

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Palestine Polytechnic University



College of Engineering & Technology
Mechanical Engineering Department

Graduation Project

Movempick Hotel Swimming Pools, Spa & Ornamental Water
Features

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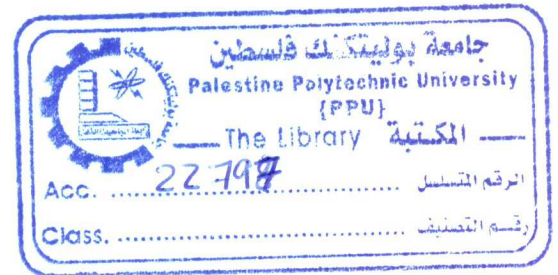
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Dedication

We gift this graduation project
To who carry candle of science
To light his avenue
Of live

To all students & who
Wish to look for
The future

To who love the knowledge &
Looking for all is new
In this world

Acknowledgement

Our thanks go first to our advisor Eng. Jamal Shweiki. His guidance and support made this work possible. His constant encouragement, intuitive wisdom, and resolute Leadership was instrumental in completing this work.

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Abstract

This project aims to design the swimming pools and recreation water features for Movempick hotel in Ramallah.

We talk about swimming pools; definition, basic components, types, dimensions, shapes, plumbing and pool shell equipment such as floor drains, skimmers, gutter and inlet lines.

Pipes and fittings have also great deal of information which include types of pipes, methods of connections, accessories and friction head.

We also talk about filters, definition, types, function, turnover and flow rate. In addition we talk about centrifugal pumps, dynamic head, priming, performance curves and motors.

Chemical treatment of water is covered to deal with microorganism and balance water ph to prevent corrosion or scale formation.

Water features include waterfalls, water curtain, fountains and water umbrella are included in this project in addition to the accessories that are used in this project such as ladders, diving boards, slides, cleaning devices, covers and safety equipment.

The second part of this project covers design procedure, calculations and selection of all the equipment needed. Also the mechanical drawing and details will be prepared .

3-D simulation of the project will be shown.

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CHAPTER ONE

INTRODUCTION



1 Introduction

1.1 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. Caliph Omar bin Al-Khattab - R.A - 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 built 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 recreational; It's known that in summer and spring the temperatures rise much which make people feel the need to something joyful in order to relief themselves , break the routines of life and work and to go out from their houses for recreation. They can find that in the places which are full of public parks and swimming pools where enjoyment and refreshment are.

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

1.2 History



Figure (1.1) Structure dubbed the great bath in the excavated Mohenjo-Daro ruin

The history of pools begins at the "great bath" constructed at the site of Mohenjo-Daro. It was most likely dug during the 3rd millennium BC. The pool, twelve by seven meters, is lined with bricks and during its time the pool was covered with a tar-based sealant.

Artificial swimming pools have also been built by the ancient Greeks and Romans who used them for athletic training in the palaestras and also for nautical games, and military exercises. Roman emperors had private swimming pools in which fish were also kept, hence the Latin word for pool, *piscina*.

Ancient Sinhalese built what is known as "Kuttam Pokuna" a pair of pools in the ancient kingdom of Anuradhapura, Sri Lanka (4th Century BC). Such pools were decorated with flights of steps, punkalas or pots of abundance and scroll design. Modern-day swimming pools did not become popular until the middle of the 19th century. By 1837, six indoor pools with diving boards were built in London, England. After the modern Olympic Games began in 1896 and swimming races were among the original events, the popularity of swimming pools began to spread .

The Amateur Swimming Association was founded in 1869 in England, but it was much later, in 1909, that Oxford Swimming Club came into existence. One might guess that the presence of indoor baths in the cobbled area of Merton Street of London persuaded the less hardy of the aquatic brigade to join. Therefore, bathers gradually became swimmers, and bathing pools swimming pools. In 1939, Oxford, England had its first major public indoor pool at Temple Cowley. After the pool was installed, swimming began to take off and soon Oxford Swimming Club became Oxford City Swimming Club, and Temple Cowley Pool was its home.

The Racquet Club of Philadelphia clubhouse (1907) boasts one of the world's first modern above ground-level swimming pools. The first swimming pool to go to sea on an ocean liner was installed on the Olympic.

After World War I and the departure of "Long John" style swimming costumes, the interest in competitive swimming grew. Standards improved and training became essential.

1.3 Reasons for the selections of this project

This project is a principal requirement for Refrigeration and Air-Conditioning Engineering bachelor degree.

In Palestine, The need for swimming pools came to light because of occupation .The large number of street blocks made it extremely difficult for the civilians to travel from one city to another. so local investors started to install(construct) public parks and swimming pools.

It's known also that Palestine lies on the Mediterranean sea which is hot in summer and big numbers of people come to recreational places because of the modern installation development, the being of swimming pools ,fountains and waterfalls became something common in Palestine . In Palestine construction of special houses with modern styles prevails because the building rocks are obtain locally.

The increase in demand to build special or public swimming pools and the shortage in Mechanical engineers specialized in this field are the reasons that made us to think about doing such project about pools and other water features .

1.4 general project descriptions

The following information for the situation of a hotel.

- ❖ **Hotel Name:** Movempick.
- ❖ **Hotel Address:** Ramallah, Almasion, near PLC.
- ❖ **Hotel Area:** 8000 m².

This project aims at designing the swimming pools and recreation water activities for Movempick hotel in Ramallah. It includes:

- 1) Overflow swimming pool, public type.
- 2) Skimmer swimming pool.
- 3) Spa .
- 4) Water features (umbrella, cascade jets, aerating jets) .

The design includes mechanical room or equipment room.

The following information for the situation of our project.

1) Overflow swimming pool

- Type of the swimming pool: Public.
- Pool surface Area: 411.7 m².
- Pool Depth:
 - Minimum depth: 40 cm.
 - Maximum depth: 140 cm.
 - Average depth: 90 cm.
- Volume of Water : 416.872 m³.

2) Skimmer swimming pool

- Type of the swimming pool: Public.
- Pool surface Area: 29.32 m².

- Pool Depth:
 - Minimum depth : 50 cm.
 - Middle depth : 105 cm .
 - Maximum depth: 110 cm.
- Volume of Water : 23.449 m³.

3) Spa

- Surface area : 17.35 m².
- Number of seats : 8 .
- Depth : 110 cm .
- Water volume : 19.08 m³.

4) Water features

❖ Umbrella fountain

- Situation : in overflow swimming pool
- Height : 220 cm

❖ Cascade jets

- Situation : in skimmer swimming pool .
- Number of jets : 18 jets

❖ Aerating jets

- Situation : at entrance of a hotel.
- Number : 2
- Height of water : 2 m

1.5 Time table of the first semester

Table(1.1): Explains the required time in the first semester of project:-

Subject	Week #																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Choosing the project title	■																
General study		■															
Visit to project site			■														
Introduction				■	■	■											
Studying of the Swimming pool							■	■									
Studying of the Pool shell equipments									■								
Studying of the piping										■	■						
Studying of the Filters												■					
Studying of the Pumps													■				
Studying of the Water chemistry														■			
Studying of the Water features														■			
Studying of the Accessories															■		
Printing and finishing																■	
Presentation																	■
Documentation	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

1.6 Time table of the second semester

Table(1.2): Time table in the second semester of project

Subject	Week #															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Overflow pool design	■	■	■	■												
Selection the pool equipments		■	■	■												
Drawing the mechanical room			■	■	■											
Drawing the 3-D pool.				■	■	■	■	■								
Deign the skimmer pool.						■	■									
Drawing the mechanical room of the skimmer pool.							■	■	■							
Spa design.									■	■						
Umbrella fountain design.											■					
Cascade jets design.												■				
Aerating jets fountain design.													■	■		
Drawing the mechanical room of the water features.											■	■	■			
Printing & finishing															■	
Presentation																■
Documentations	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

1.7 Budget

In the following list is the estimation of cost of the project that executant's:-

- ❖ Transportations:400 NIS.
Visiting to Ramallah city and the sites of swimming pools in Hebron city.
- ❖ Telecommunications : 200 NIS.
- ❖ Internet: 200 NIS.
- ❖ Printing and binding: ٢٦٥٠ NIS.
- ❖ Buying a book:130 NIS
- ❖ Others cost: 300 NIS.
- ❖ Total cost: ٣٨٨٠ NIS.

1.8 Project outline

Chapter Two: Swimming pools

This chapter is about swimming pools ; definition, basic components types, dimensions and capacity ,shapes and plumbing.

Chapter Three: Pool shell equipment

Pool shell equipment of swimming pools contain many equipment such as floor drains ,gutters ,skimmers ,inlet lines , and electricity of pools.

Chapter Four: Pipes and fittings

This chapter shows types of pipes, methods of connections and losses in pipes in general. After that we have to specify the types of pipes that are used in pools and the losses and finally how to select pipes and fitting.

Chapter Five: Filters

This chapter contains functions of filters, types, working method, turnover, flow rate and how to connect mechanical room with pumps.

Chapter Six: Pumps

This chapter is about the pumps; definition of function, types, self-priming and non-self, flow rate, head (static & dynamic) and pump motors.

Chapter Seven: Chemical treatment

This chapter is about the characteristics of pool water, which explain water qualities, transmissions and preventions of diseases, PH of water, alkalinity, and calcium hardness, total dissolve solids and disinfection of water.

Chapter Eight: water features

This chapter contains water features; waterfalls, water curtain, fountains and water umbrella. It explains type of water features, forms, determinations of water motion, fixture and fitting.

Chapter Nine: Accessories

This chapter contains accessories that are used in this project such as ladders, diving board, slides, cleaning devices, lighting, float lines, pool covers and safety equipment.

Chapter Ten: Design of swimming pool and water features

- ❖ Selection of all mechanical components of swimming pools; skimmer, floor drain, pump, filter, chlorine device and return inlets.
- ❖ Selection of all mechanical components of spa and water features, and drawing of mechanical rooms.

CHAPTER TWO

SWIMMING POOLS



2 Swimming pools

2.1 Introduction

A swimming pool, swimming bath, or wading pool is an artificially enclosed body of water intended for recreational or competitive swimming, diving, or for other bathing activities that involve swimming, e.g. playing, water exercise, or merely cooling off in the hot day.

2.2 Basic mechanical components of swimming pools

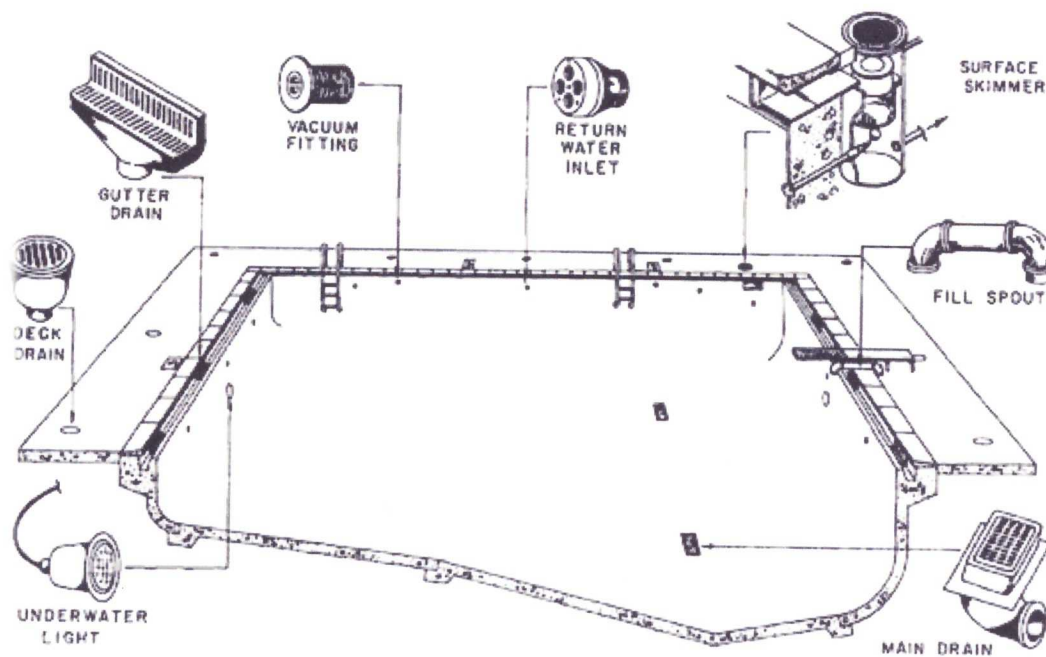


Figure (2.1): Basic components of swimming pool

The basic mechanical components 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 particulate 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 exchanger 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) Make-up 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:

$$\text{Meters of Water depth} \times \text{Pool Surface Area (m}^2\text{)} = \text{cubic meter of Water}$$

2.3 How swimming pools work

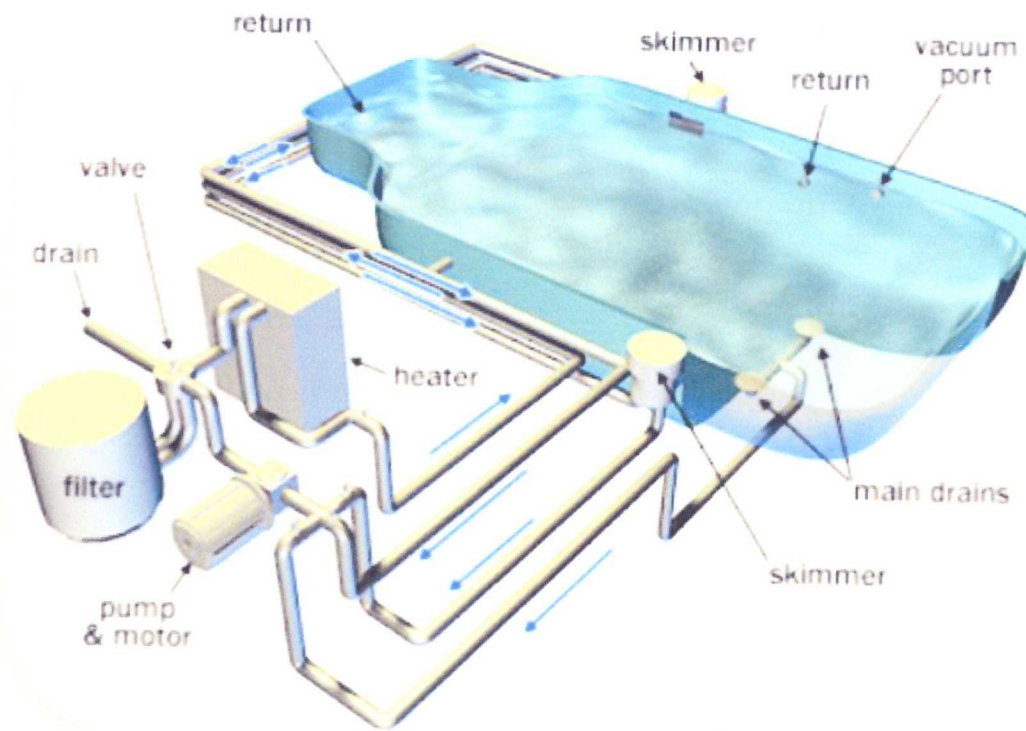


Figure (2.2): circulation of water in Swimming pool

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 the water circulation through the system is the recirculation pump. Typically, a centrifugal pump is used to recirculation the pool water.

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.

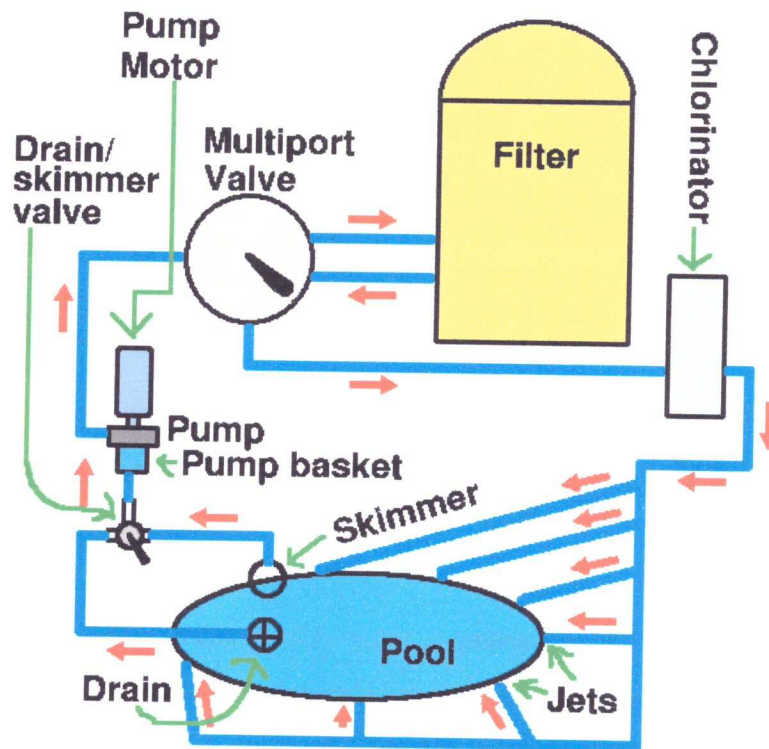


Figure (2.3): Simple pool water cycle

Start from the pool; water is sucked out of 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. The way valve determines the percentage of water sucked through the skimmer relative to the drain. It can do this because each the drain and skimmer has their own pipe leading to the way valve.

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 is a centrifugal 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.

The now cleansed water is pushed out of the filter and into the chlorinator, a simple canister which houses solid tablets of chlorine so that they dissolve 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.

2.4 Types of swimming pools

There are many types of swimming pools, and we can not specify them in one classification, so that they are specified by their shapes and its locations (residential or public), but the most common classification is by their usages.

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

1- Ocean pools



Figure (2.4): 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 modern 'Olympic' pools.

2- Private pools



Figure (2.5): 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.

3-Public pools



Figure (2.6): Public pools

Public pools are often found as part of a larger leisure centre 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 a "natatorium".

Many public swimming pools are rectangles either 25 m or 50 m length, but a backyard pool can be any size and shape desired. There are also very elaborate pools, with artificial waterfalls, fountains, 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.

4-Competition pools



Figure (2.7) : The starting block of a competition swimming pool.

Competition pools are generally indoors and heated to enable them to 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.

5-Olympic Swimming Pool



Figure (2.8): 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 a public type (hotel pool).

2.5 Shapes of swimming pools

Shapes of swimming pools allows choosing from traditional geometric shapes like rectangles or other shapes such as Grecian ends, L's, Lazy L's, Oval, Kidneys, Mountain Lake, Custom shapes and Spas hot tubs.

Pictures below show some shapes of pools:



Rectangle with Straight Corner Step and Diagonal Corners



Rectangle with 2' Radius End Step and 2' Radius Corners



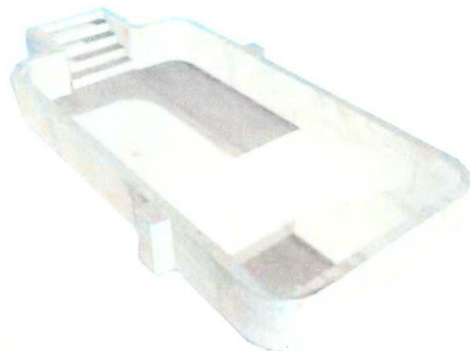
Rectangle with Roman End Step and Roman End



Rectangle with Roman End Step and 2' Radius Corners



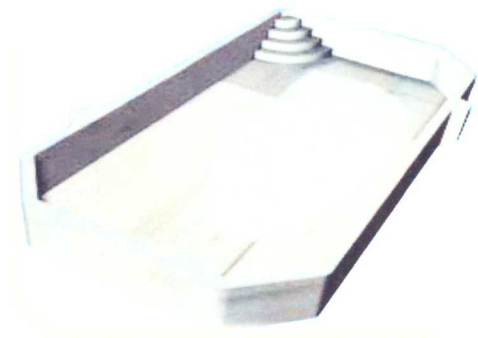
Rectangle with 10' Diameter Outside Step & 9'



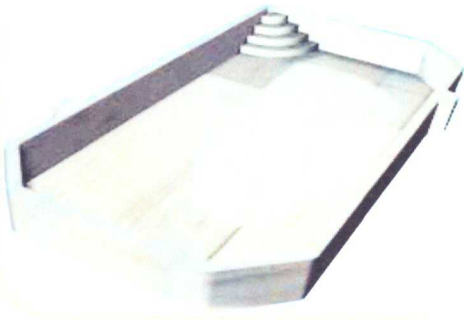
Rectangle with Outside Steps and 2' Radius Corners



Rectangle with Outside Step and 2' Radius Corners



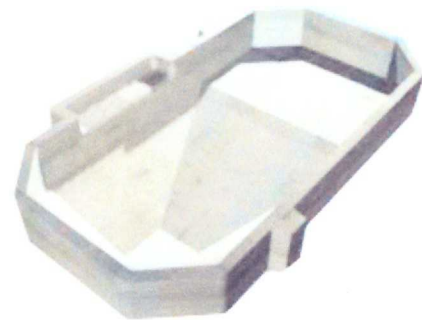
Rectangle with Radius Corner Step and 2' Radius Corners



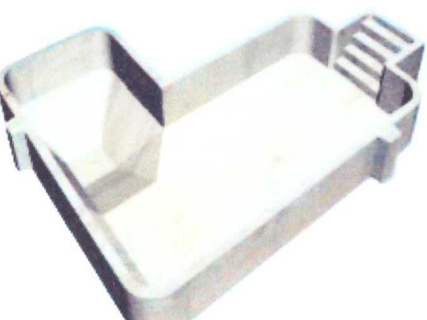
Grecian with Radius Corner Step



Grecian with Outside Step



Grecian with Swimout

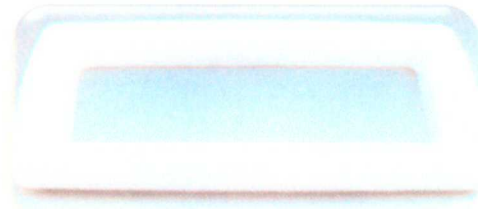


L with Outside Step and 2' Radius Corners

2. Skimmer lid thermometer



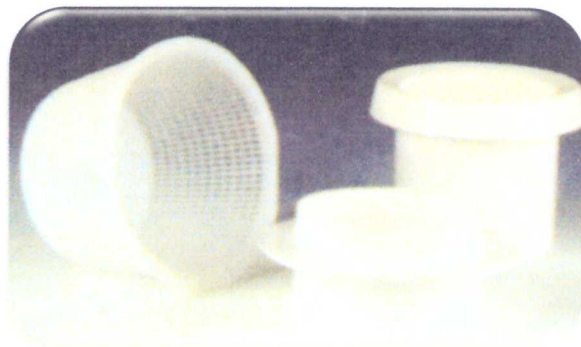
3. Decorative wide mouth skimmer face flat



4. Protective cover



5. Floating weir assembly



3.1.2 Skimmer plumbing:

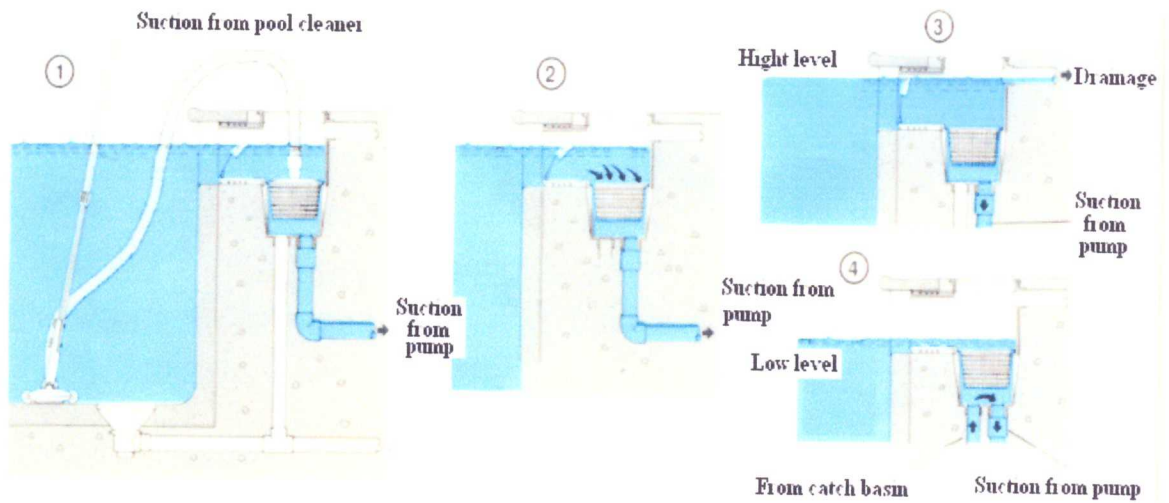


Figure (3.4): Skimmer plumbing

The various skimmer outlets allow different connections to be made.

- 1) Suction connection for pool cleaner.
- 2) Standard application as surface skimmer.
- 3) Overflow drainage.
- 4) Facility to avoid sucking air into the suction line in low water level condition.

3.1.3 Skimmer accessories

1. Skimmer cover extension ring



of the pool and that through the main outlet. It makes a further contribution to simple pipe work if it also provides a connection for the hose of a vacuum cleaner.

The number of skimmers required depends on the size and purpose of the pool. Their arrangement on a small outdoor pool should promote surface flows across the pool in conjunction with the return fittings and the prevailing wind.

3.1.1 Type of skimmers

a) Plastic

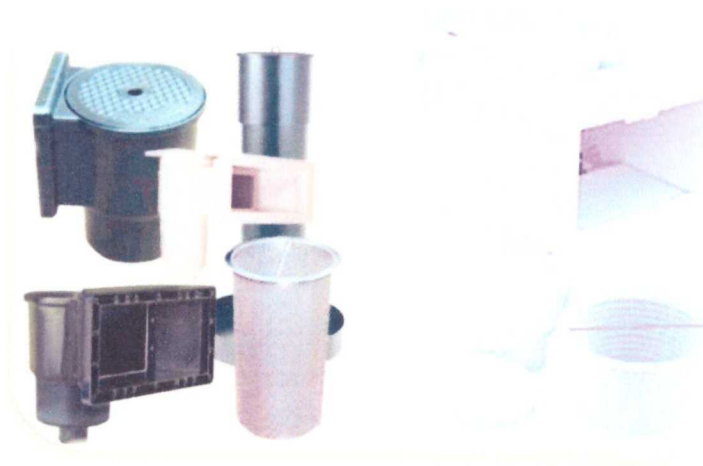


Figure (3.2): Shapes of plastic skimmers

b) Stainless steel

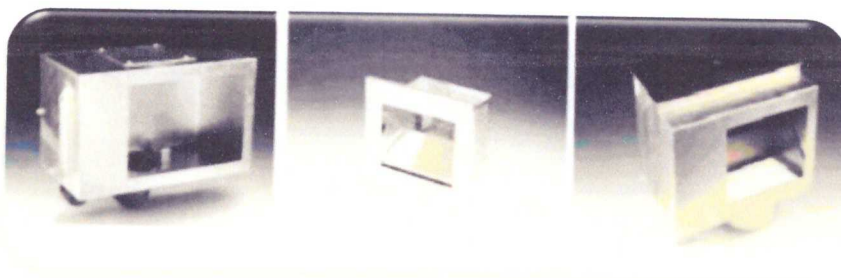


Figure (3.3): Shapes of Stainless steel skimmers

3. Pool shell equipment

3.1 Skimmer

Skimmer is mounted in the pool wall at water level, and is connected to a branch of the suction piping from the filter pump, (see fig 3.1) .

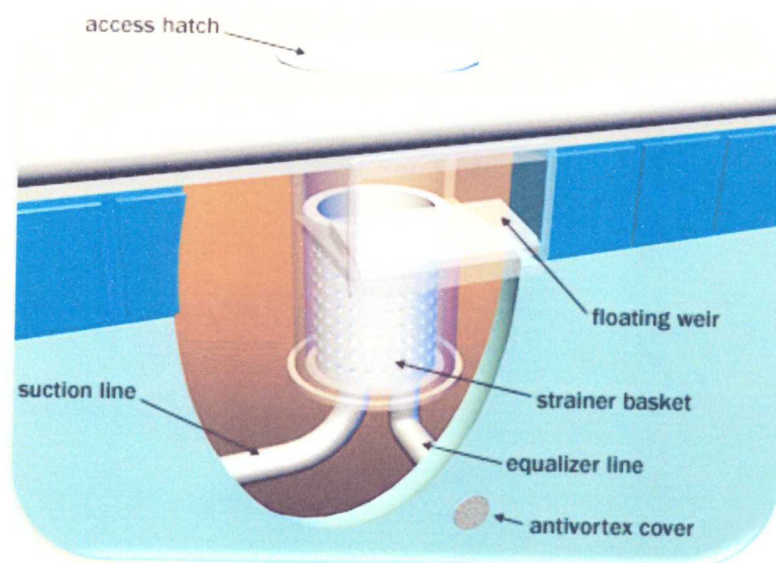


Figure (3.1): Skimmer position

Skimmer aims at promoting the 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. A combination skimmer connects directly into the line between the main outlet and the filter pump. It incorporates a trimmer valve, which divides the total flow through the filter between that across the surface

CHAPTER THREE

POOL SHELL EQUIPMENT



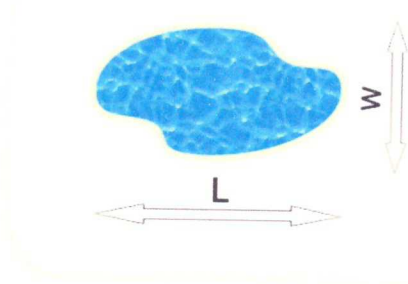
The determination of sizes of pipe, fittings and valves on the complete main pump suction line from the swimming pool shall be based on the rate of friction losses for piping of not more than (1.8288m) per (30.48m) of pipe.

All piping on the discharge side of the pump of filtration and to the point for discharge of backwash water from the filter plant shall have pipe sizes determined by basic friction losses which shall be not more than (3.65m) per (30.48m) and the velocity in any pipe shall not exceed (3.048m) per second.

All pool piping shall be supported by piers or otherwise to preclude against possible settlement which with either provide dirt traps or air pockets and a condition which would result in rupture of the line .

All pressure and suction lines shall have a uniform slope in one direction of not less than (0.9144m) per (30.44) gravity waste lines around the pool (0.1524m) . Or smaller shall have a minimum slope of (0.0031m) per (0.3048), Lines larger than (0.1524m) and all outfall waste main shall be designed with a size of pipe and slope to freely carry the maximum flows required with no surcharge or back pressure in the lines. All piping and equipment shall be provided with positive means of completely draining all water to prevent damage from freezing .

- **Irregularly Shaped Swimming Pools**



Surface area X Average Water Depth = Pool Volume

- **Irregularly slope Swimming Pools**

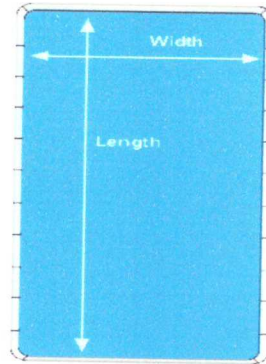
To calculate the capacity of swimming pool which has no regular slope , we can divide the pool into parts of the same slope, then we calculate each part as previous methods .

2.7 Pool Plumbing



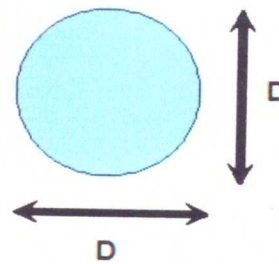
Figure (2.9): plumbing system

- **Rectangular or Square Swimming Pools**



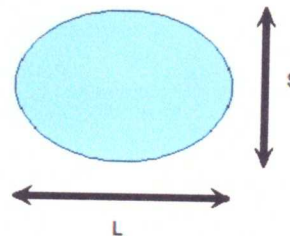
$$\text{Length} \times \text{Width} \times \text{Average Water Depth} = \text{Pool Volume}$$

- **Circular Swimming Pools**



$$\text{Diameter} \times \text{Diameter} \times \text{Average Water Depth} = \text{Pool Volume}$$

- **Oval Swimming Pools**



$$\text{Long Diameter} \times \text{Short Diameter} \times \text{Average Water Depth} = \text{Pool Volume}$$

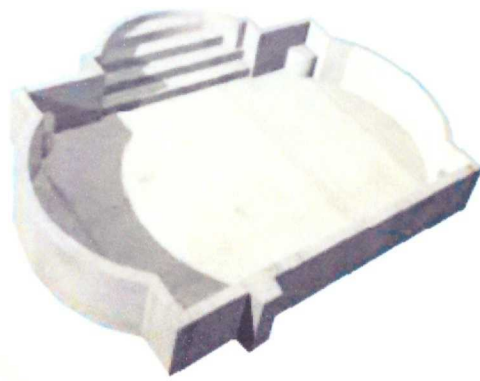
2.6 Pool Capacity

The volume of water in the pool is important to select the pool equipment. While a precise figure is always best, for most applications a reasonably close approximation will suffice. In the long term, the amount of chemicals required depends on bather usage, location, exposure and maintenance practices, as well as the actual pool water volume. Interior pool surface area is important to determine the cost of a resurfacing job or the amount of paint required for a refinishing.

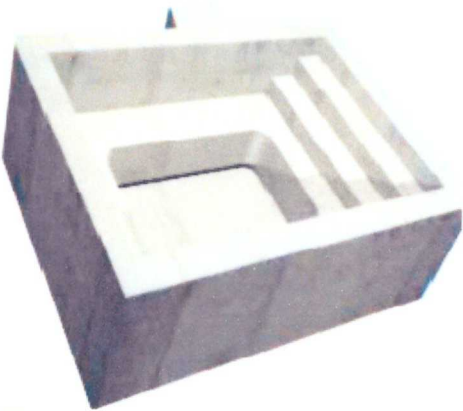
The volume of a swimming pool is quite simple to determine. Every pool has certain measurable factors; however, these factors differ depending on the shape of the pool. The most common and most basic is the rectangular swimming pool. To determine the volume of rectangular pools, multiply the length of the pool by its width and by its average depth. For a circular pool, multiply the pool surface area by average depth. For an elliptical pool, multiply $\pi/4$ by the major diameter, minor diameter, and average depth. For irregular shapes, calculating the volume is less accurate. You will need to determine of volume of a normal shape within the given area and then approximate the volume of the remaining parts of the pool. Volume of a swimming pool is given in units of cubic meters, liters, or gallons.



