surface.

2) Floor Drain

The outlet or outlets within the construction of pool floor; which function is to suck or take the pool water into the piping network, then the water enters the filter to be cleaned. Its function is similar to the function of the skimmer or gutter.

3) Return Inlets

An opening or fitting through which filtered water enters the pool, it is either wall mounted or floor mounted.

4) Pumps and Motors

A pump is a device that raises or transfers fluids from one location to another. Pumps are selected for processes to not only raise and transfer fluids, but also to meet some other criteria. This other criteria may be to obtain constant flow rate or constant pressure.

There are two main categories of pumps, they are dynamic and displacement pumps. These two categories also have many subcategories of pumps.

Pumps are used for variety applications, in swimming pool the pump used for recirculation system.

5) Filters

Filter is a mechanical device for straining suspended particles from pool water, it deals with particular matter. It strains out suspended solids down to sub-micron size in order to retain water clarity. It does not remove dissolved salts and other microorganisms. Filtration combined with disinfection produces effective water purification treatment that keeps water:

- clear and non-toxic
- odorless and tasteless
- free of bacteria and algae
- Balanced to prevent corrosion or scale formation.

6) Chlorine Device

This device used to control the chlorine in the pool water and it is very important in the chemical treatment of the pool water.

7) Flow Meter

A device that measures pressure differential across a calibrated orifice and indicates the rate of flow at that point. Usually expressed in liter per second (L/s).

A flow meter is required in each pool and spa recirculation system. The flow meter measures the quantity of water passing a given point in a unit of time

8) Pool Water Heater

The need for pool water heater depends on the purpose of the pool and the general climate. A heated pool is more enjoyable at all times and extends the season at both ends by at least a month. The heater is connected into a loop in the return line from the filter, and may either be gas-fired, oils-fired, electric, or consist of a heat exchange where steam or hot water service is available.

The heater is more vulnerable to lime deposits and corrosion than other pool equipment. As a result it should be checked frequently during the early weeks of operation to ensure that it suffers no adverse effects from the pool water chemistry.

9) Balance Tank

It is helpful to be able to calculate the amount of make-up water that needs to be added to make up for water lose through filter backwashing, splash-out, evaporation or leaks. To do so, determine the number of meters of water depth required to fill the pool and your pool's surface area (length x width) and supplement them into the following formula:

$$\text{Volume of balance tank} = \text{water surface area} * F \qquad (3.1)$$

3.2.2 How swimming pool work

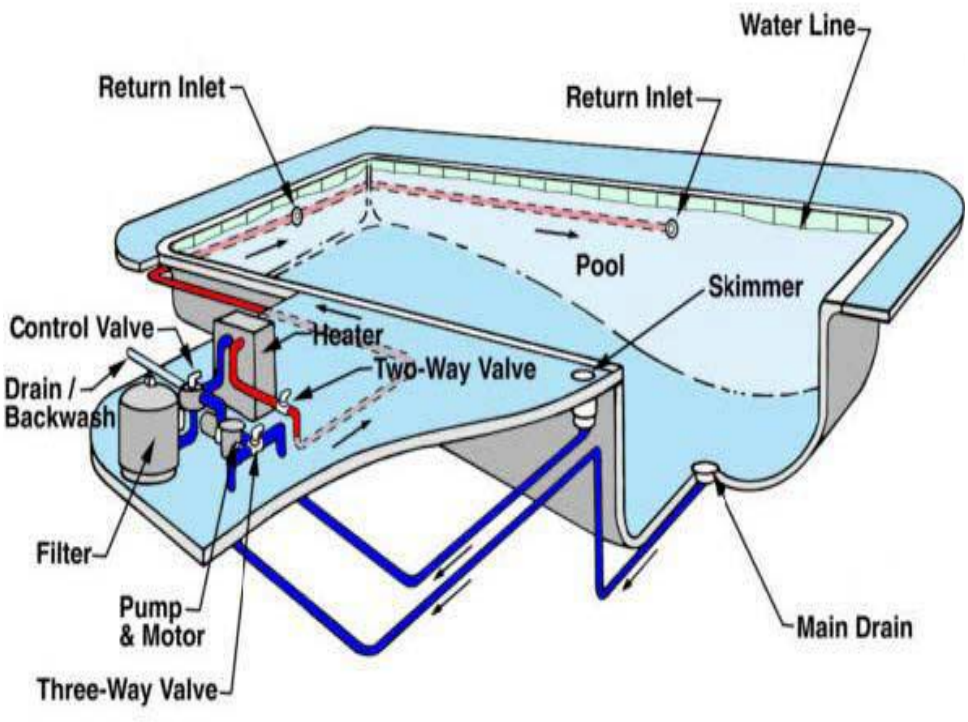


Figure 3.2 How swimming pool work

The process of pumping water from the pool through the filter system and returning it to the pool is called recirculation. Typical components of the recirculation system include the piping, pump, valves, inlets, outlets, surge tank, pressure gauges, and flow meter. The source of the power used to recirculation the water through the system is the recirculation pump. Typically, a centrifugal pump is used to recirculation the pool water.

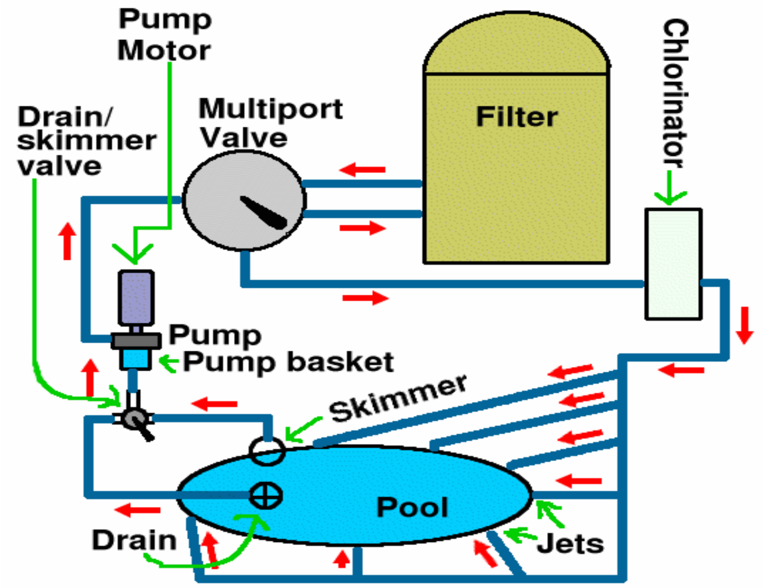


Figure 3.3 Simple pool water cycle

In the diagram below, the red arrows represent the direction of water flow, the green arrows simply point to components and the thick blue lines are pipes.

Start from the pool; water is sucked out from the pool, usually at two points, the bottom drain and the skimmer or overflow gutter (depend on the pool), which is indented into the wall in the deep end, near the surface. The surface traps floating debris as it sucks in water. From the drain and skimmer, the water is sucked to a way valve near the pump and filter.

From the way valve, the water is sucked into the pump basket. The pump basket is a reservoir containing water for the pump to suck. The pump basket also contains a screen to trap large debris such as small twigs and leaf parts. Theoretically, such debris should have been stopped by the skimmer screen or the drain cover, but sometimes it's not. The screen in the pump basket should be cleaned regularly.

From the pump basket, water is sucked into the pump. It sucks water into the center, and via spinning blades throws it to the outside, where it's shot out into the outgoing pipe.

Coming out of the pump, the water is pushed to the filter valve. The exact configuration of the filter valve depends on the type of filter. The basic use of the filter valve is to either direct the water into the filter or out to the street via a hose. Obviously, normal operation requires direction to the filter. Filters requiring backwashing or rinsing require filter valves with additional positions to accomplish those functions.

Next, the water is pushed through the filter. The water passes through and the , suspended particulates are caught and held by the filter. After the filter has caught too much particulate matter, its ability to pass water is compromised, in which case either the filter's cartridge must be changed if it's a cartridge, or it must be backwashed. Filters have a pressure gauge to tell you when they have absorbed too much particulate.

Then water is pushed out of the filter and into the chlorinator, a simple canister which houses solid tablets of chlorine so that they dissolves over time and keep the chlorine level somewhat constant. From the chlorinator the water goes through underground pipes back to the pool, where it enters through the water jets on the sides of the pool. Thus completing the water cycle.

3.3 Types of Swimming Pools

There is many classifications of swimming pools, so that they are specified by its shape, and its location (residential or public), but the most common classification is by its usage.

The following is types of swimming pools that are classified by usage:

3.3.1 Private Pools

In countries and regions with some warmer climates, open-air swimming pools in gardens are common. In some places like southern Florida, they are extremely common, and it is rare to find a new house built without a pool. Increasingly private pools are becoming a feature of homes in more northerly locations. In London, for example, many larger homes are now being redesigned to incorporate indoor pools, usually in the basement or in a conservatory.

Private pools are normally much smaller than public ones. There are also demountable private pools. However these pools are not very stable and can sometimes collapse, causing flooding.

Figure 3.4 private pools

3.3.2 Public Pools

Figure 3.5 Public pools

Public pools are often found as part of a larger part of a leisure center or recreational complex. These centers often have more than one pool, e.g. an indoor heated pool, an outdoor saltwater or unheated chlorinated pool, a shallower 'children's pool', and a paddling pool for children. There may also be a sauna area. In the swimming pool area and/or in the sauna area there may be one or more spa pools or Jacuzzis

If a swimming pool (sometimes combined with facilities for allied sports and activities such as a diving tank) is located in a separate building, the building is called "natatorium".

Many public swimming pools are rectangles either 25 m or 50 m long, but a backyard pool can be any size and shape desired. There are also very elaborate pools, with artificial waterfalls, fountains, and splash pads, wave machines, varying depths of water, bridges, and island bars. Public pools may also belong to a hotel or holiday resort.

There are often lockers for clothing and other belongings. The lockers generally require a coin to be inserted as deposit or payment outright. Also there are often showers ready for use after a person has finished swimming.

3.3.3 Ocean Pools

In the early part of the 20th century, especially in Australia, ocean pools were constructed typically on headlands by enclosing part of the rock shelf, with water circulated through the pools by flooding from tidal tanks or by regular flooding over the side of the pools at high tide. There were often separate pools for women and men, or the pool was open to the sexes at different times with a break for bathers to come without fear of observation by the other sex. Segregated changing sheds and showers were provided. These were the fore-runners of modem 'Olympic' pools.

3.3.4 Competition Pools

Figure 3.6 The starting block of a competition swimming pool

Competition pools are generally indoors and heated to enable their use all year round, and to more easily comply with the regulations regarding temperature, lighting, and Automatic Officiating Equipment and other swimming pool equipment. The competition pools must be 25 m or 50 m long and at least 1.35 m deep.

3.3.5 Olympic Swimming Pool

Figure 3.7 Olympic Swimming Pool

An Olympic Swimming Pool is a pool that used for the Olympic Games and for world championship events. It must be 50 m in length by 25 m wide, divided into eight lanes of 2.5 m each plus two areas of 2.5 m at each side of the pool. The water must be kept at 25-28°C and the lighting level at greater than 1500 lux. Depth must be at least 2 m, and there are regulations for color of lane rope, positioning of backstroke flags, and so on. Our swimming pool project is an Olympic swimming pool.

3.4 Olympic Pool

3.4.1 Introduction

The Facilities Rules are intended to provide the best possible environment for competitive use and training. These Rules are not intended to govern issues related to the general public.

It is the responsibility of the owner or controller of a facility to provide supervision for activities undertaken by the general public.

3.4.2 General

FINA Olympic Standard Pools: All World Championships (except the Masters World Championships) and Olympic Games must be held in pools that comply with Rules FR 3, FR 6, FR 8, and FR 11 at FINA catalogs.

FINA General Standard Pools: other FINA events should be held in FINA Olympic Standard Pools, but the Bureau may waive certain standards for existing pools if they do not materially interfere with the competitions.

FINA Minimum Standard Pools: All other events held under FINA Rules Should be conducted in pools that comply with all of the minimum standards contained within these Facilities Rules.

3.4.3 Swimming Pools for Olympic Games and World Championship

In order to protect the health and safety of persons using swimming facilities for the purposes of recreation, training and competition, owners of public pools or pools restricted only to training and competition must comply with the requirements established by law and the health authorities in the country where the pool is situated. New competition equipment (e.g. starting blocks, lane-ropes, etc.) must be available by 1st January in the year of the Olympic Games and FINA World Championships.