Lazy L with End Step



Double Roman End
with Roman End Step



Rectangle Spa with End step



Square Spa with
Seat and Steps



Round Spa with Seat and Steps



Kidney with no Step



Kidney with Radius Inside Step



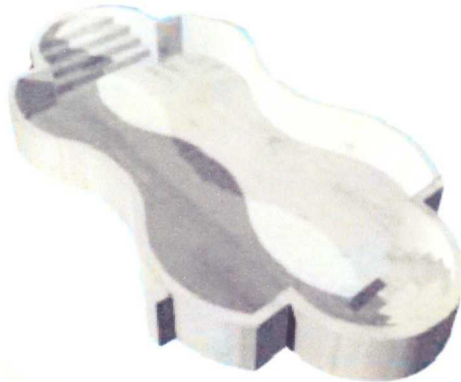
16' x 36' or 18' x 39' Mountain Lake with no step



16' x 32' or 18' x 32' Mountain Lake with Radius Inside Step



Built to Pool Dealer Designs



Peanut shape with



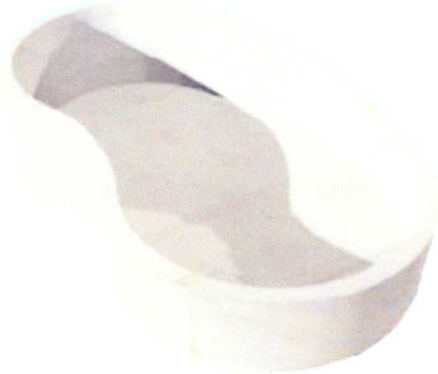
Oval with Radius Outside Step



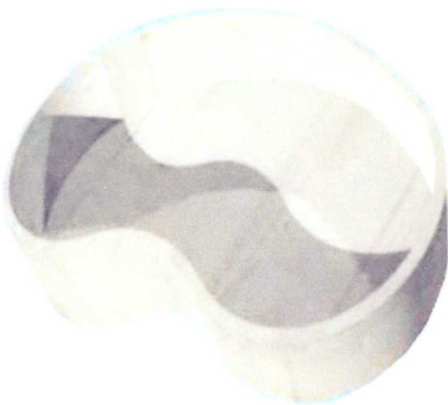
Oval with Radius Inside Step



Oval with no Step



3.5 x 7 Meter Kidney with no step



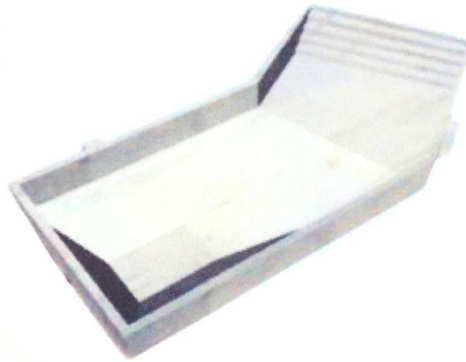
4 x 8 Meter Kidney
with no step



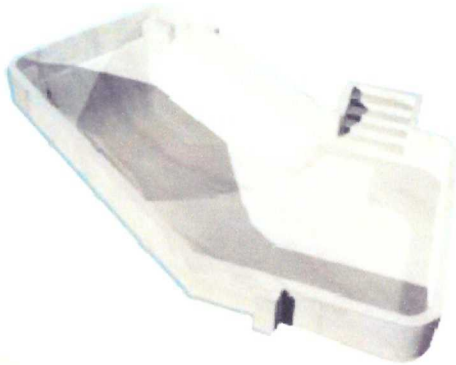
Kidney with Radius Outside Step



Lazy L with End Step
and Grecian End



Lazy L with End Step
and 90° Corners



Lazy L with Outside Step
and 2" Radius Corners with
Corners corner bench seat



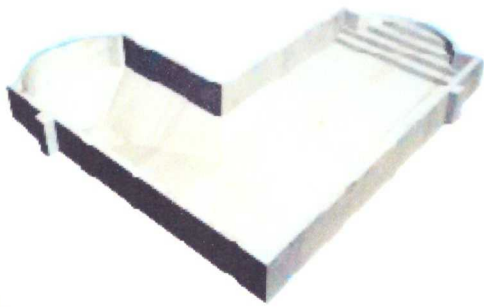
Lazy L with Outside Step
and 6" Radius



Lazy L with Radius Corner Step
and 2" Radius Corners



Lazy L with Straight Corner Step
and 2" Radius Corners



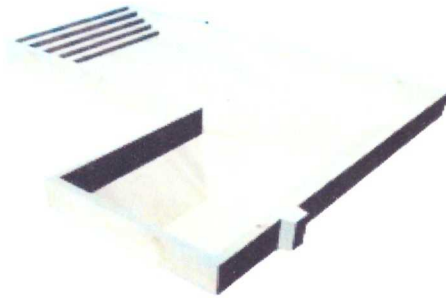
L with Roman End Step
and Roman End



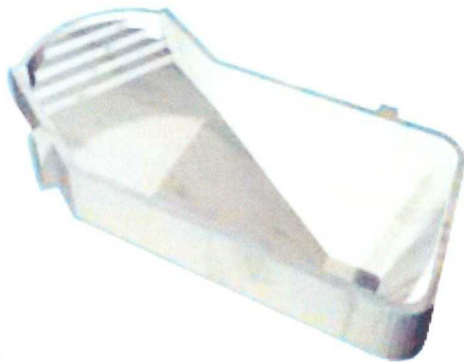
L with Straight Corner Step,
Swimout and 6" Radius Corners



L with 2' Radius Corners



L with End Step and 90° Corners

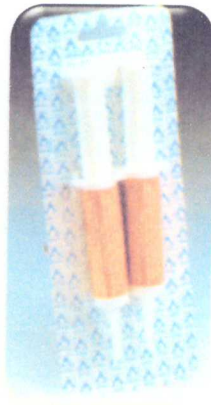


Lazy L with Roman End Step
and 2' Radius Corners



Lazy L with Outside Step
and Diagonal Corners

6. Parts repairing kit



Skimmers are essential for a pool, which receives only periodical attention, whereas a large pool with full-time attendants may have an overflow gutter instead of skimmers.

3.2 Overflow gutter

The overflow gutter extends around the pool at water level, and incorporates drains at frequent intervals. These feed into a recirculation tank connected to the filter pump. The principal function of the recirculation tank is to salvage treated water, which would otherwise go to the sewer. It is arranged to prevent air being drawn into the filter pump, and allows convenient introduction of raw water ahead of the filter and other apparatus.

Overflow gutter components:

1. Overflow grid
2. White PVC overflows gutter profile
3. Myrtha panel
4. Myrtha "Diagonal Flow" gutters
5. Structural buttress

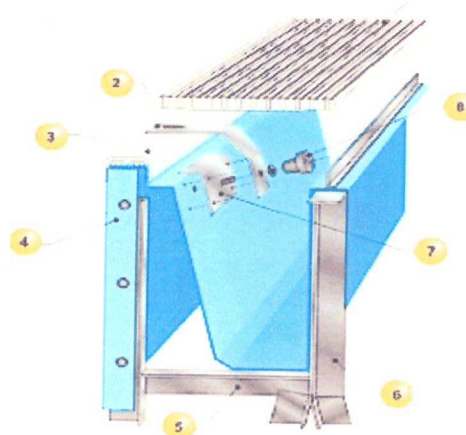


Figure (3.5): Overflow gutter components

6. Plate for fixing to the channel
7. Racing lane anchor
8. Hand wheel

3.3 Return inlets

Return inlets are nozzles that used to return the water to the pool after the filtration process. There are two types of return inlets; wall and floor inlets.

3.3.1 Types of return inlets

A) Wall inlet circulation systems

Side wall flow to main drain and skimmers, or perimeter over flow or opposite side wall outlet. High inlets help surface clearance, and low inlets help heat distribution.

Inlets aim to sweep pool broadly or in streams, concentrating upon heavy load areas. Best for shallow pools, if short circuiting can be avoided. Large inlets/low flow (laminar even distribution) sweep towards deep drain point. Small inlets/ high flow (turbulent rapid distribution) increase mixing to avoid dead spots.



Figure (3.6): Wall inlet

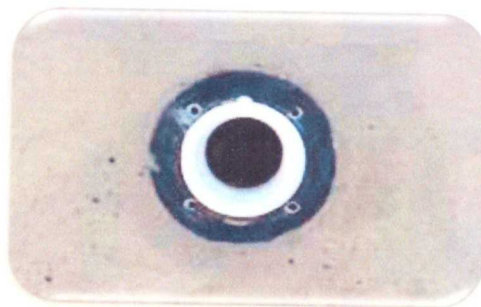


Figure (3.7): Construct wall inlet

End wall ribbon flow to main drain/over flow or opposite end wall outlet. Clearing shallow end to deep ensuring a continual supply of treated water at maximum pollution load area. An even, wide flow requires careful inlet positioning for corners. Surface clearance at (25-30) percent flow to filter. Ribbon circulation is boosted with secondary in-flow from grilles set in the transition slope towards main drain.

B) Floor inlet circulation systems

❖ Definition :

Floor flow grilles to main drain and/or skimmers/overflow. Effective circulation from pool floor with the number of inlets increased for shallow, polluted parts. The better distribution of heated water from this system is increasingly favored in north America, plus a shallow to deep end drift arrangement. Up-flow center strip or low wall inlet (0.2 m above floor), with or without floating weirs. 100 percent surface clearance removing greatest pollution in shortest possible time. Treated water rises along whole pool floor center line the maximum rate allocated to shallow end.



Figure (3.8): Construct floor inlets



Figure (3.9): Adjustable angled floor inlet Figure (3.10): Floor inlet

Sometimes additional end wall inlets with deep end main drains are included to offer lengthwise circulations as well.

3.3.2 Return inlet capacity and distribution

The capacity of return inlets varies between 4 m³/h to 20 m³/h, it depends on the volume of water, the type of the return inlet, and its position.

Distribution of the return inlets depends on the surface area of the pool and its number depends on turnover rate.

3.4 Main drains

3.4.1 Definition and purpose

It is located at the deepest point of the pool on the end of the suction piping from the filter pump.

It draws water from the bottom of the pool where dirt accumulates and permits complete drainage of the pool for maintenance purposes.

The main drain has one or more plumbing ports . One port feeds a pipe to the pump . In a spa , there might to be several ports for several pipes leading to different pumps.

Another port is a one way valve (check valve) that allows water that might collect under the pool to enter the pool , but no water can flow out. Figure (3.) depicts a main drain.



Figure (3.11): Main drains

Water collecting under the pool creates extreme upward pressure that can crack the pool . This pressure which is called hydrostatic pressure, is relieved by this valve.

Hydrostatic pressure is an important consideration when planning to drain a pool for any reason. Obviously, it is not wise to drain a pool completely during the rainy season or if there is any other suspicion of groundwater.

In some spas, there might be more than one main drain so that if one becomes covered with a foot or hand, water pulls from the other, avoiding injury to the bather. These drains are usually located at least 30 centimeters apart. Obviously, in a pool

where the main drain is very deep, this is not a concern, so safety suction lines are not added. Also, the suction in a pool is usually divided between the main drain and the skimmer, so one is not dangerously stronger than the other.

In any case, the drain area is covered by a gate, usually 20 to 30 centimeters in diameter that screws or twist-locks into a ring that has been plastered into the pool bottom.

3.4.2 Main drains models:

There are many models of main drains such as:

- ❖ Circular main drain Φ 200 mm with anti vortex grill



Figure (3.12): Anti vortex grill main drain

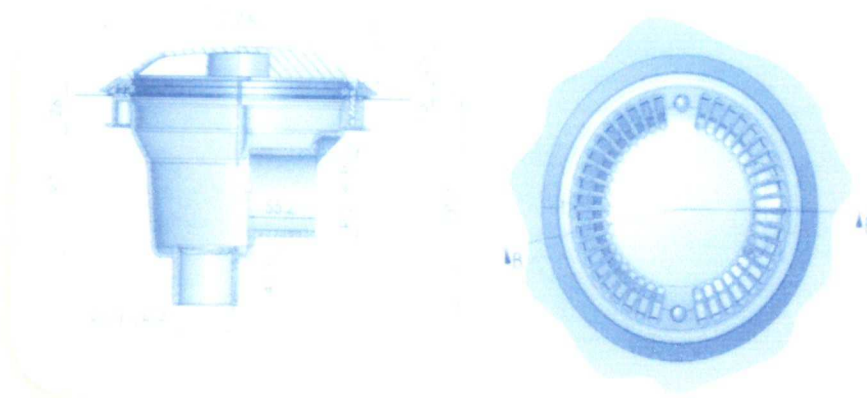


Figure (3.13): Anti vortex grill main drain cross section.

- ❖ Circular main drain Φ 200 mm with flat grill



Figure (3.14): Flat grill main drain

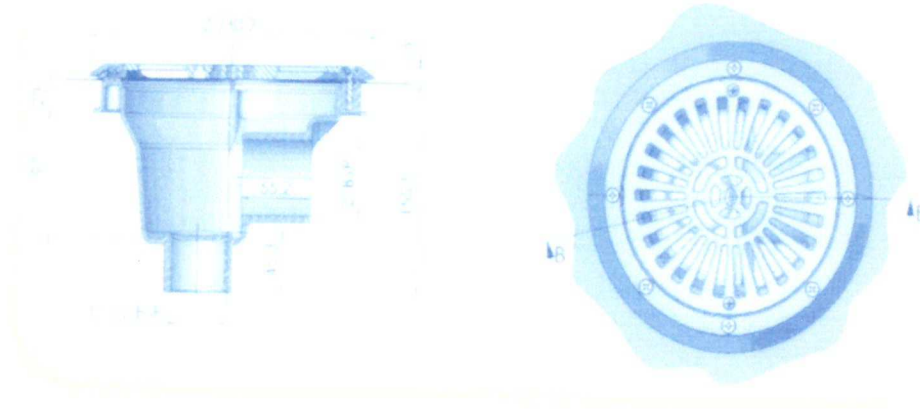


Figure (3.15): Flat grill main drain cross section.

- ❖ Square outlet



Figure (3.16): Square outlet main drain

❖ Circular outlet



Figure (3.17): Circular outlet main drain

3.4.3 Main drains surface area and distribution:

There are many different main drains surface areas; depend on pool surface area and pool capacity.

The main drain surface area is very important to determine the outlet water velocity. The maximum velocity of the main drain is 0.5 m/s , then the bathers comfort conditions are available by decreasing the suction water under their feet and bodies.

All main drains made of plastic provided with protected grills. The minimum distance between drains greater than 2 meters.

3.4.4 Main drain accessories

1. Hydrostatic valve



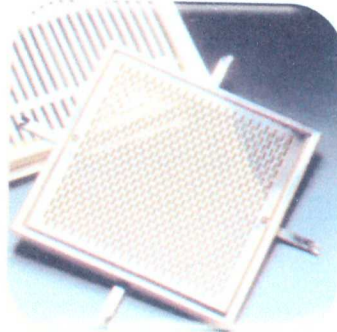
2. Drainage tube



3. Flush anti-vortex lid



4. Drain grilles



3.5 Pool lighting

3.5.1 Low voltage lighting

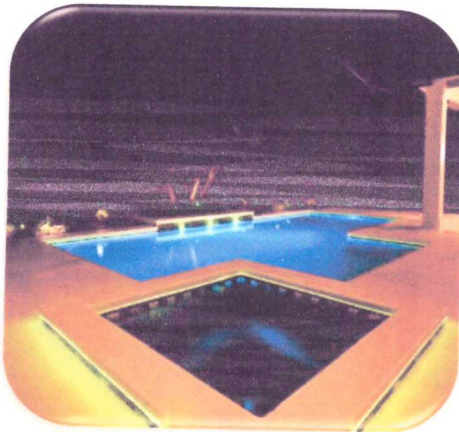
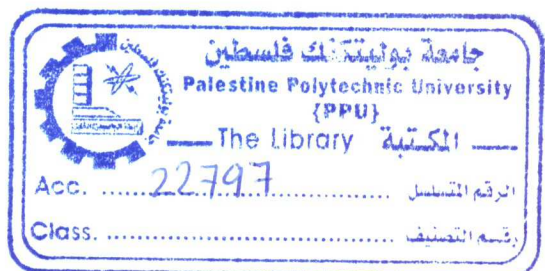


Figure (3.18): Low voltage lighting

Common systems are 12 or 24 v and they should be wired to provide balanced lighting intensity for multiple unit.



- ❖ Size is selected according to the distance and load involved, with the maximum permitted voltage drop at percent.

Transformers which are made to protect casing should be double-wound with grounded metal screen between primary and secondary winding :

Also they should include allowance for adjustment of low voltage tapping up to a 50 percent variation.

3.5.2 In ground Pool Lights

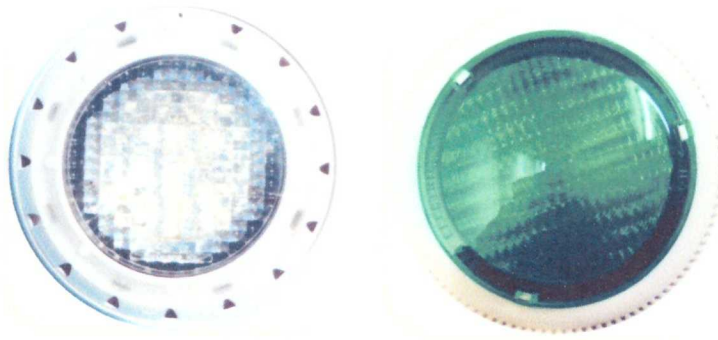


Figure (3.19): In ground Pool Lights

We provide the latest in ground Swimming Pool Lighting. We provide the standard white light such as the Hayward Astrolite or the latest LED technology. LED Lights can bring the fiber optic affect and color into your pool. With such companies as Super Vision, Pentair and Fiberstars you can set the mood with soothing colors .

۳.۵.۳ Above Ground Pool Lights



Figure (3.20): Above Ground Pool Lights

Above Ground Pool Lights are now a possibility. The Pentair Aqualuminator fits right into return fitting. It also comes in a color changing light affect. Purchase the Glow Buoy that lights your pool while it floats around our swimming pool. Clip a nitelighter onto the side of your above ground pool.

CHAPTER FOUR PIPES & FITTINGS



4 Pipes and fittings

4.1 Introduction

Pipes play a basic and important role in practical life; they are the channels used to carry gases and liquids from a certain place to another. their importance appear in many practical fields; Some of these include:

Water and fire nets, refrigeration and air conditioning nets, all kinds of gas nets, and rain and sanitary drainage nets. In addition to that, tubes are used also for many industrial applications like chemical materials, food and medicines.

4.2 Types of pipes

Pipes are divided into two basic parts; metals and nonmetals.

a) Metal pipes:

Pipes which are manufactured from different metals such as :

- Steel and iron pipes.
- Red copper pipes.
- Pipes with special applications; stainless steel, lead, aluminum, and titanium pipes.

b) Nonmetal pipes :

Pipes that are used in relative low pressure and temperature applications
Such as plastic, glass, clay, and others.

In this chapter we will talk about plastic pipes; because they are used much nowadays in swimming pools.

4.3 Advantages of Plastic Pipe Systems

There are many advantages of plastic pipes such as:

- light weight,
- easier to install than metal piping systems,
- Faster to install as well as being more cost effective than metal piping systems.
- They are used for both above and below ground applications.
- A well-installed and well-maintained Plastic Pressure Pipe System could have a life cycle of up to 50 years. This is dependent upon the medium, temperature, chemical consistency, pressure and type of plastic pressure pipe system selected.

4.4 Common Plastic Pipes

- ABS Pipe (Acrylonitrile butadiene styrene)
- PVC Pipe (Polyvinyl chloride)
- UPVC Pipe or PVC-U Pipe (Polyvinyl chloride, unplasticized)
- CPVC Pipe (Polyvinyl chloride, post chlorinated)
- PP Pipe (Polypropylene)
- PVDF (Polyvinylidene fluoride)
- PE Pipe or MDPE Pipe (Polyethylene) also known as LDPE, MDPE and HDPE

Note

LDPE, MDPE and HDPE = low, medium, and high density Polyethylene.

4.5 Selections of pipe materials

In order to select the most suitable material for a pipe system the following factors need to be considered:

- Medium or type of fluid and its chemical composition
- Operating temperature
- Operating pressure

These factors are interlinked and only when all have been addressed can the correct type of Plastic Pressure Pipe System be selected.

This chapter shows PVC type of plastic piping.

4.6 PVC pipes

Polyvinylchloride, widely known by its abbreviation PVC, is one of the most important and oldest mass produced plastics. PVC is a polymer having approximately 56% by weight of chlorine. Only by using additives, does it become a workable and implement able material. The additives allow a wide variation in characteristics and so allow matching to the planned application. PVC is an environmentally compatible product and can be recycled.

Characteristics of PVC pipes

1. Basic properties: chemically inert; water, corrosion and weather resistant; high strength-to-weight ratio; tough, dent-resistant; an electrical and thermal insulator; and maintains properties over long periods.
2. Process versatility; can be made in different form to permit processing on a wide variety of equipment; each form can be altered further by compounding to achieve particular properties in products, which range from soft to rigid in nature.
3. Properties can be provided at an economic cost. In the long term, PVC products are less energy-intensive on an installed basis than most conventional materials. Their lightweight, insulating-and maintenance-free characteristics contribute to conservation of energy over the life of the product.

4.7 U-PVC pipes

Unplasticised polyvinyl chloride (U-PVC) is the most widely used of all plastics used for pipe installations. It is rigid, versatile.

The following general properties of this type :

- Temperature range: 0°C to 60°C.
- Abrasion resistant.
- Non-toxic and taint free.
- Rigid pipes: no special support needed.
- Ideal for above and below ground use.
- Resistant to many inorganic chemicals.
- Threading possible.
- Resistant to most solutions of acids, alkalis and salts.
- No special tools required for installation.
- Jointing by cold solvent welding or rubber ring mechanical joints.
- Not resistant to aromatic and chlorinated hydrocarbons.

4.8 C-PVC pipes

The abbreviation PVC-C stands for chlorinated polyvinylchloride. It is made by post-chlorination of PVC whereby chlorine is attached to the PVC chain.

The following general properties of this type :

- Temperature range: 0°C to 80°C.
- Good mechanical strength.
- Low thermal conductivity.
- Odorless and tasteless.
- Rigid pipes are suitable for above ground use.
- Resistant to many inorganic chemicals.
- Threading possible.
- No special jointing tools required.

- Uninflammable and self-extinguishing.
- Not resistant to organic solvents.

4.9 Plumbing methods

The concept of joining PVC pipe involves welding the material together by using glue that actually melts the plastic parts to each other. In truth, each joint will have an area that is slightly tighter than the rest. In the tightest parts, this welding actually occurs.

In the remainder, the glue bonds to each surface and itself becomes the bonding agent. Obviously, the strongest part of each joint is the welded portion; but in either case, the key is to use enough glue to ensure total coverage of the surfaces to be joined.

Following is the correct procedures for plumbing with PVC (Fig.4.1).

1. Cut and Fit: Cut and dry fit all joints and plumbing planned. It is easy to make mistakes in measuring or cutting and sometimes fittings are not uniform so they don't fit well. Dry fitting ensures the job is right before gluing. If you need the fitting and pipe to line up exactly for alignment with other parts, make a line on the fitting and pipe (Fig. 4.1A).with a marker when dry fitting so you have a reference when you glue them together.

2. Sand: Lightly sand the pipe (Fig.4.1B) and inside the fittings so they are free of burrs. The slightly rough surface will also help the glue adhere better.

3. Prime: You might need to apply a preparation material, called primer, to the areas to be joined before gluing (Fig.4.1C), Some PVC glues are solvent/glue combinations and no primer is required. In some states, however, use of primer might be required by building code, so check that before selecting an all-in-one product. If you use primer, apply it with the swab provided to both the pipe and the inside of the fitting. Read and follow the directions on the can.

4. Glue: Before gluing, be ready to fit the components together quickly because PVC glue sets up in 5 to 10 seconds. Apply glue to the pipe and inside of the fitting (Fig.4.1D).

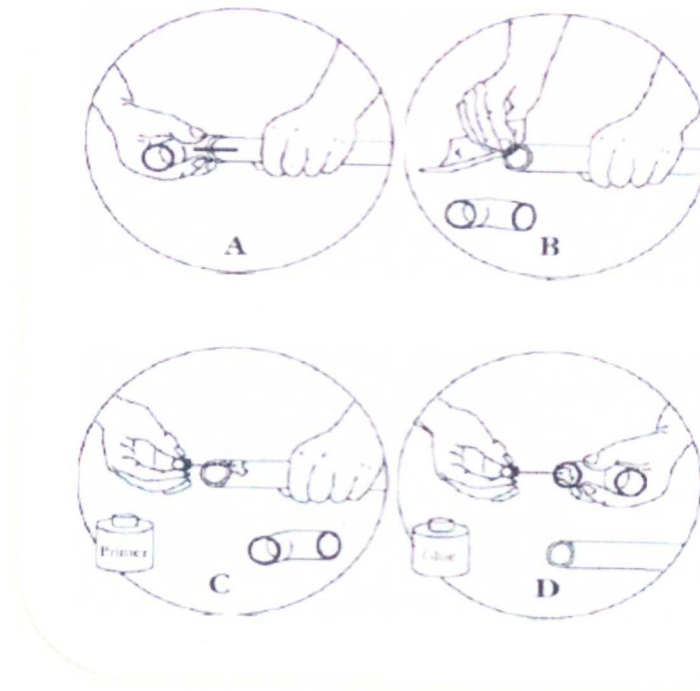


Figure (4.1) Step-by-step PVC plumbing.

5. Join: Fit the pipe and fitting together, duplicate your dry fit, and twist about a half turn to help distribute the glue evenly, realigning the lines drawn on the pipe and on the fitting. If using flexible PVC, because it is made by coiling a thin piece of material and bonding it together, do not twist it clockwise. This can make the material swell and push the pipe out of the fitting. Get in the habit of twisting all pipe counterclockwise (even though it makes no difference with rigid PVC) and you will never make that mistake.

6. Seal With rigid PVC, hold the joint together about a minute to ensure a tight fit; about two minutes with flex PVC. Although the joint will hold the required working pressure in a few minutes (and long before the glue is totally dry), allow overnight drying before running water through the pipe to be sure. I have seen demonstrations with some products (notably Pool-Tite solvent/glue) where the gluing was done underwater, put immediately under pressure, and is held just fine. I don't, however; recommend this procedure as I have gone back on too many plumbing jobs to fix leaks a few weeks later because I hastily fired up the system after allowing only a few minutes drying time.

4.10 Losses in Pipe and Fittings

Losses of head are incurred by fluid, which occurs at fitting such as bends or valves, and by frictional resistance at the pipe wall. For long pipe line the head losses due to fittings is negligible, on the other hand, for short pipe the head loss is pig due to the local mixing near the fitting.

The head loss in piping system is divided into two types:

1) Major losses:

They are due to viscous resistance in straight constant diameter pipes.

2) Minor losses:

They appear due to localized effects, which mainly a rise changes in the flow cross-sectional area (such as in nozzles, diffusers, valves, floe meters, etc....) or changes in the flow direction due to the bends and elbows.

4.10.1 Major losses:

The friction head loss: It represents the amount of energy converted into heat per unit weight of fluid.

The losses h_f is defined as follows:

$$h_f = f \frac{L}{D} \frac{v^2}{2g}$$

Where:

h_f : head losses due to friction.

f: friction factor.

L: length of pipe.

D: diameter of pipe.

And the friction is related to Reynolds (Re), which related the type of flow whether it is laminar or turbulent.

For laminar flow:

$$f = \frac{64}{\text{Re}}$$

For turbulent flow:

$$f = 0.079 \text{Re}^{-\frac{1}{4}}$$

and

$$\text{Re} = \frac{\rho v D}{\mu}$$

μ : coefficient of absolute viscosity of the fluid.

4.10.2 Minor losses:

The fittings are used in many pipes connections, and there are several types of these fittings like:

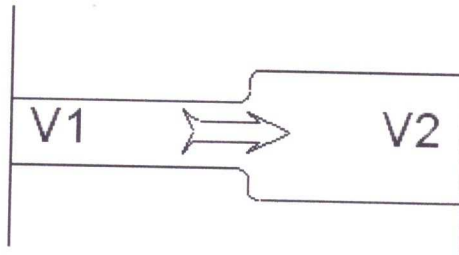
1- Elbows and bending:

$$h_f = K \frac{v^2}{2g} \quad (\text{m})$$

where:

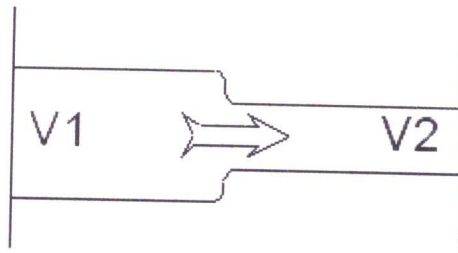
K: fitting constant.

2- Sudden enlargement:



$$h_f = \frac{v_1^2 - v_2^2}{2g}$$

3- Losses due to sudden contraction:



$$h_f = \frac{v_2^2 - v_1^2}{2g}$$

4.10.3 Fitting equivalent length

Theoretically, we can replace the fitting a pipe, which will cause the same head loss, as the replaced fitting, so we can determine the length of the pipe as follows:

$$h_f = K \frac{v^2}{2g} = f \frac{L}{D} * \frac{v^2}{2g}$$

$$K = f \frac{L}{D}$$

$$L = D \frac{K}{f}$$

K: fitting constant.

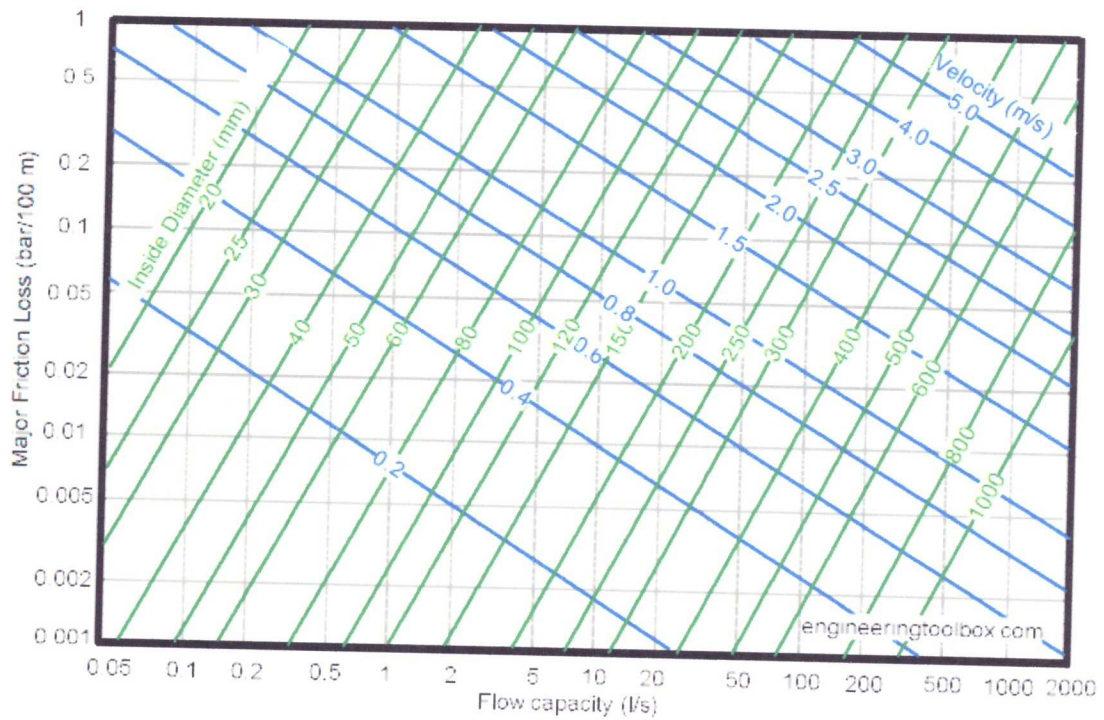


Figure (4.2): PVC Major Friction loss in pipes

4.11 PVC fittings and accessories

PVC 90 elbow



PVC 45 elbow



PVC - T 90



PVC union socket



PVC adaptor nipple



PVC 3species union



PVC Ball valve



PVC pipe



Bush coupling



8 lateral ring manifold



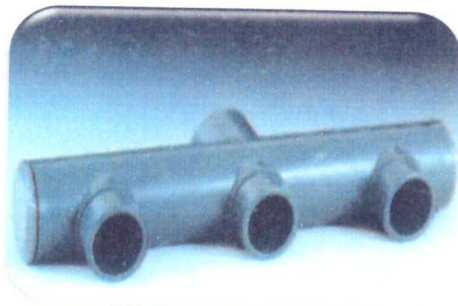
3/4 in. lateral



filter sprinkler



Collector pipe for valve manifold



4.12 Pressure fluid handling PVC accessories

Dissolvent for PVC



PVC- Gel

It is used for large diameter pipe for handling pressure fluids, moderating initial setting time and permitting locating the parts in place . Gel consistency eliminates any glue cob webbing, all are supplied with brush.



PVC- blue

It is special for pools, for use in pool installations. Its high gel composition and covering capacity eliminate cob webbing.



CHAPTER SIX

PUMPS



6 Pumps and Motors

6.1 Introduction

A pump, in general may be defined as a machine, when driven from some external source, lifts water or some other liquids from a lower level to a higher level. Or in other words, a pump may also be defined as a machine, which converts mechanical energy into pressure energy.

Pump and motor are two different elements of the water circulation system, not the same thing, not interchangeable. The motor is the device that converts electrical energy into mechanical energy. It powers the pump, which is the device that actually causes the water to move. One is not much use without the other.

Since the olden times, the man has been trying to find some convenient ways of lifting water to higher levels, for water supply or irrigation purposes. It is believed, that the idea of lifting water, by centrifugal force, was first given by L.D. Vinci (an Italian scientist and engineer) in the end of 16th century. Then this idea was put to experiments by French scientist and they designed centrifugal pump, having impeller and blades. At that time, the reciprocating pumps were very popular.

Then a continuous advancement of this pump has brought it to a high degree of perfection, which is used all over the world these days.

Pool and spa pumps are classified as centrifugal pumps. That is, they accomplish their task of moving water thanks to the principle of centrifugal force. To imagine this concept, hold a bucket with some water in it at the end of your arm and spin it around in a big sweeping circle. Centrifugal force is what keeps the water in the bucket as you spin it. If you poke a hole in the bucket and spin it again, that same force, pushing the water to the bottom of the bucket, sends it shooting out the hole. If

The pump which raises water or a liquid from a lower level to a higher level by the action of centrifugal force, is known as a centrifugal pump.

It will be interesting to know that the action of a centrifugal pump is that of a reversed reaction turbine. In a reaction turbine, the water at high pressure, is allowed to enter the casing which gives mechanical energy at its shaft; whereas in a pump, the mechanical energy is fed into the shaft and water enters the impeller (attached to the rotating shaft) which increases the pressure energy of the out-going fluid. The water enters the impeller radially and leaves the vanes axially.

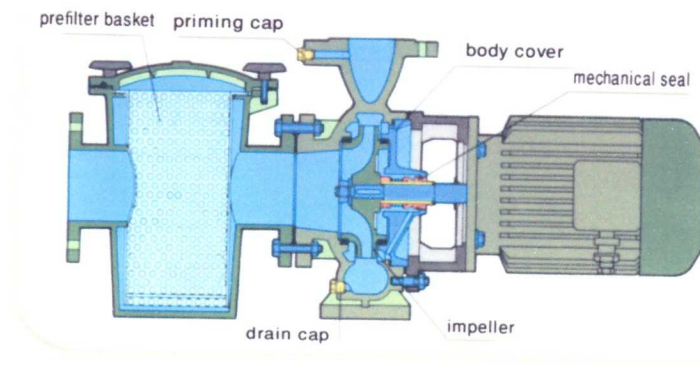


Figure (6.4) : Cross section of a centrifugal pump.

6.2.1 Types of Casings for the Impeller of a Centrifugal Pump

We have discussed that a centrifugal pump consists of an impeller, similar to that of a turbine, to which curved vanes are fitted. The impeller is enclosed in a water-tight casing, having a delivery pipe in one of its sides. The casing for a centrifugal pump is so designed that the kinetic energy of the water is converted into pressure energy before the water leaves the casing. This considerably increases the efficiency of the pump. Following are the three types of casings or chambers of centrifugal pumps:

you spin the bucket faster, the water shoots out with more force. Obviously, if you make a larger hole, more water will shoot out as you spin it around.

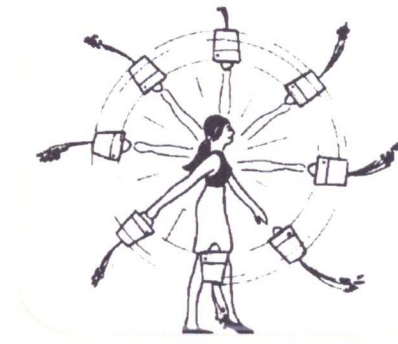


Figure (6.1) : Centrifugal force.

The pump operates the same way (Fig. 6-2). The impeller in the pump spins, shooting water out of it. As the water escapes, a vacuum is created that demands more water to equalize this force. Water is pulled from the pool or spa and sent on its way through the circulation plumbing.

Just as various designs in your swinging bucket and its hole determine the amount of water and how fast it escapes, so too the various designs of impellers, diffusers, and volutes determine the same features in a pool pump. This is discussed in more detail in later sections.

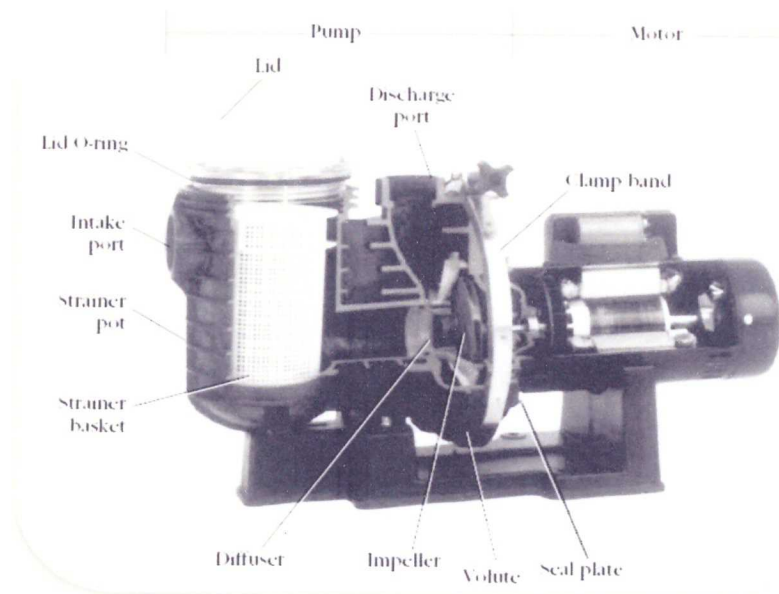


Figure (6.2) : Typical pump and motor combination.

In this chapter, we shall discuss the centrifugal pumps only.

6.2 Centrifugal Pump

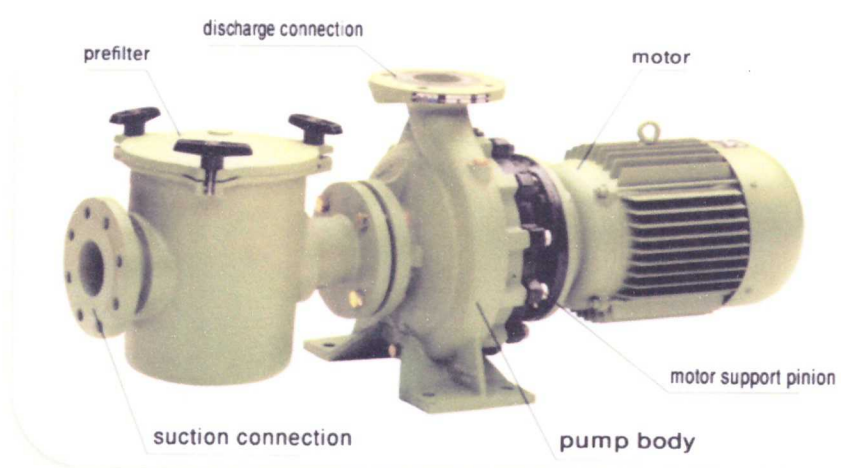


Figure (6.3) : Main parts of centrifugal pump.

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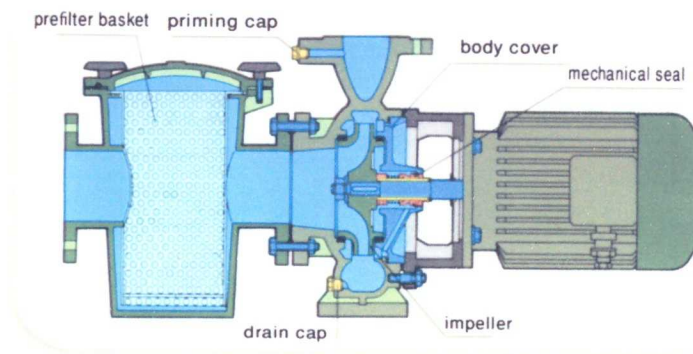


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1. Volute casing (spiral casing).
2. Vortex casing.
3. Volute casing with guide blades.

1.Volute Casing (Spiral Casing)

In a volute chamber, the impeller is surrounded by a spiral casing as shown in Fig.(6.4.a) Such a casing provides a gradual increase in the area of flow; which decreases the velocity of water, with a corresponding increase in pressure.

A considerable loss takes place due to the formation of eddies in this type of casing.

2.Vortex Casing

It is an improved type of a volute casing, in which the spiral casing is combined with a circular chamber as shown in Fig.(6.4.b). In a vortex casing, the eddies are reduced to a considerable extent and an increased efficiency is obtained.

3.Volute Casing with Guide Blades

In this type of casing, there are guide blades surrounding the impeller as shown in Fig.(6.4.c). These guide blades are arranged at such an angle, that the water enters without shock and forms a passage of increasing area, through which the water passes and reaches the delivery pipe.

The ring of the guide blades is called diffuser and is very efficient.

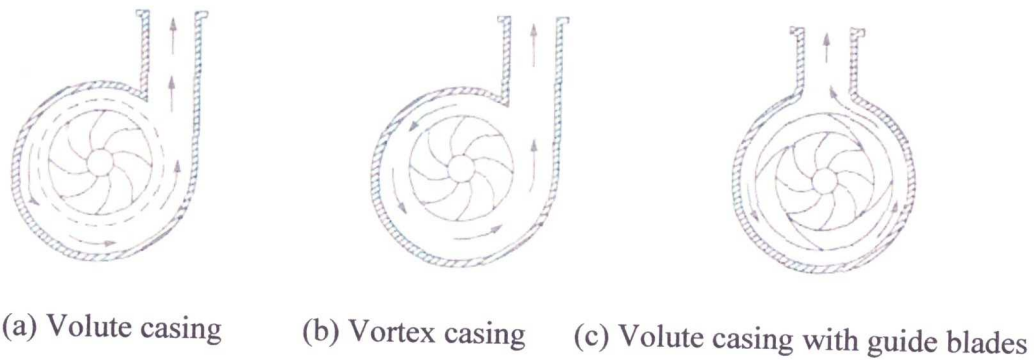


Figure (6.5) : Types of casing for the Impeller of a Centrifugal Pump.

6.2.2 Pump plumping

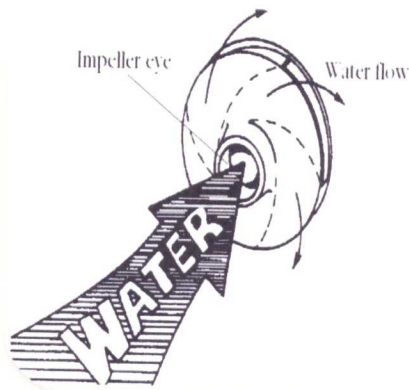


Figure (6.6) : Working method of centrifugal pump.

The successful working of a centrifugal pump depends on the correct selection and lay out of its piping system. An extreme care should always be taken in selecting the sizes of the pipes and their arrangement. In general, a centrifugal pump has suction pipe and delivery pipe.

(a) Suction pipe

The suction pipe, of a centrifugal pump, plays an important role in the successful and smooth working of the pump. A poorly designed suction pipe causes insufficient net positive suction head (NPSH), vibration, noise, water hammer, excessive wear etc. While laying the pipe, a great care should be taken to make it air tight. A strainer foot-valve is connected at the bottom of the suction pipe to avoid the entry of foreign matter. Since the pressure at the inlet of the pump is suction (i.e., negative) and its value is limited to avoid cavitations, it is therefore essential that the losses in the suction pipe should be as small as possible. For this purpose, bends in the suction pipe are avoided and its diameter is often kept larger.

Sometimes, to reduce the axial thrust, the suction pipe is branched into two parts and the liquid is allowed to enter the impeller from both sides. Such a pump is called double suction pump.

(b) Delivery pipe

A check valve is provided in the delivery pipe near the pump in order to protect the pump from mechanical hammer and also to regulate the discharge from the pump. The size and length of the delivery pipe depends on the requirement.

6.2.3 Head of the pump

Suction Head: by restricting the intake or requiring the pump to lift water from a source below it, you also create head. This is called suction head, sometimes called vertical feet of water, it's the same thing.

Each foot on the suction side equals a similar foot on the discharge side, called discharge head. The only thing to remember here is that head (resistance) is created on both sides and must be calculated when determining pump size.

Dynamic and Static Head: Up to now suction head described as the head created by the weight of standing (static) water. This is only a small portion of the total head in the system. The rest is created by the friction of water flowing through the entire system, called dynamic (moving) head. The diameter of the pipe and the speed of the water determines how much resistance is created by friction. Further friction is created when water must go through or around other obstacles, such as through the filter, heater, and plumbing fittings.

And just to be clear at the outset, the length of the pipe (in m) does not always translate directly into the same number of feet in head loss. There are reference tables that tell you what head loss to expect for each foot of pipe or each fitting.

Total Dynamic Head: Total dynamic head (TDH) is the total of plumbing and equipment head for the entire system. Vacuum head (suction) plus pressure head (discharge) equals total dynamic head.

Total head = static head + friction losses in piping (suction, delivery) + dynamic head in (main drains, return inlets, and skimmers) $\frac{v^2}{2g}$ + dynamic head in (filter, heater, and water chlorine device).

There are two positions where the swimming pool pumps are mounted :

- 1) Where the pump is above pool water level :

The check valve prevents water draining from the suction pipe when the hair and lint strainer is opened. If the pump does not have a built-in check valve, either a separate check valve or a gate valve may be installed in the suction line for the same purpose. In addition to the valve in the suction line, the use of a gate valve in the pool return line is necessary to prevent the hair and lint strainer from emptying because of siphon action through the filter. This use of valves ensures a quick return to service because the system remains full of water so that repriming is not necessary.

In this case the static head is active.

2) Where the pump is below pool water level :

A check valve is ineffective. Gate valves in the suction and pool return lines are essential to prevent a flood in the filter bit when the hair and lint strainer is opened.

In this case the static head equals zero.

6.2.4 Discharge of a Centrifugal Pump

The discharge of a centrifugal may be found out by the same method as that of a reaction turbine. Now consider a centrifugal pump lifting water from a lower level to a higher level.

Let

D : Diameter of impeller at inlet,

V_f : Velocity of flow at inlet,

b : Width of impeller at inlet, and

D_1, b_1, V_{f1} : Corresponding values at the outlet.

Then the discharge, $Q = \pi D b V_f = \pi D_1 b_1 V_{f1}$

6.2.5 Power Required to Drive a Centrifugal Pump

The power required to drive a centrifugal pump may be found out by either of the following two methods:

1. The power required to drive the pump from the manometric head may be found out by the relation,

$$P = \frac{wQH_m}{\eta_o} \text{ kW}$$

where

H_m = Manometric head of water in meters,

Q = Discharge of the pump in m^3/sec ,

η_o : Overall efficiency of the pump.

2. The power required to drive the pump from the velocity triangles may be found out by the relation,

$$P = \frac{wQ \cdot V_{m1} \cdot v_1}{g} \text{ kW}$$

where

V_{m1} : Velocity of whirl at outlet.

v_1 : Tangential velocity of impeller at outlet.

6.2.6 Specific Speed of a Centrifugal Pump

The specific speed of a centrifugal pump may be defined as the speed of an imaginary pump, identical with the given pump, which will discharge one liter of water, while it is being raised through a head of one meter.

Let

N_s : Specific speed of the pump,

D_1 : Diameter of the impeller at outlet,

N : Speed of the impeller in r.p.m.,

v_1 : Tangential velocity of impeller at outlet, and

H : Lift of the pump in meters.

We know that the tangential velocity of the impeller,

$$v = \frac{\pi N D_1}{60}$$

Now let Q : Discharge of the pump m^3/s

b_1 : Width of the impeller at outlet, and

V_{f1} : Velocity of flow at outlet.

We know that the discharge

$$Q = \pi D_1 b_1 V_{f1}$$

$$N_s = \frac{N \sqrt{Q}}{H^{\frac{3}{4}}}$$

6.2.7 Selection of Centrifugal Pumps Based on Specific Speed

The specific speed of a centrifugal pump, like that of a turbine, helps us in selecting the type of centrifugal pump.

The following table shows the type of centrifugal pump for the corresponding specific speed.

Table (6.1) : corresponding specific speed of centrifugal pump by its type.

No	Specific speed	Type of centrifugal pump
1	10 to 30	Slow speed pump, with radial flow at outlet .
2	30 to 50	Medium speed pump, with radial flow outlet.
3	50 to 80	High speed pump, with radial flow outlet.
4	80 to 160	High speed pump, with mixed flow outlet .
5	160 to 500	High speed pump, with axial flow at outlet .
6	Above 500	Very high speed pump.

6.2.8 Net Positive Suction Head (NPSH)

It is a commercial term used by the pump manufacturers, and indicates the suction head and vapor pressure the suction head which the pump impeller can produce. We have already discussed in the last articles. There, we derived a relation for the suction head (or more accurately the limiting suction head), such as:

$$H_s = \frac{P_a - P_v}{\rho g} - H_{fs} - \frac{v_s^2}{2g} \quad \dots(\text{In terms of } P_a \text{ and } P_v)$$

$$= H_a - H_v - H_{fs} - \frac{v_s^2}{2g} \quad \dots(\text{In terms of } H_a \text{ and } H_v)$$

The right hand side of the above equations represents the suction head or net positive suction head.

For any pump installation, a distinction is generally made between the required NPSH and the available NPSH. The required NPSH varies with the pump design, its speed, capacity etc. The available NPSH depends on the site conditions and the available equipment. In order to have a smooth working of the pump, the available NPSH should be more (or equal) to the required NPSH.

6.2.9 Cavitations in Centrifugal Pumps

The phenomenon of cavitation or mechanical hammer. If a centrifugal pump, is working at high suction head or high vapor pressure, cavitation is formed. It damages the impeller.

The cavitation can be eliminated (or minimized) by the following precautions :

1. The liquid temperature should be as low as possible to keep the vapor pressure down and to obtain an increased NPSH.
2. The velocity of liquid in the suction pipe should be as low as practicable.
3. As far as possible, the sharp bends in the suction pipe should be avoided to reduce loss of head.

6.2.10 Priming of a Centrifugal Pump

A self-priming pump is a pump which will clear its passages of air if it becomes air bound and resume delivery of the pump age without outside attention.

The pressure developed by the impeller of a centrifugal pump, is proportional to the density of the fluid in the impeller. It is thus obvious, that if impeller is running in air, it will produce only a negligible pressure, which may not suck water, from its source, through the suction pipe. To avoid this, the pump is first primed, filled up with water. For doing so, first of all the suction pipe and the impeller is completely filled with water. The delivery valve is closed and the pump is started. The rotating impeller pushes the water in the delivery pipe, opens the delivery valve and sucks water through the suction pipe.

Most pumps are self-priming centrifugal pumps. These pumps must have a vacuum chamber, commonly known as a pump housing. The pump housing must be filled with water in order for any pump to create a vacuum, resulting in your pump

pulling the water out of your pool or spa. The pump housing will remain full of water while the pump is on, and will remain full or partially full of water when the pump is shut off.

When you turn on the pump the motor will begin to rotate on high speed. The motor drives the pump impeller, located inside the pumps center portion at the opposite end, away from the electrical switch portion of the motor. While the motor is rotating, the tips of the impeller are sealed hydraulically inside of the pump diffuser, this allows self-priming to occur.

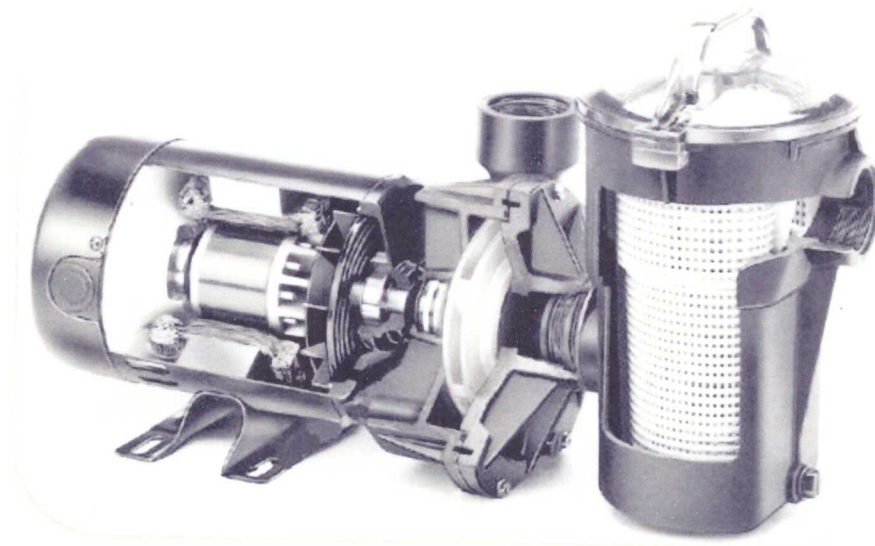


Figure (6.7) : Cross section of a centrifugal pump.

Self-priming can only occur when the pump has a diffuser. Some pumps have a separate diffuser, others have the diffuser molded into the pump's cover, refer to your Owner's Manual for your pump. The diffuser helps to eliminate any air coming into the pump housing, suction piping, or hoses on above ground pools. When all the air is being removed from the system, you will notice the bubbles returning to the pool through the return fittings.

A charge of liquid sufficient to prime the pump must be retained in the casing (See Fig.6.8. A) or in an accessory priming chamber. When the pump starts, the rotating impeller creates a partial vacuum; air from the suction piping is then drawn into this vacuum and is entrained in the liquid drawn from the priming chamber. This air-liquid mixture is then pumped into the air separation chamber (within the casing) where the air is separated from the liquid with the air being expelled out the discharge piping (Fig.6.8.B) and the liquid returning to the priming chamber. This cycle is repeated until all of the air from the suction piping has been expelled and replaced by pumpage and the prime has been established (Fig.6.8.C).

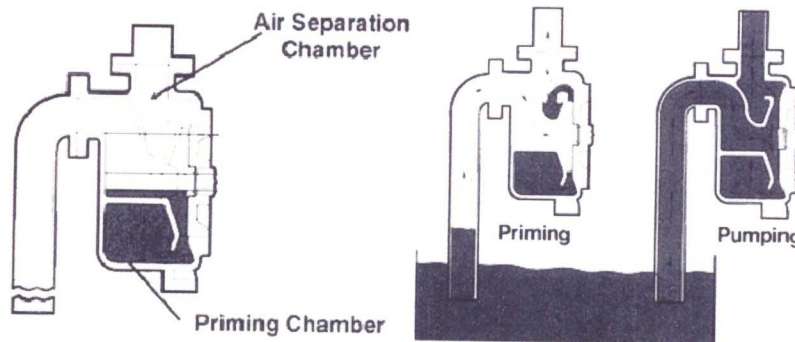


Fig.(6.8.A)

Fig.(6.8.B) / Fig.(6.8.C)

Non-self-priming pumps, particularly for freestanding pools, must be situated below water level, even if charged by hand with water to start working, since the smallest pinhole in the pipe work can cause failure of prime.

The following considerations should be made when designing a piping system for which a self-priming pump is to be used:

- 1) Care should be exercised to insure that adequate liquid is retained in the priming chamber. For outdoor/remote installations, a heating element may be required to prevent freezing. For dirty services, a strainer may be required to keep solids from accumulating in the priming chamber, thus displacing priming liquid.

- 2) The static lift and suction piping should be minimized to keep priming time to a minimum. Excessive priming time can cause liquid in the priming chamber to vaporize before prime is achieved.
- 3) All connections in the suction piping should be leak-free as air could be sucked in, thus extending/compromising priming of the pump. (Pumps sealed with packing should be flushed to prevent air from being introduced.)
- 4) A priming bypass line (See Fig.6.8.D) should be installed so that back pressure is not created in the discharge piping during priming which would prevent the pump from priming itself. (Self-priming pumps are not good air compressors!)
- 5) The suction piping should be designed which no high points are created where air can be trapped/accumulate which can prevent priming. Historically, this has been problematic on top unloading of rail cars. (See Fig.6.8.E)

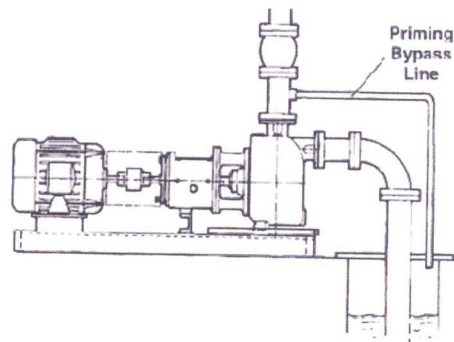


Fig.(6.8.D)

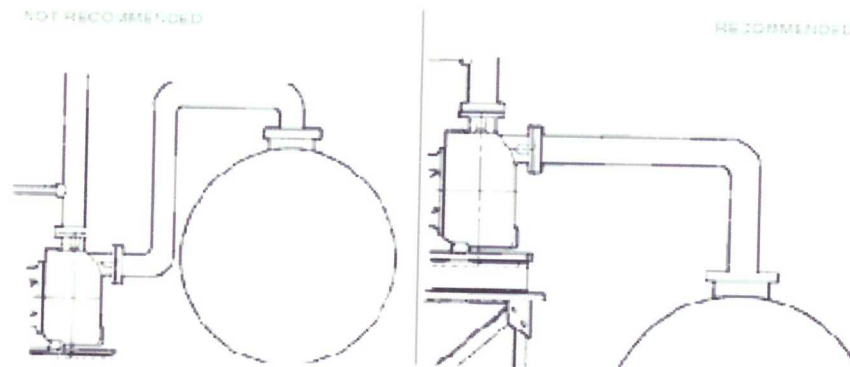


Fig.(6.8.E) : Tank Car Unloading

Figure (6.8): self priming centrifugal pump.

6.2.11 Priming Time Calculations

To calculate the total priming time for a given system:

1. Select the correct size and speed pump from the performance curve for the given rating.
2. Calculate the NPSH Available for the system. The available NPSH must be equal to or greater than the NPSH Required by the selected pump at the rating point.

$$NPSH_A = P - (L_s + V_p + h_f)$$

where:

P : Pressure on surface of liquid in feet absolute

L_s : Maximum static lift in feet from free surface of the liquid to the centerline of the impeller.

V_p : Vapor pressure of the liquid at maximum pumping temperature in feet absolute.

h_f : Suction pipe friction loss in feet at the required capacity.

3. Determine the effective static lift.

$$L_{es} = L_s \times \text{Sp. Gr.}$$

where:

L_{es} : Effective static lift in feet.

L_s : Maximum static lift in feet from free surface of the liquid to the centerline of the pump suction, or the highest point in the suction piping, whichever is greater.

Sp. Gr. : Specific gravity of the liquid.

4. Enter the priming time curve at the effective static lift calculated in Step 3. Proceed across to the impeller diameter selected for the specified rating and then downward to the bottom coordinate to determine the priming time (PT_{LES}) to achieve the given lift.

5. Insert the priming time from Step 4 into the following formula to calculate the total system priming time:

$$PT_T = PT_{LES} \times \frac{SPL}{L_{es}} \times \left(\frac{D_p}{D_s} \right)^2$$

where:

PT_T : Total system priming time.

PT_{LES} : Priming time in seconds for the effective static lift (Step 4.)

SPL : Total suction pipe length above the free surface of the liquid in feet.

L_{es} : Effective static lift.

D_p : Nominal pipe diameter.

D_s : Nominal pump suction diameter.

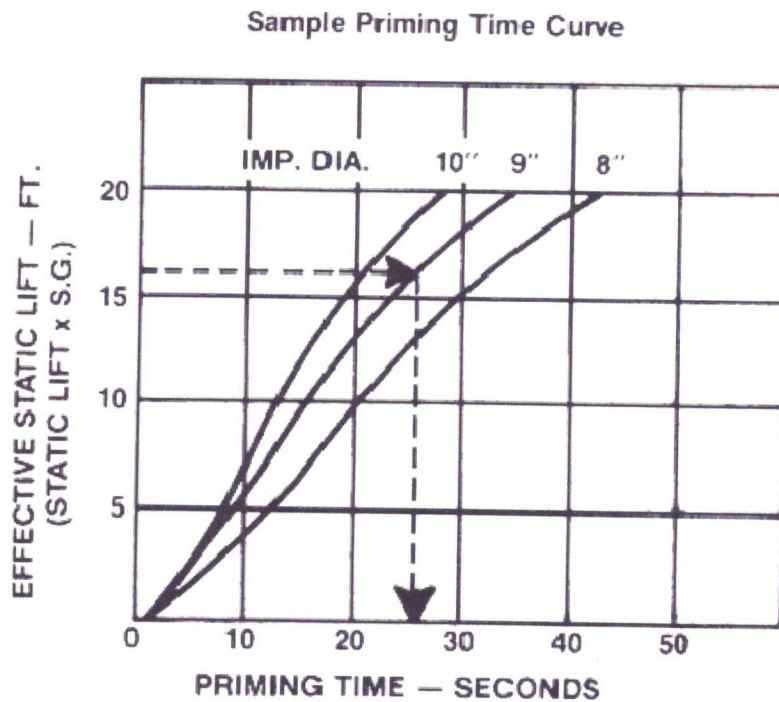


Fig.(6.9) : sample priming time curve.

6.2.12 Characteristic Curves of Centrifugal Pumps

As a matter of fact, a centrifugal pump like a turbine is designed and manufactured to work under a given set of conditions (or a limited range of conditions) such as discharge, speed, power required, head of water, efficiency... etc. But a pump may have to be used under conditions, other than those for which it has been designed. It is, therefore, essential that the exact behavior of the pump under varied conditions should be predetermined. This is represented graphically by means of curves, known as characteristic curves. Though there are many types of characteristic curves, yet the following are important from the subject point of view :

1. Characteristic curves for speed.
2. Characteristic curves for discharge with varying speeds.

1. Characteristic curves for speed

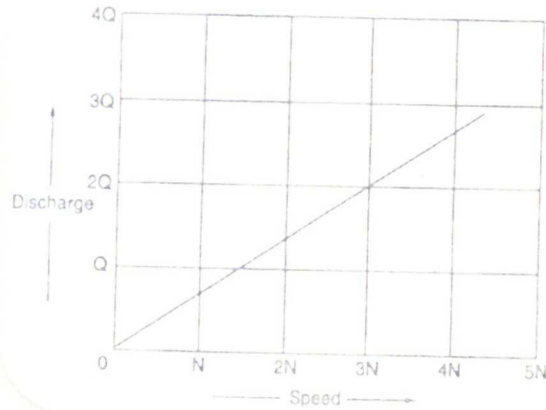


Fig.(6.10): Characteristic curve for Speed versus discharge.

Fig.(6.10) :shows the performance of a centrifugal pump under constant head. It is a straight line, which shows that the discharge increases with the speed.

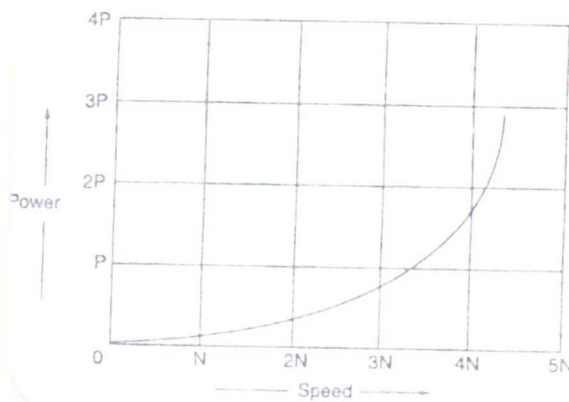


Fig. (6.11): Characteristic curve for speed versus power.

Fig. (6.11): shows the performance of a centrifugal pump under a constant head and discharge. It is a parabolic curve, which shows that the power increases with the speed .

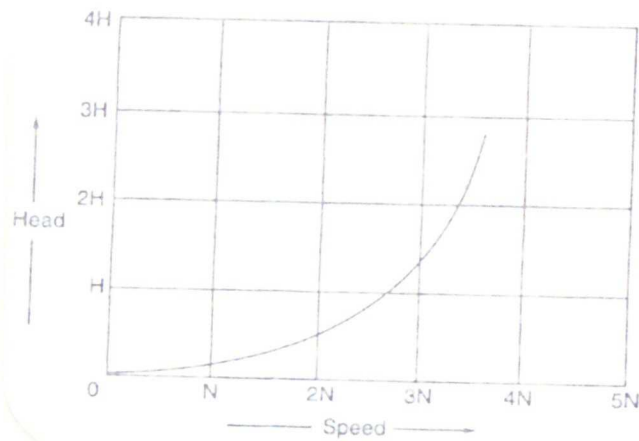


Fig. (6.12): Characteristic curves for Speed versus head.

Fig. (6.12): shows the performance of a centrifugal pump under constant discharge. It is a parabolic, curve which shows that the head increases with the speed.

2. Characteristic curves for discharge with varying speed

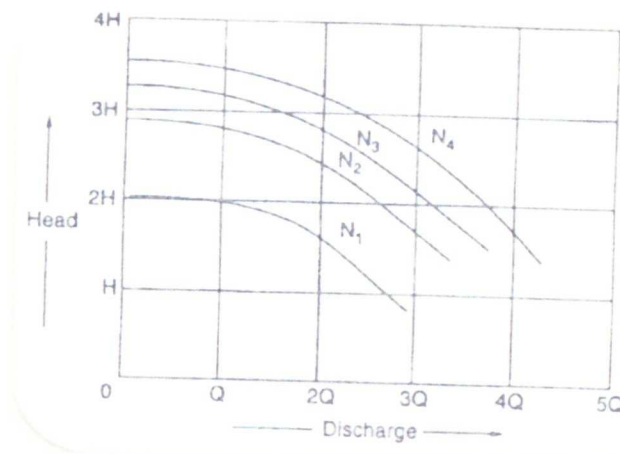


Fig. (6.13): Characteristic curves for Discharge versus head.

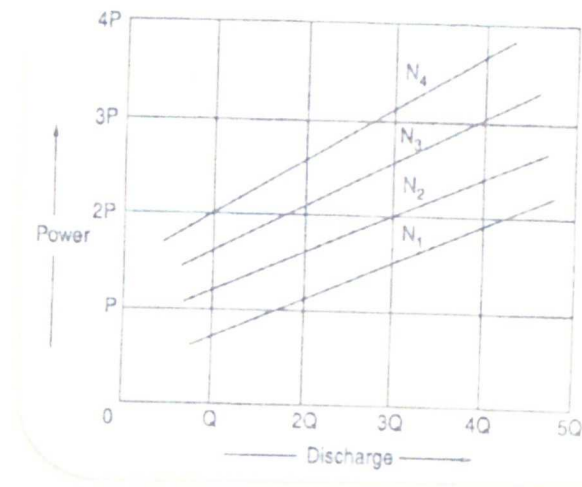


Fig.(6.14): Characteristic curves for discharge versus power.

Fig.(6.14): shows the performance of a centrifugal pump under variable rotational speeds. It is a parabolic curve, which shows that for a given rotational speed, the dynamic head decreases with the discharge.

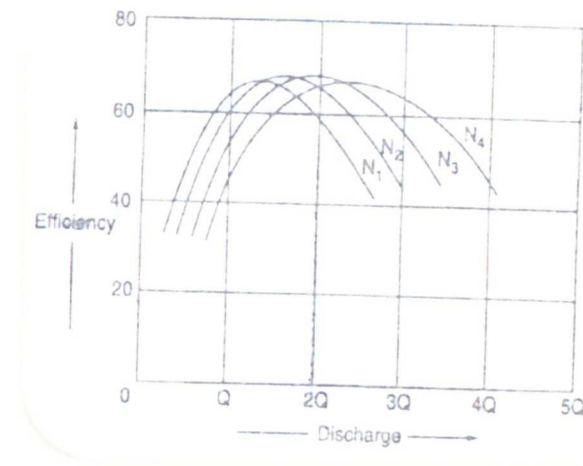


Fig. (6.15) : Characteristic curves for discharge versus efficiency.

Fig. (6.15) : shows the performance of a centrifugal pump under variable rotational speeds. It is a parabolic curve, which shows that for a given rotational speed, the

efficiency increases with the discharge. And beyond a certain discharge, the efficiency decreases.

6.3 Motor of pump

The motor is the device that converts electricity into mechanical power. Motors, like the pumps they drive, are rated by horsepower, usually in pool and spa work as $\frac{1}{2}$, $\frac{3}{4}$, 1.0, 1.5, and 2.0 horsepower. Commercial installations might use higher rated systems, but these are the most common.

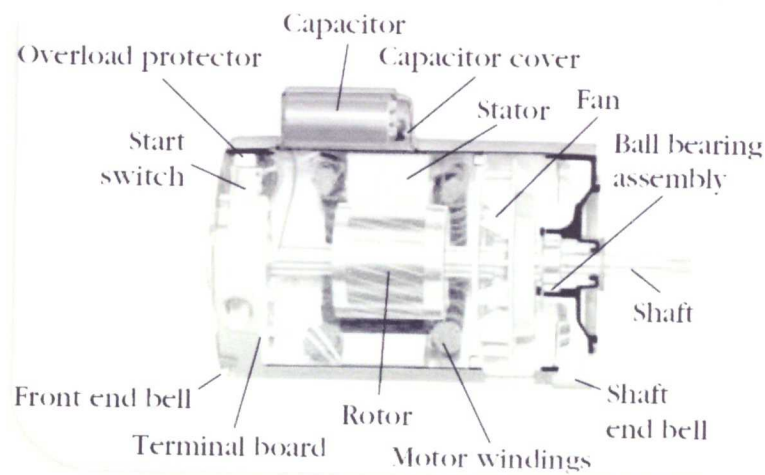


Fig. (6.16) : Typical cross section pool pump motor.

As shown in Fig.(6.16) : electricity flows through the motor windings, which are thin strands of coiled copper or aluminum wire. The windings magnetize the iron stator. If you paid attention in your first grade science class, you recall that opposite poles of a magnet attract each other, but like poles repel. Using this concept, the rotor spins, turning the shaft. Some designs employ one set of windings for the start-up phase where greater turning power (torque) is needed and another set for normal running.

The shaft rides on ball bearings at each end. A built-in fan cools the windings because some of the electrical energy is lost as heat. The caps on each end of the motor housing are called end bells. A starting switch is mounted on one end with a small removable panel for electrical connection and maintenance access.

This is where you will also find the thermal overload protector. This heat-sensitive switch is like a small circuit breaker. If the internal temperature gets too hot, it shuts off the flow of electricity to the motor to prevent greater damage. As this protector cools, it automatically restarts the motor, but if the unit overheats again, it will continue to cycle on and off until the problem is solved or the protector burns out.

It takes a great deal of electricity to start a motor but far less to keep it going (in fact, about five to six times as much). The capacitor, as the name implies, has a capacity to store an electrical charge. The capacitor is discharged to give the motor enough of a jolt to start, then it is able to run on a lower amount of electricity. Without the capacitor, the motor would need to be served by very heavy wiring and high-amp circuit breakers to carry the starting amps. The start-up amperage of a motor is about twice that of its running amperage. The capacitor is located in a separate housing mounted atop the motor housing or inside the front end bell.

Some motors are designed to operate at two speeds. For example, some spas operate at high speed for jet action, but lower speed for circulation and heating. In pool and spa work, the normal rotation speed is 3450 revolutions per minute (rpm) and the low speed is 1750 rpm.

6.3.1 Nameplate

All of what you need to know about a motor is printed on the nameplate, a sticker applied to the housing. Here's what you can learn from the nameplate.

The nameplate also tells you the amperage. It might say "10.5/5.2." This means the start-up draw is 10.5 amps, and the normal running draw is 5.2 amps. Make sure you are reading this information from the area that says "Maximum Load" or "Maximum Amps." Some makers publish the amps required to power the nominal horsepower as well. These are lower than the maximum and should not be used when sizing wire or circuit breakers.