3.4.3.1 Length

Fifty meters length .See Fig(3.14)

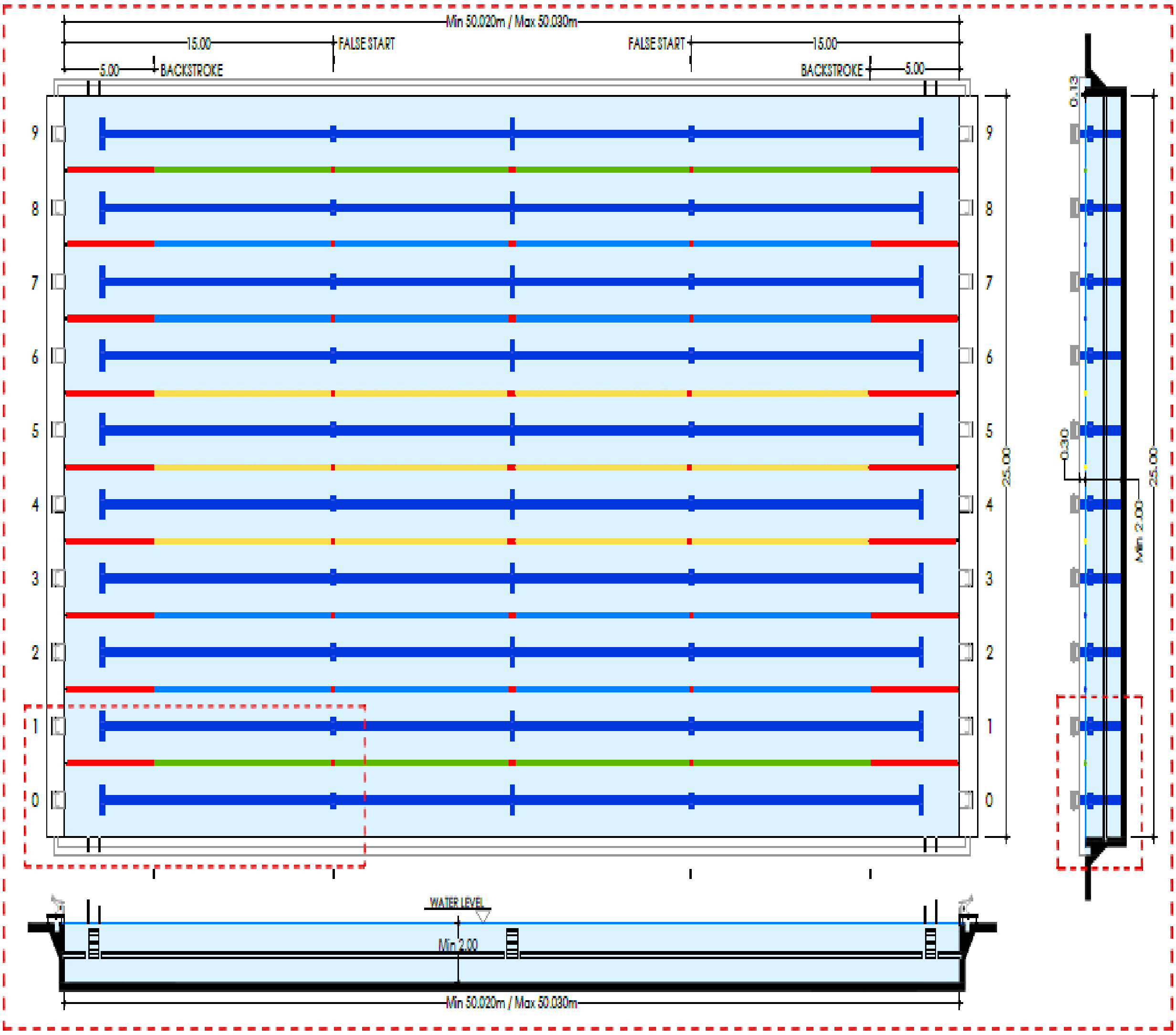


Figure 3.8 *Length of Swimming Pools*

3.4.2.2 Width

Twenty-five meters width. See Fig (3.15)

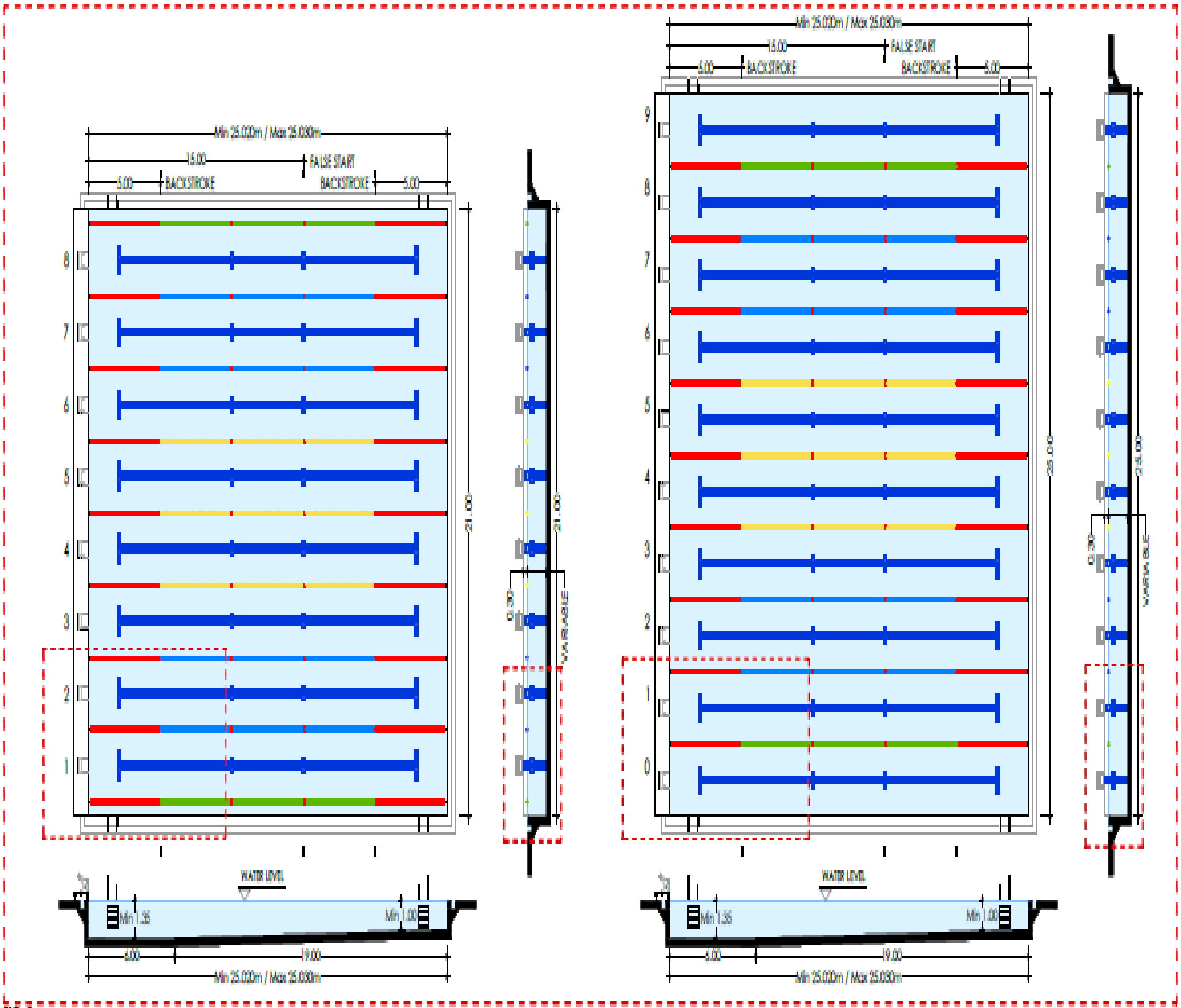


FIG. 2

Figure 3.9 Width of the Olympic pool

3.4.2.3 Dimensional Tolerances

Against the nominal length of 50meters, a tolerance of plus 0.030 meter in each lane minus 0.0 meter on both end walls at all points from 0.30 meter above to 0.80 meter below the surface of the water is allowed. These measurements should be certified by a surveyor or other qualified official, appointed or approved by the Member in the country in which the pool is situated. Tolerances cannot be exceeded when touch panels are installed**.** See fig (3.14)

Against the nominal length of 25 meters, a tolerance of plus 0.030 meter in each lane minus 0.00 meter on both end walls at all points from 0.30 meter above to 0.80 below the surface of the water is allowed. These measurements should be certified by a surveyor or other qualified official, appointed or approved by the Member in the country, in which the pool is situated. Tolerances cannot be exceeded when touch panels are installed. See Figure (3.15).

3.4.2.4 Depth

2 Meters (minimum); 3 meters recommended, when using the pool for multi disciplines i.e. synchronized swimming.

3.4.2.5 Walls

End walls shall be vertical, parallel and form 90 degree right angles to the swimming course and to the surface of the water. They shall be constructed of solid material, with a non-slip surface extending 0.8 meter below the water surface, so as to enable the competitor to touch and push off in turning without hazard.

Pools for Olympic Games and World Championships must be equipped with flush walls (consistently flat) at both ends.

3.4.2.6 Lanes

Number of lanes: 8 (eight), for World Championships and Olympic Games: 10 (ten). Lanes shall be 2.5 meters wide with 2 spaces 2.5 meters wide outside of lanes 1 – 8. There must be a lane rope separating these spaces from lanes 1 and 8 for Olympic Games and world championships. If 10 lanes, these must be marked from 0 to 9.

Lane Ropes: Lane Ropes shall extend the full length of the course, secured at each end wall to anchor brackets recessed into the end walls. The anchor shall be positioned so that the floats at each end wall of the pool shall be on the surface of the water. Each lane rope will consist of floats placed end-to-end having a minimum diameter of 0.05 meter to a maximum of 0.15 meter. In a swimming pool the colour of the lane ropes should be as follows:

• Two (2) GREEN ropes for lanes 0 and 9
• Six (6) BLUE ropes for lanes 1, 2, 3, 6, 7 and 8
• Three (3) YELLOW ropes for lanes 4, 5

The floats extending for a distance of 5.0 meters from each end of the pool shall be of RED colour. There shall not be more than one lane rope between each lane. The lane ropes shall be firmly stretched.

Figure3. 10 Numbers and Colours of Lanes

3.4.2.7 Starting Platforms

Starting Platforms shall be firm and give no springing effect. The height of the platform above the water surface shall be from 0.5 meter to 0.75 meter. The surface area shall be at least 0.5 meter x 0.5 meter and covered with a nonslip material. Maximum slope shall not be more than 10 degrees. The starting platform may have an adjustable setting back plate. An adjustable back stroke starting platform may also be used. The platform shall be constructed so as to permit the gripping of the platform by the swimmer in the forward start at the front and the sides; it is recommended that, if the thickness of the starting platform exceeds 0.04 meter, grips of at least 0.1 meter width on each side and 0.4 meter width in the front be cut out to 0.03 meter from the surface of the platform. Handgrips for the forward start may be installed on the sides of the starting platforms. Handgrips for backstroke starts shall be placed within 0.3 mete to 0.6 meter above the water surface both horizontally and vertically. They shall be parallel to the surface of the end wall and must not protrude beyond the end wall. The water depth from a distance of 0.1 meter to 0.6 meters from the end wall must be 1.35 meters where starting platforms are installed. Electronic read-out boards may be installed under the blacks. Flashing is not allowed. Figures must not move during a backstroke start. See Fig. (3.11)

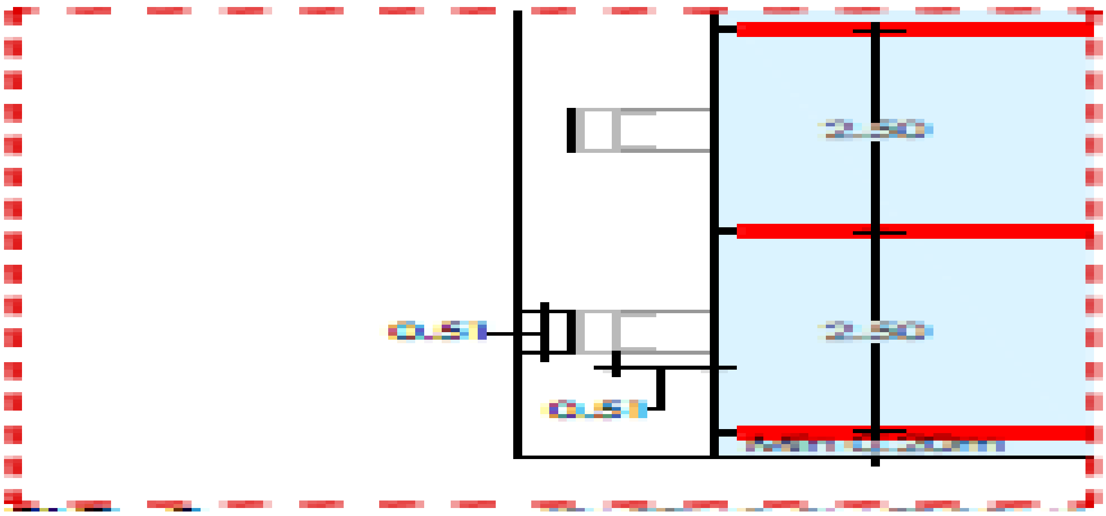


Figure 3.6 Starting Platforms

3.4.2.8 Water Temperature

Shall be 25° - 28°. During competition the water in the pool must be kept at a constant level, with no appreciable movement. In order to observe health regulations in force in most countries, inflow and outflow is permissible as long as no appreciable current or turbulence is created.

3.4.2.9 Lighting

Light intensity over the whole pool shall not be less than 1500lux.

3.5 Mechanical Design

3.5.1 Introduction

The design of swimming pools and other water features is actually quite simple and the math involved is very basic. It only looks tough because there are so many factors to consider. Such as number and kind of bathers, the degree of atmosphere pollution, wind velocity and direction, the location of swimming pool and the weather changeover .

The selection of the pool equipment size is more art than science, because of all of the factors that can affect the selection. Such as, the increase of the head as dirt builds up in filter, the variable resistance of heater to water flow with time, the change of pump flow rate with the change of head …etc.

3.5.2 Swimming Pool Design

3.5.2.1Pool Capacity Calculation

The first step in pool design is the calculation of the volume of water in the pool.

Volume of water = Surface area of the pool x average depth.

$$\text{The average depth} = \frac{\text{Shallow end depth + deep end depth}}{2} \qquad (3.2)$$

The formula used above for the calculation of average depth can be used if the slope of the bottom of the pool is gradual and even. If the slope of the bottom is not gradual, then you have to treat the pool as two or three parts each with gradual bottom slope, and calculate the volume of each part and then add these volumes together to determine the total water volume of the pool.