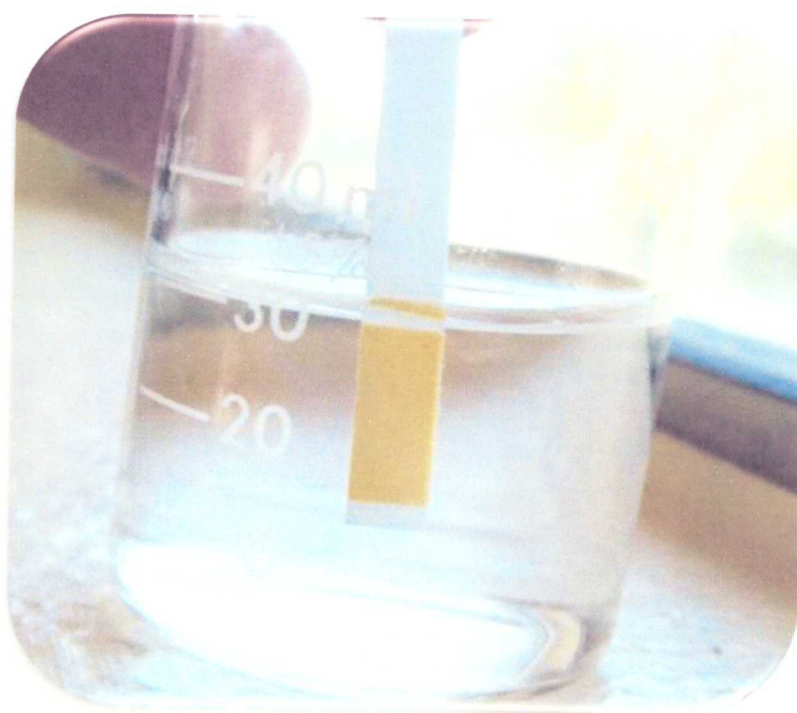
The nameplate also lists the electrical phasing (single phase or 1) and cycle frequency (called hertz). Alternating current in the United States runs on 60 hertz. In Europe it is 50 hertz, and that's why you can't use some appliances from one country in another, even with a voltage converter, because things like VCRs and TVs rely on the cycles as well as the voltage. "Stupid" appliances like toasters or shavers only care about voltage.

6.3.2 Horsepower

The relative strength of the motor is expressed in horsepower and corresponds to the specifications of the pump that is to be driven by the motor.

CHAPTER SEVEN

WATER CHEMISTRY



7. Water Chemistry of Swimming Pools and Diseases

7.1 Introduction

Proper water chemistry is essential to maintain safe and consistent swimming pool operation. Chemicals used in swimming pools include disinfectants to destroy harmful or otherwise objectionable organisms; Alkalinity and pH Adjusters used to maintain a consistent acid-base relationship in a pool water. Algaecide to kill and prevent algae, and to help remove foreign material. This chapter contains and explains various factors which affect water, chemistry, how they affect swimming pools and how to use pool chemicals to restore balanced water chemistry properly .

7.2 PH



Figure (7.1): PH testing.

PH is the single most important element in swimming pool water chemistry. It affects every other chemical balance in pool water.

PH is a measure of hydrogen ion (H⁺) concentration in water. It indicates the relative acidity or basicity of pool water. PH is measured on a scale of 0 (strong acid) to 14 (strong base) with 7 being the neutral PH.

In pools, a slightly alkaline PH of 7.4 to 7.6 is most desirable because this range is most comfortable to the human eye.

If PH is too low (below 7)

- Water becomes acidic.
- Chlorine residuals dissipate rapidly.
- Eye irritation occurs and affects human lathers.
- Plaster walls are etched.
- Metal fittings, pump impeller, heater core may corrode.
- Dissolved metals may leave stains on walls.
- Rapid Loss of alkalinity.
- Affect mucous membranes.

If PH is too high (above 8)

- Chlorine activity is slowed and inefficient and will not act as bacteria.
- Scale formation and discoloration of pool walls.
- Water becomes cloudy.
- Filter is overworked.
- Eye irritation may occur.

7.2.1 PH Adjustment

To avoid the problems listed previous, PH must be maintained between 7.2 and 7.8. The most desirable level for PH is between 7.4 and 7.6. If PH is too low - run alkali demand test if available. Raise PH by adding soda ash (sodium carbonate). Never add more than 2 lbs per 10,000 gallons in a single treatment. Be sure the pump is running when chemicals are added. Allow to recirculation then retest to determine if further treatment is necessary. Caustic soda (sodium hydroxide) is sometimes used with chemical feed pumps to raise PH. If problems with low PH persist, it may be necessary to raise total alkalinity to stabilize the PH.

Table (7.1): Raising PH with Soda Ash

(If PH is fewer than 7.4, add this amount of soda Ash (gram), then retest)

PH	Gallons in pool						
	1,000	5,000	10,000	15,000	20,000	25,000	50,000
7.2-7.4	18.9g	85.05 g	170.1g	255.15g	340.2g	454g	908g
7.0-7.2	21.3g	113.4g	226.8g	340.2g	454g	567.5g	1135g
6.6-7.0	35.4g	170.1g	340.2g	454g	681g	908g	1816g
Under 6.7	42.5g	226.8g	454g	681g	908g	1135g	2270g

If PH is too high - run acid demand test if available. PH is lowered by adding muriatic acid (hydrochloric acid) or sodium bisulfate. Carefully, we pour acid at the deep end of the pool. Acid should not touch the pool walls or fittings.

Table (7.2): Lowering PH with Muriatic Acid

(If PH is over 7.6, adds this amount of acid, then retest)

PH	Gallons in pool						
	1,000	5,000	10,000	15,000	20,000	25,000	50,000
7.2-7.4	35.4g	170.1g	340.2g	510.3g	680.4g	0.9463 L	1.8926 L
7.0-7.2	42.5g	226.8g	453.6g	680.4g	0.9463 L	1.183 L	2.366 L
6.6-7.0	70.9g	340.2g	680.4g	1.183 L	1.419 L	1.8926 L	3.785 L
Under 6.7	85.05g	453.6g	0.9463 L	1.183 L	1.8926 L	2.366 L	4.73 L

7.3 Total Alkalinity (TA)

Total alkalinity is closely associated with PH but rather than a measure of hydrogen ion concentration, it is a measure of the ability of a solution to neutralize hydrogen ions. Expressed in parts per million (ppm), total alkalinity is the result of alkaline materials including carbonates, bicarbonates and hydroxides - mostly bicarbonates. This acid neutralizing capacity of water is desirable because it helps preventing wide variations in PH whenever small amounts of acid or alkali are added to the pool. Total alkalinity is a measure resistance of water to change in PH.

Total alkalinity should be maintained in the range of 80 to 150 ppm.

❖ If total alkalinity is too low:

PH changes rapidly when chemicals or impurities enter the water. PH may drop rapidly, causing etching and corrosion

- ❖ If total alkalinity is too high:

PH becomes difficult to adjust. High PH often occurs causing other problems such as; cloudy water, decreased disinfectant effectiveness, scale formation and filter problems.

7.3.1 Raising total Alkalinity

Total alkalinity can be raised by the addition of bicarbonate of soda (sodium bicarbonate, baking soda). 1.4 lbs. bicarbonate of soda per 10,000 gallons will raise total alkalinity 10 ppm.

Table (7.3): Raising Alkalinity Using Sodium Bicarbonate

Increase (ppm)	Gallons in pool						
	1,000	5,000	10,000	15,000	20,000	25,000	50,000
10	63.6g	317.8g	635.6g	953.4g	1271.2g	1589g	3178g
20	127.1g	635.6g	1271.2g	1906.8g	2542.4g	3178g	6356g
30	190.7g	953.4g	1906.8g	2860.2g	3813.6g	4767g	9534g
40	254.2g	1271g	2542.4g	3813.6g	5084.8g	6356g	12712g
50	317.8g	1589g	3178g	4767g	6356g	7945g	15890g

In some cases, soda ash can be used to raise total alkalinity. Kilogram for kilogram, soda ash raises alkalinity 60 percent more than sodium bicarbonate and is cheaper than sodium bicarbonate. The problem with using soda ash to increase alkalinity is that it drastically increases PH. This can cause cloudy water and scale formation. Soda ash should only be used to increase total alkalinity if you also need to increase the PH or if only small increases in alkalinity are needed.

Table (7.4): Raising Alkalinity Using Soda Ash

Increase (ppm)	Gallons in pool						
	1,000	5,000	10,000	15,000	20,000	25,000	50,000
10	40.9g	199.8g	399.5g	599.3g	803.6g	1003.3g	2006.7g
20	81.7g	399.5g	803.6g	1203.1g	1602.6g	2006.7g	4008.8g
30	118.0g	599.3g	1203.1g	1802.4g	2406.2g	3005.5g	6015.5g
40	158.9g	803.6g	1602.6g	2406.2g	3209.8g	4008.8g	8017.6g
50	199.8g	1003.3g	2006.7g	3005.5g	4008.8g	5012.2g	10024g

Chemical manufactures are now marketing a total alkalinity increaser, which combines the effects of sodium bicarbonate and soda ash. The product sodium sesquicarbonate or sodium hydrogen carbonate affects total alkalinity more than sodium bicarbonate, but doesn't cause quite as much increase in PH as soda ash does.

Table (7.5): Raising Alkalinity Using Sodium Sesquicarbonate

Increase (ppm)	Gallons in pool						
	1,000	5,000	10,000	15,000	20,000	25,000	50,000
10	59.0g	286.0g	567.5g	853.5g	1135g	1421.0g	2837.5g
20	113.5g	567.5g	1135g	1702.5g	2270g	2837.5g	5675g
30	172.5g	853.5g	1702.5g	2556.0g	3405g	4258.5g	8512.5g
40	227g	1135g	2270g	3405g	4540g	5675g	11350g
50	286.0g	1421.0g	2837.5g	4258.5g	5675g	7096.0g	14187g

7.3.2 Lowering total Alkalinity

Total alkalinity can be lowered by adding muriatic acid or sodium bisulfate. Acid may be added in doses of up to 1 quart per 10,000 gallons. Total alkalinity tests and further required additions of acid can be made every 2 hours.

Table (7.6): Lowering Alkalinity Using Muriatic Acid

Decrease (ppm)	Gallons in pool						
	1,000	5,000	10,000	15,000	20,000	25,000	50,000
10	72.6g	0.378 L	0.757 L	1.1355 L	1.514 L	1.893 L	3.785 L
20	145.2g	0.757 L	1.514 L	2.271 L	3.03 L	3.785 L	7.57 L
30	217.7g	1.1355 L	2.271 L	3.4066 L	4.542 L	5.68 L	11.36 L
40	290.3g	1.514 L	3.03 L	4.542 L	6.06 L	7.57 L	15.14 L
50	362.9g	1.893 L	3.785 L	5.68 L	7.57 L	9.46 L	18.93 L

Table (7.7): Lowering Alkalinity Using Sodium Bisulfate

Decrease (ppm)	Gallons in pool						
	1,000	5,000	10,000	15,000	20,000	25,000	50,000
10	95.3g	481.2g	967.0g	1448.3g	1929.5g	2410.7g	4826.0g
20	195.2g	967.0g	1929.5g	2896.5g	3859g	4826.0g	9647.5g
30	290.6g	1448.3g	2896.5g	4340.2g	5788.5g	7236.8g	14473g
40	385.9g	1929.5g	3859g	5788.5g	7718g	9647.5g	19295g
50	481.2g	2410.7g	4826.0g	7236.8g	9647.5g	12058g	24121g

7.4 Calcium Hardness:

Calcium hardness is a measure of the dissolved calcium salts in water. Under normal conditions, this should not be a problem in properly operated swimming pools. Estimates of the proper range of calcium hardness vary widely but the ideal level for pool is generally considered about 250 ppm. If calcium hardness is very low, then water may leach calcium from pool walls causing pitting of the plaster surface. Very high calcium hardness may contribute to scale formation and clouding of the water. To raise calcium hardness - add calcium chloride.

Table (7.8): Raising Hardness with Calcium Chloride

Increase (ppm)	Gallons in pool						
	1,000	5,000	10,000	15,000	20,000	25,000	50,000
10	56.7g	283.5g	567.5g	794.5g	1135g	1475.5g	2837.5g
20	113.4g	567.5g	1135g	1702.5g	2270g	2827.5g	5675g
30	170.1g	794.5g	1702.5g	2497g	3405g	4313g	8512.5g
40	3632g	1135g	2270g	3405g	4540g	5675g	11350g
50	283.5g	1362g	2837.5g	4313g	5675g	7150.5g	14187g

❖ To lower calcium hardness

1) Anhydrous trisodium phosphate may be used. One-pound trisodium phosphate per 10,000 gallons will lower calcium hardness 11 ppm. Use in small increments or clouding may occur.

2) Another method of lowering calcium hardness is to simply drain off part of the pool water and dilute the remaining water with fresh make up water.

7.5 Total Dissolved Solids (TDS)

After a pool has been in use for a time, dissolved solids may begin to accumulate. These unilateral solids include body wastes, chlorines, algaecide, dirt, pollen, etc. Normally, this problem is less with outdoor pools than indoor ones because of rainwater and no use during winter months. Indoor pools sometimes have a buildup of dissolved solids requiring draining the pool and refilling it with fresh water. Most pools should be drained after 3 to 5 years. Ideally, pool water contains under 450 ppm total dissolved solids.

7.6 Disinfection of Pool Water

A proper balance of the previously described water chemistry factors will provide water that will not damage pool components and is non-irritating to swimmers. It is then necessary to provide for disinfection of the water to prevent the spread of disease organisms from person to person and prevent unwanted growth of bacteria and algae in the pool.

7.6.1 Chlorine



Figure (7.2): Chlorine testing.

The most commonly used disinfectant for swimming pools is chlorine. In its elemental form chlorine is a heavy greenish yellow gas, which is so toxic, has been used as a weapon in chemical warfare. Because of the extremely high potential for injury or death from improper use of chlorine gas, a number of chlorine compounds have been formulated to provide chlorine in forms that can be handled and used safely by swimming pool operators .

The following forms of chlorine are commonly used in swimming pools .

- **Gas chlorine:** 100%available chlorine.

Advantages:	Disadvantages:
Cheapest form of chlorine	Extremely dangerous
No residue from carriers	Special room needed for chlorine
	Feed equipment is expensive
	Special training and safety equipment needed
	Lowers PH, must constantly add PH increaser

- **Calcium Hypochlorite:** granular or palletized 65% available chlorine

Advantages:	Disadvantages
Relatively cheap	Not stabilized - may lose strength if not tightly covered.
Can be mixed into solution for feed pumps	Does not dissolve completely - leaves residue
Can be used in some specially designed erosion feeders	Does not dissolve completely - leaves residue
	High PH (11.7) raises PH of pool
	Highly reactive - may cause fires

- **Sodium Hypochlorite:** Liquid bleach 12.5% available chlorine

Advantages:	Disadvantages:
Next to gas is the cheapest chlorine available	Bulky and heavy
No dissolving required - no residue	Not stabilized-loses strength rapidly
Can be used with chemical feed pumps	High PH (10-13) raises PH of pool

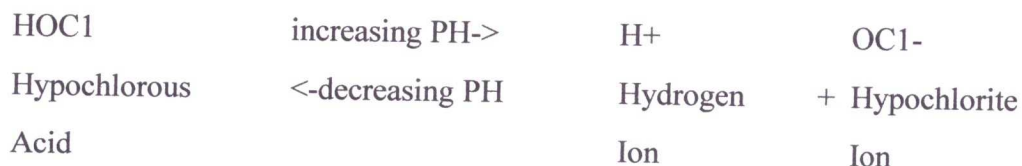
- **Trichloroisocyanuric Acid:** sticks or tablets 90% available chlorine

Advantages:	Disadvantages:
Stabilized - chlorine doesn't dissipate	Lowers PH(2.8)
Easy to handle	Lowers total alkalinity
Low cost, low maintenance erosion feeders	May elevate cyanuric acid levels
Highly concentrated - 90% available chlorine	Not suitable for superchlorination
Dissolves completely - very little residue	

Other forms of chlorine less commonly used are lithium hypochlorite, potassium dichloroisocyanuric acid, and sodium dichloroisocyanuric acid.

7.6.2 Effect of PH to free chlorine

Residual Chlorine reacts with water to form Hypochlorous acid (HOCl). The reaction is different for each form of chlorine but hypochlorous acid is produced by each of those reactions and is the form in which chlorine serves best as a disinfectant. Hypochlorous acid is a weak acid and is easily dissociates to an ionized hypochlorite state as shown below.



This is important because both hypochlorous acid and the hypochlorite ion are counted as free chlorine residual on your test kit but only the hypochlorous acid portion is an effective disinfectant. The balance between hypochlorous acid and the hypochlorite ion is affected by pH. The higher the pH, the less hypochlorous acid present and the less effective free chlorine becomes. At a pH of 7.2 about 66% of free chlorine is hypochlorous acid. At a pH of 7.8 only about 33% of free chlorine is hypochlorous acid. Thus, pH control is essential for maintaining the effectiveness of chlorine as a disinfectant.

7.6.3 Stabilizer - Cyanuric Acid

Hypochlorous acid is a highly unstable molecule, which dissipates rapidly in the presence of sunlight. This result in considerable loss of free chlorine form pools exposed to sunlight. Proper stabilization of chlorine with cyanuric acid slows the rate of chlorine dissipation without appreciably sacrificing oxidation and disinfection activity. Reaction of free chlorine with cyanuric acid produces a form of combined chlorine (chloramines) which is active enough to aid disinfection and show up as free chlorine residual on your test kit. Proper stabilization requires 30 to 50 ppm cyanuric acid. Outdoor pools should be initially treated with 40-ppm cyanuric acid.

The table below can be used to determine the amount of cyanuric acid needed.

Table (7.9): Establishing or Increasing Cyanuric Acid Level

CYA increase (ppm)	Gallons in pool						
	1,000	5,000	10,000	15,000	20,000	25,000	50,000
10	35.4g	184.3g	361.5g	567.5g	756.7g	908g	1816g
20	70.9g	361.5g	794.5g	1135g	1513.3g	1816g	3783.2g
30	70.9g	311.9g	605.2g	908g	1210.4g	1513.3g	5675g

Cyanuric acid dissolves very slowly and is best predissolved in warm water before introducing into the pool. If it is not predissolved, it may take several days to dissolve completely. Once added to the pool, cyanuric acid does not dissipate. It is removed from the pool only by splash out and backwash waste. Stabilized chlorine products such as trichloroisocyanuric acid will add stabilizer to the pool and may cause a gradual rise in cyanuric acid concentration. Excessive amounts of cyanuric acid can interfere with the disinfection process and at concentrations above 100 ppm may cause "chlorine lock" and clouding of the pool. Cyanuric acid level is lowered by draining part of the water out of the pool and diluting the remaining water with fresh water. Generally, cyanuric acid level should be kept below 60 ppm. Stabilized forms of chlorine should not be used for superchlorination because cyanuric acid level may be increased.

7.6.4 Bromine

Bromine is chemically very similar to chlorine. Bromine compounds tend to react more slowly than chlorine compounds; so bromine is generally more stable and less subject to dissipation in sunlight. The dissociation of hypobromous acid into the bromine ion is less affected by pH than the corresponding reaction of chlorine. This makes bromine active over a larger range of pH than chlorine. Bromine will combine with ammonia to form bromamines similar to chloramines but unlike chloramines, bromamines are effective bactericides and do not produce the degree of odor and eye irritation associated with chloramines. Bromine is less affected by high temperature and nitrogen wastes than chlorine; so it is particularly attractive for use in hot water spas. Bromine is more expensive than chlorine and has not yet received widespread acceptance by swimming pool operators.

The form of bromine most commonly used in pools and spas is the organic chemical bromo-chloro-dimethylhydantoin, which contains both bromine and chlorine. It is marketed under various trade names.

Bromine residual should be maintained between 2 and 4 ppm. Bromine residual is measured using the DPD test used to measure free chlorine. If your test kit does not include a bromine scale then bromine residual is approximately 2.25 times the reading on the chlorine scale.

7.6.5 Biguanide Disinfectants

The only disinfectant other than chlorine and bromine which has been accepted as a primary disinfectant in public swimming pools is polyhexamethylene biguanide. Biguanide is used at a concentration of 30 to 50 parts per million and a pH of 7.2 to 7.8 to kill germs and control algae growth. A special test kit is needed to test the biguanide residual. The main advantage of biguanide is the disinfectant concentration remains fairly stable so it requires less frequent adjustment than chlorine. No automatic chemical feeder is needed.

Biguanide is not an oxidizer and will not destroy organic wastes the way chlorine and bromine do. It must be used in conjunction with a peroxide shock treatment to prevent organic wastes from accumulating in pool water. Biguanide is incompatible with chlorine and most algaecides. Chlorine in make-up water can cause clouding of biguanide pools. Biguanide increases the staining potential of dissolved metals in a pool so copper based algaecides, copper ion generators, and pool heaters should not be used.

Table (7.10): standard values of chemical properties

	Minimum	Ideal	Maximum
Free Chlorine, ppm	1.0	1.0-3.0	3.0
Combined chlorine, ppm	None	None	0.2
Bromine, ppm	2.0	2.0-4.0	4.0
pH	7.2	7.4-7.6	7.8
Total Alkalinity, ppm	60	80-100 (for Liquid Chlorine, Cal-Hypo and Lithium Hypo) 100-120 (for gas chlorine, dichlor, trichlor and bromine compounds)	180
TDS,ppm	300	1000-2000	3000
Calcium Hardness, ppm	150	200-400	500-1000+
Cyanuric Acid, ppm	10	30-50	150

7.7 Algae Control

Algae are tiny plants that bloom and grow in swimming pools if nutrients are present and a sufficient level of free chlorine is not maintained.

Below are descriptions of the three most common algae problems in swimming pools.

- Green Algae The most common algae in swimming pool.
- Mustard Algae settles on pool walls and causes a slimy yellow film.
- Black Algae appears in "buds" or clumps attached to tile grout, corners, steps and pool surfaces.

Solution:

Green Algae - is very susceptible to chemical treatment. Superchlorinate with 10 to 20 ppm chlorine in the evening. Keep the filter running and brush the pool walls and bottom. Periodically, check chlorine and maintain above 3 ppm until water clears. Using an algaecide containing quaternary ammonia, the next morning will help prevent the return of green algae.

Mustard Algae - is much more resistant to chemical treatment and clings more tightly to pool walls than green algae. Adjust pH and superchlorinate as for green algae then brush diligently. Later vacuum the pool, check chlorine and superchlorinate again if necessary. Mustard algae will generally return unless treated with a special mustard algaecide or a copper-based algaecide. Algaecide should be added in the morning to treat algae in daylight - its most active period.

Black Algae - is very difficult to get rid of. It can be controlled to some extent by frequent superchlorination and diligent brushing with a stiff brush. Spot treatments can be made by turning off the recirculation pumps and pouring granular chlorine directly on recently brushed spots. Trichlor tablets can also be rubbed on recently brushed areas to spot treat. Black algae can usually be controlled with the use of strong alicides and maintenance of relatively high free chlorine residual, but complete removal of black algae may require draining and cleaning the pool.

7.8 Water Kind requirements:

The following conditions should be taken in consideration before opening the pool:

1. The water used must be from a healthy and safe source which has the potable water qualities.
2. Water temperature is maximum 24 C in summer and maximum 28 in winter measured at 50 cm depth from the water surface.
3. Providing a special record book for writing the free chlorine surplus readings and the PH.
4. Providing chlorine surplus test system and PH test system.
5. Using materials against mosses according to the producing company directions.
6. In the case of having big amounts of mosses or having a high concentration of united chlorine, water in the pool should be provided with condensed dosage of chlorine in the rate of 5-10 parts/million within night hours.
7. Total bacteria number in the pool mustn't surpass 2000/ml.
8. (TC) bacteria number shouldn't surpass 10/100ml.
9. Pool water should be a free of:
 - (FC) bacteria.
 - Salmonella.
 - Pseudomonas.
 - Streptococcus.
 - Staphylococcus.
 - Fungus and yeasts.
10. Swimming pools water should be free of floating materials.
11. Concentration of melting solid materials in the water of swimming pools is maximum 2500 part/million.
12. Turbidity degree in pool water mustn't surpass 5 turbidity degrees measured by (NTU).

13. Its very important to have a qualified trained supervisor who is able to observe pool water and able to do additional chemical tests required to make balances for concentrations .

14. Adding water in a rate of 30 liters / swimmer daily to compensate lost water .

15. Tests repetition:-

Different tests of pool water done as the following schedule.

Table (7.11): Situation of different tests of pool water

№	Test	Repetition	Place of taking samples
1	Chlorine surplus concentration	Once every two hours	On depth of 50 cm of low depth area surface
2	PH level	Once every two hours	On depth of 50 cm of low depth area surface
3	Turbidity	Once a week	On depth of 50 cm in middle of the pool
4	Total bacteria	Once every month	On depth of 50 cm in middle of the pool
5	Total FC bacteria	Once every month	On depth of 50 cm in middle of the pool
6	Total TC bacteria	Once every month	On depth of 50 cm in middle of the pool
7	Alsalamonia	Once every month	On depth of 50 cm in middle of the pool
8	Pseudomonas	Once every month	On depth of 50 cm in middle of the pool
9	Streptococcus	Once every month	On depth of 50 cm in middle of the pool
10	Staphylococcus	Once every month	On depth of 50 cm in middle of the pool
11	Bungers and yeasts	Once every month	On depth of 50 cm in middle of the pool
12	Alkalinity	Once every month	On depth of 50 cm in middle of the pool
13	Alcaianoric acid	Once every month	On depth of 50 cm in middle of the pool

V.4 Transmission of diseases in swimming pools

Swimming pool and spas water can become contaminated by germs from swimmers or incoming water from unsafe water supplied. Contaminated recreational water can cause a variety of diseases such as diarrhea and skin, ear, and upper respiratory infections, particularly if the swimmer's head is submerged.

The risk of illness or infection associated with swimming pools, spas and similar recreational-water environments has been linked to fecal contamination of the water. The fecal contamination may be due to feces released by bathers or contaminated source water. Many of the outbreaks related to swimming pools have occurred because disinfection was poorly or not at all applied. The majority of reported swimming pool-related outbreaks have been caused by viruses; recently, however, reported outbreaks have been more frequently associated with bacteria and protozoa. Non-fecal human shedding (e.g., from mucus, saliva, skin) in the swimming pool, spa or similar recreational-water environments is a source of potential non-enteric pathogenic organisms. Mucus, saliva and skin of infected users can directly contaminate pool or spa waters and the surfaces of objects or materials at a facility with sufficient numbers of primary pathogens (notably viruses or fungi), which can consequently lead to infections in other swimmers who come in contact with the contaminated water or surfaces.

Opportunistic pathogens (notably bacteria) can also be shed from users and transmitted via contaminated water in pools or spas. In addition, certain free-living aquatic bacteria and amoebas can grow in pool or spa waters, in pool or spa components or facilities (including heating, ventilation and air conditioning systems) or on other wet surfaces within the facility to a point at which some of the opportunistic pathogens may cause a variety of respiratory, dermal or central nervous system infections or diseases. People with diarrhea illnesses are more prone to contaminate the water. Children who wear diapers or are just learning to control their bowels are more likely to have fecal accidents and, if they are ill with diarrhea, the

germs in their stool can contaminate the pool. Then when swimmers accidentally swallow this fecally contaminated water, can become ill. In addition, some germs such as *Cryptosporidium* can come with the municipal water, and are not easily killed by disinfectants in the pool, increasing the risk of disease.

V.10 Prevention of diseases in swimming pools and spas

Disease prevention should be a part of every water quality management program for pool operators, just like the prevention of drowning, injuries, and sunburn. People are less likely to be exposed to polluted water at swimming pools and spas that are monitored regularly and audited for health hazards. The pool water has to be continuously disinfected by disinfectants so that the concentrations set by standards are maintained throughout the pool water, and the pH, the clarity and the total alkalinity of the water has to be maintained in accordance with the requirements set by standards.

The education of parents of small children and other people with regard to good hygienic behavior at swimming pools is also important for improving health safety at swimming pools and spas. People should also be cautioned about swimming in pools if they are suffering from gastroenteritis or other illnesses where viral pathogens might be transmitted from swimmer to swimmer via pool water.

Since most swimmers are exposed to pathogens by swallowing the water, people will be less likely to get sick if they swim without submerging their head.

CHAPTER EIGHT

WATER FEATURES



8 Water Features

Are defined as the full range of water related garden decor, which includes garden fountains, waterfalls, pools, ponds, and cascading water. Typically, landscapers and garden architects will refer to large, centerpiece garden fountains as water features.

Fountains, koi (large goldfish) ponds, waterfalls, wading pools, and other decorative systems are grouped together under the collective term water features. Water features are essentially small swimming pools, requiring circulation, filtration, and chemical balance like any other water vessel. The differences between water features and swimming pools are based on the intended use of the water feature.

8.1 Fountains

8.1.1 Introduction

Fountains are usually powered by small submersible pump and motor combinations and are circulated without filtration. The only way to clean a fountain is to remove as much debris as possible with a leaf rake and spa vacuum or to drain the vessel completely, scrub it out, and refill it.

Larger fountains or waterfalls are powered by larger pool-style pump and motor systems and are filtered. They include skimmers for vacuuming and often include water fill lines with automatic fillers. Since most fountains and waterfalls are shallow with extensive water surface area, evaporation is a problem. First, keeping enough water cir-

culating is important. Second, the high rate of evaporation can leave extensive scale deposits on decorative tile or rock at the waterline.

The other hazard of fountain maintenance is wind. Wind not only accelerate evaporation, but also blow water out of the fountain. Again, the answer is to keep the water supply adequate to prevent the pump from running dry. In extreme conditions, shut down the unit.

Building fountains and waterfalls is a specialty that has been elevated to new levels in recent years with artificial rock and unique lighting. Designers are realizing that water provides a unique living enhancement to indoor and outdoor settings and the limits are only the imagination. because of the unique engineering requirements of each design, however, there are no simple or standard outlines for designing and building waterfalls or fountains. If your customer wants to add a water feature to a yard or existing pool, I recommend an expert and work with the designer or builder to complete the job. The hydraulic requirements of lifting and moving water for fountains and waterfalls are unique and demanding.

8.1.2 History

Early fountains depend on the natural gravitational flow of water, from a spring or aqueduct supplied by a distant and higher source of water, which provided hydraulic head. Hellenistic hydraulic engineers employed great originality in designing fountains, where the water pressure might be employed to animate automata and water organs.

Other early fountains were geometrically regularized springs, developed in the classic Persian garden. In the 16th century elaborate fountain displays were garden features of Mannerist gardens of Central Italy and the Mughal gardens of India. Early Modern English employed fountain to refer to a natural spring water or source which the 16th century garden fountain might consciously imitate in a grotto. Christian allegory made much use of the concept of the fountain, specifically the Fountain of Life, associated with the rebirth that was intended to be experienced at the Baptismal font. The Fountain of Life appears in Christian illuminated manuscripts of Late Antiquity, and elaborate Gothic fountains formed centerpieces for enclosed gardens.



Figure (8.1): Old fountain

The practical Romans marked the delivery end of aqueducts with a public fountain, a practice that was revived in Rome in the 15th century, when the restored Aqua Felice once more delivered a symbolic presentation of its waters to Rome in the original Trevi Fountain, since replaced by the familiar Baroque fusion of water, architecture and sculpture.

8.1.3 Animated fountains



Figure (8.2): Animated fountain in front of the Brooklyn Museum consists of laminar flow water jets.

Animated fountains often use laminar jets that provide water that moves like ping pong balls in animation, so that it breaks up, as the height varies, and the behavior of each jet operates independently with up to 5 Hz modulation frequency (1/5 second), so that the water packets collide with themselves. For example, such fountains can spit up one ball of water which then explodes showering people with a fine mist.

A musical fountain is a type of fountain that uses laser and harmonics principles to create three-dimensional images that look like holograms.

8.1.4 Fountains that are musical instruments



Figure (8.3): Water flute with 45 finger-embouchure holes

A hydraulophone ("water flute") is a fountain that people can play (it's a musical instrument) as well as play in. These fountains are like woodwind instruments (e.g. flutes) but they use water instead of air. The embouchure of the instrument occurs at the finger holes (referred to as "mouths"). Water flutes often have multiple "mouths", so that a player can put each finger into a different mouth at the same time, in order to play chords, while independently manipulating each finger for separate and individual control of the embouchure of each note in a chord. A skilled hydraulist can slightly "bend" each note in order to play just intonation in any desired key, or to gently and fluidly vary intonation or temperament as a piece of music changes from one key to another.

Hydraulophones installed in parks, pools, playgrounds, etc., make playing in a fountain an educational and culturally rewarding experience

8.1.5 Water quality issues

There is a need for good water quality in contemporary fountains, regardless of their avowed intended use. Regardless of the fact that some fountains are designed and built not as bathing fountains, but are rather used simply as architectural decor, people will often drink from, bathe or wash their hands in any fountain. Additionally, fountain spray can contain legionella bacteria and has been linked to legionnaires' disease outbreaks. Therefore, minimum water quality standards are necessary, regardless of intended use. Guidelines have been developed for control of legionella in ornamental fountains.

Theoretically, a freestanding water feature should not have a bather load and consequently, many builders would not choose to install filters or sanitation devices. In reality, however; people will interact with ornamental water fountains in the most surprising ways.

8.1.6 Mushrooms fountain

In this kind of fountains water has the form of mushrooms, see fig(8.4).
Dimensions of mushrooms are as follows:
Height: 2.3 m

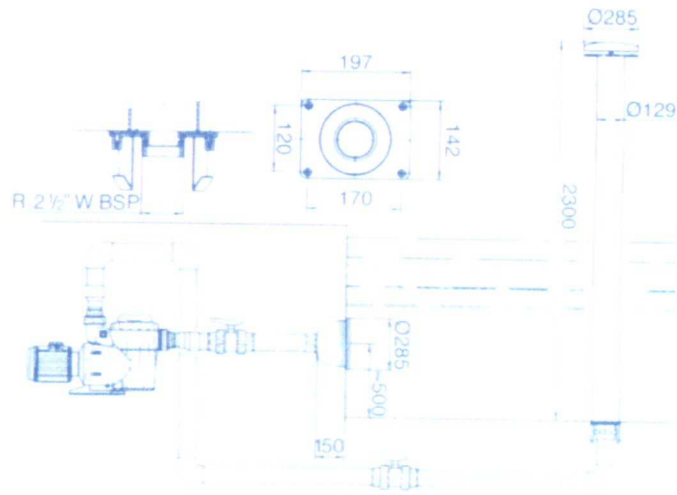


Figure (8.4): Mushrooms fountain

8.1.7 Umbrellas

In this kind of fountains water has the form of umbrella, see fig(8.5).

There are many stainless steel umbrella sizes such that:

- 1- \varnothing 1100 mm
- 2- \varnothing 1500 mm
- 3- \varnothing 2000 mm
- 4- \varnothing 2500 mm
- 5- Column 129 mm
- 6- Column 254 mm

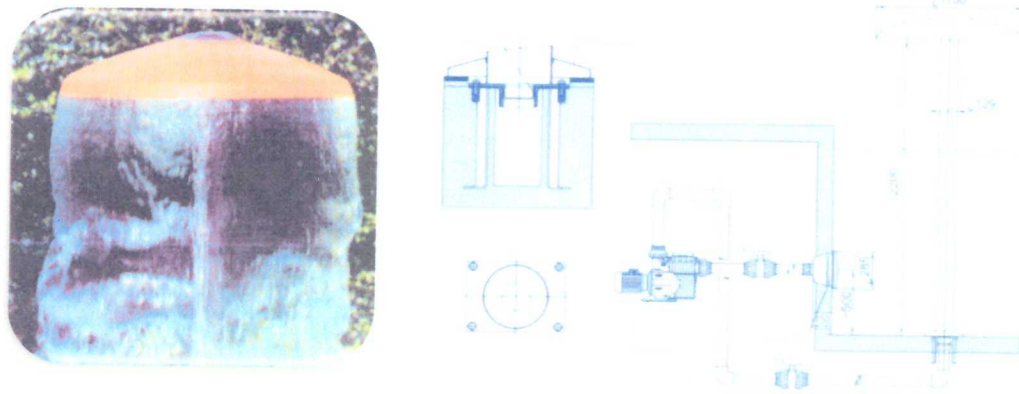


Figure (8.5): umbrella

8.2 Waterfalls

A few words about waterfalls. Adding a fall to an existing pool requires a decision to add the fountain head to the circulation system, treating it essentially like any other return line, or adding a separate suction line, pump, and return to the waterfall. Many technicians are intimidated by the engineering required for installing a fountain or waterfall to a pool or water feature and miss out on valuable jobs. The truth is that the manufacturer of the display has done all this work for us!

Manufacturers of each fountain head, spray design, or waterfall weir provide data sheets explaining flow requirements, resistance (dynamic head expressed in feet or meters), plumbing size requirements, and spray characteristics (such as diameter or distance of fall curve). Of course, flow and head change as the height, volume, and diameter of the discharge changes.