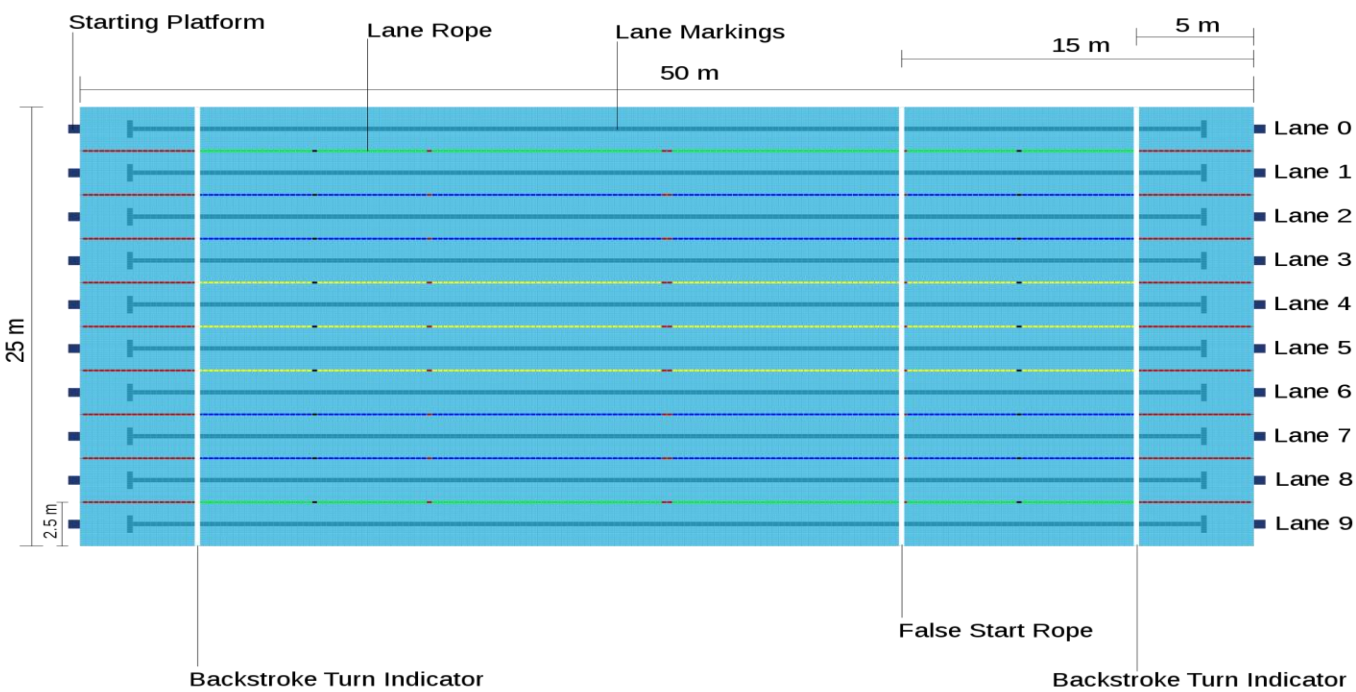


Figure 3.7 Swimming Pool Plan

Volume of the water in the pool:

$$= 50 \times 25 \times \left(\frac{2+2}{2} \right)$$
$$= 2500 m^3 \quad (3.3)$$

3.5.2.2 Turnover Time

The turnover time represents the number of hours required to recirculate the total capacity of the pool water (total water volume) through the filter.

Pools become polluted at different rates. Generally the shallower the water, the faster it become turbid, simply because more people wash off more dirt, occupying less water.

Turnover times are subject to local regulation, but typical examples are given in Table (3.1) based on the usage and location of the different types of pools. The intensively used pools require a far higher turnover than rarely used or decorative pools.

Table 3.3 Typical examples of Turnover times for different types of pools

Class of pool	Contamination	Turnover time(hour)
Spas	Extra heavy	0.5-1
Wading pools	Extra heavy	1-2
School and Olympic, institutional and public	Very heavy	3-6
Hotel and community	Moderate	5-6
Diving and light private	Light	6-7
Indoor residential	Extra Light	8-10

The Palestinian National Community for swimming pools, requiring that the filter turnover cycle shall be of a capacity to completely filter the entire pool body in not more than 6 hours.

So many variables make calculations of turnover time complex and unreal. Hence turnover time is best taken from Engineers having a practical experience in the field of swimming pools in our country. According to (Eng. Jamal Shweiki) The turn over time for Olympic pools as it is the case in our project should be taken 6-hours and depend for the following reasons:-

1. The bathing load (number of bathers) is more than the recommended which is one bather per four meter square of pool surface area according to the Palestinian National Community..
2. The environmental air in our Country is highly polluted.
3. More dirt is carried by each bather. Since we don't use pre-cleanse facilities.
4. 1Most of the bathers do not use swimming pools Clothes.
5. The hardness of the water in our country is very high (Amount of dissolved minerals such as calcium and magnesium). Poor Chemical treatment disinfection rates and pool owners do not wish to operate the pump for long time. Basic turn over with filter at clean running pressure & full working head.

$$Turnover \quad Time \quad (hr) = \left(\frac{Pool \quad capacity \quad (m^3)}{Filter \quad Rate \quad (m^3/hr)} \right)$$

$$= \left(\frac{Volume \quad of\, water \quad in \quad pool \quad (m^3)}{rate \quad of \quad water \quad flow \quad throgh \quad recirculation \quad system \quad (m^3/hr)} \right) \tag{3.4}$$

3.5.2.3 The Balance Tank

The balance tank is provided as a reservoir for a volume of water extra to that of the pool. The size of this tank must be able to hold water at least equal to that of the total displacement that could be caused should the maximum bathing load enter the pool all at one time (Base Capacity). In addition to this, waves caused by movement within the water mean it must be able to contain an extra volume of water (Surge Capacity) and an additional margin for safety (safety capacity).

If we consider that the average water displacement by a bather is in the region of 60 liters and that in shallow water 75% of this will be displaced, approximate volumes will become evident.

Balance tank volume of formula may be calculated in many ways. The tank will also be designed to incorporate a non-return valve to prevent fall back of water to the pool. A flap valve is a common inspection and cleaning to maintain a good seating.

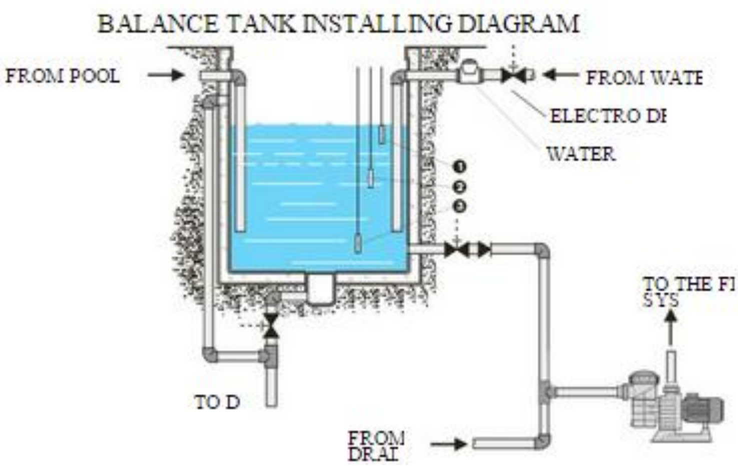


Figure 3.8 Balance tank diagram

Where:

The following information explains the numbers on the picture:

1) Maximum water level signal in balance tank for starting the pumping system and electro driven valve shut down.

2) Minimum water level signal in compensation tank for opening and shutting the electrically operated valve for makeup water.

3) Minimum level signal in compensation tank for shutting down the pumping system.

3.5.2.3.1 Balance tank volume formula

Volume = water surface area * F

The sum of this calculation is only the base capacity which contribute to only 33% of the required volume.

F: may be taken from the following

Table 3.4 Tank volume factor

Type of pool	F
Commercial pool with excessive activity	75 - 100
Commercial pool with play/water features	50 - 75
Commercial pool (swimming only)	25-50
Private pool	15-20

In this project:

Base surface area = water surface area * F (3.5)

water surface area = 50 * 25 = 1250 m^2 ; F = 75 liter

Base capacity in balance tank = 1250 * 75 = 93750 liter = 93.75 m^3 = 94 m^3

B.T.C: Balance Tank Capacity.

B.T.C = base capacity (33.3%) + surge capacity (33.3%) + safety capacity (33.3%)

= 94 + 94 + 94

= 282 m^3

The balance tank will be fitted with the following :

- Easy access inspection covers

- Safety overflow
- Level indicator
- Suction valve

3.5.2.3.2 Total capacity of water

Total capacity of pool = Volume of the water in the pool + base capacity in balance tank (3.6)

$$= 2500 + 94$$

$$= 2594 \ m^3$$

3.5.2.4 Filter sizing and selection

3.5.2.4.1 Filtration rate

To calculate the filtration rate we use the following equation:

$$\text{Filter Rate } (m^3 / \text{hr}) = \frac{Water\ Capacity}{Turnover\ Time} \quad (3.7)$$

$$= \frac{2594}{6} = 433 \ (m^3 / \text{hr})$$

* The chosen design Filtration velocity = 30 $m^3/\text{hr}/m^2$ of filter surface area

$$Filter \quad surface \quad area \quad (m^2) = \left(\frac{Filteration \quad flow \quad rate \quad (m^3/hr)}{Filtration \quad velocity \quad (m^3/hr/m^2)} \right) \quad (3.8)$$

$$= \left(\frac{433}{30} \right) = 15m^2.$$

3.5.2.4.2 Pressure loss through filter

A clean filter usually create 3psi head loss (difference between the input and output pressure) as water is circulated downward through silica sand. As the dirt accumulates within the filter, the resistance to flow also increases, the filter pump cannot maintain the required rate of flow against the increased resistance (head) . Consequently the filter requires regular cleaning, or Backwash to maintain its efficiency. Most filter manufactures recommends that this backwashing should be done when the pressure gauge indicates an increase of 0.5kg/cm², that equals (7.1psi) with respect to the initial pressure of the filter (clean filter). Therefore the maximum head resistance of filter is:-

3psi + 7.1 psi = 10.1 psi (6.7m head loss). This should be used as the design pressure loss through filter.

3.5.2.4.3 Selection of the filter

- From Astral company catalogue, we find that the filter of code No 28134, with the following specifications match our design requirements:-

  - Filter Name : Volcano Industrial filter.
  - Filtration surface area : 3.14 m².
  - Filter diameter : 1560 mm.
  - Filter flow rate = Velocity of filtration x filter surface area (3.9)

    = 30 x 3.14 = 94.2 m³/hr.

  - Gravel sand (1-2 mm) : 675 kg.
  - Sand (0.4 – 0.8 mm) : 3650 kg.
  - Volume = 3850 m³
  - weight : 245 kg

Number of filter = $\frac{Total\ flow\ rate}{flow\ rate\ of\ one\ filter} = \frac{433}{94.2}$ = 4.59 = 5 filters (3.10)

3.5.2.5 Main Drains Selection

Main drain selection which forms the suction equipment from the pool should be based on the following:

1. The main drain is always situated at the lowest point in the pool , main drain aperture should be at least 4-times outlet pipe working area with a recommended maximum grill flow velocity of 0.5m/sec, but 0.2m/sec or lower is better.
2. In practice main drain grill must be designed never to allow excess suction or to be removable by swimmers.
3. Usually try to install more than one main drain, so that if one is blocked the other takes the full flow.
4. Minimum distance between drains more than 2 m.

Total filtration rate = flow rate from main drain + flow rate from balance tank.

From the experience of the professional in swimming pools design (eng Jamal Shweiki), we find that the best way is to take 20% of the total filtration rate from main drains and 80% flow rate from balance tank.

- Flow rate from main drains = 20% of the total filtration rate (3.11)

  = 0.02 * 433

  = 86.6 = 87 m^3/hr.

From Astral catalogue we selected two concrete pool main drains of code No 22418 each of the following specifications:

- Main Drain Name: Concrete Pools-Main Drains ,Square main drain with grille, outlet of 110mm.
- Recommended flow rate: 42 m^3/hr.
- Side connection: 110mm.

- ✓ But according to practical experiences, the possibility of repayment main drains, the possibility of running filtering process without balance tank, reduce suction head to a minimum which enhance pump efficiency, and for emptying the pool as soon as possible.
  So, we select eight main drains rather two main drain.

3.5.2.5.1 Drains of over flow gutter selection

From Palestinian National Community

- o Minimum depth of overflow gutter is 7.5cm and the slope is 2% to overflow Drains.
- o Maximum distance between drains and overflow gutter is 4.5m and its diameter is 2 in.
- o Minimum distance between drains of overflow gutter is 0.5m

- The perimeter of pool in our project is 151.2m (AutoCAD Application)
- Flow from overflow gutter = 80% of filtration rate (3.12)
  = 0.80 * 433 = 346.4 = 347 m^3/hr

From Astral catalogue, we select the overflow grating, modular transversal grating for curves, and the following specifications:

- Code : 00223
- Standard packing : 250
- Standard weight : 18.1 kg
- Maximum advisable flow rate : 7 m^3/hr

To determine the number of overflow channel drainage we select the flow rate of each overflow drains is half of the maximum advisable flow rate; for more safety.

Flow rate for each overflow drain = 50% * 7 = 3.5 m^3/hr

$$\text{Number of overflow drains} = \frac{total\ flow\ rate}{3.5} = \frac{347}{3.5} = 99.1 \qquad (3.13)$$

Then the number is 99

Distance between over flow drain = $\frac{151.2}{99}$ = 1.5 m

Dimensions of overflow channel

1. Length = perimeter = 151.2m

2. Width = 25cm

3. Depth = 20cm

3.5.2.6 Return inlets selection

The calculated total circulation rate is 433 m³/hr, and by referring to Astral cataloger we choose Concrete Pools return inlet of code No 08317 each of the following specifications:

- Flow rate :Φ295 mm = 5-20 m³/hr at max and we choose 7.25 m³/hr
- Recommended max flow velocity: 0.4 m/sec.

$$No \quad of \quad required \quad return \quad inlets = \left(\frac{Filtration \quad flow \quad rate \quad (m^3/hr)}{Flow \quad rate \quad for \quad each \quad inlet} \right) \qquad (3.14)$$

$$= \left(\frac{433}{7.25} \right) = 59.7 = 60.$$

Select 60 return inlets of this type.

3.5.2.7 Pool Pipe Sizing

Pool piping shall be sized to permit the rated flows for filtering & cleaning without exceeding the maximum head at which the pump will provide such flows.

Today the most common type of piping used in pool and spa plumping is PVC plastic pipe (polyvinyl chloride).Which is simple of installation, resistance to corrosion and economy for labor and materials.

Pipe Sizing considerations:-

1. Required flow rate of water, measured in gpm or m^3/hr.

2. Length of plumping runs and equivalent length of fittings.

3. The main suction line plays a critical part in the wear and efficiency of the pump. This pipe line should be short, straight and full-pored, allowing a water flow of between

4. (0.5 – 1 m/sec), which equals (1.6 – 3.3 ft/sec), with maximum friction losses 6ft/100ft.

5. All piping on the discharge side of the pump for filtration shall have pipe sizes determined so that the velocity in any pipe should be between (1.0 – 3.0 m/sec), which equals (3.3 – 10.0 ft/sec), with maximum friction losses 12ft/100ft.

6. Pump is weakest at suction side, therefore ensure shortest possible suction runs.

7. In the determination of pipe sizes required ,the criteria which could call for the largest pipe size shall govern. The larger the pipe the better, there is less restriction and therefore less strain on all equipment and plumbing. Use the largest diameter pipe and fitting for the job.

8. Use full flow valves and large inlets.

9. Pool pipe work is a low pressure, low temperature recirculation system (0ºc - 28ºc). If we need specially in spas higher temperatures we should use CPVC pipe (chlorinated polyvinyl chloride).

10. All discharge and suction lines shall have a uniform slope in one direction of not less than 3in/100ft.

11. $$Water\ flow\ velocity\ (m/\sec) = \left(\frac{Pump\ flow\ (m^3/\sec)}{Pipe\ cross\ sectional\ area\ (m^2)} \right) \qquad (3.15)$$

12. And the discharge and suction line pipe sizing had shown on details on AutoCAD drawings.

3.5.2.8 Selection of Pump

The pump is the heart of swimming pool .It must operate economically and reliably, reasonably quietly and be compact. The pool filter pumps are centrifugal type, powered by a close-coupled electric motor; they usually include an integral strainer basket before the impeller and volute. Most pool pumps are self-priming, they still best suited just below water level with a direct flooded suction line rising evenly and slowly to the pump. Most self-priming pumps can extract air from the circulation system even with suction line full of air, providing there is some water in the pump chamber to lubricate the pump seal.

The recirculating pump shall be selected to meet the conditions of flow rate required for filtering and cleaning the filters with the total dynamic head developed by the recirculation system (The recirculation system includes all the pipes, fittings and equipment concerned with filtering , heating and disinfecting the pool water). Head is the resistance of water flow through plumping and equipment created by friction, resistance, distance or lift expressed in meters.

Figure (5.19) shows typical performance curves for pool pump. Therefore to select the suitable pump ,we should calculate the amount of head (resistance) in our pool and desired flow rate.

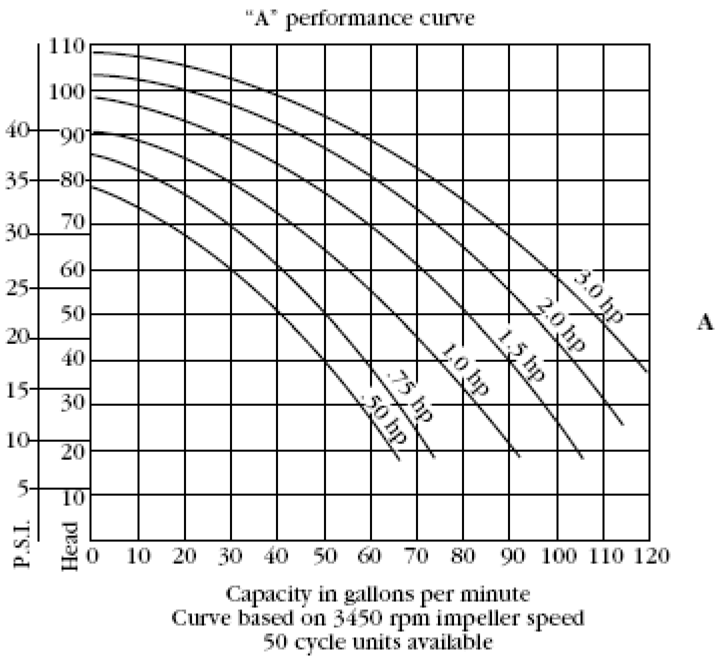


Figure 3.14 Typical performance curves for pool pump

Reference : The Ultimate Pool Maintenance Manual, Terry Tamminen.

3.5.2.8.1 Pump Head Calculations

The total pump head = static head + dynamic head

Where:

- Static Head equals zero, because the pump suction and delivery below water surface , and according to Bernoulli's equation the static head will be zero.

- Dynamic Head: Is the friction resistance of water flowing through suction lines, discharge lines, valves and equipment, but mainly from within the filter.

The friction head (dynamic head) calculations include :

a. Friction head losses in piping (both suction and discharge piping), fittings and valves.

b. Friction head losses within filter.

c. Friction head losses through main drains, skimmers and return inlets.

Where:

- Friction head in pipes = friction head loss in suction line + friction head loss in discharge line

$$= 2.54 + 1.075 = 3.615 \text{ m.} \qquad (3.16)$$

- Friction head in filter = 6.7m.
- Friction head through main drains, skimmers and return inlets, should be taken from manufacture specifications for each one. However general rule of thumb is to add 1.5 m of head to allow for the total of such component of the system.

Total head = friction head in suction line + friction head in discharge line

+ friction head in filter + friction head in main drains, skimmer,

and return inlets. (3.17)

= 2.54+1.075+6.7+1.5= 11.89m.

3.5.2.8.2 Pump Selection

Required specifications of the pump are:-

- Total head = 11.89 m.
- Flow rate = 433 m^3/hr.

By referring to Astral catalogue, we select maximum pump of code No 01204, which have the following specifications:-

- Pump Name : Aral C-3000 Pump

- Power: (8.7 HP), 230/400 V III.
- Inlet and outlet diameter: Φ140 mm.
- At a head of 10 m, have a flow rate of 158 m^3/hr.

So we select four pumps: 3 pumps duty and 1 pump standby

3.5.2.9 Chlorine tank and treatment pool system

- Chlorine tank

From Astral catalogue, we select the following compact dosage tank:

- Code : 16632
- Standard packing : 1
- Standard weight : 18 kg
- Standard volume : 0.185 m^3

compact dosage tank 60 liter

- Tricolor (for pool from 500 to 1000 m^3)

Figure 3.15 Chlorine tank

- Treatment pool systems

There are two treatment systems used to regulation the pool water : manual and automatic treatment.

In our project we select the automatic regulation treatment because the pool is public Olympic type and location in a central building.

The figure below explains the connection of automatic regulation system.

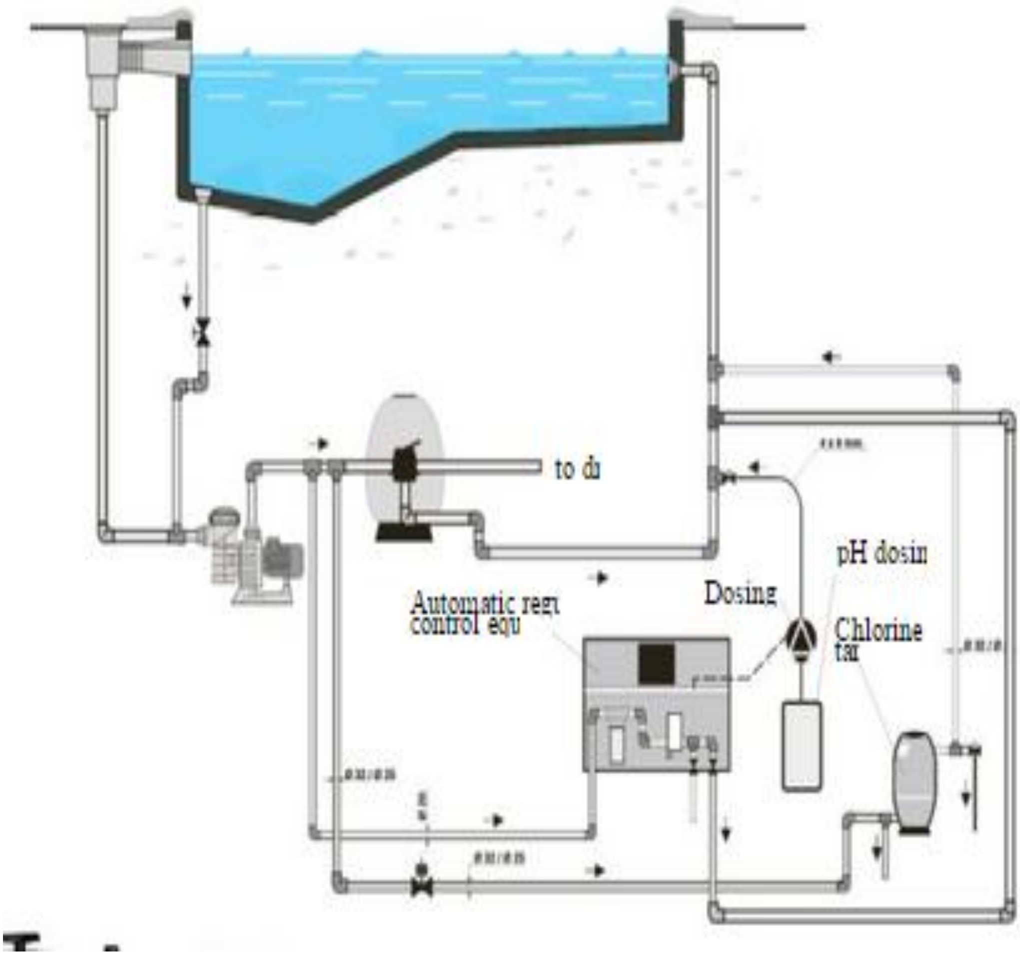


Figure 3.16 Automatic regulation connection

3.5.2.10 Pool lighting

Submerged light is the main light in the pool, where the power of the lamp chosen should be 300 watt per meter square of the pool surface area.

From Astral pool catalogue we select lamp (code 07833) with power 300 watt for half deep pool

Number of lights = $\frac{pool\ surface\ area}{25} = \frac{1250}{25} = 50$ (3.18)

Distance between lights = $\frac{perimeter}{number\ of\ lights} = \frac{150}{50} = 3$ m (3.19)

Figure 3.17 Pool lights

3.5.2.11 Pool ladders

From Palestinian National Community, each 25m perimeter of we need one ladder.

In our project:

Swimming pool perimeter = 150 m

Number of ladders = $\frac{pool\ perimeter}{25} = \frac{150}{25}$ = 6 ladders (3.20)

Distance between ladders = $\frac{pool\ perimeter}{number\ of\ ladders} = \frac{150}{6}$ = 25 m (3.21)

From Astral catalogue, we select ladders with the following specification.

- Ladders width 500mm
- Handrail in hand polished stainless steel (Φ43 mm)
- Steps in stainless steel
- Compete with fixing anchors earth connection.

Figure 3.18 Pool ladder

CHAPTER FOUR

PLUMPING SYSTEMS

4.1 Introduction

The most basic human is reliable table supply of potable water and getting rid of human waste product's, so the goal of modern plumbing design for building is to safely and reliable, provide domestic water, cold water and remove sanitary waste.

In this chapter we will discussed the designs of the water supply system that we have, the domestic hot water and the sanitary drainage system.

4.2 Water system

4.2.1 Calculations of hot and cold water

To determine the pipe size for cold and hot water we must calculate the water supply fixture unit (WSFU) for each fixture and fixture unit total on each piping run out and determine the minimum flow pressure required at the most remote outlet.

Example: To calculate the water supply unit (WSFU) in the Bath room shown.

We have three fixtures (lavatory, shower, water closet with flush tank) each have (WSFU) as follow:

Figure 4.1 Bathroom 1

1- Lavatory is a fixture with both cold and hot water supplies, so the weights for maximum separate demands may be taken as three-quarters (3/4) the list demand for the supply in table (4.1) , so the lavatory (private) gives 1 WSFU for the total demand (for both clod and hot water) so, for cold water only or hot water only we take (3*4 WSFU = 3/4 * 1 = 3/4) & (WSFU = 1For both cold and hot water).

2- Water closet is fixture with cold water supply only.

3- Bath tub is a fixture with both cold and hot water supplies, so the weights for maximum separate demands may be taken as three –quarters (3/4) the list demand for the supply in table (4.1) , so the lavatory (private) gives 2 WSFU for the total demand (for both cold and hot water), so for cold water only or hot water only we take (3/4 * WSFU = 3/4 * 2 = 1.5) & (WSFU = 2 for bath cold and hot water).