Actual installation of a fountain head or spray display is simple plumbing, with the addition of a gate or ball valve to regulate the flow, thereby adjusting the height or

diameter of the discharge. The actual fountain head can be plumbed onto standard plumbing and fittings, distributed directly off of a return line of the pool.

In the case of a dedicated system, with its own plumbing and a pump separate from the circulation system, the plumbing process requires a separate suction and return line added where it is most practical or aesthetic. The only additional concerns with a separate system are sizing the plumbing and pump.

Once again, the answer lies in the specification sheet provided by each manufacturer. For waterfalls, a chart details the required flow. If, for example, you wanted the fall to curve out over the pool (curve projection) 60 centimeters before falling into the pool, you might require a flow rate of 132 liters per minute. A curve projection of 1.2 meters might require double that flow rate. The specifications also recommend piping size, usually suggested by the size of the adapter fitting on the fountain head or weir itself.

Pump sizing is then a matter of following the calculations of total dynamic head in the system and using a pump that can overcome that resistance and still deliver the desired flow rate. In this case, a slightly larger pump and related plumbing is better, since you can always reduce the flow with a valve, but it is impossible to increase the flow once you have completed the installation or waterfall weirs, because the variety and sizes are endless. The warehouse staff should be able to recommend a special supply house or manufacturer that does. These supply houses and manufacturers can also supply suggestions and technical advice. You can request copies of the manufacturer's specification charts in advance to plan the work and discuss it with your customer.

One unique use of falling water is the vanishing edge , also called the negative edge, this waterfall employs one or more sides where the top of the wall is slightly below the water level of the rest of the pool. The water then evenly cascades over this "low wall," pouring into a catch basin. From the basin, it is pumped to the equipment and returned to the pool in a normal fashion.

Vanishing edges are features that must be designed into a pool in the first place or added during a major remodeling. Engineering is demanding. You must ensure that the basin can hold enough water to allow return to the pool before the pool becomes empty, without overflowing when the pump is turned off. For the technician, the vanishing edge is the ultimate skimmer, since the overflow acts as a natural removal system for leaves and dirt. The basin must be cleared of leaves or other debris regularly to avoid clogging, much like a huge skimmer. The basin must also be vacuumed, or dirt can be brushed toward the suction drain, where it will be taken to the filter. The suction drain is normally designed to accommodate a vacuum hose and the basin itself is shallow enough to reach in, remove the screen or drain cover, attach your hose and vacuum, just like the skimmer.

Creating a soothing grandeur of a beautiful waterfall. The first ever ABS waterfall fountain made to resist pool water corrosion, Operating with the pool circuit and maximum installation height of 1.20 m.



Figure (8.6): power fall

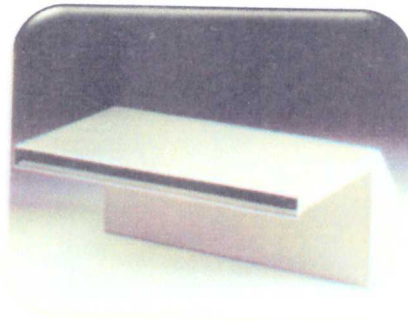


figure (8.7): water fall

Fiber fall is variation of the power fall which you can enjoy the soothing water fall sound even during the night. A rich variety of magical colors will glow your water fall curtain by fitting the fiber optic lighting system, The fiber optic connection requires a 9 m cable and maximum installation height 1.20 m.

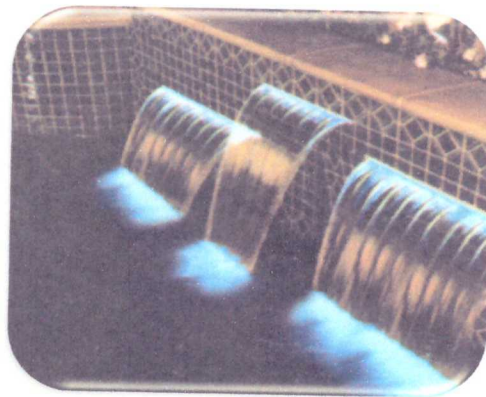


Figure (8.8): fiber fall

The Mini-jet adds a touch of distinction giving your pool a visual and audible effect Upgrading the surrounding pool beauty. The number of Mini-jets to be connected will depend on the pump capacity.

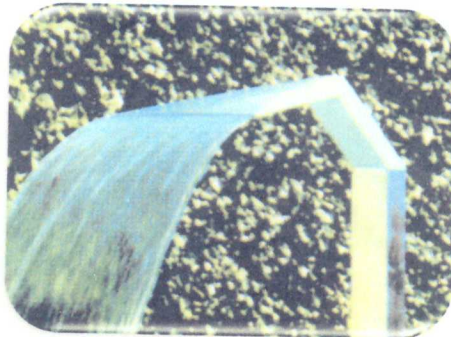


Figure (8.9): Mini jet

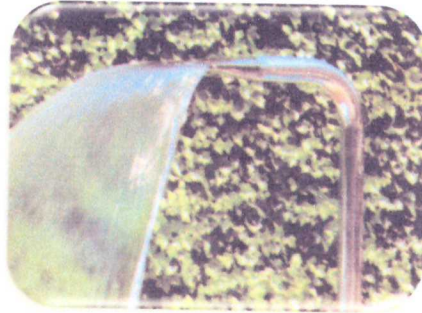
8.3 Water curtain

There are many models of curtain such that:

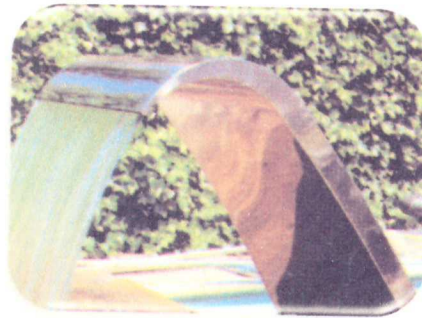
- A) Water curtain 600 mm with height 1.2 m



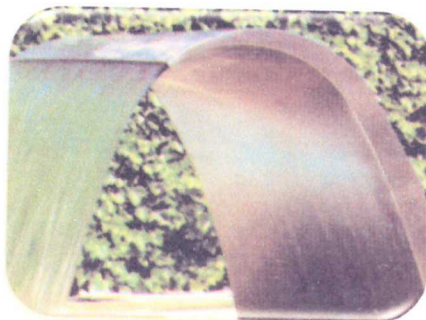
B) water curtain width 340 mm and height 1.2 m.



C) Deluxe water curtain , height 0.8 m.



D) Arched water curtain, there are three shapes.



CHAPTER NINE

ACCESSORIES



9 Accessories

This chapter contains accessories used in the swimming pools such as ladders, diving boards, pool chairs, cleaning devices, floating devices and safety.

9.1 Diving Boards

Diving boards are not as popular as they once were because pools today are built smaller and shallower as people try to save water and energy and because more people use pools for swimming exercise laps rather than for jumping into deep water. Still, there are many boards out there, and as they age, they need repair or replacement. Diving boards are wood, for flexibility, covered with fiberglass, for waterproofing, with a nonskid tread applied on the top.

Diving boards come in simple fulcrum models and spring-assisted jump models for extra bouncing action.. Residential boards are from 1.8 to 3.6 meters in length and 45 centimeters wide. Commercial boards are usually 50 centimeters wide and up to 5 meters in length. Some building and safety codes specify pool dimensions for a diving board to ensure that there is adequate water area and depth for safe diving.

Generally, to accommodate the smallest board, a pool must be at least 2.3 meters deep and at least 4.6 meters wide by 8.5 meters long.

❖ Shapes of diving board

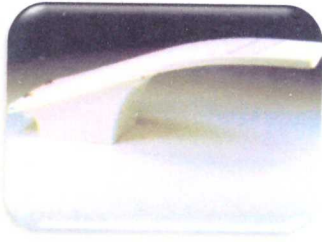


Figure (9.1a): Flexible springboard dynamic.

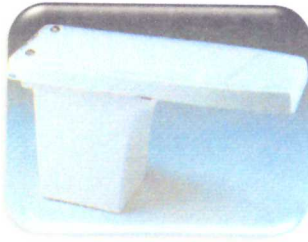


Figure (9.1b): Diving board dynamic.

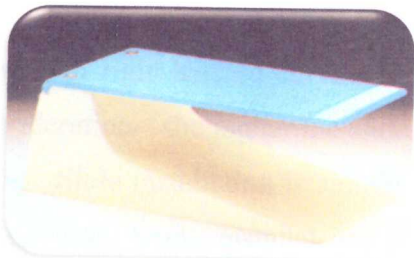
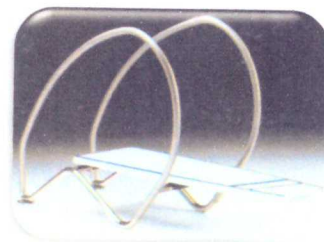


Figure (9.1c): Clip model.

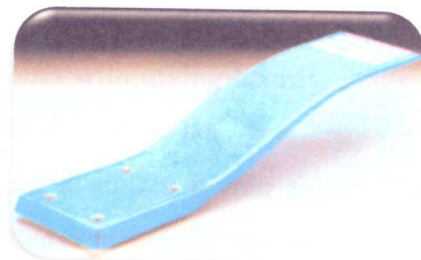


Figure (9.1d): Dolphin model springboard.



Figure (9.1e): Ballista model .

Figure (9.1): Models of diving boards

9.2 Slides

Slides are generally made of fiberglass with metal frames and steps. A straight slide will be 2.5 to 4 meters long, requiring a lot of deck space. If deck space is limited, left-handed or right-handed curved slides are available. As with diving boards, safety is a key consideration—the higher the slide, the deeper the pool needs to be.

Slide installation is simple and anchor kits are available at your supply house with instructions. Some installations provide brackets that you bolt to the deck with special concrete fasteners. Others require drilling 40- or 50-millimeter holes for each of four legs and securing the installation with quick-set cement.

❖ Shapes of slides



Fig(9.2a): Prana model.



Fig(9.2b):Curved model .



Fig (9.2d): Slides for public use. Figure (9.2): model of slides

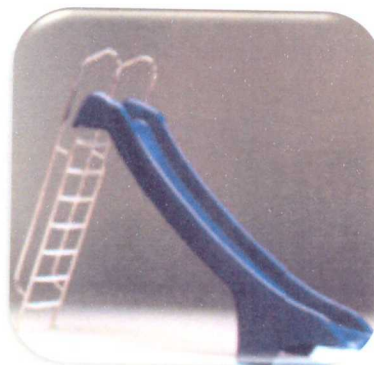


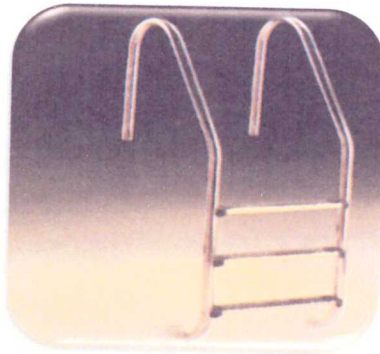
Figure (9.2): Shapes of slides

9.3 Ladders and Rails

Ladders and rails are available in a wide variety of configurations to meet the design needs of any pool or spa. Some are anchored in the deck only, simply resting on the bottom or side of the pool, while others are anchored in the deck and pool.

Installation of a rail or ladder is easy, in fact easier than the manufacturers try to make it. Most installation kits have you drill holes in the concrete deck and/or pool floor and fit the holes with bronze cups that are equipped with bolts and wedges. then mounted the cup in the hole, secured by some quick-set concrete, then put the legs of the rail or ladder into the cups and tighten the wedge.

❖ Common shapes ladders



Fig(9.3a): Standard with handrails



Fig(9.3b): Overflow



Fig(9.3c): Easy access model.



Fig (9.3d): Split pool ladder.

Figure (9.3): Model of ladders

9.4 Automatic Pool Cleaners

There are numerous designs of automatic pool cleaner available today. Some of them are no longer manufactured but you might encounter them in existing installations.

There are two categories of automatic pool cleaner in common, use today and three other less effective.

9.4.1 Electric Robot

The electric robot type of automatic pool cleaner sounds futuristic, but is nothing more than a battery-powered (some are 120 volt, some transformed down to 12 volt) vacuum cleaner with a bag that catches debris as the unit patrols the pool bottom. As you might guess, these are expensive and are found most often on large commercial pools.

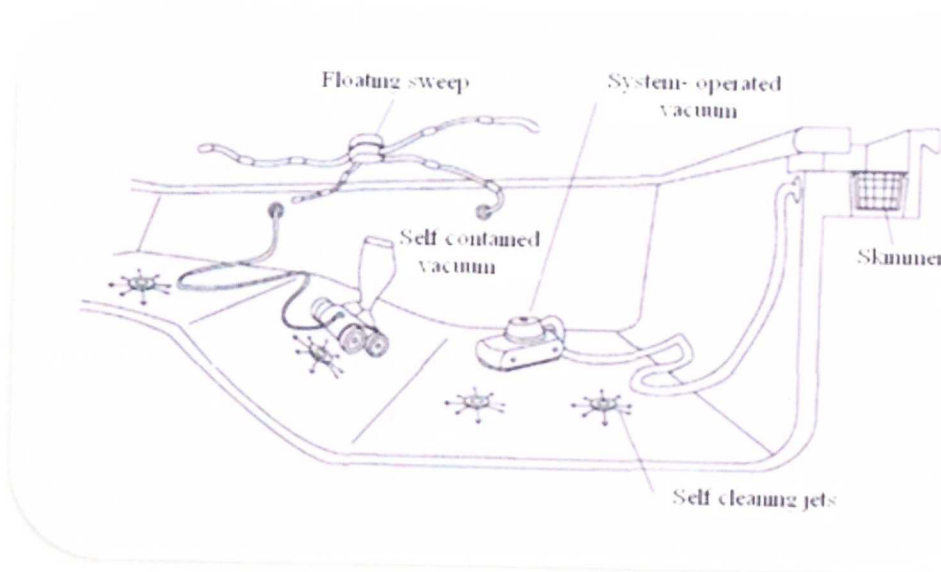


Figure (9.4): Styles of automatic pool cleaners.

9.4.2 Booster less Water Pressure Designs

Some automatic cleaners work like your leaf vacuum by sending a pressurized stream of water up into a catch bag, creating a vacuum for the unit as it patrols the bottom. The pressure is created by taking return water and boosting the pressure with a separate pump and motor. There is nothing wrong with this bolstered type of automatic cleaner.

A variation on this theme, however, is the unit that uses the circulation pump itself as the booster, by connecting to the return line after the pump but before the filter. This style is called booster less because it uses no separate water pressure-boosting device. These units require an automated valve and control system so that the heater does not try to operate while the cleaning unit is in operation.

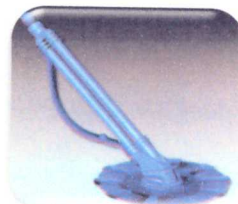
9.4.3 Common shapes of pool cleaners



Bolero



Tornado



Samba



Navigator

Figure (9.5): Pool cleaner's models

9.5 Covers

Pool and spa covers have come into increasing use over the past ten years in an effort to save heating energy costs and water through evaporation. As water evaporates, the

minerals in it are left behind in the remaining pool or spa water. Chlorine, which is made from salt, leaves minerals in the water as well. Covers slow down the rate of evaporation and, therefore, reduce chemical use. Covers keep out leaves and dirt, which also absorb chemicals. Keeping out the dirt means, you vacuum less and clean filter less.

Shielding the water from the sun further cuts down on chemical use. The result is the water in the pool or spa does not get so hard, so quickly. Chemical costs, expensive draining and acid washing, and, as if that were not enough, the heater does not scale up inside from hard water. Covers also help retain heat. Some studies say a cover alone will heat the pool or spa (5° to 7°C), meaning money is saved on gas or electricity. When you do turn on the heater, the water starts out warmer and heats, up faster—a real benefit to a spa when you have a hot date on a cold night

Covers can provide safety. Heavy-duty spa covers can prevent kids from falling into spas, especially when combined with straps or locks to ensure only adults can remove them. Detailed safety standards are set out by Underwriter's Lab and other accrediting agencies for pool safety covers to ensure that a person's weight will be supported if they inadvertently fall into the pool. Of course, not all covers are built with these properties, so the intended users are a critical factor in selecting the right pool or spa cover.

9.5.1 Sheet Vinyl

Particularly, in cold climates where it is desirable to cover pool in winter. Sheet vinyl has little insulating value and does not float, but it is very cheap. Some building and safety codes require pool to have covered, that someone falling into covered pool will not sink.

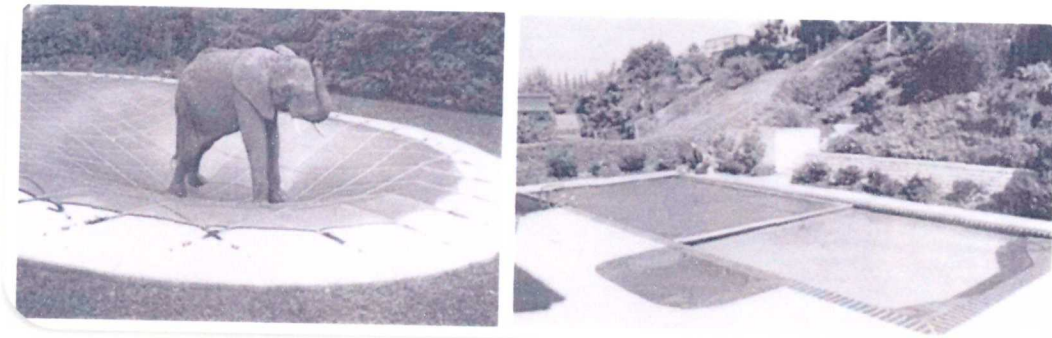


Figure (9.6): Pool covering

9.5.2 Shapes of covering



Figure (9.7): Pool covers shapes

9.6 Overflow grating

It's used to cover the overflow gutter of swimming pools and the figures shown some shapes of it .

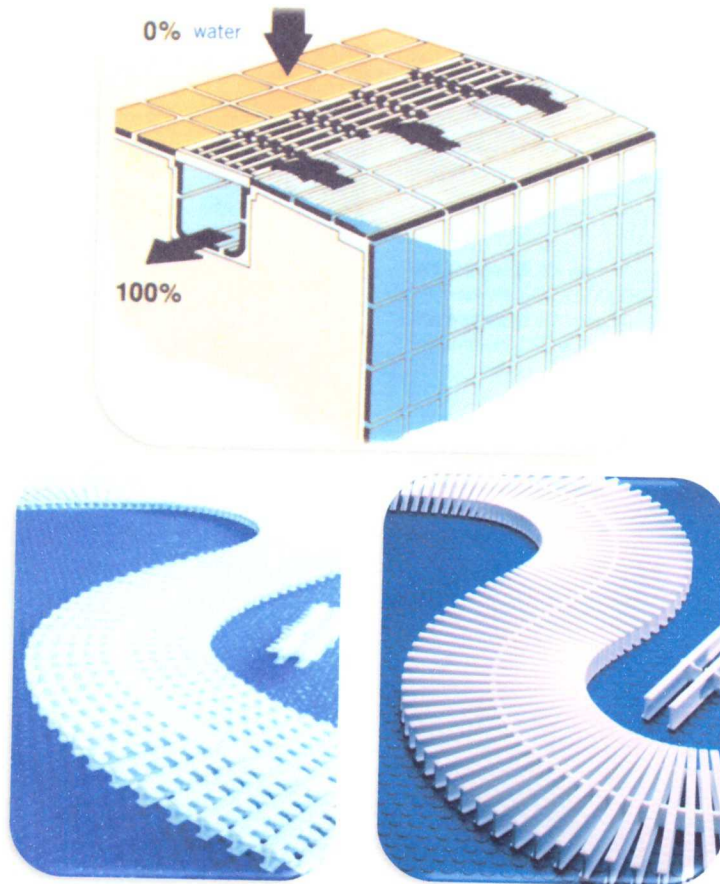


Figure (9.8): Overflow grating

9.7 Pool Timer

Pool Timers for your residential or commercial pool. Inerratic makes the best in pool timers and controls. Simple on/off trippers can keep money in your pocket and ensure the proper 8 hour cycle of your pump and filter .

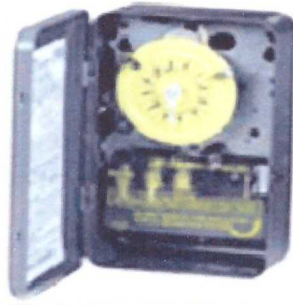


Figure (9.9): Timer

9.8 Landscape Lights



Figure (9.10): Landscape Lights

Our designer series Solar Landscape Lights are powerful enough to illuminate entryways, sidewalks, driveways, and gardens. No Underground Cable Required! Our solar lights collect energy all day long (even on cloudy days) and automatically turn on at dusk to emit long-lasting radiance throughout the night. The Designer Series lights feature the finest in solar technology. Each light is housed in a stainless steel frame with a rich copper or pewter finish (selected lights)

9.9 Pool Light Niche



Figure (9.11): Pool Light Niche

The proper pool light niche needs to be fit according to what pool light you have. For instance, if you have a Hayward light, this needs to fit into a Hayward niche. Likewise, if you own a Large Pentair Niche the Pentair and SAM lights will fit into that niche. The Supervision Galaxy light fits into most Pentair and Hayward niches.

9.10 Transformers

These Safety Transformers are specifically designed to supply 12 volts to pool / spa lights, submersible fixtures and outdoor garden lights. A grounded shield between the primary and secondary windings assures safe operation and the built-in circuit protection will disconnect power to the transformer in case of defect or overload .

9.11 Safety

9.11.1 Surrounding area of the pool



Figure (9.12): Surrounding area of the pool

The area that surrounds the pool must have:

1. An aisle around the pool in the width of at least 1.2 meter.
2. The aisles must have a slope of 2% in the remote part of the pool.
3. Water must not go from the surrounding aisles of the pool inside it.
4. Supplying surface drains, one for each 10 meter square from the area that surrounds the pool.
5. Surrounding area of a pool has to be free of grassy places, sandy or natural soil and dangling plants.
6. Supplying links for water tubes of at least 3/4 inches diameter so as to clean the surrounding area of the pool of about 15 m radius.
7. Supplying the place with garbage containers one for every 50-meter square.

8. Supplying it with drinking places in the average of one for every 25-meter square of the pool's area.
9. Supplying it with sufficient lighting sources and wires should be safely designed.
10. Putting path tubes to cleanse feet on the pool entrance. The area of each is at least 1 meter square and it has a cleaning material permitted from the Ministry of Health.

9.11.2 Safety and public Health Requirements

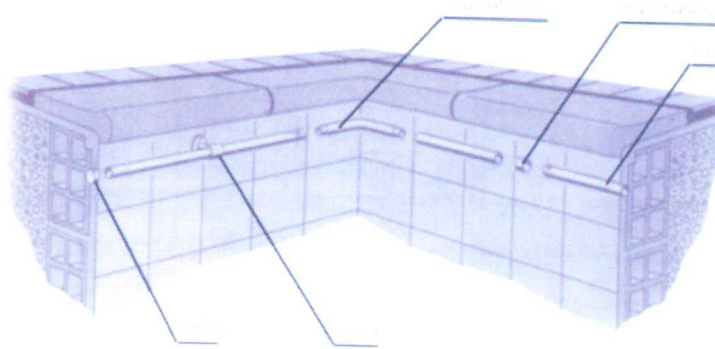
The pool must have the following to keep people's safety.

1. At least one rescuing platform.
2. Rescuing plat form should be against sunrise (in the southern or western side) in order to see people who want to dive.
3. Above the jumping platform, the highest should be at least 5 meters in the case of closed pools.
4. The increase of the water depth in the pools must be shown on the pool sides and on the surface which surrounds the pool by letters and figures in a height of at least 10 cm.
5. A first aid kit in the pool painting on it a red cross inside a red crescent. Its components are limited according to the Ministry of Health directions.
6. Providing the pool with a seat in the width of at least 15 cm for comfort on the outer walls of the pool around the pool in the depth of 120 cm from the water surface.
7. Providing it with usable loudspeakers.

8. Providing it with rescuing light column, it's length is at least 5 m with a semicircle arc on its head.
9. Supplying the pool with two lifebelts; these are put in close places to the pool sides.
10. In the case of closed pools, there should be air suction system to insert pure air.
11. Putting a board on the entrance of the system room written on it " Not for visitors".
12. Putting a caution board on the entrance of color room written on it "depth danger".
13. Putting wallboards in clothes – changing room asked visitors to restrict themselves to the lifeguard directions.
14. Providing the pool with emergency exits in emergency cases.
15. Putting a fire – extinguisher ready for use.
16. The ground and the sides of the pool must be marked with a red line in the depth of 120 cm; The width of that line is 20 cm.. In addition, there must be aboard written on it "Be careful deep water" with clear languages.
17. Providing the pool with at least a telephone ready for use.
18. Writing boards to leave the place clean like please, keep the place clean in many clear places.
19. Writing at least two boards on the entrance and inside the pool that- show the directions of safety and swimming by a big and clear line.

9.11.3 Life saving

There are many accessories used to save the human life's such as Handrails ,Life Saving Hook, Float Lines, Life belt and Life belt Holder. Figures below shown some it .



Fig(a): Handrails

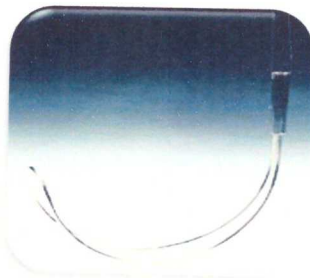
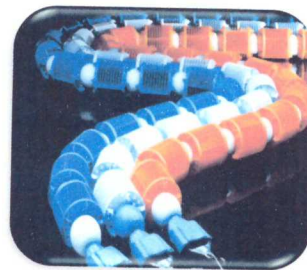


Fig (b):Life Saving Hook.



Fig(c): Float Lines.



Fig (d):Life belt.



Fig(e): Life belt Holder.

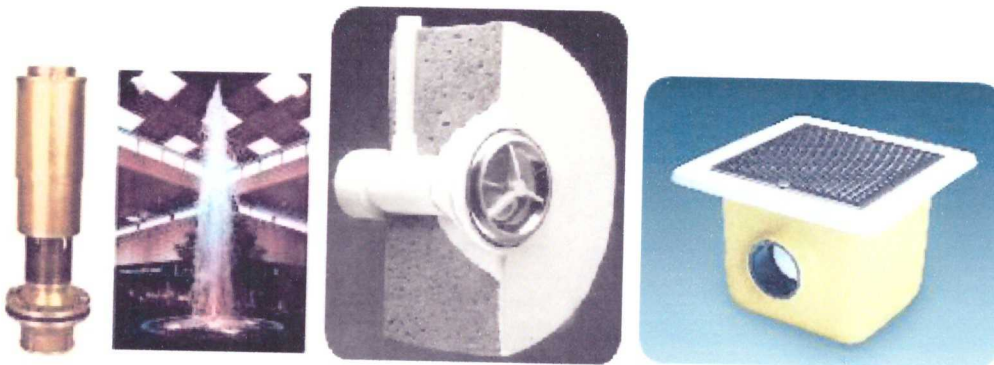
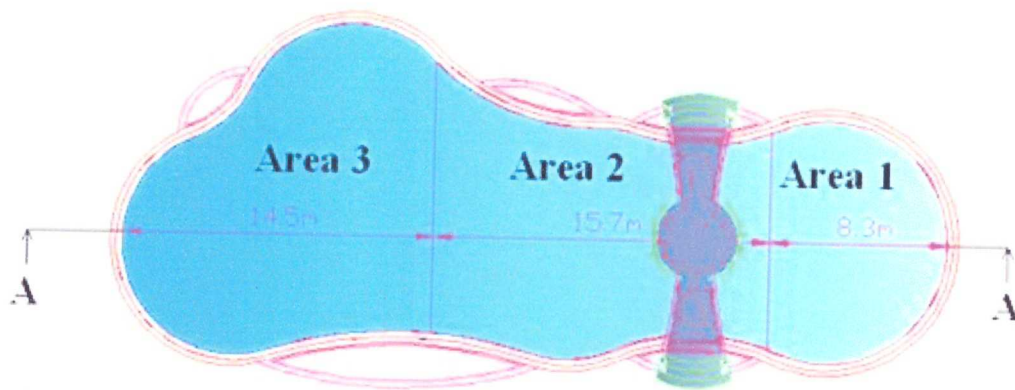
Figure (9.13): life saving tools

CHAPTER TEN

DESIGN OF SWIMMING POOLS

AND

WATER FEATURES



10.1 Overflow swimming pool

10.1.1 Capacity of pool

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 * average depth

$$\text{Average depth} = \frac{\text{max .depth} + \text{min .depth}}{2}$$

If the slope of the bottom not gradual as it in our project then we have to treat the pool as 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.

The figure below shows the swimming pool plan.

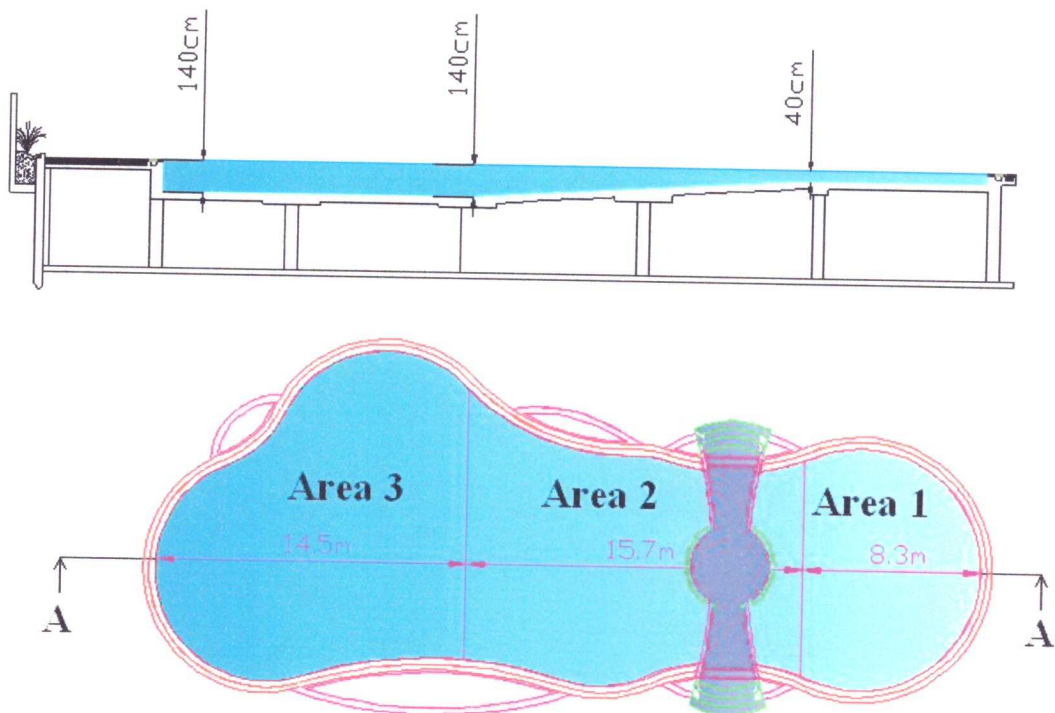


Figure (10.1): Swimming pool plan

Area 1 = 79.027m² (By AutoCAD applications).

Minimum depth= maximum depth = 40 cm .

Area 2 = 161.069 m²

Minimum depth = 40 cm.

Maximum depth = 140 cm.

Average depth = $\frac{\text{maximum depth} + \text{minimum depth}}{2} = \frac{140 + 40}{2} = 90 \text{ cm}$

Area 3 = 171.649 m²

Minimum depth= maximum depth = 140 cm .

Volume of water = area * depth

$V = V1 + V2 + V3$

$V1 = 79.027 * 0.40 = 31.61 \text{ m}^3$

$V2 = 161.069 * 0.9 = 144.962 \text{ m}^3$

$V3 = 171.649 * 1.40 = 240.30 \text{ m}^3$

$V = 31.61 + 144.962 + 240.30$

$= 416.872 \text{ m}^3 .$

10.1.2 Turnover

Turnover is the number of hours it takes the filter to pass one pools worth volume of water.

Turnover formula

Pool water at peak load conditions depends on a filtration system meeting the rate of progressive pollution, which involves:

- Type of the pool: its environment, indoor or outdoor, town or country.
- The water: area and volume, temperature and PH, soluble salts and chemical treatment and disinfection rates.
- The filter performance: its capacity and degree of filtration, flow rate and area, media and grade and the filter condition.

- The circulation efficiency: inlet and outlet positions, head loss in system and pump rating.
- The bathing load: the number of bathers and their distribution.
- Personal hygiene standards: pre-cleanse facilities and even the wealth and the capability of the pool owner.

So many variable things make calculations complex and unreal. Hence, turnover is best taken as a practical guide to optimum pool water purification at different conditions, and it is based on how often the whole water needs to be filtered.

Basic turnover with filter at clean running pressure and full working head :

$$\text{Turnover} = \frac{\text{Pool Capacity } m^3}{\text{Filter Rating } m^3/h}$$

The turnover periods should always relate to the type of pool and features contained within .

In our project turnover should be calculated on the largest volume possible at any given time.

Table (10.1) : Ideal turnover periods

Type of pool	Hours
Paddling, intensive use learner, spa, beach of a leisure pool, teaching ,therapeutic, play, intensive use leisure .	1
Public, intensive use hotel leisure.	2
School, Olympic/50m,outdoor public.	3
Training /competition, light use school, outdoor private.	4
Hotel, diving	5
Residential	7
Indoor small private	10

10.1.4 The balance tank

The balance tank is provided as a reservoir for a volume of water extra to that of the pool tank. 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 that, waves caused by movement within the water mean it must also 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 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 feature to achieve this and is an item that should require occasional inspection and cleaning to maintain a good seating.

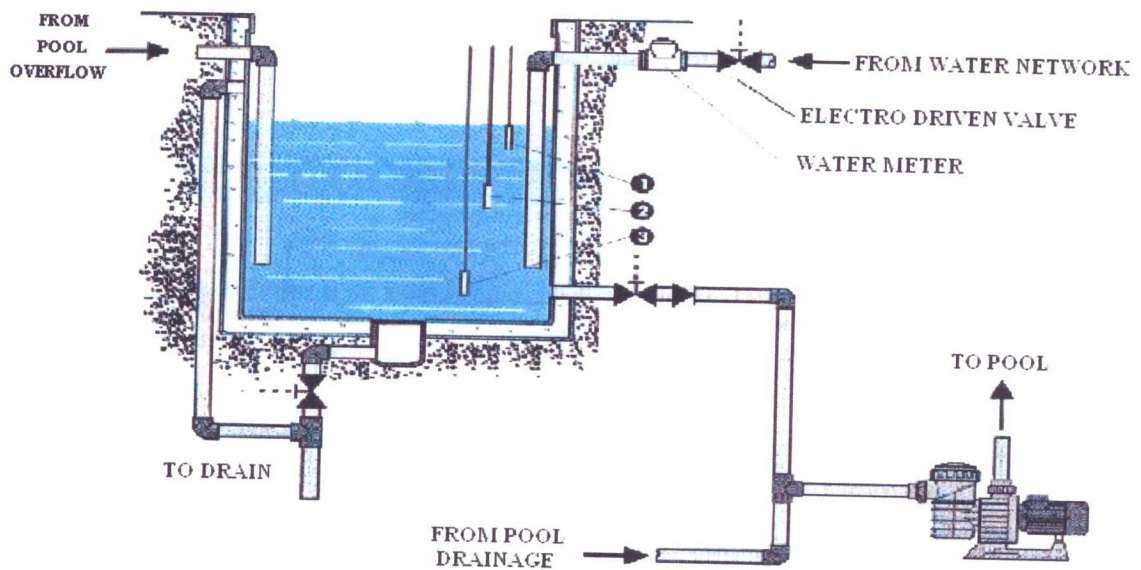


Figure (10.2): Balance tank diagram

Where :

The following information explain the numbers in figure:

- 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 make up water.
- 3) Minimum level signal in compensation tank for shutting down the pumping system .

10.1.4.1 Balance tank volume formula (SPTA construction)

$$\text{Volume} = \text{water surface area} * F$$

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 (10.3): Tank volume factor

Type of pool	F (liter)
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 our project :

Base capacity in balance tank = water surface area * F

$$\begin{aligned} \text{Water surface area} &= \text{Area1} + \text{Area2} + \text{Area3} \\ &= 411.745 \text{ m}^2. \end{aligned}$$

F: from table (10.3) for the commercial pool with play / water features (50 – 75) liter, we select (62.5) liters (the average).

$$\begin{aligned} \text{Base capacity in balance tank} &= 411.745 * 62.5 \\ &= 25743 \text{ liter} \\ &= 25.743 \text{ m}^3. \end{aligned}$$

B.T.C :Balance Tank Capacity.

$$\begin{aligned} \text{B.T.C.} &= \text{base capacity (33.3\%)} + \text{surge capacity (33.3\%)} + \text{safety capacity (33.3\%)} \\ &= 25.743 + 25.743 + 25.743 \\ &= 77.229 \text{ m}^3. \end{aligned}$$

The balance tank will be fitted with the following :

- Easy access inspection covers
- Safety overflow
- Level indicator
- Suction valve

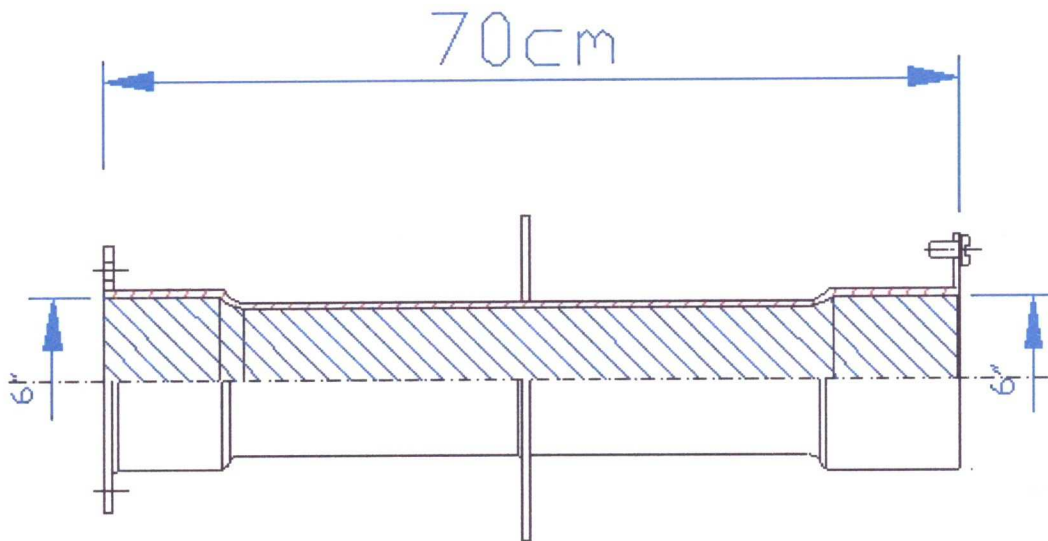


Figure (10.3): Pipe from balance tank

10.1.4.2 Total capacity of water

$$\begin{aligned}
 \text{Total capacity of water} &= \text{Pool capacity} + \text{Base capacity in balance tank} \\
 &= 416.872 + 25.743 \\
 &= 442.615\text{m}^3
 \end{aligned}$$

10.1.5 Filter sizing and selection

10.1.5.1 Filtration rate

To calculate the filtration rate we use the following equation :

$$\text{TurnoverTime}(hr) = \frac{\text{WaterCapacity}(m^3)}{\text{FilterRate}(m^3 / hr)}$$

$$\text{FilterRate}(m^3 / hr) = \frac{\text{WaterCapacity}(m^3)}{\text{TurnoverTime}(hr)}$$

$$\text{FilterRate}(m^3 / hr) = \frac{442.615m^3}{3.5hr} = 126.46$$

$$\text{FilterRate}(L / sec) = \frac{126.46 * 1000}{3600} = 35.12$$

➔ The chosen design Filtration velocity = 25 m³/hr/ m² of filter surface area .

$$* \text{ Filter surface area} = \frac{\text{FiltrationRate}}{\text{FiltrationVelocity}} = \frac{126.46}{25} = 5.06m^2$$

10.1.5.2 Pressure loss through filter

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

$$3 \text{ psi} + 7.1 \text{ psi} = 10.1 \text{ psi} = 6.7 \text{ m}$$

Which should be used as the design pressure loss through filter.

10.1.5.3 Selection of the filter

- Filtration rate is 126.46 m³/hr.
- Filtration velocity is 25 m³/hr/m² of the filter surface area.

From Astral catalogue (copy 2004-2005,page 112) we selection the filter for the following specifications :-

- ❖ Filter name Atena model (Bobbin Wound filter)
- ❖ Filtration surface area : 2.54m².
- ❖ Filter diameter : 1800 mm .
- ❖ Filter flow rate = velocity of filtration * filter surface area

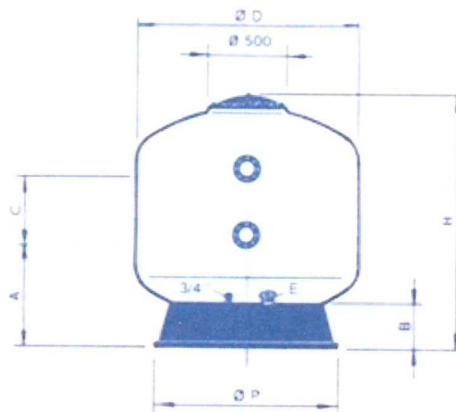
$$= 25 * 2.54$$

$$= 63.5m^3/hr.$$
- ❖ Volume : 3400 L .

- ❖ Sand : (0.4 – 0.8) mm , 3100 kg .
- ❖ Gravel : (1.0 – 2.0) mm , 750 kg .
- ❖ Weight : 270 kg .
- ❖ Total weight in operation : 5100kg .

$$\text{Number of filter} = \frac{\text{Total flow rate}}{\text{Flow rate for one filter}} = \frac{126.46}{63.5} = 1.99$$

Then the number of filters is two .



A	B	C	ΦD	ΦP	H	E
720mm	280mm	465mm	1800mm	1370mm	1887mm	140mm

Figure (10.4): Pool filter

10.1.6 Drains sizing and selection

10.1.6.1 Main drains selection

The main floor drain selection should be based on the following :

- 1) 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 0.5 m/sec, but 0.2 m/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 blocked the other takes the full flow.
- 4) Minimum distance between drains more than 2 m .

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

From the experience of the professionals in swimming pools design (our supervisor 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

$$= 0.20 * 126.46$$

$$= 25.29 \text{ m}^3/\text{hr}$$

From Astral catalogue(copy 2004-2005,page 67) we choose the concrete pool main drains of code No. 00273 , and the following specifications are :

- ❖ Main drains name : concrete pools – main drains, square main drains with grille, outlet of 2 ".
- ❖ Recommended flow rate : 13 m³/hr
- ❖ Side connection : 2"

$$\text{Number of main drain} = \frac{\text{Flow rate of main drains}}{\text{Flow rate for each main drain}} = \frac{25.29}{13} = 1.945$$

We select two main drains to:

- Reduce the main drains grill velocity lower than 0.5 m/sec .
- Avoid extra suction through main drain if one is blocked .
- Reduce suction head to a minimum which enhance pump efficiency .

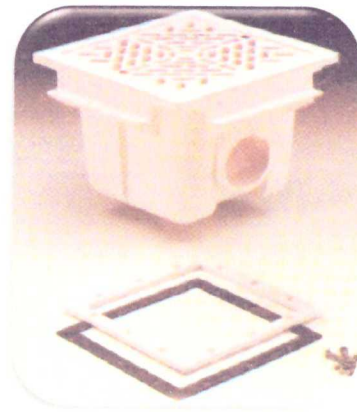


Figure (10.5): Square main drain

❖ Main drains distribution

The minimum distance between drains is more than 2m. (Astralpool catalogue, 2004-2005, page 66).

We chose to install two main drains in the deepest region of the pool and the distance between main drains is two meters and so between main drains and walls.

10.1.6.2 Drains of over flow gutter selection

From Palestinian National Community

- Minimum depth of overflow gutter is 7.5cm and the slope is 2% to overflow Drains.
- Maximum distance between drains of overflow gutter is 4.5m and its diameter is 2 in .
- Minimum distance between drains of overflow gutter is 0.5m.
 - ❖ The perimeter of pool in our project is 93.7m(AutoCAD Application).
 - ❖ Flow from overflow gutter = 80% of filtration rate

$$= 0.80 * 126.46$$

$$= 101.168 \text{ m}^3/\text{hr}$$

From Astral catalogue(edition 2004-2005,page 58) ,We select the overflow channel drainage point, body and grill in ABS , screws in S.S. to be glued to external Φ 63mm , and the following specifications:

- Code : 00302
- Standard packing : 12
- Standard weight : 3.1 kg
- Standard volume : 0.016 m³
- Maximum advisable flow rate : 7 m³/hr

To determine the number of over flow channel drainage we selected 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 m³/hr

$$\text{Number of overflow drains} = \frac{\text{total flow rate}}{3.5} = \frac{101.168}{3.5} = 28.9$$

Then the number is 29 .

$$\begin{aligned} \text{distance between overflow drain} &= \frac{\text{Perimeter}}{\text{number of overflow drains}} = \frac{93.7}{29} \\ &= 3.23 \text{ m} \end{aligned}$$



Figure (10.6): Over flow channel drainage

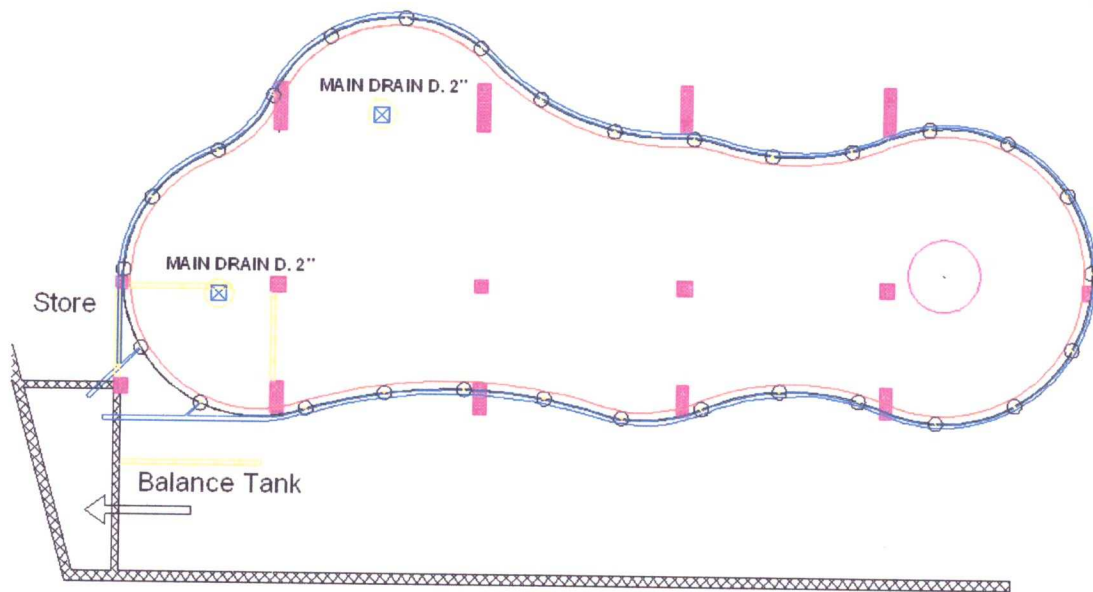


Figure (10.7): Main drains and overflow drains distribution

dimensions of overflow channel : _

1. Length = perimeter = 93.7m
2. Width = 25cm
3. Depth = 20 cm

10.1.7 Return inlets selection

Flow rate of all floor inlets = filtration rate = 126.46 m³/hr

From Astral catalogue (copy 2004-2005, page 71) we choose the ABS inlets with Φ 63 mm and maximum flow rate 12 m³/hr .

We select 9 m³/hr for design and dosing .

$$\begin{aligned} \text{Number of floor inlets} &= \frac{\text{total flow rate}}{\text{flow rate for one inlet}} \\ &= \frac{126.46}{9} = 14.05 \end{aligned}$$

Then the number of floor inlets is 14 .

Specifications of each floor inlet :

- ❖ 2" external thread
- ❖ $\Phi 63\text{mm}$
- ❖ Code 20139
- ❖ Standard volume : 0.021 m^3

Distance between floor inlets is 3m in all directions.



Figure (10.8): Return inlet

Figure below shows the distribution of all floor inlets in swimming pool .

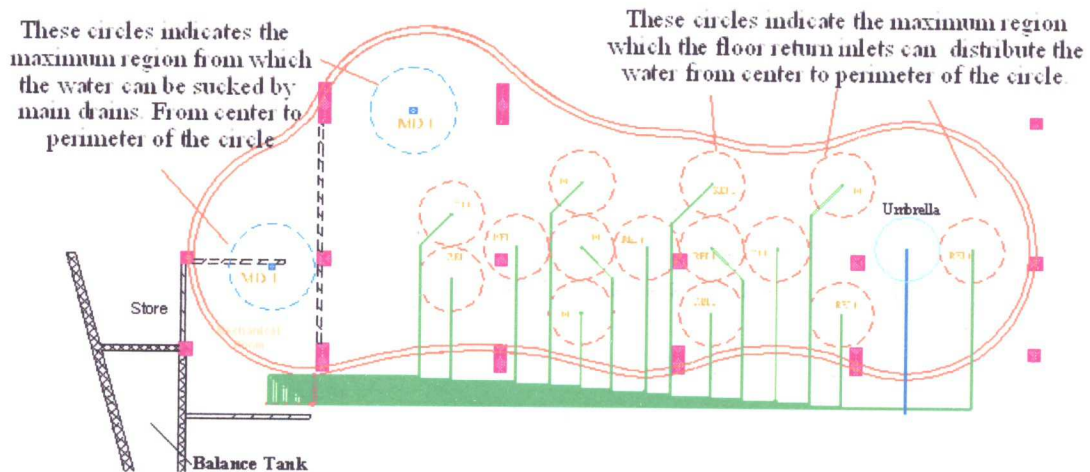


Figure (10.9): Return inlets distribution

10.1.8 Pool pipes system

1. The main suction line plays a critical part in the wear and efficiency of the pump. This pipeline should be short, straight and full-pored, allowing a water flow of between (0.5-1 m/sec), which equals (1.6-3.3 ft/sec) with maximum friction losses 6ft/100ft.
2. All piping on the discharge side of the pump for filtration shall have pipe size 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.
3. Pump is weakest at suction side. Therefore; ensure shortest possible suction runs.
4. All discharge and suction lines shall have a uniform slope in one direction of not less than 3in/100ft.

10.1.8.1 Discharge Lines Pipe Sizing

The discharge line from the pump to the various return inlets is shown in the schematic diagram. In this diagram, the required flow rate for each part of the discharge line is shown.

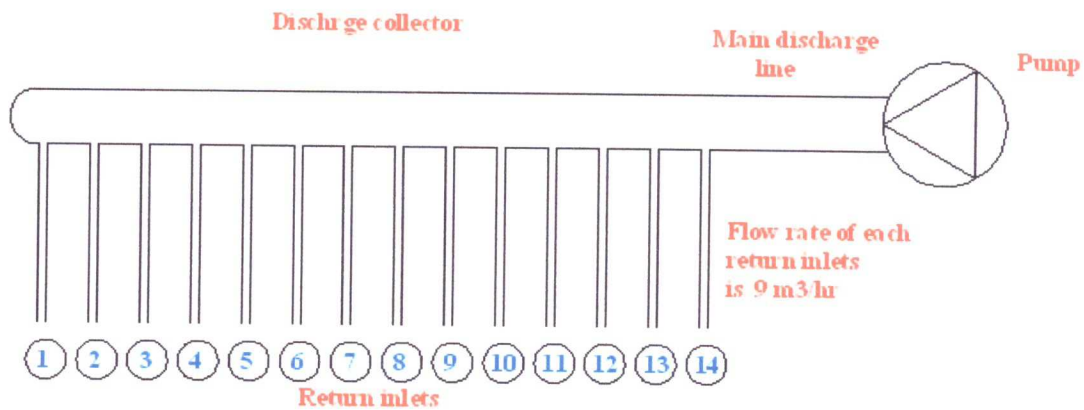


Figure (10.10): Schematic diagram for discharge line

Information of main discharge lines and collector

- Flow rate = $126.46 \text{ m}^3/\text{hr} = 556.42 \text{ gpm}$
- Maximum velocity acceptable = 10 ft/sec
- Maximum friction loss = $12 \text{ ft}/100\text{ft}$
- Length = 19.30 m (from AutoCAD drawing by measurement)

From PVC tables in Appendix A , and by interpolation at the following values:

Flow rate (gpm)	Friction head (ft/100ft)	Velocity (ft/sec)
500	1.5	5.6
556.42	f	V
750	3.3	8.4

By interpolation we find :

- Friction head = $1.9 \text{ ft}/100\text{ft}$
- Velocity = 6.23 ft/sec
- Diameter = 6 in

Return inlets information

(From PVC pipes tables in Appendix A)

Table (10.4): Return inlets information for overflow pool

N _o	Flow rate (m ³ /hr)	Flow rate (gpm)	Length (m)	Diameter (mm)	Friction head (ft/100ft)	Velocity (ft/sec)
1	9	39.6	17.80	50	2.8	3.9
2	9	39.6	15.50	50	2.8	3.9
3	9	39.6	19.85	50	2.8	3.9
4	9	39.6	24.95	50	2.8	3.9
5	9	39.6	19.73	50	2.8	3.9
6	9	39.6	24.76	50	2.8	3.9
7	9	39.6	25.49	50	2.8	3.9
8	9	39.6	30.11	50	2.8	3.9
9	9	39.6	25.51	50	2.8	3.9
10	9	39.6	30.50	50	2.8	3.9
11	9	39.6	31.40	50	2.8	3.9
12	9	39.6	36.50	50	2.8	3.9
13	9	39.6	31.32	50	2.8	3.9
14	9	39.6	40.19	50	2.8	3.9

Each return inlet flow rate = total flow rate (m³/hr)/ number of return inlets.

Note: 1m³/hr = 4.4 gpm

Pressure drops in the discharge lines

To calculate the total pressure drop in the discharge line, we have to calculate the total equivalent length of the pipes, which is the pipe length, and the equivalent length of the fittings.

Total equivalent length = pipe length * 2

Note

- ❖ 1m pipe length = 3.28 ft
- ❖ The pipe diameter from the discharge line to each return inlet is (50mm), because the selected return inlets connections equal (50mm).

The total friction head from discharge line is

$$\begin{aligned} &= \Sigma (\text{total equivalent length of each pipe (ft)} * \text{friction head for each (ft/100 ft)}) \\ &= (19.30 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (1.9 \text{ ft}/100 \text{ ft}) + (40.19 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (2.8 \text{ ft}/100 \text{ ft}) \\ &= 9.78 \text{ ft} = (9.78/3.28) \text{ m} = 2.98 \text{ m} \end{aligned}$$

10.1.8.2 Suction line

The suction line from balance tank and main drains to the pump is shown in the schematic diagram.

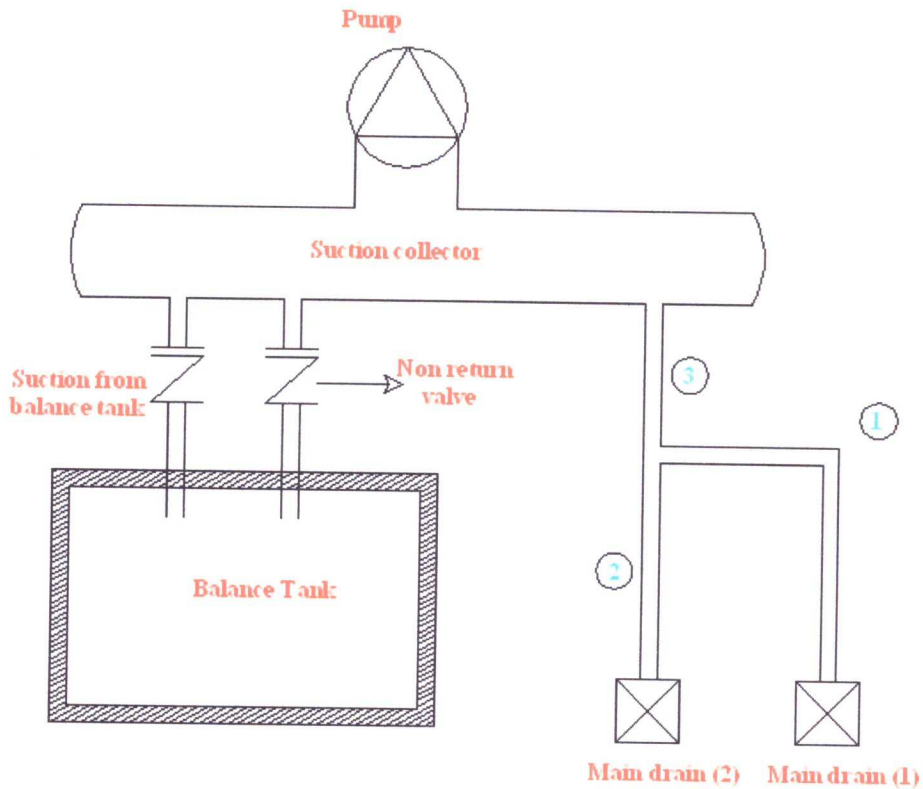


Figure (10.11): Schematic diagram for suction line

Information for main drains pipes

- Maximum velocity acceptable = 3.3ft/sec
- Maximum friction loss = 6 ft/100ft

From PVC tables in Appendix A , and by interpolation at the following values:

Pipe №	Flow rate (m ³ /hr)	Flow rate (gpm)	Length (m)
1	13	57.2	20.06
2	13	57.2	6.32
3	26	114.4	7.10

Where : The length from AutoCAD drawing by measurement.

By interpolation we find :

Pipe №	Diameter (in)	Friction head (ft/100ft)	Velocity (ft/sec)
1	2	5.8	5.9
2	2	5.8	5.9
3	4	0.73	2.95

Information for pipes from balance tank

- Maximum velocity acceptable = 3.3ft/sec
- Maximum friction loss = 6 ft/100ft
- Total flow rate required from balance tank = 101.16 m³/hr = 445.104 gpm

From stainless steel pipes tables Appendix A:

At flow rate 445.104 gpm , diameter 5" , the velocity is more than 3.3ft/sec .

To decrease the velocity we divided the flow rate into two parts, each part is 222.5 gpm .

Then: at 222.5 gpm and diameter 6"

Velocity = 2.3 ft/sec

Friction head = 0.8 ft/100ft

These values in the rang acceptable .

Where : the length of each pipe is 1.30 m (from AutoCAD drawing)

Suction collector information

- Maximum velocity acceptable = 3.3 ft/sec
- Maximum friction loss = 6 ft/100ft
- Flow rate = 126.46 m³/hr = 556.42 gpm
- Length = 2.0 m (from AutoCAD drawing)

From PVC tables in Appendix A , and by interpolation at the following values:

Flow rate (gpm)	Friction head (ft/100ft)	Velocity (ft/sec)
500	0.3	2.9
556.42	F	V
750	0.4	3.2

By interpolation at 8" diameter we find :

- Friction head = 0.32 ft/100ft
- Velocity = 2.96 ft /sec
- Diameter = 8 in

Pressure drop in the suction line

The total friction head from suction equals =

$$\begin{aligned} &= \Sigma (\text{total equivalent length of each pipe (ft)} * \text{friction head for each (ft/100 ft)}) \\ &= (20.06\text{m}) * 2 * (3.28\text{ft/m}) * (5.8\text{ft}/100\text{ft}) + (6.32\text{m}) * 2 * (3.28\text{ft/m}) * (5.8\text{ft}/100\text{ft}) + \\ & (7.10\text{m}) * 2 * (3.28\text{ft/m}) * (0.73\text{ft}/100\text{ft}) + ((1.30\text{m}) * 2 * (3.28\text{ft/m}) * (0.8\text{ft}/100\text{ft})) * 2 \\ & + (2.0\text{m}) * 2 * (3.28\text{ft/m}) * (0.32\text{ft}/100\text{ft}) \\ &= 10.53 \text{ ft} \\ &= (10.53\text{ft}) / (3.28\text{ft}/\text{m}) \\ &= 3.21\text{m} \end{aligned}$$

Pipe lines from drains of gutter to balance tank

There are two lines with slope 2% (1/4 in/ft).

$$\begin{aligned} \text{Velocity of water flow} &= \frac{\text{Circulation rate } \left(\frac{m^3}{hr}\right)}{\text{Free open area of grill } (m^2) * 3600} \\ &= \frac{126.46 (m^3/hr)}{0.25 m * 0.2 m * 3600} = 0.7m/s \end{aligned}$$

To determine the diameter we apply the continuity equation :

$$Q = A * V \quad \text{then } A = \frac{Q}{V}$$

Where :

- Q : Flow rate of water in pipe
- A : Cross section area of pipe $\left(\frac{\pi D^2}{4}\right)$
- V : Velocity of water flow

$$A = \frac{Q}{V} \quad \text{then} \quad \frac{\pi D^2}{4} = \frac{Q}{0.7 * 3600}$$

$$D^2 = \frac{4}{\pi} * \frac{1}{0.7 * 3600} * Q$$

$$D = 0.0225 \sqrt{Q} \quad (\text{diameter in meter})$$

$$D = 22.5 \sqrt{Q} \quad (\text{diameter in millimeter})$$

The figure below explain the pipe from gutter channel to balance tank .

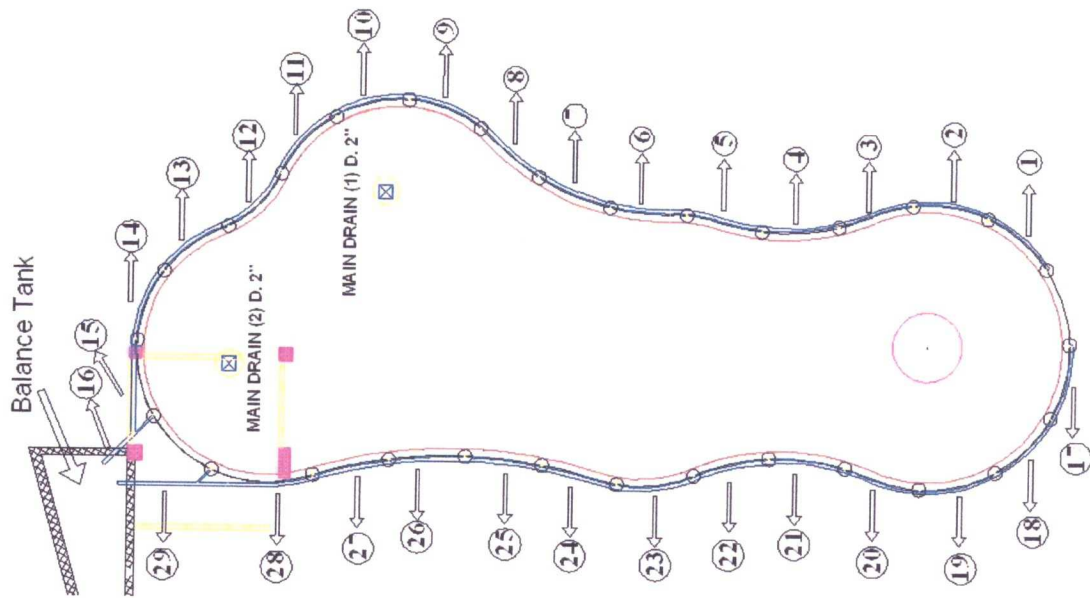


Figure (10.12): Gutter pipes

Calculation diameter for pipe No 1 :

- Flow rate of pipe No 1 = $3.5 \text{ m}^3/\text{hr}$.
- $D = 22.5 \sqrt{3.5} = 42 \text{ mm}$.
- Design diameter is $63 \text{ mm} = 2 \text{ in}$.

The table below explains the diameter in each pipe .

Table (10.5): Diameter of gutter pipes

Pipe	Flow rate (m ³ /hr)	Calculated diameter (mm)	Design diameter (mm)	Design diameter (in)
1	3.5	42	63	2
2	7	59.5	63	2
3	10.5	72.9	75	2 1/2
4	14	84	90	3
5	17.5	94	110	4
6	21	103	110	4
7	24.5	111.4	125	5
8	28	119	125	5
9	31.5	126.3	140	6
10	35	133.1	140	6
11	38.5	139.6	140	6
12	42	145.8	160	7
13	45.5	151.7	160	7
14	49	157.5	160	7
15	52.5	163	200	8
16	56	168.4	200	8
17	3.5	42	63	2
18	7	59.5	63	2
19	10.5	72.9	75	2 1/2
20	14	84	90	3
21	17.5	94	110	4
22	21	103	110	4
23	24.5	111.4	125	5
24	28	119	125	5
25	31.5	126.3	140	6
26	35	133.1	140	6
27	38.5	139.6	140	6
28	42	145.8	160	7
29	45.5	151.7	160	7

10.1.9 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 Bernolli's equation the static head will be zero.
- ❖ Dynamic head

It 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 :

- Friction head losses in piping (both suction and discharge piping), fittings and valves.
- Friction head losses within filter .
- Friction head losses through main drains and return inlets.

Where:

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

$$= 3.21 + 2.98 = 6.19 \text{ m}$$

- ❖ Friction head in filter = 6.7m .
- ❖ Friction head through main drains and return inlets should be taken from manufacture specification for each one .However general rule of thumb is to add 1.5m 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 filters + friction head in main drains and return inlets

$$= 6.19+6.7+1.5= 14.39 \text{ m}$$

Pump selection

Required specification of the pump are :

- ❖ Total head = 14.39 m
- ❖ Flow rate = 126.46 m³/hr

By referring to Astral catalogue (copy 2004-2005,page 159), the flow rate is very high, then we divided the flow rate into two pumps.

Flow rate for one pump = $126.46 / 2 = 63.23 \text{ m}^3/\text{hr}$

Total head for one pump = 16.05 m because the tow pumps are parallel connected.

We select three pumps , two for working and others standby working.

Specifications for each pump :

- ❖ Pump name : cast iron 1450 rpm
- ❖ Code No. : 01213
- ❖ Power : 5.5 kw (7.5 HP)
- ❖ Flow rate : 77m³/hr at 16 m head .
- ❖ Connection : suction Ø90 mm, discharge Ø75 mm



Figure (10.13): Cast iron pump

10.1.10 Chlorine tank and treatment pool systems

- Chlorine tank

From Astral catalogue (copy 2004-2005, page 208), we select the following compact dosage tank :

- ❖ Code : 16632
 - ❖ Standard packing : 1
 - ❖ Standard weight (kg) : 18
 - ❖ Standard volume (m³) : 0.185
- ➔ Compact dosage tank 60 L
- ❖ Triclor (for pool from 500 to 1000 m³)
 - ❖ Bromine (for pool from 300 to 450 m³)



Figure (10.14): Chlorine tank

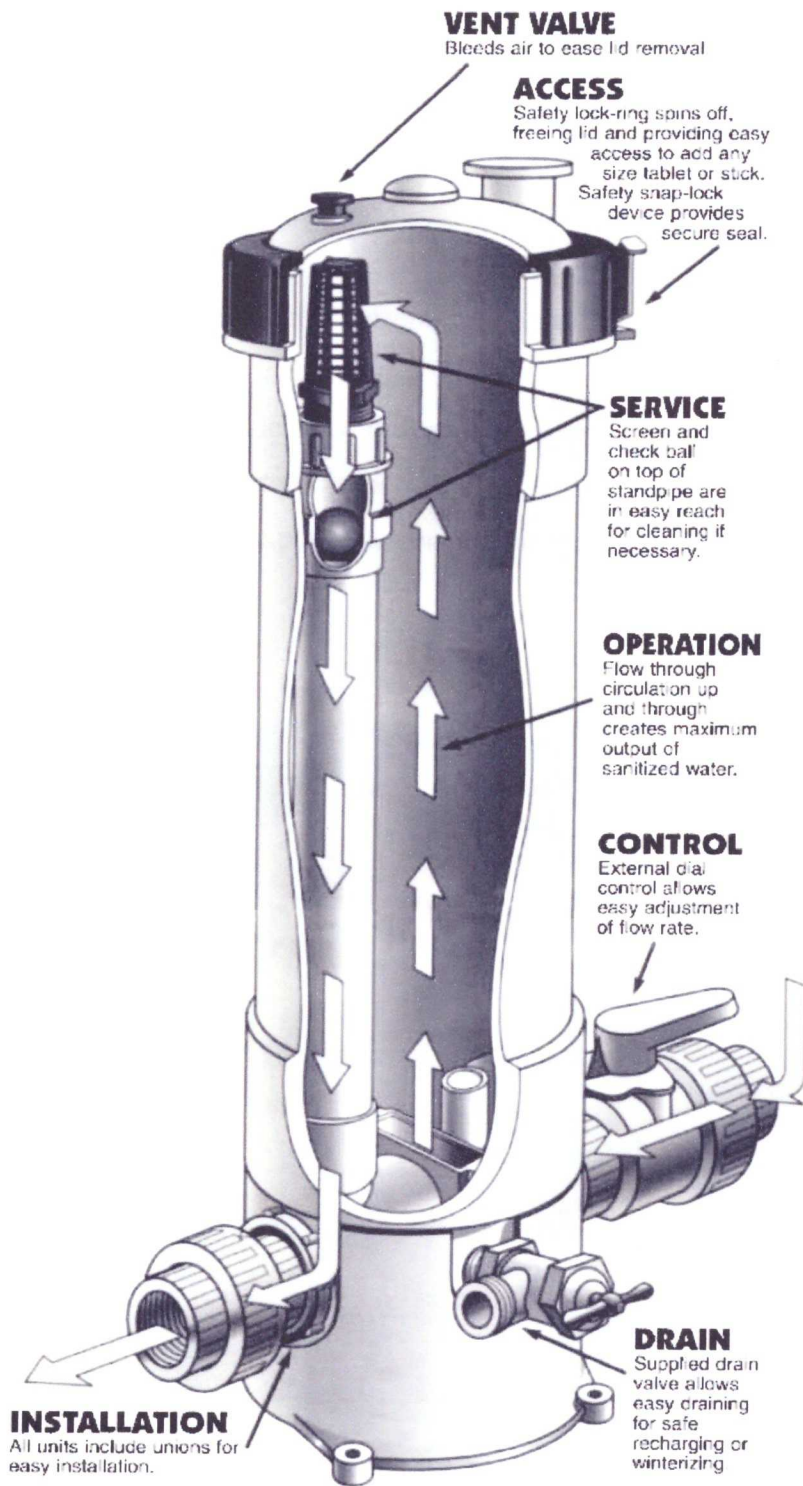


Figure (10.15) : chlorine tank operation

- **Treatment pool systems**

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

In our project we selected the automatic regulation treatment because the pool is public and located in a hotel .

The figure below explain the connection of automatic regulation system .