4- So, from the above information we can do the following table:

Table 4.5 WSFU for the for the Bathroom 1

Fixture unit	No. of Units	WSFU from Table(A-1)	Total no. of WSFU for cold water	Total no. of WSFU for hot water	Total no. of WSFU for hot & cold water
Lavatory (private)	1	3/4 * 1	¾	3/4	1
Bath tub (private)	1	3/4 *2	1.5	1.5	2
Water closet flush tank (private)	1	3	3	--------	3
--------	-------	--------	∑ = 4.75 WSFU	∑ = 2.25 WSFU	∑ = 6 WSFU

Now we calculate the number of fixture in each floor from mechanical drawing, and so we can do the following table:

Table 4.6 Number of fixture in each floor

Floor name	Total lavatory (General)	Total kitchen sink (General)	Total shower (General)	Total water closet flush tank(General)	Total urinal (General)
Ground floor	15	1	____	22	5
First floor	21	3	18	29	8
Second floor	4	1	____	4	____

Now we calculate the (WSFU) for each floor as following in table:

Table 4.7 The (WSFU) for ground floor

Fixture unit	No. of Units	WSFU from Table(A-1)	Total no. of WSFU for cold water	Total no. of WSFU for hot water	Total no. of WSFU for hot & cold water
Lavatory (General)	15	3/4 * 2	22.5	22.5	30
Water Closet flush tank (General)	22	5	116	--------	110
Urinal (General)	5	5	25	--------	25
Kitchen sink	1	3/4 * 4	3	3	4
--------	-------	--------	∑ = 160.5 WSFU	∑ = 25.5 WSFU	∑ = 169 WSFU

Table 4.8 The (WSFU) for first floor

Fixture unit	No. of Units	WSFU from Table(A-1)	Total no. of WSFU for cold water	Total no. of WSFU for hot water	Total no. of WSFU for hot & cold water
Lavatory (General)	21	3/4 * 2	31.5	31.5	42
Water Closet flush tank (General)	29	5	145	______	145
Urinal (General)	8	3	24	--------	24
Kitchen sink	3	3/4 * 4	9	9	12
Shower	18	3/4 * 4	54	54	72
--------	-------	--------	∑ = 132.5 WSFU	∑ = 45.5 WSFU	∑ = 295 WSFU

Table 4.9 The (WSFU) for second floor

Fixture unit	No. of Units	WSFU from Table(A-1)	Total no. of WSFU for cold water	Total no. of WSFU for hot water	Total no. of WSFU for hot & cold water
Lavatory (General)	4	3/4 * 2	6	6	8
Water Closet flush tank (General)	4	5	20	_____	20
Kitchen sink	1	3/4 * 4	3	3	4
--------	-------	--------	∑ = 29 WSFU	∑ = 9 WSFU	∑ = 32 WSFU

4.2.2 Flow rate in gpm

To calculate flow rate in gpm:
For Ground Floor:

By using table (A-2 / Appendix A) for supply system predominantly for flush tank for ground the estimating demand in gpm for cold water = 160.5 WSFU

So, by using interpolation = 57.1 gpm

Now we calculate the (gpm) for each floor so, (gpm) for each floor as in the following tables:

Table 4.10 The gpm for each floor

No. Of Floor	Total no. Of WSFU For cold water	Total no. Of WSFU for hot water	Total no. Of WSFU for hot & cold water	Total no. Of gpm for cold water	Total no. Of gpm for hot water	Total no. Of gpm for hot & cold water
Ground floor	160.5	25.5	169	57.1	17.3	58.8
First floor	132.5	45.5	295	51.5	27.2	84
Second floor	29	9	32	19.4	7.25	21
				$\sum = 128$	$\sum = 51.75$	$\sum = 163.8$

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 250 person uses the central:
  Assume 2.5 gal per person per day :

  - daily hot water use = 2.5 * 250 = 625 gal
  - max. hourly demand = (1/5) * 625 = 125 gal
  - storage tank size = (1/5) * 625 = 125 gal
  - heating capacity = (1/6) * 625 = 104.2 gal

  Since the maximum hourly demand is 125 gal and its duration is 2 hr , we have
  hot water required for peak load = 2 * 125 = 250 gal

- heating capacity (recovery) = (1/7) * 625 = 89.2 gal/h

required recovery = (total peak demand - storage) / peak hour

= (250 - ((3/4) *125))/ 2 = 78.125 gal / h ≤ 89.2 gal / hr.

4.3 Sanitary Drainage System

The sanitary drainage system is an underground carriage system specifically for transporting sewage from houses and commercial buildings...etc. through pipes to treatment or disposal.

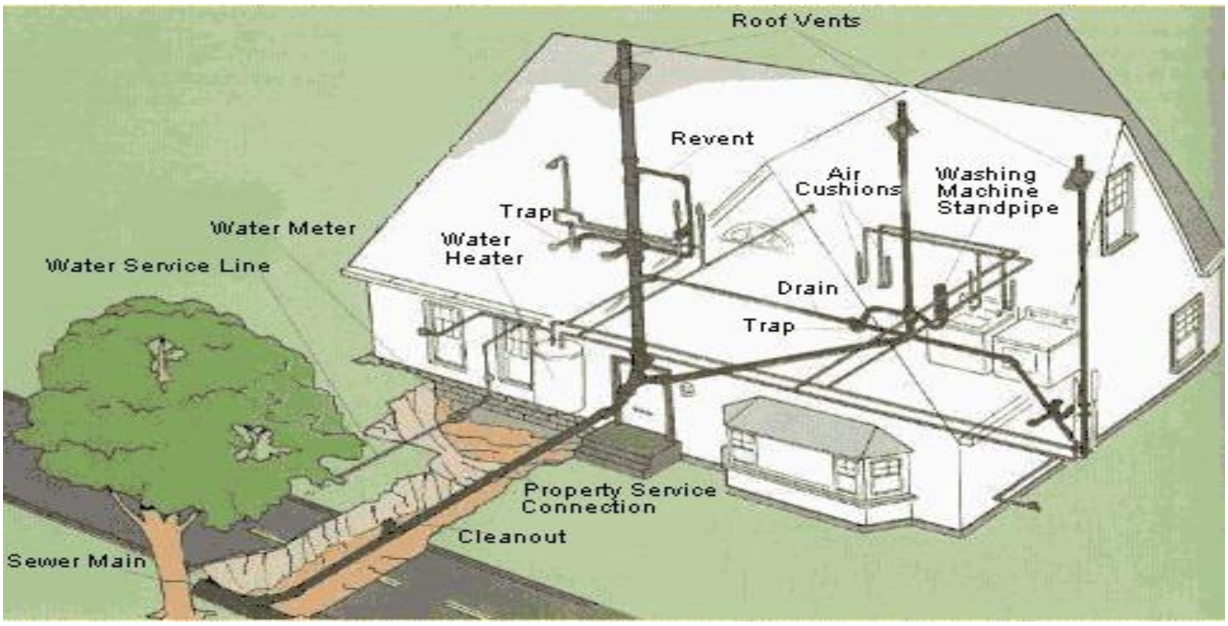


Figure 4.2 Drainage system for a building

The purpose of the sanitary drainage system is to remove the effluent discharged from plumping fixtures and other equipment's to an approved point of disposal .A sanitary drainage system generally consists of horizontal branches, vertical stack, a building drain inside the building and a building sewer from the building wall to the point of disposal .

4.3.1 Sample of Drainage System

In our project we well design the drainage system for the bathrooms and kitchens and any other water fixture that we have so the design of that drainage well be as you can see in the figure bellow:

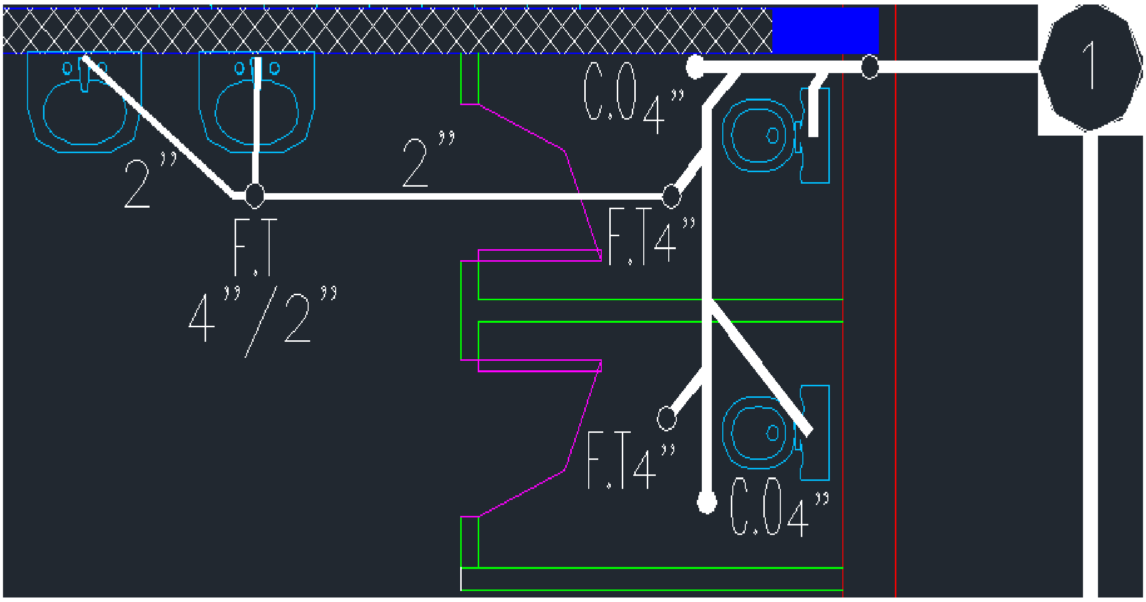


Figure 4.3 A sample of the drainage design .

1. We will use pipes from fixture units to the floor drainage (F.D) with diameter (2") for lavatory and shower and with slope (2%).
2. We will use pipes from fixture unit to the manhole with diameter (4")for water closet with slope (1%-2%) .
3. The pipes between the manholes will be with diameter of (6") and with slope 1.5% .
4. We will use a stack with diameter (4") in order to drain the waste water to the manholes.
5. We will use clean outs (C.O) at the end of the branches in order to clean the pipes from any things that close the pipe.

4.3.2 Manholes Design

The manholes design will be around the building so as that the sewage comes from the stack it will flow from one manhole to another to reach the main manhole.

always the depth of the first manhole must not be less than 50cm and the depths of the other manholes will depend on the distance between the manholes and the slope of the pipe that connecting them . for us we will use the following types of manholes according to the depths of them :

- 60cm diameter manhole for depths between (50-99.9) cm.
- 80cm diameter manhole for depths between (100-149.9) cm.
- 100cm diameter manhole for depths between (150-249.9) cm.
- 120cm diameter manhole for depths > 250 cm.

CHAPTER FIVE

FIRE FITTING SYSTEM

5.1 The Fire Triangle

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

Fuel – to vaporize and burn

Oxygen – to combine with fuel vapor

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

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

Figure 5.1 the fire triangle

5.2 classification of fire

Fires are classified as follows:

Class A fires: fires in ordinary combustible materials, including cellulosic such as wood, cloth, and paper as well as rubber and many plastics.

Class B fires: fires in flammable liquids, combustible liquids, petroleum greases, tar; oil, oil-based paints, solvents, lacquers, alcohols, and flammable gases.

Class C fires: fires that involve energized electrical equipment

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

Class K fires: fires in cooking appliances that involve combustible cooking media (vegetable or animal oils and fats).

5.2.1 Fire signature

Afire signature is any fire effect (smoke, heat, light , etc.) that can be sensed by afire detector. The amount of heat released by a fire varies in accordance with the type of combustible, arrangement of the combustible, availability of oxygen, and numerous other factors.

5.2.2 Travel Distance

Defined as the actual walking distance from one point to another.

If a class A occupancy has a maximum travel distance of 75 feet (22.875m).

If a class B occupancy has a maximum travel distance from 30 feet (9.15m) to 50 feet (15.25m) depends on type of hazard (low, moderate, high).

If a class C occupancy are permitted to be spaced in accordance with class A or class B hazards.

If a class D occupancy has a maximum travel distance of 75 feet (22.875m).

If a class K occupancy has a maximum travel distance of 30 feet (9.15m)

5.3 Types of Firefighting Systems

Fire systems are classified as follows:

5.3.1 Portable Fire Extinguishers

Portable fire extinguishers can contain a wide variety of extinguishing agents; the potable fire extinguishers enable an individual with minimal training to extinguish an incipient fire.

A portable fire extinguisher should not be considered as the sole solution to fire protection analysis of a building but, rather, only one of many components of a total fire protection plan.

Figure 5.2 Portable Fire Extinguishers

- **Type of Portable/Semi-portable Fire Extinguishers**

1) Water extinguishers.
2) Water sprays water extinguishers.
3) Antifreeze solution extinguishers.
4) Foam fire extinguishers, hand and wheeled.
5) Carbon dioxide extinguishers.
6) Clean agent extinguishers.

7) Dry chemical extinguishers, hand and wheeled.

8) Wet chemical extinguishers.

9) Liquid gas-type extinguishers.

10) Combustible metal extinguishers hand and wheeled.

11) Residential kitchen cooking fire extinguishers.

- **The types of occupancies for protection by fire extinguishers are:**

1. Light (low) hazard occupancy:

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

2. Ordinary (moderate) hazard occupancy:

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

3. Extra (high) hazard occupancy:

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

It could consist of wood working, vehicle repair, air craft and boat servicing, cooking areas.

4. Mixed occupancies:

Building featuring more than one occupancy may be protected on a room or area basis, with extinguishers appropriately placed for the occupancy.

An example is a school, which would be expected to be protected with extinguishers rated for class A hazards and light hazard occupancy, but also may contain a laboratory with a significant quantity of flammable liquid hazard, which would be protected by extinguishers rates for class B hazards and ordinary hazard occupancy.

5. Specialized occupancies:

Aircraft hangar.

5.3.1.1 Carbon dioxide extinguishers

Carbon dioxide is a gaseous fire protection agent, also known by its chemical designation CO_2; normally the air we breathe contains 21% oxygen, 79% nitrogen, and only a trace amount of carbon dioxide, 0.03%. The presence of significantly higher percentages of carbon dioxide in a room cannot be detected by human senses because it is colourless and odourless.

The cylinders for CO_2 Fire Extinguishers are seamless and extruded from high grade Chrome Molybdenum Steel or Manganese Steel or Carbon Steel. Carbon Dioxide is discharged as a white cloud of snow which throttles a fire by eliminating the oxygen. Designed to protect areas where class B (flammable liquids and gases) or Electrical class of fires could occur.