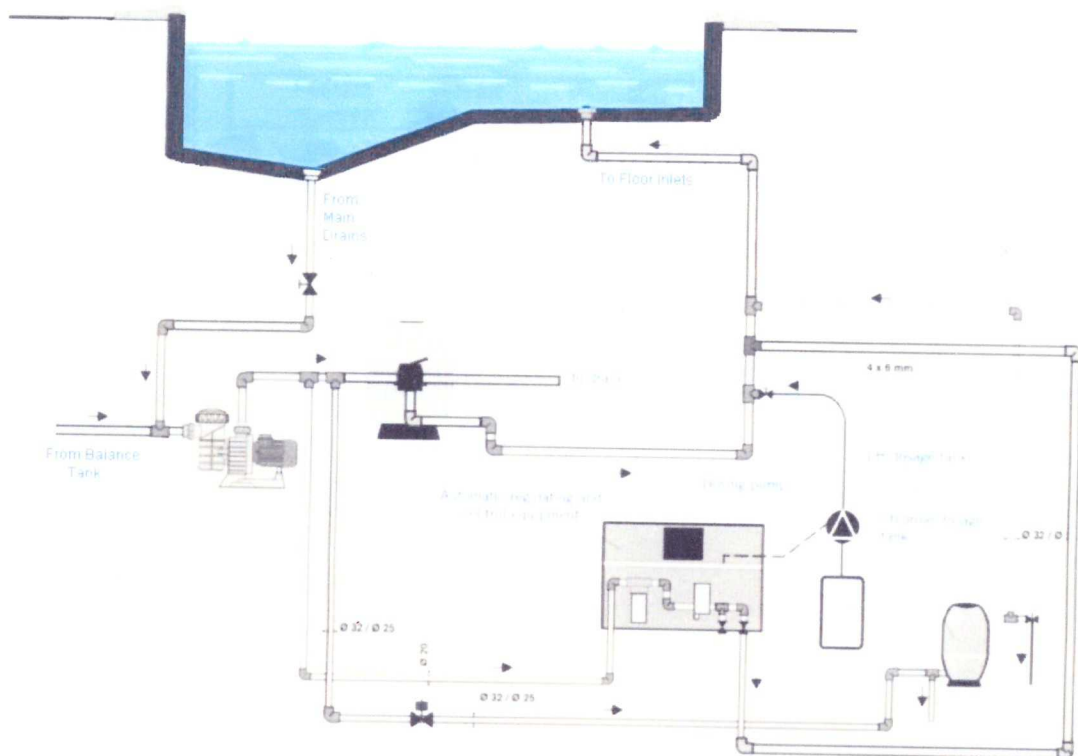


Figure (10.16): Automatic regulation connection for overflow pool

10.1.11 Pool lighting

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

From Astral catalogue (copy 2004-2005, page263,code 07833)we select lamp with power 300 watt for half deep pool

$$\text{number of lights} = \frac{\text{pool surface area}}{25} = \frac{411.7}{25} = 16.468$$

Then the number is 17 .

$$\text{distance between lights} = \frac{\text{Perimeter}}{\text{number of lights}} = \frac{93.7}{17} = 5.5 \text{ m}$$

Our project drawing contains distribution of the lights in large swimming pool .



Figure (10.17): Pool lights

10.1.12 Pool ladders

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

In our project :

Large swimming pool perimeter = 93.7 m

$$\text{Number of ladders} = \frac{\text{pool perimeter}}{25} = \frac{93.7}{25} = 3.748$$

Then we need 4 ladders

$$\text{distance between ladders} = \frac{\text{pool perimeter}}{\text{number of ladders}} = \frac{93.7}{4} = 23.4 \text{ m}$$

From Astral catalogue (copy 2004-2005, page 4) we select ladders with the following specifications.

- ❖ Ladder width 500 mm .
- ❖ Handrail in hand polished stainless steel ($\Phi 43\text{mm}$) .
- ❖ Steps in stainless steel or plastic .
- ❖ Complete with fixing anchors and earth connection .



Figure (10.18): Pool ladder

10.2 Skimmer swimming pool

10.2.1 Capacity of pool

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

Volume of water = surface area of the pool * average depth

$$\text{Average depth} = \frac{\text{max .depth} + \text{min .depth}}{2}$$

The figure below shows the swimming pool plan.

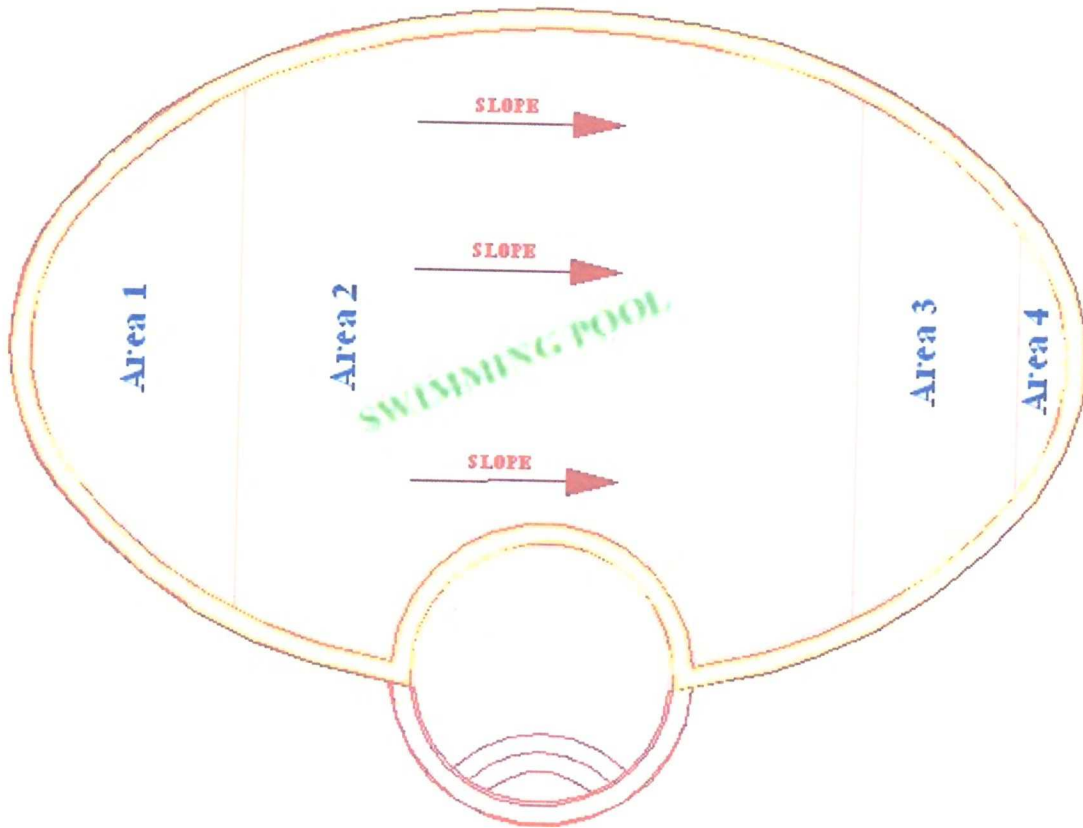


Figure (10.19): Small swimming pool plan

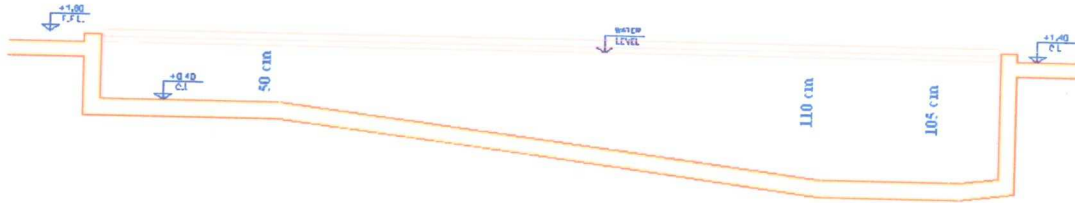


Figure (10.20): Small swimming pool section

Area 1 = 4.429 m² (By AutoCAD applications).

Minimum depth= maximum depth = 50 cm .

Area 2 = 20.469 m²

Minimum depth = 50 cm.

Maximum depth = 110 cm.

$$\text{Average Depth} = \frac{\text{maximum depth} + \text{minimum depth}}{2} = \frac{50 + 110}{2} = 80 \text{ cm}$$

Area 3 = 3.9516 m²

Minimum depth= maximum depth = 110 cm .

Area 4 = 0.4769 m²

Minimum depth = 105 cm.

Maximum depth = 110 cm.

$$\begin{aligned} \text{Average Depth} &= \frac{\text{maximum depth} + \text{minimum depth}}{2} = \frac{105 + 110}{2} \\ &= 107.5 \text{ cm} \end{aligned}$$

Volume of water = area * depth

$$V = V1 + V2 + V3 + V4$$

$$V = 4.429 * 0.5 + 20.469 * 0.8 + 3.9516 * 1.10 + 0.4769 * 1.075 = 23.449 \text{ m}^3$$

10.2.2 Turnover

This pool is a wadding pool type(children pool) We selected the turnover time one hour for the following reasons :

- 1) The surface area is relatively large compared with the volume of water (depth is very small).
- 2) The pollution area is very high.
- 3) The number of children is more than recommended .

10.2.3 Filtration rate

To calculate the filtration rate we use the following equation :

$$\text{TurnoverTime}(hr) = \frac{\text{PoolCapacity}(m^3)}{\text{FilterRate}(m^3 / hr)}$$

$$\text{FilterRate}(m^3 / hr) = \frac{\text{PoolCapacity}(m^3)}{\text{TurnoverTime}(hr)}$$

$$\text{FilterRate}(m^3 / hr) = \frac{23.449m^3}{1hr} = 23.45$$

$$\text{FilterRate}(L / sec) = \frac{23.45 * 1000}{3600} = 6.513$$

10.2.4 Filtration velocity

The Palestinian code recommended a filtration velocity of 8 m³/hr/ m² as a minimum, and a maximum of 40 m³/hr/ m² . By referring to manufacture catalogue, we find that the filter efficiency is nearly 100% at a velocity of 20 m³/hr/ m² and 70% at a velocity of 30 m³/hr/ m² . Therefore; in our project we decided to choose filtration velocity of 25 m³/hr/ m² to have crystal clean water with a filter which is acceptable in size and price.

10.2.5 Filter sizing and selection

The filter removes insoluble suspended solids from the re-circulated water in order to retain water clarity. It neither removes dissolved salts nor deals with micro-organisms. Filtration combined with disinfection produces effective water purification treatment that keeps water :

- Clean and non-toxic.
- Odorless and tasteless.
- Free of bacteria and alga.
- Balanced to prevent corrosion or scale formation.

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

$$3 \text{ psi} + 7 \text{ psi} = 10.1 \text{ psi} = 6.7 \text{ m}$$

This should be used as the design pressure loss through filter.

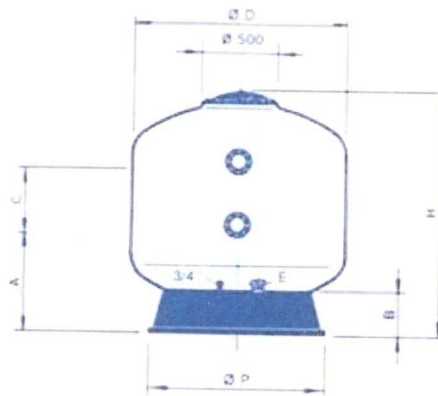
Filter selection:

- Filtration rate : 23.45 m³/hr
- The design filtration velocity : 25 m³/hr/ m² of filter surface area

$$\text{Filter surface area} = \frac{\text{FiltrationRate}}{\text{FiltrationVelocity}} = \frac{23.45}{25} = 0.938\text{m}^2$$

From Astral catalogue (copy 2004-2005,page 112) we selection the filter for the following specifications :-

- ❖ Filter name : Bobbin Wound Filters, Atena model.
- ❖ Code No. : 11512.
- ❖ Filter diameter: 1200 mm .
- ❖ Filter flow rate: 22-33 m³/hr.
- ❖ Standard Volume (m³): 2.7 .
- ❖ Sand 0.4 – 0.8 mm (kg): 1375 .
- ❖ Gravel 1 – 2 mm (kg) : 300 .
- ❖ Total weight in operation (kg): 2700 .



A	B	C	ΦD	ΦP	H	E
570mm	230mm	640mm	1200mm	940mm	1792mm	90mm

Figure (10.21) : Pool filter

10.2.6 Skimmer and main drain selection

The skimmer and main drain selection which forms the suction equipment from the pool should be based on the following :

- 5) 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 0.5 m/sec but 0.2 m/sec or lower is better.

- 6) In practice, main drain grill must be designed never to allow excess suction or to be removable by swimmers.
- 7) Drains and skimmer must be tough and durable. They must be neither trap fingers nor toes, or catch skin nor in any way corrodible.
- 8) Skimmer must face the main drift from inlets and the prevailing wind out door.
- 9) The flow rate from all skimmer should be approximately 50% of the required filter flow rate.

Selection of skimmer :

The calculated total water circulation rate is $23.45 \text{ m}^3/\text{hr}$. Therefore; the suction flow rate through skimmers which should be 50% of the total flow rate is :

$$50\% \text{ of filtration flow rate} = 0.50 * 23.45 = 11.725 \text{ m}^3/\text{hr}.$$

From Astral catalogue (copy 2004-2005,page 45) we selected tow concrete pool skimmers for the following specifications :-

- ❖ Skimmer name : concrete pool 17.5L skimmer with standard throat.
- ❖ Code No. : 05589.
- ❖ Recommended flow rate : 7500 L/hr which equal $7.5 \text{ m}^3/\text{hr}$.
- ❖ Suction threaded connection: $\Phi 50\text{mm}$.



Figure (10.22): Pool skimmer

Selection of main drains :

From Astral catalogue(copy 2004-2005,page 52) we choose the concrete pool main drains of code No. 00258 and the following specifications are :

- ❖ Main drains name : concrete pools – main drains, square main drains with grille, outlet of 2 ".
- ❖ Recommended flow rate : 13 m³/hr
- ❖ Side connection : 2"



Figure (10.23): Pool main drain

10.2.7 Return inlets selection

The return inlets in the pool wall below water level controls the flow rate and direction of the filtered water entering the pool. So that arrangement on small outdoor is usually provided in sufficient quantity and shall be properly spaced to provide a maximum circulation of the main body and water surface in conjunction with the skimmers and the prevailing winds.

The selection of the return inlets is based on the following :-

- 1) They must have large enough apertures to prevent backpressure into filters.
- 2) Adjustable or eyeball are used for directional currents in free from pool. So that they spread returned water to the side up and down to mix with all shallow end levels.

- 3) High-level inlets help push surface debris skimming system. Whilst low level inlets improve heat circulation. Best arrangement is a mixture of floor wall level and wall downward flow returns.
- 4) Set wall grills of return inlets 0.4 m below water surface.

Return inlets selection :

The calculated total circulation rate is 23.45 m³/hr, and by referring to Astral catalogue (copy 2004-2005,page 73) we chose the Adjustable return inlets of code No. 15839, and the following specifications are :

- ❖ Return inlets name: Adjustable return inlets.
- ❖ Flow rate : 14m³/hr.
- ❖ 2 " external thread.
- ❖ Made of stainless steel

$$\text{No of required return inlets} = \frac{\text{filtration flow rate (m}^3\text{/hr)}}{\text{flow rate for each inlets (m}^3\text{/hr)}} = \frac{23.45}{14} = 1.675$$

Then we select 2 return inlets of this type.



Figure (10.24): Return inlet of the pool

10.2.8 Pool pipes system

10.2.8.1 Discharge Line Pipe Sizing

The discharge line from the pump to the various return inlets is shown in the schematic diagram. In this diagram, the required flow rate for each part of the discharge line is shown.

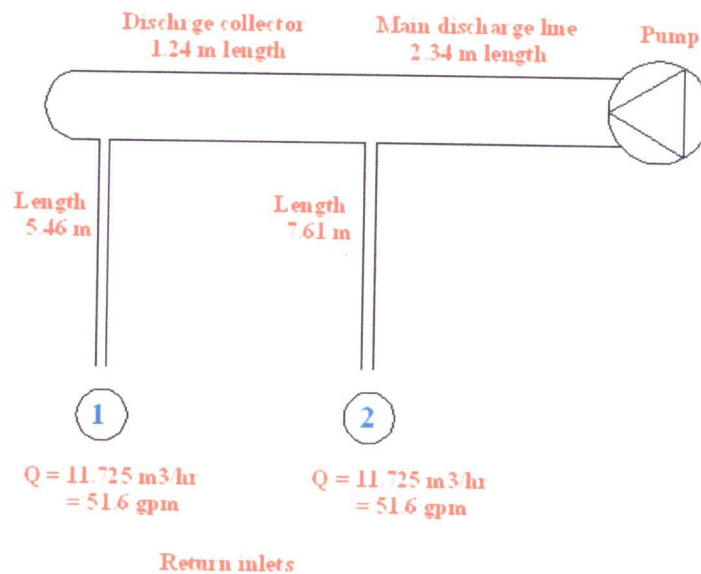


Figure (10.25): Schematic diagram for discharge lines

Information of main discharge lines and collector

- Flow rate = $23.45 \text{ m}^3/\text{hr} = 103.18 \text{ gpm}$
- Maximum velocity acceptable = $10 \text{ ft}/\text{sec}$
- Maximum friction loss = $12 \text{ ft}/100 \text{ ft}$
- Length = 3.58 m (from AutoCAD drawing by measurement)

From PVC tables in Appendix A, we find :

- Friction head = $6.72 \text{ ft}/100 \text{ ft}$
- Velocity = $7.02 \text{ ft}/\text{sec}$
- Diameter = $2 \frac{1}{2} \text{ " (75 mm)}$

Return inlets information

(From PVC pipes tables in Appendix A)

Table (10.6): Return inlets information for skimmer pool

N ^o	Flow rate (m ³ /hr)	Flow rate (gpm)	Length (m)	Diameter (in)	Friction head (ft/100ft)	Velocity (ft/sec)
1	14	61.6	5.46	2"	6.12	6.012
2	14	61.6	6.71	2"	6.12	6.012

Each return inlet flow rate = total flow rate (m³/hr)/ number of return inlets.

Where:

- ❖ 1m³/hr = 4.4 gpm
- ❖ The pipe diameter from the discharge line to each return inlets is 2" because the selected return inlets connections equal 2" .

Pressure drop in the discharge line

To calculate the total pressure drop in the discharge line, we have to calculate the total equivalent length of the pipes which is the pipe length and the equivalent length of the fittings.

Total equivalent length = pipe length * 2

The total friction head from discharge line is

$$\begin{aligned} &= \Sigma (\text{total equivalent length of each pipe (ft)} * \text{friction head for each (ft/100 ft)}) \\ &= (3.58 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (6.72 \text{ ft/100ft}) + (6.71 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (6.12 \text{ ft/100ft}) \\ &= 4.27 \text{ ft} = (4.27 / 3.28) \text{ m} = 1.3 \text{ m} \end{aligned}$$

Note

1m pipe length = 3.28 ft

10.2.8.2 Suction line

The suction line from balance tank and main drains to the pump is shown in the schematic diagram.

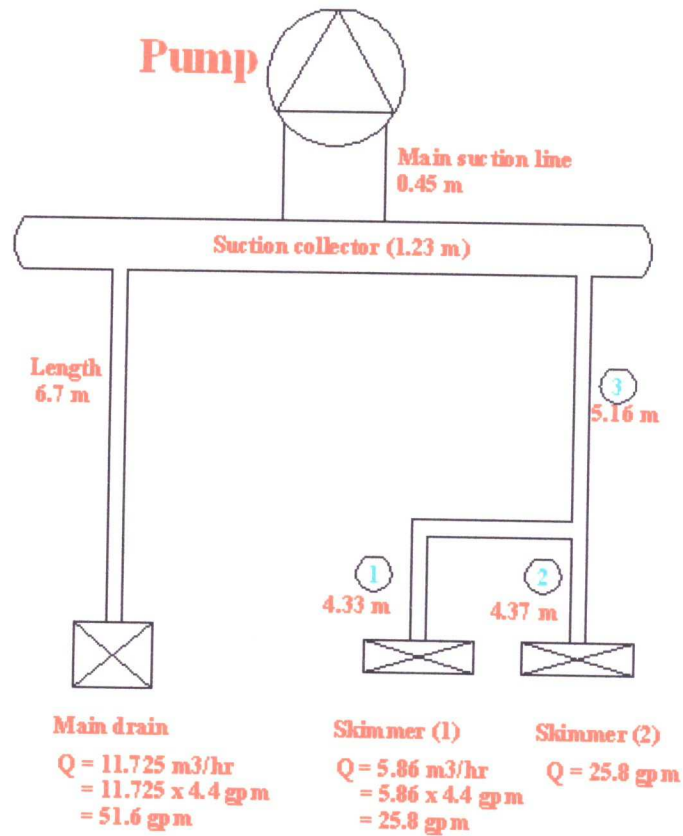


Figure (10.26): Schematic diagram for suction lines

Information for main drain pipes

- Flow rate = 11.725 m³/hr = 51.6 gpm
- Maximum velocity acceptable = 3.3 ft/sec
- Maximum friction loss = 6 ft/100ft
- Length = 6.70 m (From AutoCAD drawing)
- Diameter = 2" (63 mm), because the selected connection equal $\Phi 63$ mm .

From PVC tables in Appendix A, at 51.6 gpm & $\Phi 63$ mm, we find:

- Friction head = 4.45 ft/100ft

Information for skimmers pipes

- ❖ Maximum velocity acceptable = 3.3 ft/sec
- ❖ Maximum friction loss = 6 ft/100ft

Pipe No 1 :

- Flow rate = $5.86 \text{ m}^3/\text{hr} = 25.8 \text{ gpm}$
- Length = 4.33 m (From AutoCAD drawing)
- Diameter = 1 1/2" (50 mm), because the selected connection equal $\Phi 50 \text{ mm}$.

From PVC tables in Appendix A, at 25.8 gpm & $\Phi 50 \text{ mm}$, we find:

- Friction head = 4.24 ft/100ft

Pipe No 2 :

- Flow rate = $5.86 \text{ m}^3/\text{hr} = 25.8 \text{ gpm}$
- Length = 4.37 m (From AutoCAD drawing)
- Diameter = 1 1/2" (50 mm), because the selected connection equal $\Phi 50 \text{ mm}$.

From PVC tables in Appendix A, at 25.8 gpm & $\Phi 50 \text{ mm}$, we find:

- Friction head = 4.24 ft/100ft

Pipe No 3 :

- Flow rate = $11.72 \text{ m}^3/\text{hr} = 51.6 \text{ gpm}$
- Length = 5.16 m (From AutoCAD drawing)

From PVC tables in Appendix A, at 51.6 gpm & with acceptable friction head and velocity , we find:

- Velocity = 2.3 ft/sec.
- Friction head = 0.65 ft/100ft
- Diameter = 3" (90 mm).

Suction collector & Main suction line information

- Maximum velocity acceptable = 3.3 ft/sec
- Maximum friction loss = 6 ft/100ft
- Flow rate = $23.45 \text{ m}^3/\text{hr} = 103.18 \text{ gpm}$
- Length = 1.68 m (From AutoCAD drawing)

From PVC tables in Appendix A, at 103.18 gpm & with acceptable friction head and velocity , we find:

- Velocity = 2.7 ft/sec.
- Friction head = 0.64ft/100ft
- Diameter = 4"(110 mm).

Where :

The pipe diameter from skimmer to the suction collector is $\Phi 50\text{mm}$, according to the selected skimmer. Also the pipe diameter from main drain to suction collector is $\Phi 63\text{mm}$ according to the selected main drain diameter.

Pressure drop in the suction line

$$\begin{aligned} &\text{The total friction head from suction equals =} \\ &= \Sigma (\text{total equivalent length of each pipe (ft) * friction head for each (ft/100 ft)}) \\ &= (1.68\text{m}) * 2 * (3.28\text{ft/m}) * (0.64\text{ft}/100\text{ft}) + (6.7\text{m}) * 2 * (3.28\text{ft/m}) * (4.45\text{ft}/100\text{ft}) + \\ &(4.33\text{m}) * 2 * (3.28\text{ft/m}) * (4.24\text{ft}/100\text{ft}) + (4.37\text{m}) * 2 * (3.28\text{ft/m}) * (4.24\text{ft}/100\text{ft}) + \\ &(5.16\text{m}) * 2 * (3.28\text{ft/m}) * (0.65\text{ft}/100\text{ft}) \\ &= 4.66\text{ft} \\ &= (4.66\text{ft}/3.28\text{ft/m}) \text{ m} \\ &= 1.42 \text{ m} \end{aligned}$$

10.2.9 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 Bernolli's equation the static head will be zero.

❖ Dynamic head

It 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 :

- Friction head losses in piping (both suction and discharge piping), fittings and valves.
- Friction head losses within filter .
- Friction head losses through main drains, skimmer and return inlets.

Where:

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

$$= 1.42 + 1.30 = 1.72 \text{ m}$$

❖ Friction head in filter = 6.7m .

❖ Friction head through main drains, skimmer and return inlets, should be taken from manufacture specification for each one .However; general rule of thumb is to add 1.5m 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 filters + friction head in main drains, skimmer and return inlets

$$= 1.72 + 6.7 + 1.5 = 9.92 \text{ m}$$

Pump selection

Required specification of the pump are :

- ❖ Total head = 9.92 m
- ❖ Flow rate = 23.45 m³/hr

From Astral catalogue(copy 2004-2005,page 159), we select the pump with the following specification:

- ❖ Pump Name : Maxim Pump 2860 rpm .
- ❖ Code : 08003
- ❖ At a head of 12 m, have a flow rate of 42m³/hr
- ❖ Power : 3.5 hp, 3 ph
- ❖ Inlet and outlet diameter : Φ90mm .
- ❖ Motor protection : IP-54

Water supply :

We supply water of this pool from hotel well which we use electrical valve connects with a sensor to control of water level .

10.2.10Chlorine tank and treatment pool systems

- Chlorine tank

From Astral catalogue (copy 2004-2005,page 208), we selected the compact dosage tank with Code No. 16632 .

- Treatment pool system

As the overflow pool we selected the automatic regulation treatment because the pool is a public type and located in a hotel .

The figure below explain the connection of automatic regulation system .

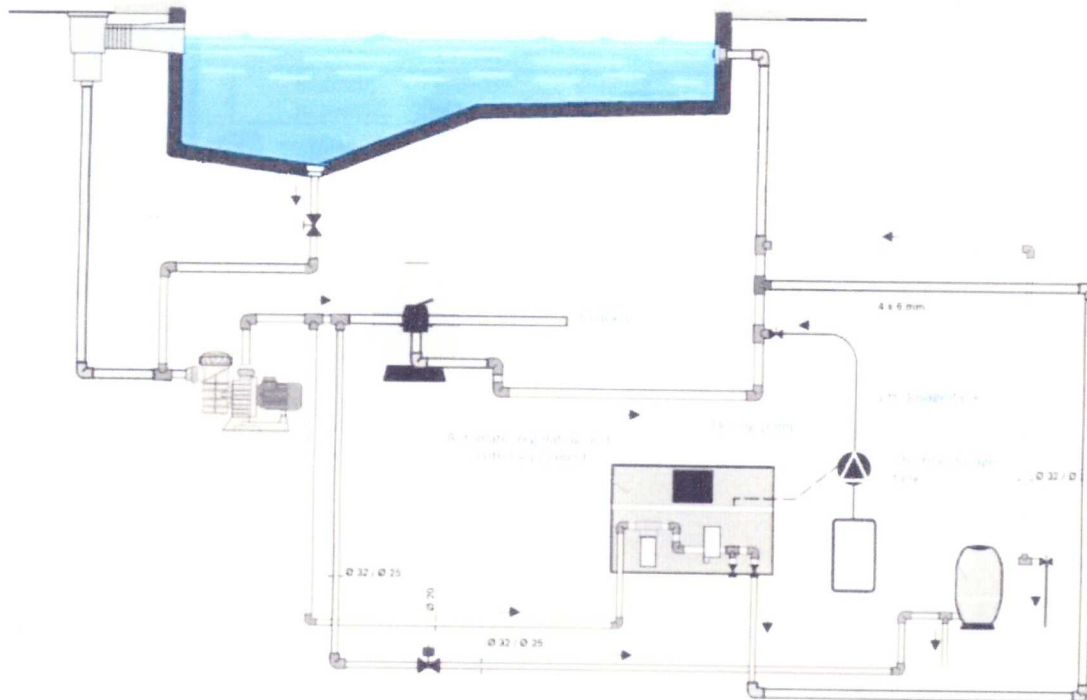


Figure (10.27): Automatic regulation connection for skimmer pool

10.2.11 Pool lighting

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

From Astral catalogue (copy 2004-2005, page263,code 07833)we select lamp with power 300 watt for half deep pool

$$\text{number of lights} = \frac{\text{pool surface area}}{25} = \frac{29.32}{25} = 1.173$$

Then the number is 2.



Figure (10.28): Pool lights

10.2.12 Pool ladders

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

In our project :

Large swimming pool perimeter = 21.84 m

$$\text{Number of ladders} = \frac{\text{pool perimeter}}{25} = \frac{21.84}{25} = 0.874$$

Then we need one ladders put in the deeper region of the pool .

From Astral catalogue (copy 2004-2005, page 4)we select ladders with the following specifications.

- ❖ Ladder width 500 mm .
- ❖ Handrail in hand polished stainless steel ($\Phi 43\text{mm}$) .
- ❖ Steps in stainless steel or plastic .
- ❖ Compete with fixing anchors and earth connection .



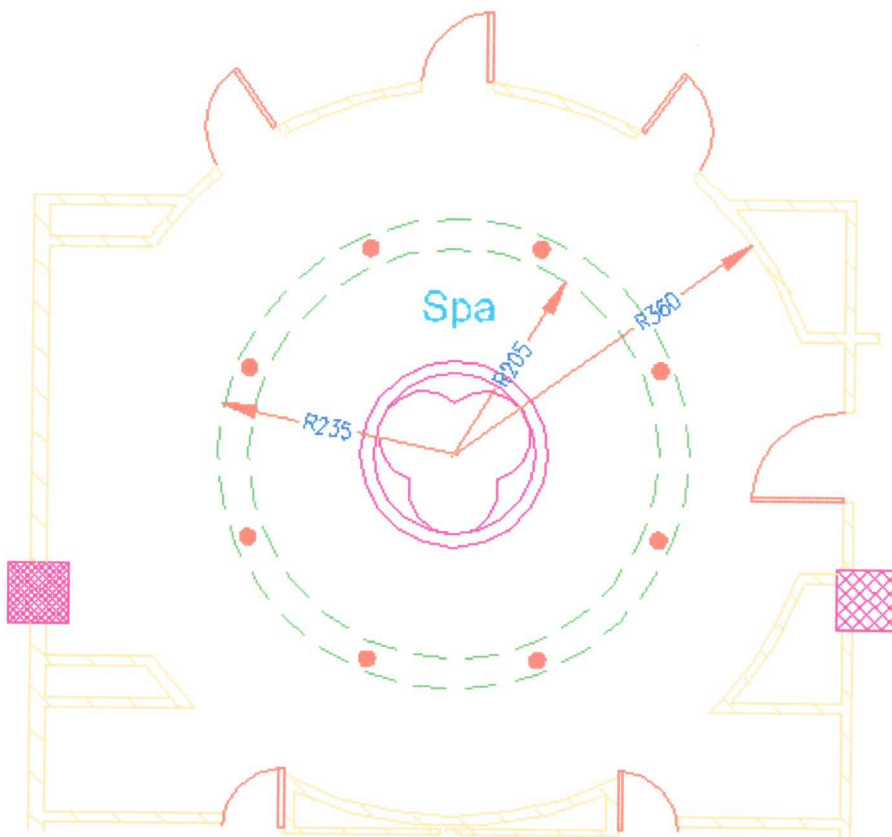
Figure (10.29): Pool ladder

10.3 Spa Design

Many people simply regard a spa as a small swimming pool and though , the two tanks of water have much in common they are in practice very different . The spa is used mainly for relaxation and has series of water and air jet provide a therapeutic massage effect .whereas, the swimming pool is mainly used for exercise swimming .

Spa design is divided into two parts :

- ❖ One system to power the turbo charge jets .
- ❖ The second system to filter and heat the spa water .



Figure(10.30): Spa plan

10.3.1 Turbo Charge Jet System

A. Turbo charge jets :

It is required to decide on the number and location of the jets . In our project the spa is a public type and have 8 jets located at the middle of the seats . According to hydro air catalogue, we selected Gunit jets of code No 10-4320, which have the following specifications:

- ❖ Jet Name : Gunit Jet.
- ❖ Flow rate : $5 \text{ m}^3/\text{hr}$.
- ❖ Head : $9 \text{ m H}_2\text{O}$.



Figure (10.31): Gunit Jet

Therefore; the total water flow rate for the eight Gunit Jets equals $8 \times 5 = 40 \text{ m}^3/\text{hr}$.

Note that Gunit jets are turbo charge jets (need air flow mixed with water flow).

B. Air blower :

Air blower is an electric powered mechanical device that forces air into spa. The blower is plumbed into the air line of spa jets to turbo charge the jet massage .

Air blower sizing is calculated on the depth of water through which the air must be forced. The resistance created by horizontal plumbing of angled fitting is expressed as depth, so we can determine the total depth that the blower must overcome .

Procedure of calculation depth :

1. We measure the actual depth of the water above the air outlet. Remember that water displacement by bathers will rise the water level between (15 – 20 cm). In our spa the depth of the turbo charge jets is 30 cm below the skimmer level, we added another 20 cm for the rise of the water level due to the baths and the air blower placed in the mechanical room at a height of 115 cm and the spa height is 110 cm. Therefore; the maximum depth is 55 cm .

The figure below show the air blower in a mechanical room .

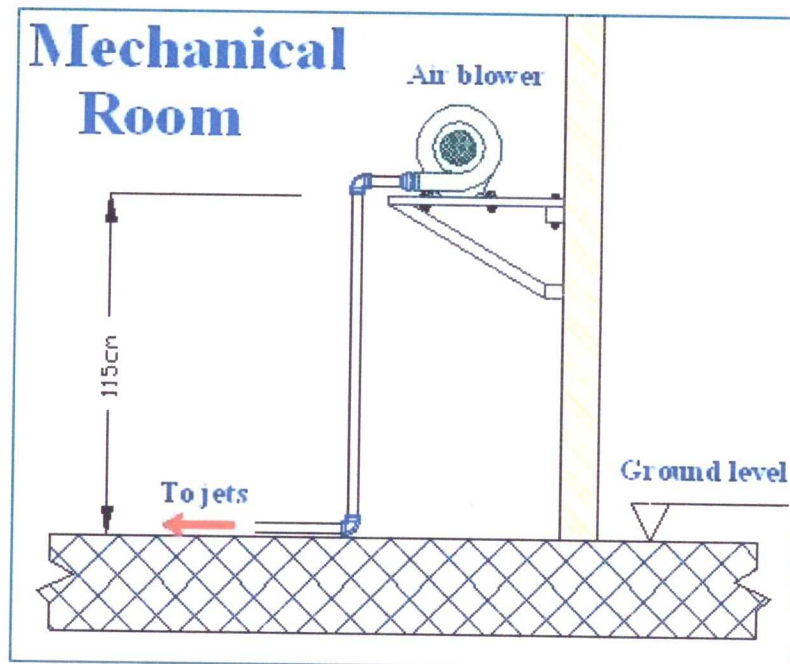


Figure (10.32): Air blower situated

2. Blower is plumbed with 50 mm PVC. We measured the total length of all pipes between the blower and the spa; for every 300 cm of pipe length add

2.5 cm to the total water depth and add 1.25 cm to the total water depth for every 90° fitting. In a spa of this hotel, the total length of air pipes from the blower outlet to the farthest turbo jet is 1237 cm and the number of 90° fitting are 19 .

The total depth is equal = Actual depth of turbo charge jet (cm) + Length of pipe (cm) * (2.5/300 cm) + Number of 90° fitting * 1.25

$$= 60 + \left[\frac{1237 * 2.5}{300} \right] + 19 * 1.25 = 89.06 \text{ cm} = \left[\frac{89.06}{2.54} \right]'' = 35.06''$$

The selection of air blower is according to the following table :

Table (10.7): Power according to depth of the air blower .

Total depth	Power
Less than 36"	1 hp
36" – 48"	1.5 hp
48" – 55"	2 hp

For a total water depth of 35.06" , the required blower size is 1.0 hp, according to Astral catalogue (copy 2004-2005, page 477), we selected air blower with the following specifications :

- ❖ Code : 04089
- ❖ Power : 1 hp (746 W)
- ❖ Flow rate : 65m³/hr
- ❖ Head : 1 m water

C. Floor main drain :

From Astral catalogue (copy 2004-2005,page 68) we selection the floor main drain for the following specifications :-

- ❖ Main Drain Name : In polyester and fiberglass,355 X 355
- ❖ Code : 22418
- ❖ Recommended flow rate : 42 m³/hr.
- ❖ Outlet connection : Φ110 mm .

D. Pipes dimensions

Pipe selection procedure is the same of the pool pipe selection.