Carbon dioxide is 1.5 heavier than air, so it forces oxygen out of a room or significantly reduces the concentration of oxygen at breathing level.

5.3.2 Uses for carbon dioxide extinguishers

Carbon dioxide is an effective extinguishing for:

1. Ordinary combustibles – Class A commodities
2. Flammable liquids – Class B commodities
3. Electrical hazards – Class C commodities

5.3.3 Total Number of carbon dioxide extinguishers

Table 5.1 total Number of carbon dioxide extinguishers for health care centre

Number	Area(m^2)	extinguishers Weight(Kg)	Capacity (Kg)	Number of extinguishers
A10	31.20	10.5	3	1
A5	230.00	16.3	5	2
B11	30.56	10.5	3	1

5.3.4 Selections of carbon dioxide extinguishers

Carbon dioxide extinguishers made by SFFECO Company, and will installing in every spaces need it.

5.4 Installed Firefighting Systems

Automatic fire fighting system are designed and installed in buildings to protect them from fire, these systems are operating as automatic without any human influence when the fire be started.

Every installed system has a general components such as pipes, smoke and fire detectors, nozzles and sprinklers, alarm, control panel, and firefighting materials, these systems are divided into two main parts mechanical and electrical parts, the mechanical parts are explained above and electrical component as software installed on CPU and memory in control panel to control of subsystem, the control panel supplied by AC current and DC current from batteries if the current from network is cutoff .

- **Types of Installed Firefighting Systems**

1) Water firefighting system.

  - Sprinklers.
  - Spray.
  - Foam.

2) Carbon dioxide system.

3) Dry chemical system.

4) Halon system.

5) FM 200 system.

5.5 FM 200 Firefighting Systems

FM-200 (Heptafluoropropane, CF3CHFCF3) is a colorless, non-toxic gas, and a clean and effective fire suppression agent. It is normally shipped and stored as a liquefied compressed gas, and hence is typically handled under saturated conditions; the liquid and vapor phases coexist in equilibrium. An understanding of the physical properties of FM-200 and the safe and proper techniques for handling liquefied compressed gases allows the agent to be safely transferred from shipping cylinders to the desired end-use container**.**

5.5.1 Physical and Chemical Properties of FM 200

Some of the more important physical and chemical properties of FM-200

Table 5.2 physical properties of FM200

Physical Properties	**Measurement**
Molecular weight	170.03
Boiling point at 1 atm	–16.34 °C
Freezing point	–131 °C
Critical temperature	101.75 °C
Critical pressure	2.91 MPa
Critical volume	1.61 L/Kg
Critical density	594.25Kg/L
Critical compressibility	0.225
Acentric factor	0.356
Specific heat, saturated liquid	1.184 (Cp) at 25°C, KJ/Kg per °C
Specific heat, saturated vapor	0.859 (Cp) at 25°C, KJ/Kg per °C
Specific heat, superheated vapor	0.808 (Cp) at 25°C, KJ/Kg per °C
Thermal conductivity, liquid	0.069 W/Mk at 25°C
Thermal conductivity, vapor	0.0126 W/Mk at 25°C
Viscosity, liquid	0.184Centipoise at 25°C
Viscosity, vapor	0.0127Centipoise at 25°C
Surface tension	7.00 MN/M at 25°C

Table 5.3 chemical properties of fm200

Chemical Properties	**Measurement**
Chemical Name	1,1,1,2,3,3,3-Heptafluoropropane
Molecular Formula	CF3CHFCF3

Molecular weight	170.03
CAS Registry Number	431-89-0
ASHRAE Designation	HFC-227ea

5.5.2 Advantages and Disadvantages of FM 200

- **Advantages of FM200**

    - Fast and effective.
    - No significant reduction in oxygen levels.
    - Clean gaseous agent leaving no residue.
    - Zero ozone depleting potential.
    - Low global warming potential related of Halon.
    - Short atmospheric life span.
    - Electronically non-conductive.
    - Safe for use in fully occupied areas.
    - Minimal storage requirement.
    - Versatile range of containers, nozzle and ancillaries.
    - Extensively tested, recognized and approved worldwide.
    - Effective on-site installation.

- **Disadvantages of FM 200**

    - Forms minimal decomposition products.
    - Higher agent cost.

5.6 Sequence of Operations of FM 200 Systems

FM 200 system is gas suppression system extinguished in the space as gas vapor at high pressure (4-6) bar to cover the protected area in the following sequence of operation:

1) Once first detector in the space sending smoke directly sends signal to control panel.

2) Control panel sending the following signal:

- Actuating 1st stage alarm.
- Shutdown A/C or ventilation system.
- Closing automatic roll up shutter.

3) On control panel receiving signal from 2nd detector, sending the following signal.

- Actuating 2nd stage alarm system.
- To fire alarm system in the building.
- Actuating FM200 solenoid valve directly controlling the FM 200 gas flow.
- After (30-60) sec, the solenoid valve start relapsing the gas from cylinder.
- After (20-40) sec, the solenoid valve start relapsing the gas.

4) Anyone in the building can release manually the gas in case there is fire and the system not responded automatically.

5.7 Clean Agent Estimation.

The clean agent (FM-200) Heptafluoropropane is widely used as a substitute for Halon. Halon 1301 is an effective fire suppressant and has been widely used in total flooding gas protection system**,** but the physical and chemical properties of FM-200 are not the same as .Halon 1301, FM200 has better properties than Halon 1301

The steps needed to design the system including the limitations imposed on the requirements .(of standards (NFPA2001

:To design FM-200 system, we must follow these steps

1) Perform a hazard analysis and survey of protected area.
2) Determine the design concentration required for the hazard.
3) Calculate the volume of the protected area.

4) Calculate FM-200 agent quantity to provide required design concentration at minimum expected ambient temperature in protected area.

First of all, is must select the type of hazard which the system will operate with it, and the hazard is three types as:

- **Class A Fires**: Fire in ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics.
- **Class B Fires**: Fire in flammable liquids, oils, greases, tars, oil-based paints, lacquers, and flammable gases.
- **Class C Fires**: Fire that involves energized electrical equipment where the electrical resistivity of the extinguishing media is of importance.

The second step, is determine the design concentration and this value depend on type of hazard, from (NFPA2001) chart the minimum design concentration of three class as following:

- **Class A Fires**: minimum design concentration is 1.2%.
- **Class B Fires**: minimum design concentration is 1.3%.
- **Class C Fires**: minimum design concentration is 1.2%.

Third step, is calculating the volume of spaces that need to install FM200 in it with following equation

V= L*W*H (5.1)

Where is:

V: volume of space [m^3].

L: length of space [m].

W: Width of space [m].

H: High of space [m].

Finally, the last step to calculate the weight of FM200 we need to protect this area by this equation:

$$W=\frac{V}{S}*(\frac{C}{100-C}) \qquad (5.2)$$

Where is:

W: Weight of FM200 [kg].

V: Net Volume of the Hazard [m^3].

S: Specific Volume of superheated agent vapor at 1 atmosphere and the design temperature[m^3/Kg].

C: FM 200 Design Concentrations.

The specific volume of superheated FM-200 vapor, S, may be approximated using the :following equation

$$S = 0.12693 + 0.0005131\ T \qquad (5.3)$$

Where

T = temperature in °C

Nozzles in the system must be installed in a vertical position with the nozzle facing down, nozzles are available in both 180° and 360° discharge patterns. The 180° (sidewall) nozzle is designed for installation along the walls of the hazard, with the discharge directed away from the wall on which it is installed. The 360° nozzle is designed to be installed in the center of .the area being protected

180° nozzles must be located 0.3 ± 0.05m from a wall, with the orifices directed away from the wall. The nozzle shall be located as close to the centre of the wall as possible, but at least 1/3 of the way along the wall.

180° nozzles have a maximum coverage area defined as any rectangle that can be inscribed in a semicircle of distance 14.73m (48.3 ft), as seen in table 5.3

180° nozzles may be used in a back-to-back configuration. The nozzles should be placed 0.3 m to 0.6 m (1 to 2 ft) apart.

Nozzles must be located as close to the centre of the enclosure apossible.360° °360 Nozzles have a maximum area defined as any rectangle that can be inscribed in a circle of radius 9.06 m (29.7 ft) , as seen in table 5.3

Nozzles must be installed so that the orifices are located 0.15 ± 0.05 m (6 ± 2 inches) below .the ceiling

Table 5.4 maximum nozzle straight line distances

Nozzle	Distances (m)	Distances (ft)
180°	14.73	48.33
360°	9.06	29.73

When designing pipe network systems, the following design parameters should be considered to avoid system reject as 70.6 psi (4.87 bar) minimum nozzle pressure, 80% maximum agent in pipe, and between 6 - 10 seconds discharge time.

So the pipes diameter are determined depending on flow rate of FM200, and the flow rate of gas can be calculated by division the weight of FM200 on 10 sec, 10sec is the maximum time for discharge gas into spaces, the following table from (NFPA2001) chart explain the relationship between flow rate and pipes diameter.

Table 5.5 relation between pipe diameter and flow rate

Pipe Size(in)	Minimum Flow Rate (kg/sec)	Maximum Flow Rate (kg/sec)
3/8	(0.27)	(0.91)
1/2	(0.45)	(1.36)

3/4	(0.91)	(2.50)
1	(1.59)	(3.86)
1 1/4	(2.72)	(5.67)
1 1/2	(4.08)	(9.07)
2	(6.35)	(13.61)
2 1/2	(9.07)	(24.95)
3	(13.61)	(40.82)
4	(24.95)	(56.70)
5	(40.82)	(90.72)
6	(54.43)	(136.10)

5.8 Sample of Weight for FM200.

For first floor.

For room #A6.

1) V= L*W*H (5.1)

V= 152.562*3 = 457.686 m^3

2) W = $\frac{V}{S}$ *($\frac{C}{100-C}$) (5.2)

For maximum weight at T=27°C, S= 0.1420 [m^3/Kg].

W= (457.686/0.1377)*(8.4/100-8.4) = 304.8 Kg.

For minimum weight at T=21°C, S= 0.1377 [m^3/Kg].

W= (457.686/0.1420)*(8.4/100-8.4) = 295.57 Kg.

3) Flow rate of FM200.

Q = 457.686/10 = 45.76 [kg/sec]

The diameter pipe from table (5.5) is 3 in .

The number of nozzle is three from 360° type.

5.9 Total Weight of FM200 for health care center.

Table 5.6 total weight of FM200 for ground floor (ZONE 1)

Number	Area(m^2)	FM Weight(Kg)	Number of Nozzle 180°or 360°	Pipe Diameter(in)
A6	152.56	305	3-360°	3
A7	80.00	160	2-360°	2
A8	87.78	176	2-360°	2
A9	76.57	153	2-360°	2
A4	133.51	267	2-360° 1-180°	2 1/2
Total		1061		

The diameter of outlet pipe of cylinder is 5(in), from (NFPA2001) chart.

Table 5.7 total weight of FM200 for ground floor (ZONE 2)

Number	Area(m^2)	FM Weight(Kg)	Number of Nozzle 180°or 360°	Pipe Diameter(in)
A12	37.24	112	1-180°	1 1/4
A13	31	62	1-180°	1 1/4
A14	15.11	31	1-180°	1
Total		205		

The diameter of outlet pipe of cylinder is 2 (in), from (NFPA2001) chart.

Table 5.8 total weight of FM200 for ground floor (ZONE 3)

Number	Area(m^2)	FM Weight(Kg)	Number of Nozzle 180°or 360°	Pipe Diameter(in)
A16	127.59	255	2-360°	2 1/2
A17	71.38	143	2-360°	2
A18	166.67	334	3-360°	2 1/2
A19	131	161	2-360° 1-180°	2 1/2
Total		863		

The diameter of outlet pipe of cylinder is 4(in), from (NFPA2001) chart.

Table 5.9 total weight of FM200 for first floor (ZONE 4).

Number	Area(m^2)	FM Weight(Kg)	Number of Nozzle 180°or 360°	Pipe Diameter(in)
B5	12.27	13	1-180°	3/4
B6	63.69	128	1-360° 1-180°	1 1/2
B7	112.48	337.44	2-360°	2
Total		478.44		

The diameter of outlet pipe of cylinder is 3(in), from (NFPA2001) chart.

Table 5.10 total weight of FM200 for first floor (ZONE 5)

Number	Area(m^2)	FM Weight(Kg)	Number of Nozzle 180°or 360°	Pipe Diameter(in)
B12	12.27	25	1-180°	1/2
B11	63.69	128	1-360° 1-180°	1 1/2
B10	56.30	169	1-360°	1 1/2
Total		322		

The diameter of outlet pipe of cylinder is 2 ½ (in), from (NFPA2001) chart.

Table 5.11 total weight of FM200 for first floor (ZONE 6)

Number	Area(m^2)	FM Weight(Kg)	Number of Nozzle 180°or 360°	Pipe Diameter(in)
B21	23.90	48	1-180°	1
B22	23.90	48	1-180°	1
B23	58.85	118	1-360°	1 1/2
Total		214		

The diameter of outlet pipe of cylinder is 2 (in), from (NFPA2001) chart.

Table 5.12 total weight of FM200 for second floor (ZONE 7)

Number	Area(m^2)	FM Weight(Kg)	Number of Nozzle 180°or 360°	Pipe Diameter(in)
C10	58.85	118	1-360°	1 1/2
C11	23.90	48	1-180°	1
C12	23.90	48	1-180°	1
Total		214		

The diameter of outlet pipe of cylinder is 2 (in), from (NFPA2001) chart.

Table 5.13 total weight of FM200 for second floor (ZONE 8)

Number	Area(m^2)	FM Weight(Kg)	Number of Nozzle 180°or 360°	Pipe Diameter(in)
C5	30.69	61	1-360°	1 1/2
C6	73.30	146	2-360°	2
C7	73.30	146	2-360°	2
C8	72.10	145	2-360°	2
Total		246		

The diameter of outlet pipe of cylinder is 2 (in), from (NFPA2001) chart.

5.10 Selections of other FM200 System Components

1) **Nozzles.**

Type of nozzles are installing in parts of health care center. That's made by FIKE Company.

Model: (180°-80-060/80-066), (360°-80-052/80-058).

(See Catalog)

2) **Heat Detector.**

Heat detectors made by EDWARDS SIGNALING Company, and will installing in every spaces protecting by firefighting system.

Model: 281B-PL.

(See Catalog)

3) **Smoke Detector.**

Smoke detectors made by Imagination at Work Company, and will installing in every spaces protecting by firefighting system.

Model: 541NCSRXT.

(See Catalog)

4) Control Panel.

Every zone need control panel to process any signal coming from any sensor.

Model: HCP-1008E.

(See Catalog)

5) Cylinder of FM200 Agent.

Cylinders that's used in every zone made by FIKE Company .

Model: 4BW500.

(See Catalog)

5.11 Fire hose

5.11.1 types of fire hose

1. Hose reel

It is a rubber hose coiled on a reel, used by individuals within buildings.

2. Hose rack

It is a cloth-reinforced hose riding on Base often used by civil defence.

Figure 5.3 Hose reel

Figure 95.4 Hose rack

There are two fire hydrants, one 1 "or 1 ½", a special untrained individual people, which gives 100 gpm at a pressure of 4.5 bar, and the second type 2 ½ ", a special civil defence, which gives 250 gpm at a pressure of 4.5 bar

5.11.2 Position of Fire hose

1. Exposed:

Be prominent from the wall and out of it a distance of 25 cm, and Fund riding on the surface of the wall.

2. Semi predated:

Be prominent from the wall a distance of 10 cm, and inside the wall 15 cm.

3. Recessed:

Be inside the entire wall.

5.11.3 Installing the Hose Cabinet

1. Near escape ladders.

2. In the garage entrances and exits of cars.

3. Tap covers 30 m and takes into account the Travel Distance, the distance the tap guardian passes with no obstructions such as walls, even up to the fire and the extent of the length of the water coming out of the tap 6 meters.

4. next to the main door of the building.

5. Fund height from the ground of the limits of 90 cm to 150 cm.

5.11.4 Total Number of Fire hose in the health care center

Table 5.14 total number of fire hose in the building

Number	Number of fire hose
A1	1
B1	1
B13	1
B14	1
B15	1
B20	1
B24	1
C1	1
C3	1
C9	1
C13	1

5.11.5 Pump Selection

Assumption and Pipe Selection

it is loss coefficient k=0.26 The pipe is manufacturing from the steel,

We select riser pipe with diameter D = 4 inch, and branch pipe with diameter D = 2 inch and it is diameter getting smaller to be up D = 1.5 inch.

For riser pipe

4 Inch = 0.1016 m

1100 gpm = 0.0694 m^3/s

Area (A) = $\frac{\pi D^2}{4} = \frac{\pi * 0.1016^2}{4} =$ (5.4)

0.0081 m^2

Total flow rate **(**Q_{efectiv}) = 1100 gpm .

Calculations:

The velocity in the pipe defined in the equation

$$V = \frac{Q}{A} = \frac{0.0694}{0.0081} = 8.56\, \boldsymbol{m/s} \quad (5.5)$$

Reynolds number (Re):

μ_{water}@25 ℃=0.001

Re $= \frac{\rho VD}{\mu} = \frac{1000*8.56*0.1016}{0.001} = 869696$

(5.6)

From mody chart the friction factor (f) = .065

$h_{f(branchs)} = \frac{flV^2}{2gd} = \frac{0.065*10.5*8.56}{2*9.81*0.1016} = 2.9$ m

(((5.6)

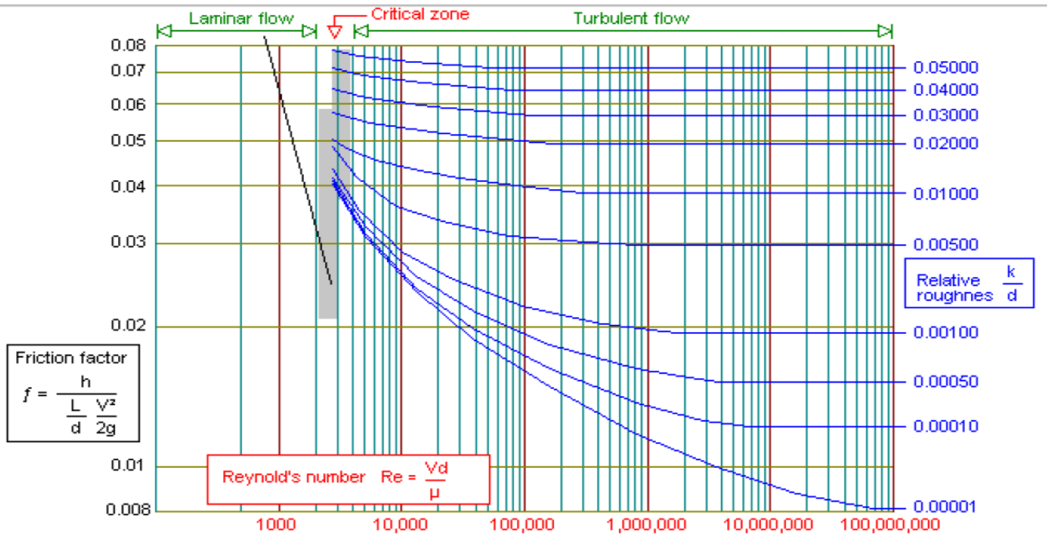


Figure 5.5 Mody chart

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For branches pipe:

2 inch = .0508 m

1100 gpm = 0.0694 m^3/s

Area (A) = $\frac{\pi D^2}{4} = \frac{\pi * 0.0508}{4} = 0.002\ m^2$

Total flow rate **(**Q_{efectiv}) = 1100 gpm

Calculations:

The velocity in the pipe defined in the equation

Reynolds number (R):

μ_{water}@25 ℃=0.001

Re = $\frac{1000*3.16*0.0508}{0.001}$ = 160588

From mody chart the friction factor (f) = .048

$h_{f(branchs)} = \frac{flV^2}{2gd} = \frac{0.048*48*3.19^2}{2*9.81*0.0508}$ = 12.64 m

Total $\boldsymbol{h_f}$ =major loss + miner loss in fitting = 19.74 m

19.74 m = 1.935 bar

Total required pressure = 1.935 + 4.5 = 6.435 bar

6.435 bar = 93.33psi

From site “xyleminc’’, we can choose the desired pump fire model: 8X6X10F

.And with Jockey pump model Peerless-J - J65F

■ Pump Selection Program

Flow Rate in GPM:	1250
Developed PSI:	95
Suction Pressure:	15
Driver Type:	Diesel Engine
Pump Series:	8100

Model	Speed	Imp Dia (in)	Max HP	Max WP (psi)	Listing	Pump Curve	Single Curve
8X6X10F	3000	10	106.00	200	UL,FM	A8792	Create

Figure 5.6 Pump selection

■ Pump Selection Program

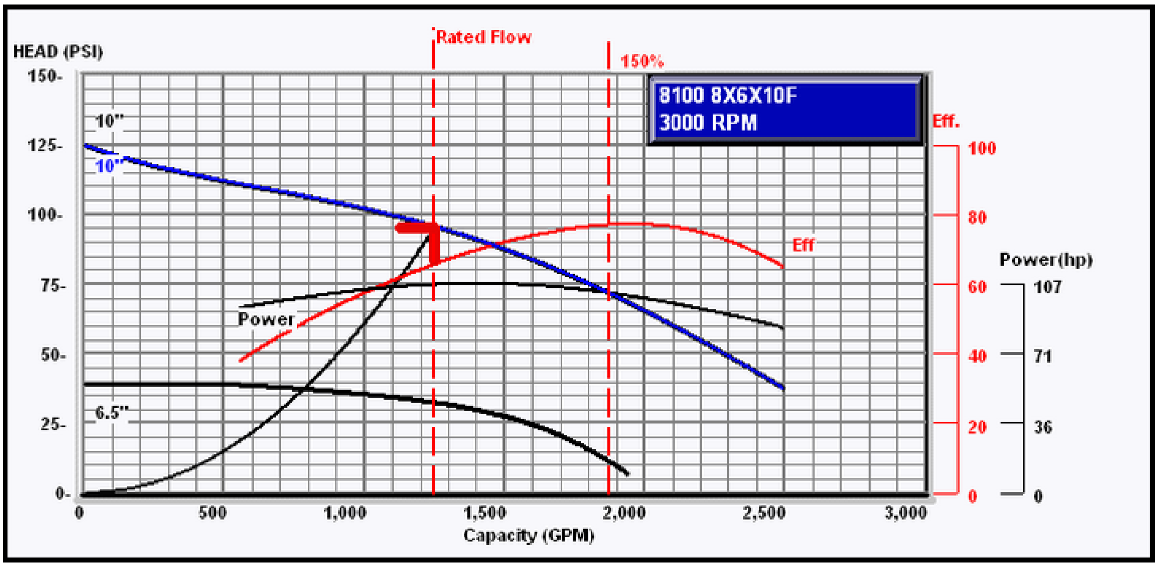

Figure 5.7 Pump selection diagram

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5.11.6 Water Tank

To calculate the size of the water tank which is to be in accordance with the degree of risk .depending on the type of threat that we own

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Table 5.15 Degree of risk

Hazard	Time
Light Hazard	**min 60 : 30**
Ordinary Hazard	**min 120 : 90**
Extra Hazard	**min 120**

.It is time that the network must work until the arrival of firefighters and civil defence

If we assume that the need of hydraulic calculations to 1100 gpm and an average degree of seriousness of Ordinary Hazard, we find that the size of the reservoir as follows

(V = 1100 gpm X 60 min X (3.785 / 1000

Tank volume equal to = 100 m^3

5.11.7 Selections of Fire hose component

1) Fire hose

Fire hose that's used in building made by SFFECO Company.

.Model: SF/4000

(See Catalog)

2) Pump

Pump that's used in building made by ITT Company.

Model: 8x8x18F

(See Catalog)

3) Jockey pump

Pump that's used in building made by PEERLESS PUMP Company.

Model: Peerless-J - J65F

(See Catalog)

APPENDIX A

APPENDIX B

DESIGN & DOCUMENTATION OF AN HEALTH CARE CENTER & OLYMPIC SWMMING POOL

Mechanical Works

Item	Description	Unit	Qty.	Rate (US$)	Amount (US$)
1	**External Sewage Drainage System**				
	Supply and install of UPVC (PS approved)drainage pipes and fittings, including connections, excavation, covering with a layer of 20 cm sand around the pipe and back filling as shown in drawings and specifications and approval of supervisor engineer.				
	size 6 inch diameter	m	406		
2	**Internal Sewage Drainage Pipes**				
	Supply and install of UPVC drainage pipes to floor drains connected to existing pipes till the nearest existing manholes, with all required fittings"Y", "T" etc. The price includes digging and plastering also incasing with concrete cover for underground pipes, as shown in drawings , specifications and approval of supervisor engineer.				
	size 2 inch diameter	m	154		
	size 4 inch diameter	m	210		
3	**Floor Traps**	No.	97		
	Supply and install 4" floor trap UPVC, include chrome plated screw type cover(15*15 cm) completed with connections to drain pipes as located in drawings, specifications and approval of supervisor engineer.				
4	**Clean Out**	No.	115		
	Supply and install Floor Clean Out 4"UPVC including chrome plated (sealed type) cover (15*15 cm) complete with connection to drain pipes as located in drawings , specifications and approval of supervisor engineer.				
5	**Sewage Manhole**				
	Supply and install and commissioning of reinforced precast concrete Manholes of 15cm thickness for walls and bottom slab, with depths as shown on drawing, with all necessary fittings, excavation, back filling as specified to the required depth complete with cast iron covers (8 tons), benching and plastering, all as shown in drawings, and approval of supervisor engineer, and as follows:				
	Manhole of 60 cm internal diam.	No.	16		
	Manhole of 80 cm internal diameter.	No.	14		
	Manhole of 100 cm internal diam.	No.	28		
	Manhole of 120 cm internal diameter.	No.	11		

DESIGN & DOCUMENTATION OF AN HEALTH CARE CENTER & OLYMPIC SWMMING POOL

Mechanical Works

Item	Description	Unit	Qty.	Rate (US$)	Amount (US$)
6	**Wash Basins** Supply and install fire glazed counter washbasin , of size 55*45 cm, complete with chrome plated mixer, chrome plated 13mm angle valves,supports, 2" waste outlet down to floor drain, chrome plated P-trap, including connection to drain and water outlets, as shown in drawings,and approval of supervisor engineer.	No.	39		
8	**Shower** Supply and install Porcelain shower , white color, type Roca or E.A, of size 80X80cm, complete with chrome plated mixers, plug and chain, 1.5m flexible hose with chrome lever handle and stand, and all associated water supply pipes, and brackets screwed to concrete or blockwork, sealing joint to worktop or wall with mastic sealant.	No. No.	18		
9	**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. No.	55		
10	**Kitchen Sink** Supply and install fire glazed double bowel kitchen sink of size 90X40cm, complete with chrome plated kitchen mixer , chrome plated 13mm stop valve, supports, 2" waste outlet down to floor , P- trap, chrome plated 13mm hose and all required parts for water supply line, including connection to drain and water outlets, as per supervisor engineer.	No. No.	5		
11	**Urinals** Supply and install of a wall-mounted ,white color , Prcelain type ROCA or equivelant urinals including necessary accessories, valves, fittings, 13mm stop angle valves,including connection to drain and water outlets as per supervisor engineer	No.	13		
12	**Cold Water Supply Pipes** Supply and install of galvanized steel main water pipe 3",with asphalt protection which will take from the main line of the city with all necessary,it will from municipality to well and balancing , with all required fittings needed for installation, i.e. elbows, tees, unions, valves,.... The price includes digging, excavation, and concrete cover above pipes, in addition to backfilling, as shown in drawings, and approval of supervisor engineer. The sizes of pipes are as follows:				
	* 3" From mancity to the well	m	70		
	* 2" From the pump to the main water collecters	m	4		
				To Collection(US $)	

DESIGN & DOCUMENTATION OF AN HEALTH CARE CENTER & OLYMPIC SWMMING POOL

Mechanical Works

Item	Description	Unit	Qty.	Rate (US$)	Amount (US$)
13	**Main Cold Water Collectors, Pex Pipes and cabinets** Supply and install copper collectors for domestic cold water system(From the pumps), of approved quality, with all necessary fittings, nipples, nuts, unions, quick shut off valves on each branch in addition to main isolation valves on each collector, brass fittings adapter, automatic vents ..Etc of approved quality. Rate includes sheet metal painted cupboard of approved type and quality. The price should also include supplying and installing 32mm pexgol plastic pipes with 5cm thick concrete layer to distreputer collectors,				
	2" CW Collector (4 eyes)	L.S	1		
	2" CW Collector (6 eyes)	L.S	1		
	Cold Water Collectors, Pex Pipes and cabinets Supply and install copper collectors for domestic cold water system, of approved quality, with all necessary fittings, nipples, nuts, unions, quick shut off valves on each branch in addition to main isolation valves on each collector, brass fittings adapter, automatic vents ..Etc of approved quality. Rate includes sheet metal painted cupboard of approved type and quality. The price should also include supplying and installing 16mm pexgol plastic pipes with its 25mm plastic conduits with 5cm thick concrete layer to fixture units outlets, copper elbows recessed in walls and all civil works needed, as per plans & engineer's and as spicified in drawings				
14	**Domeistic Hot Water Storage Tank** Supply and install hot water storage Tank of 500 Liters capacity, of approved quality. The price includes all accessories needed to complete the job, fixing the cylinder on ceiling, supplying and installing flow and feed pexgol pipes of size 20mm with collectors, with all related necessary fittings, i.e. air vent, valves, pressure relief valve, gauges, all according to drawings and engineer's instructions. The capacities of cylinders are as follows:	No.	7		
15	**Pressur Pump Set** Supply pressure end suction pump set, for water supply system. The set is composed of three pumps (2 duty and one standby), control panel . The price includes all fittings needed for installation, i.e. supply collectors, strainers, stop valves, non-return valves, flexible joints, concrete base, ani-vibration isolators, pressure switches, electric floating valve installed for well and connections to pumps, in addition to electrical and control cables and connections to MDB. The specifications of the pumps are as follows:(2 for each water well) 15m Head & 3 L/s flow rate	L.S	2		
				To Collection(US $)	

DESIGN & DOCUMENTATION OF AN HEALTH CARE CENTER & OLYMPIC SWMMING POOL

Mechanical Works

Item	Description	Unit	Qty.	Rate (US$)	Amount (US$)
16	**VRV IV (VRT) SYSTEM** Supply and installation of "R410A" VRV IV (VRT) system (Heat recovary) outdoor units antivibration treatment, additionally refrigerant charge computation base on the length of the refrigerant pipe and all necessary accessoories and installation work need to complete the proper operation of the equipment.the price include the piping of the indoor units and the control wiring and all fittings and Refnet (Y) as shown in drawings				
	outdoor set 1 :cooling capacity =38 HP	No.	1		
	outdoor set 2 :cooling capacity =52 HP	No.	1		
	outdoor set 3 :cooling capacity =54 HP	No.	1		
	outdoor set 4 :cooling capacity =52 HP	No.	1		
	outdoor set 5 :cooling capacity =52HP	No.	1		
	outdoor set 6 :cooling capacity =54 HP	No.	1		
17	**Indoor Units**				
	Supply and installation of VRT indoor unit, filter, remote controller and all necessary accessories and installation work need to complete the proper operation of the equipment.				
	Type : Ceiling Mounted Cassette (Round Flow) type :(look at the cataluges)				
	FXFQ125A	No.	15		
	FXFQ100A	No.	8		
	FXFQ80A	No.	7		
	FXFQ63A	No.	6		
	FXFQ50A	No.	4		
	FXFQ40A	No.	12		
	FXFQ32A	No.	1		
	Type : Wall mounted unit (look at the cataluges)				
	FXAQ63P	No.	3		
	FXAQ50P	No.	1		
	FXAQ32P	No.	1		
18	Supply and installation of condensate drain pipework, including 2" UPVC Pipe insulation, main raiser's and final connections to the gray water drainage system.				

DESIGN & DOCUMENTATION OF AN HEALTH CARE CENTER & OLYMPIC SWMMING POOL

Mechanical Works

Item	Description	Unit	Qty.	Rate (US$)	Amount (US$)
19	**Hydrobox**	No.	7		
	Supply and instal of a 14 kW hydro box (daikin type) with all accesores the price includes the pipes and all fittings between the hydrobox and the hot water collecters as shon in the drawings	No.			
20	**Exhaust Air Grilles**	No.			
	Supply and install white anodized Aluminum, of approved quality, exhaust air grilles, with registers. The price includes galvanized adapter with neck, opening in false ceiling, as shown on the drawings. The sizes of grilles are as follows:				
	round return air grills (Ø100mm)	No.	36		
	Return air grill (15cm×15cm)	No.	22		
21	**In-Line Exhaust Fans**				
	Supply and install ducted in-line exhaust fan. The price includes the steel sheets ducts and 3" flexible ducts, supplying and installing flexible duct connection between the steel sheets duct and the Ex.fan and grilles, flexible joints, and all accessories needed for installation and commissioning. , all according to the sizes shown on drawings, and also electrical and control cables and connections to main distribution board, all according to drawings and engineer's instructions. The fans capacities are as follows:				
	* 190 L/s Air Flow @ 0.25" Static pressure	No.	2		
	* 170 L/s Air Flow @ 0.25" Static pressure	No.	4		
	* 140 L/s Air Flow @ 0.25" Static pressure	No.	4		
22	**Gutter Drain Cover** Supply and install gutters (Perimeter overflow system) to be extend around the full perimeter of swimming pool. The gutters should be of resistant corrosion and scratches. The price including supplying and installing drainage pipes and connections to balancing tank, also excavation for trenches and backfilling, plastering according to drawings and engineer's instructions.	L.S	1		
23	**Floor Drain** Supply and install 8"/6" UPVC floor drain, include chrome plated screw type cover(20*20 cm) completed with connections to drain pipes, as located in drawings, specifications and approval of supervisor engineer.	No.	8		

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Mechanical Works

Item	Description	Unit	Qty.	Rate (US$)	Amount (US$)
24	**Pipes and Fittings**				
	Supply, install, join and test of PVC pipe (For water supply, return and drain related to swimming pool) confirming to IS : 4985 class IV 10Kg/cm2 including all fittings such as bends, elbows, reducers, tees, unions, couplers, tail piece, flanges etc. The price shall also include all civil works needed for pipes installation, with all needed supports according to specifications. Pipes shall be connected to pumps, equipments, valves, etc.. through tail piece flange as per engineer's instructions. The sizes of pipes are as follows:				
	* 110mm CPVC Pipe Diameter	MR	360		
	* 125mm CPVC Pipe Diameter	MR	12		
	* 140mm CPVC Pipe Diameter	MR	20		
	* 150mm CPVC Pipe Diameter	MR	133		
	* 200mm CPVC Pipe Diameter	MR	105		
25	**Sand Filter Tanks** Supply and install high rate sand filter tanks, made of fiberglass reinforced plastic (FRP) material, tested against NSF/ ANSI standard 50. Each sand filter should have the capability to back wash each filter at a rate of 8L/s/m^2 of filter bed area, which shall be discharge to waste through suitable gap. The media of filter is sand of suitable grade that meets the manufacture's recommendation. The price shall include all fittings and accessories needed like pressure gauge, manometer, back wash sight glass and air relief valve. The filter system should be provided with valves and pipes to allow isolation, drainage and back washing of individual filters for proper operation Tank Diameter = 1560mm Filter Area = 3.14m^2	No.	5		
				To Collection(US $)	
26	**Balancing Tank** Supply, install and test fiberglass reinforced plastic balancing tank of size (5mX4.5mX4m). The price includes automatic level control mechanism, with manual bypass fill valve provided. The tank should be connected with gutter scum, drain sump, compensate feed water supply and overflow with all fittings and accessories needed for connection and commissioning the system, all according to drawings and engineer's instructions.	No.	1		
27	**Swimming Pool Circulating Pumps** Supply, install, test and commission pneumatic booster pump set. Casing: Bronze to BS EN 1982:1999 or Cast iron to BS EN 1561:1997 Impeller: Bronze to BS EN 1982:1999 Shaft: Stainless steel to BS EN 10088-3:2005 Sleeves: Stainless steel same as shaft or cast bronze Wearing rings: Copper-tin alloy to BS EN 1982:1999 The price includes all accessories and fittings needed to complete the job, i.e. pre-filters, non-return valves, isolation valves, flexible joints and pressure gauge. The capacity of each pump is: 433m^3/hr Flow and 10m Static Head.	L.S	4		

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Mechanical Works

Item	Description	Unit	Qty.	Rate (US$)	Amount (US$)
28	**Sewage Sump Pumps** Supply, install, test and commission of submersible sump pump set of centrifugal type, consisting of two pumps, one is standby.Each pump shall be constructed with double mechanical shaft seal and close-coupled to a submersible electric motor. The sump pump shall operate automatically under level control with an alarm to alert the operator when high water level is being exceeded. Each pump shall be equipped with factory built-in suspension device. The price includes anti-corrosion steel supporting base. The pump unit itself shall be able to be easily removed from its base for inspection, repair and service. The pump shall automatically be connected to the discharge piping, such that there shall be no need for the maintenance personnel to enter the pit to carry out the work. The pump discharge shall be fitted with a resilient seal that provides a positive hydraulic seal for maximum pump efficiency. Each impeller shall be trimmed to meet the specified flow equipments. The price includes all accessories and fittings needed to complete the job, i.e. non-return valves, isolation valves, and flexible joints. The capacity of each pump is: 30L/s Flow and 30m Static Head.	L.S	2		
				To Collection(US $)	
29	**Gas Chlorination Container** Supply, install, test and commission of direct cylinder mounted type gaseous chlorinator. The container adaptor shall be designed to mount directly onto the gas outlet valve of the container by means of a positive yoke type clamp, complete with vacuum regulator, integrated safety valve, filter and pressure gauge, flow meter, ejector, non return valve, PE tubing, ammonia bottle and spanner. The filter shall be chemically inert to the effects of all forms of chlorine, and shall be capable of easy removal, cleaning and reuse. The capacity of required CL gas required is 0-5 kg/hr, including booster pump, including pressure gauge, fittings, control valves........	L.S	1		
30	**PH Adjustment System** Supply and install a PH adjustment-mechanical feed equipment for the purpose of adding a chemical for PH adjustment. The price should include all needed fittings and accessories needed to complete the works, as per plans and engineer's instructions. The capacity shall be consistent with the chlorine feed rate.	L.S	1		
31	**Controller System** Supply, install, test, and commission of microprocessor based automatic ORP and PH monitoring and controlling system. The controller should have adjustable set points, high low alarms, overfeed safety timer and proportional feed control. All control functions on front panel. This controller will monitor and control gaseous chlorinator and PH dosing / metering pumps.	L.S	1		
32	**Firefighting system** Supply, install, and test the following items complete with the necessary fixing accessories as specified and as shown in drawings.				

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Mechanical Works

Item	Description	Unit	Qty.	Rate (US$)	Amount (US$)
32-1	**Fire extinguishers**				
	Supply, lift into position, install, test, set to work, and commission fire extinguisher with the following capacity and as per drawing. 5 kg co2 fire extinguisher	No.	3		
32.2	**Fire Hose Cabinets**				
	Required the supply and installation of fund fire automatic made of Stainless steel with thickness equivalent to caliber 20 (20 GAGE) and nails of copper, and contains two valve one of them is connected to a pulley to carry me to the fire made from rubber, and the length of Khartoum at least 30 meters and diameter of 1.5 inch, and valve diameter of 1.5 inches the other for the purposes of civil defense (Landing Valve).	No.	11		
32-3	**Pumps**				
	The unit price shall also include three pumps with all components, supports, base, gate valves, check valves, Strainers, pressure gauges, collectors, pressure vessel and Frequency invertors in each control panel for each pump. The Pumps assembly should be factory assembled. and the pump we take from xylem for electric and diesel pump and peerless for jockey pump.	No.			
	Electric pump	No.	1		
	Diesel pump	No.	1		
	Jockey pump	No.	1		
32.4	**Pipes**				
	Sch.10 pipes Supply and install black steel Sch. 10 pipes jointed by welding for diameters above 2" and by threads for 2" pipes and below, all as made by E.A. The work also includes all valves, strainer, unions, nipples, fittings, hangers and all needed other accessories including painting with the final red color paint according to specifications and the approval of the Engineer.				
	4"	m	6		
	2"	m	80		
	1.5"	m	22		
32.5	**FM200**				
	Insurance system, fire extinguishing an automatic by gas (FM 200) complete with cylinders and cylinder backup for each system, pipes, detection devices and wiring and the alarm panel and connect with the alarm system of the building and with the control system and control devices within the building (BMS) Extinguishing system for the panels to the electrical inside the rooms and air handling units and pumps inside the room (Fire Trace).				