- Discharge line

The discharge line from pump to the turbo charge jets is shown in the schematic diagram below, and explain of all pipes determinations ; velocity ,friction loss, length and flow rate.

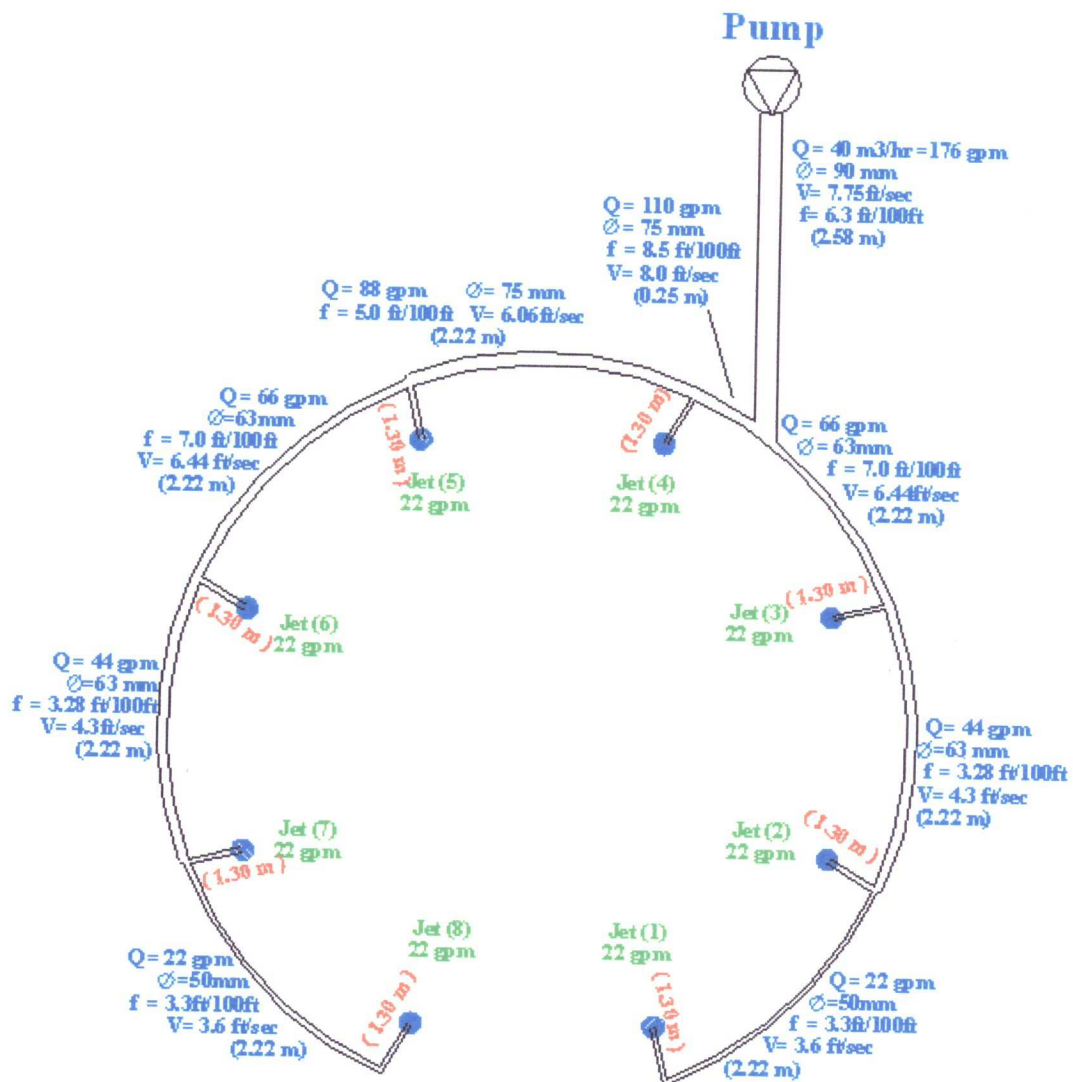


Figure (10.33) : Schematic diagram of the discharge line

Total friction head of the discharge line

$$\begin{aligned}
 &= \Sigma(\text{Total equivalent length of each pipe (ft)} * \text{friction head for each (ft/100ft)}) \\
 &= (2.58 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (6.3 \text{ ft/100ft}) + (0.25 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (8.5 \text{ ft/100ft}) \\
 &\quad + (2.22 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (5 \text{ ft/100ft}) + (2.22 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (7 \text{ ft/100ft}) \\
 &\quad + (2.22 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (3.28 \text{ ft/100ft}) + (2.22 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (3.3 \text{ ft/100ft}) \\
 &= 3.91 \text{ ft} = (3.91 \text{ ft}) / (3.28 \text{ ft/m}) = 1.19 \text{ m}
 \end{aligned}$$

- Suction line

The suction line from main drain to the pump is shown in the schematic diagram below, and explain of all pipes determinations ; velocity ,friction loss, length and flow rate.

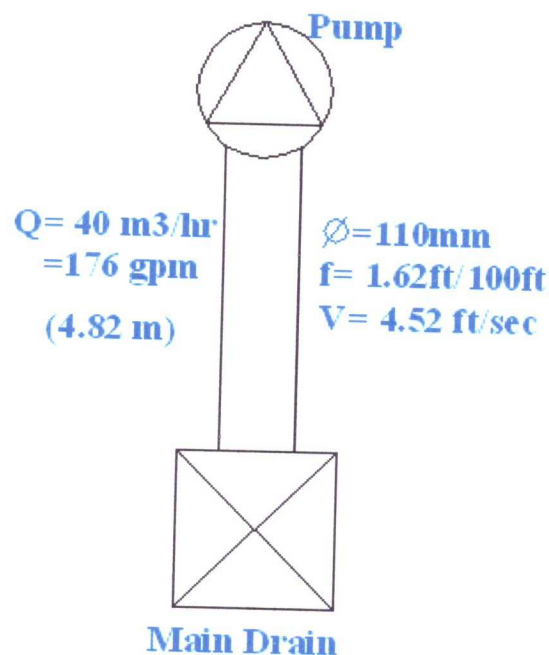


Figure (10.34) : Schematic diagram of the suction line

Total friction head of the suction line =

$$\begin{aligned}
 &= (4.82 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (1.62 \text{ ft/100ft}) \\
 &= 0.512 \text{ ft} = (0.512 \text{ ft}) / (3.28 \text{ ft/m}) = 0.156 \text{ m}
 \end{aligned}$$

Total head = friction head in suction line + friction head in discharge line + friction head in air blower + friction head in Gunite jets
= 0.156 + 1.19 + 1.0 + 9 = 11.346 m

E. Pump

- Flow rate = 40 m³/hr
- Total head = 11.346 m

From Astral catalogue(copy 2004-2005,page 159), we select the pump with the following specification:

- ❖ Pump Name : Maxim Pump 2860 rpm .
- ❖ Code : 08003
- ❖ At a head of 12 m, have a flow rate of 42m³/hr
- ❖ Power : 3.5 hp, 3 ph
- ❖ Inlet and outlet diameter : Φ 90mm .
- ❖ Motor protection : IP-54

10.3.2 Filtering system

1) **Spa capacity** = Volume of water in spa

= Surface area x Depth

$$= \pi r^2 * h = \pi (2.35)^2 * 1.1 = 19.08 \text{ m}^3$$

2) **Turnover :**

The spa is the most likely place where sanitizers level can be quickly lost, because of unintentional contamination by users. Higher water temperature encourage bacteria multiplication and the close proximities of fellow bathers make cross contamination more likely. Therefore; we selected a turnover of 30 minutes .

3) **Flow rate :**

$$\text{Flow rate} = \frac{\text{Spa Capacity}}{\text{Turnover Time}} = \frac{19.08}{0.5} = 38.16 \text{ m}^3/\text{hr}$$

4) **Filter :**

Cartridge filters are preferred choice of spa. From Astral catalogue (copy 2004-2005,page 83) we selected two cartridge filters by the following specifications :-

- ❖ Filter name : Cartridge filter, Terra series
- ❖ Code : 18220
- ❖ Filtration surface : 14 m².
- ❖ Filter diameter : 400 mm .
- ❖ Recommended flow rate : 25 m³/hr.
- ❖ Standard weight : 11.2 kg.
- ❖ Head : 2 m .

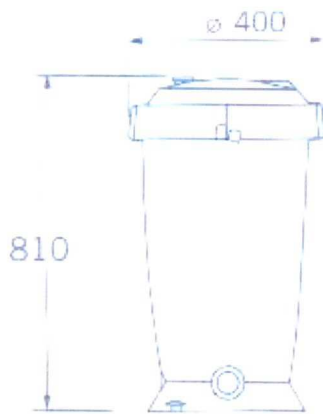


Figure (10.35): Spa filter

5) Main drain and Skimmer

- For every 25 m² of water surface area use one skimmer .
- Spa water surface area $=\pi r^2 = \pi(2.35)^2 = 17.35 \text{ m}^2$
- Then we use one skimmer .
- From Astral catalogue (copy 2004-2005,page 45) we selection the skimmer for the following specifications :-
 - ❖ Skimmer Name : Concrete pools-17.5 L, skimmer with standard throat .
 - ❖ Recommended flow rate : 7.5 m³/hr
 - ❖ Suction threaded connections: $\Phi 50 \text{ mm}$.
- Flow rate required for selection of a main drain equal 30.66 m³/hr (38.16-7.5), from Astral catalogue (copy 2004-2005,page 53) we selected the floor main drain by the following specifications :-

- ❖ Main Drain Name : In polyester and fiberglass
- ❖ Code : 20284
- ❖ Recommended flow rate : $33.5 \text{ m}^3/\text{hr} = 147.4\text{gpm}$.
- ❖ Outlet connection : $\Phi 110 \text{ mm}$.
- ❖ Main drain dimensions : 355×355



Figure (10.36): Spa main drain

6) Return inlets

- From Astral catalogue (copy 2004-2005,page57) we selection the return inlets for the following specifications :-
 - ❖ Return inlets Name : Concrete pools-ABS Inlets.
 - ❖ Code : 15863
 - ❖ Maximum flow rate : $13.5 \text{ m}^3/\text{hr}$.
 - ❖ Connection thread : $\Phi 63\text{mm}$.

$$\text{Number of return inlets} = \frac{\text{filtration rate}}{\text{flow rate for each inlets}} = \frac{38.16}{13.5} = 2.83$$

Then we use 3 return inlets .

Calculation by spa perimeter : -

- Each 5 m of perimeter length required one return inlets .
- Spa perimeter = $2 \pi r = 2 \pi * 2.35 = 14.76 \text{ m}$

$$\text{Number of required return inlets} = \frac{14.76}{5} = 2.95$$

- So its right to select 3 return inlets .

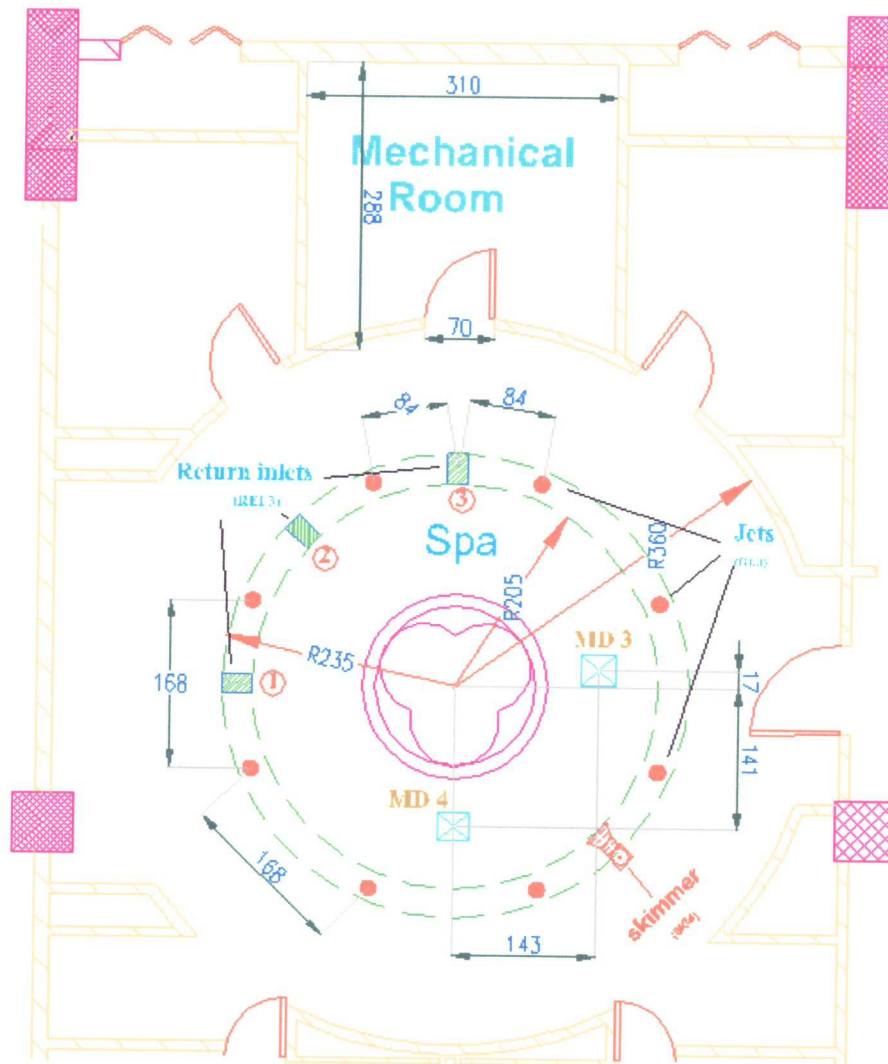


Figure (10.37): main drain, skimmers and return inlets distributions

7) Pipes dimensions

- Discharge line

The discharge line from pump to the return inlets is shown in the schematic diagram below and explanation of all pipes determinations, velocity, friction loss, length and flow rate.

Information of main discharge lines and collector

- Flow rate = 38.16 m³/hr =168 gpm
- Maximum velocity acceptable =10ft/sec
- Maximum friction loss = 12 ft/100ft
- Length = 3.43 m (from AutoCAD drawing by measurement)

From PVC tables in Appendix A, we find :

- Friction head = 5.75 ft/100ft
- Velocity = 7.4 ft /sec
- Diameter = 3 " (90 mm)

Return inlets information

(From PVC pipes tables in Appendix A)

Table (10.8): Return inlets information for spa .

Nº	Flow rate (m³/hr)	Flow rate (gpm)	Length (m)	Diameter (mm)	Friction head (ft/100ft)	Velocity (ft/sec)
1	13.5	59.4	3.85	63	5.7	5.8
2	13.5	59.4	6.43	63	5.7	5.8
3	13.5	59.4	3.54	63	5.7	5.8

Each return inlet flow rate = total flow rate (m³/hr)/ number of return inlets.

Where:

- ❖ 1m³/hr = 4.4 gpm
- ❖ The pipe diameter from the discharge line to each return inlets is Φ63mm because the selected return inlets connections equal Φ63mm .

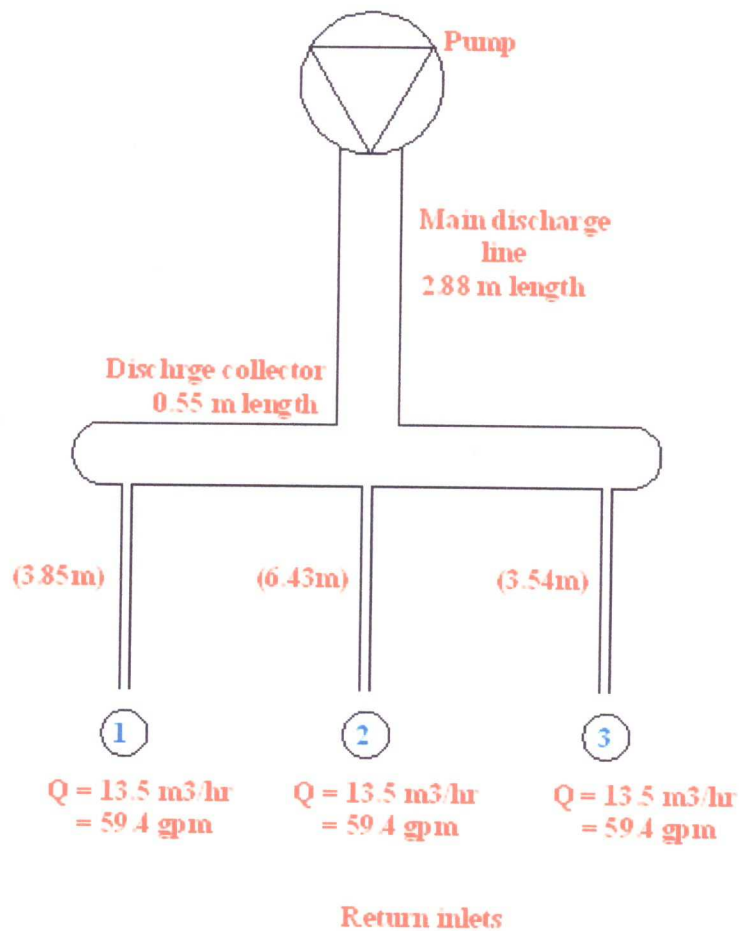


Figure (10.38) : Schematic diagram of the discharge line

Total friction head from the discharge line =

$$= (6.43 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (5.7 \text{ ft}/100 \text{ ft}) + (3.43 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (5.75 \text{ ft}/100 \text{ ft})$$

$$= 3.7 \text{ ft} = (3.7 \text{ ft}) / (3.28 \text{ ft/m}) = 1.13 \text{ m}$$

- Suction line

The suction line from skimmer and main drain to the pump is shown in the schematic diagram below, and explanation of all pipes determinations, velocity, friction loss, length and flow rate.

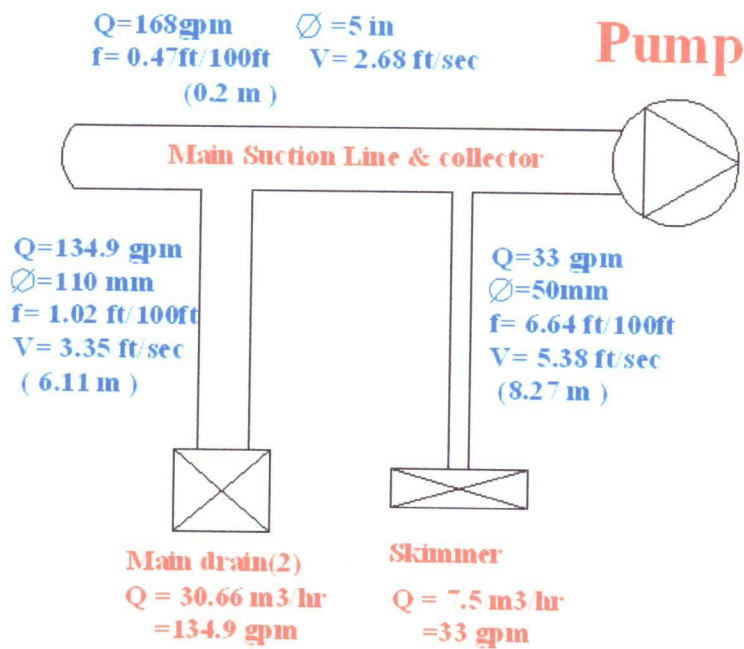


Figure (10.39) : Schematic diagram of the suction line

Total friction head of the suction line =

$$= (6.11 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (1.02 \text{ ft}/100 \text{ ft}) + (8.27 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (6.64 \text{ ft}/100 \text{ ft}) + (0.2 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (0.47 \text{ ft}/100 \text{ ft})$$

$$= 4.0 \text{ ft} = (4.0 \text{ ft}) / (3.28 \text{ ft/m}) = 1.22 \text{ m}$$

8) Heaters

Estimating heater size is more artful than science because of the many factors affect the selection process :

- Surface area of spa (large area cause large heat loss).
- Average temperature rise needed.
- How fast do you want to heat the spa.

We can calculate the total heat capacity of the heater by this equation :

$$Q = \dot{m} * C_p * \Delta T$$

Where :

Q : Total heat capacity (kw) .

\dot{m} : Flow rate (kg/s)

C_p : specific heat of water = 4.187 kJ/kg.C

ΔT : Temperature difference (C)

We need rise the temperature of the water from 10C to 40 C .

$$Q = \dot{m} * C_p * \Delta T$$

$$Q = \frac{38.16 \text{ (kg/sec) } * 1000 \text{ kg}}{3600 \text{ sec}} * 4.187 \frac{\text{kJ}}{\text{kg.C}} * 30 \text{ C}$$

$$Q = 1331.46 \text{ kJ/sec} = 1331.46 \text{ kw}$$

We want to heat the spa water in three hours, then the heater should have a capacity of $1331.46/3 = 443.822 \text{ kw}$.

9) Pump

➔ Flow rate of the pump = 38.16 m³/hr

➔ Total head for the circulation pump = suction line head + discharge line head + filter head + heater head + friction head through main drain, skimmer and return inlets

$$= 1.22 + 1.13 + 2 + 4 + 1.5 = 9.85\text{m}$$

From Astral catalogue (copy 2004-2005,page159) we selection the pump for the following specifications :-

- ❖ Pump Name :Maxim pump, 2860rpm
- ❖ Code : 08003
- ❖ Power : 3.5 hp, 3 ph
- ❖ inlets and outlets diameter :3 "
- ❖ Recommended flow rate : 42 m³/hr at 12 m head .

10.4 Fountain Design

10.4.1 Umbrella Fountain

Umbrella Fountain situated in a children region planning of a large pool; the figure below shows the situation of this fountain.

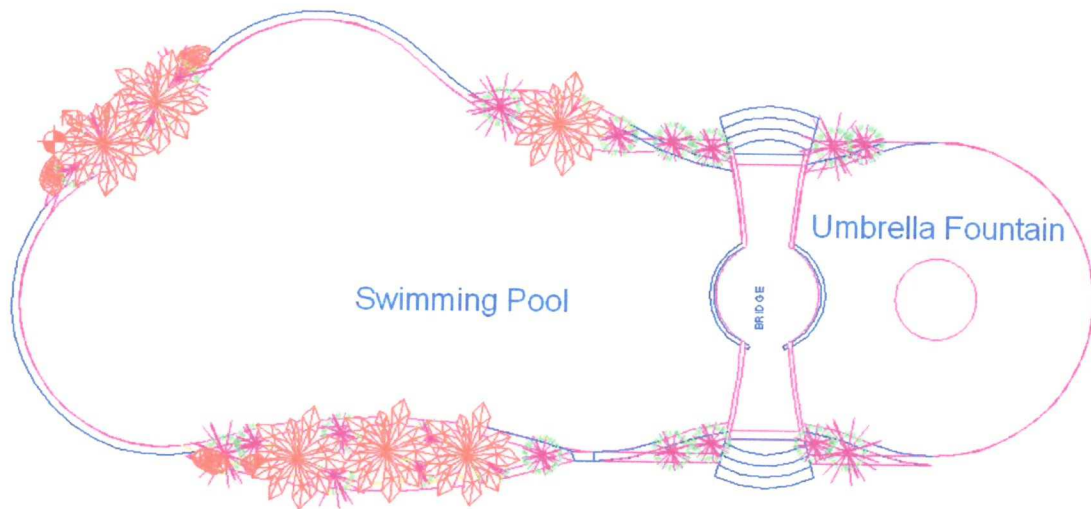


Figure (10.40): Umbrella situation

From Astral catalogue (copy 2004-2005,page 278), we selected $\Phi 1100$ mm umbrella fountain and column $\Phi 129$ mm and height of 2200 mm. The required flow rate is $30\text{m}^3/\text{hr}$ which equals 132 gpm .

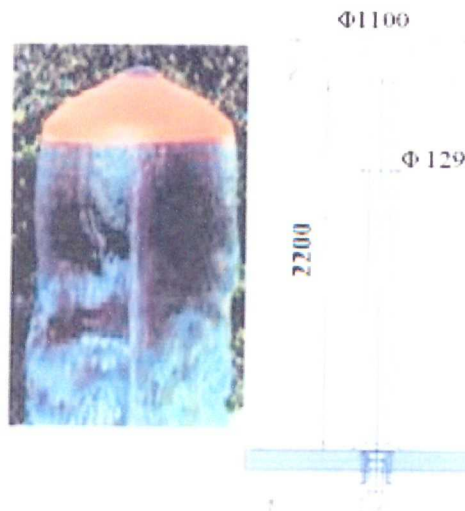


Figure (10.41): Umbrella Fountain

1) Pipe sizing

➔ Discharge Pipe from pump to the fountain :

- ❖ Length of discharge pipe : 45.53 m (from AutoCAD drawing).
- ❖ Maximum velocity acceptable = 10ft/sec .
- ❖ Maximum friction loss = 12 ft/100ft .

From PVC tables in Appendix A, At 132 gpm & with acceptable velocity and friction loss we find :

- ❖ Friction head = 10.66 ft/100ft .
- ❖ Velocity = 9.07 ft /sec.
- ❖ Diameter = 2 1/2" (75 mm) .

From Astral catalogue (copy 2004-2005,page 279) we selection the Anchor for the following specifications :-

- ❖ Anchor Name : Rectangular anchor - liner pool .
- ❖ Code : 15833.
- ❖ Earth connection : 2 1/2" (75 mm).
- ❖ Height : 203 mm .
- ❖ Standard weight : 2.5 kg .



Figure (10.42): Rectangular anchor

- ➔ Suction Pipe from main drain to the pump :
- ❖ Length of suction pipe : 16.74 m (from AutoCAD drawing).
 - ❖ Maximum velocity acceptable = 3.3ft/sec .
 - ❖ Maximum friction loss = 6 ft/100ft .

From Astral catalogue (copy 2004-2005,page 53) we selected the floor main drain for the following specifications :-

- ❖ Main Drain Name : In polyester and fiberglass
- ❖ Code : 20284
- ❖ Recommended flow rate : $33.5 \text{ m}^3/\text{hr} = 147.4\text{gpm}$.
- ❖ Outlet connection : $\Phi 110 \text{ mm}$.
- ❖ Main drain dimensions : 355 x 355



Figure (10.43): Umbrella main drain

From PVC tables in Appendix A, At 147.4 gpm & $\Phi 110 \text{ mm}$,we find of :
Friction head = 1.17 ft/100ft .

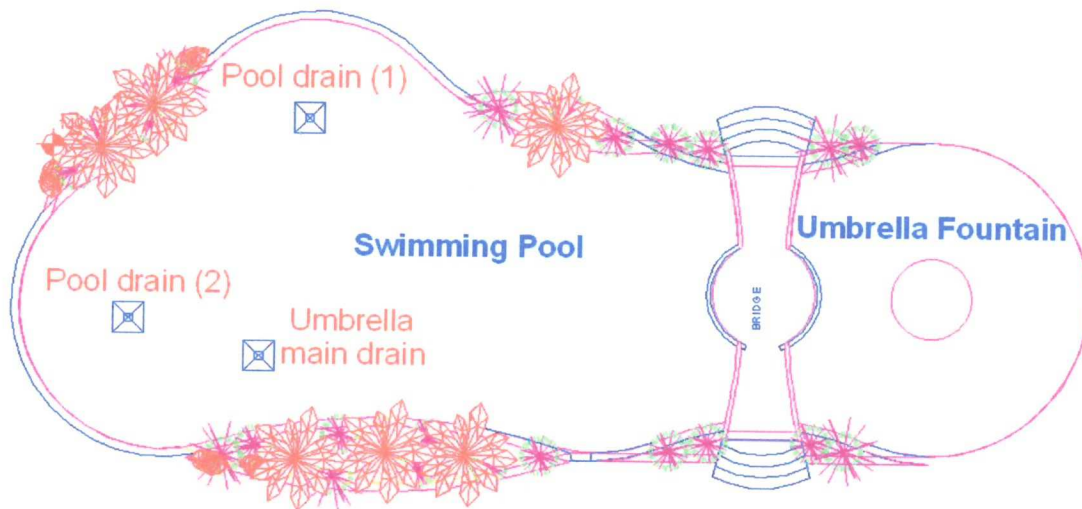


Figure (10.44): Umbrella main drain situation

2) Pump selection

Total head = dynamic head + static head

❖ Static head :

The static head in this case of fountain equals the distance between the outlet of water from umbrella and the pool water surface which equals 2.2 m .

❖ Dynamic head :

Dynamic head = total friction head in discharge line +total friction head in suction line

- In discharge line = $(43.33 \text{ m}) \cdot 2 \cdot (3.28 \text{ ft/m}) \cdot (10.66 \text{ ft}/100 \text{ ft})$
 $+ (2.2 \text{ m}) \cdot 2 \cdot (3.28 \text{ ft/m}) \cdot (0.43 \text{ ft}/100 \text{ ft}) = 30.36 \text{ ft} =$
 $(30.36 \text{ ft}) / (3.28 \text{ ft/m}) = 9.26 \text{ m} .$
- In suction line = $(16.74 \text{ m}) \cdot 2 \cdot (3.28 \text{ ft/m}) \cdot (1.17 \text{ ft}/100 \text{ ft}) =$
 $1.28 \text{ ft} = (1.28 \text{ ft}) / (3.28 \text{ ft/m}) = 0.39 \text{ m} .$

Total head = $2.2 + 9.26 + 0.39 = 11.85$ m

- Flow rate = $30 \text{ m}^3/\text{hr}$
- Total head = 11.85 m

From Astral catalogue(copy 2004-2005,page 159), we select the pump with the following specification:

- ❖ Pump Name : Maxim Pump 2860 rpm .
- ❖ Code : 08003
- ❖ At a head of 14 m, have a flow rate of $34 \text{ m}^3/\text{hr}$
- ❖ Power : 3.5 hp, 3 ph
- ❖ Inlet and outlet diameter : 3"($\Phi 90\text{mm}$) .
- ❖ Motor protection : IP-54

10.4.2 Cascade jets (Beside the skimmer pool)

According to PEM catalogue in Appendix C, we selected Cast Bronze Cascade jets with the following specifications :

- ❖ Code : PEM 53A .
- ❖ Flow rate : 93 L/min, that equals 5.58 m³/hr .
- ❖ Nozzle pressure : 2.2 m
- ❖ Outlet diameter : Φ 50 mm .



Figure (10.45): Cast Bronze Cascade jets, PEM 53A

The recommended distance between jets is 1 m where the distance measure from center to center of the jets .

In our project we have two regions of cascade jet ; the figure below explains the situation of cascade jets .

The arc length of a cascade jets = 9.1 m of each region .

Number of cascade jets = 9 of each region .

There are two regions \iff number of cascade jets = $9 \times 2 = 18$ jets

Total flow rate = Number of nozzles x flow rate for each

$$= 18 \times 5.58 = 100.44 \text{ m}^3/\text{hr}$$

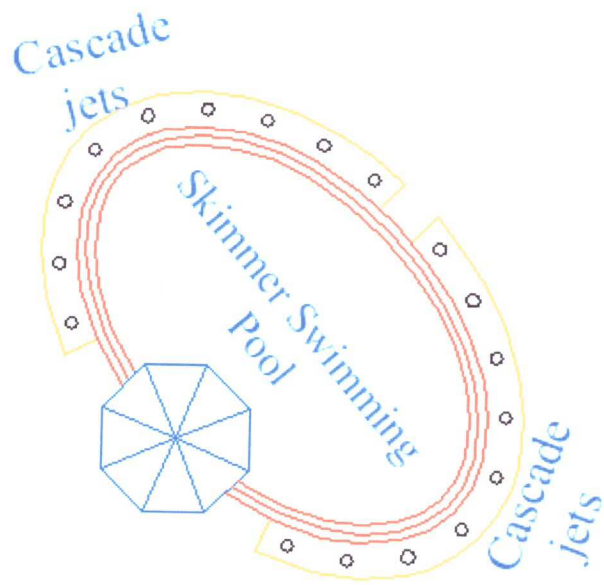


Figure (10.46): Situation of cascade jets

1) Pipe sizing

❖ Discharge line :

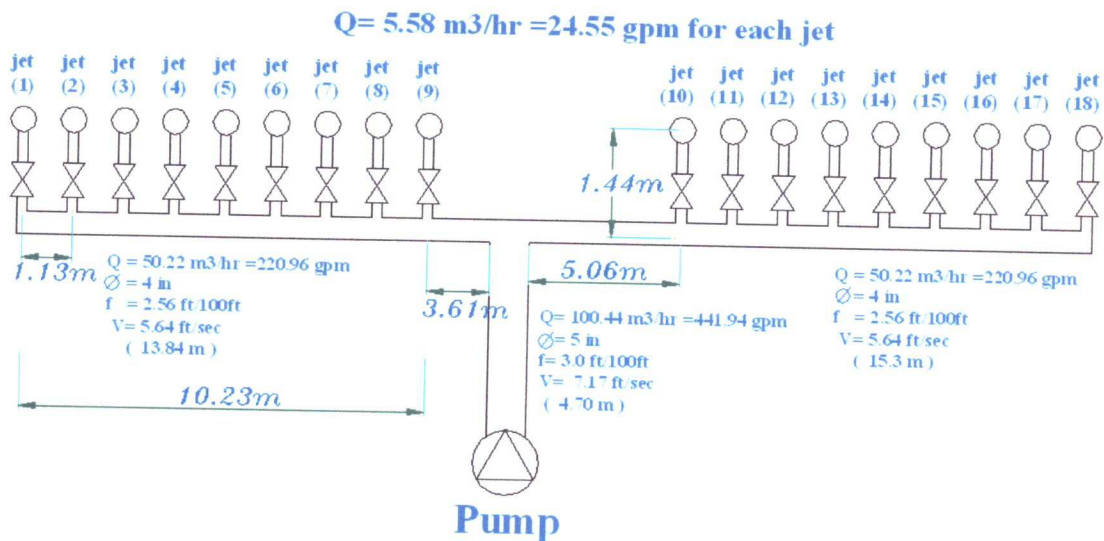


Figure (10.47): Schematic diagram for cascade jets discharge line

2) From Astral catalogue (copy 2004-2005,page 53) we selected the main drain for the following specifications :-

- ❖ Main drain Name : In polyester and fiberglass, square main drain with grill .
- ❖ Code :28713
- ❖ Recommended flow rate : $103 \text{ m}^3/\text{hr}$
- ❖ Side connection : $\Phi 200\text{mm}$
- ❖ Dimensions : $512 \text{ mm} \times 512 \text{ mm}$.

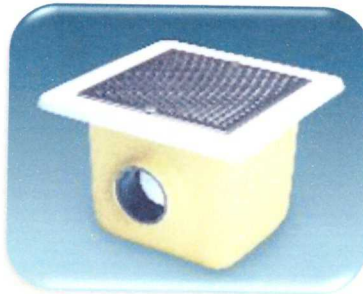


Figure (10.48): Cascade main drain

❖ Suction line :

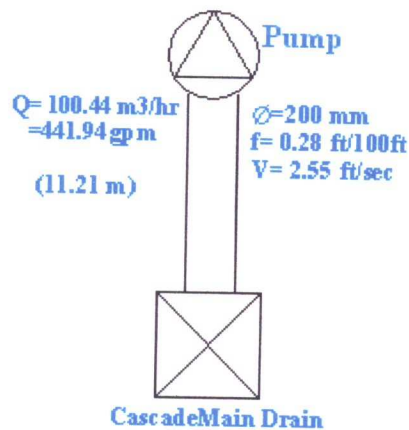


Figure (10.49): Schematic diagram for cascade jets suction line

3) Pump selections

- Flow rate of the pump = 100.44 m³/hr
- Total head for the circulation pump = nozzle head + dynamic head + static head

- Nozzle head = 2.2 m .
- Dynamic head = friction head from suction line + friction head from discharge line

$$= (11.21 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (0.28 \text{ ft}/100 \text{ ft}) + (4.70 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (3.0 \text{ ft}/100 \text{ ft}) + (15.30 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (2.56 \text{ ft}/100 \text{ ft})$$

$$= 3.7 \text{ ft} = (3.7 \text{ ft}) / (3.28 \text{ ft/m}) = 1.128 \text{ m}$$

- Static head : the difference between the outlet of the nozzle and the surface water in basin = 2 mm = 0.002 m .

$$\text{Total head} = 2.2 + 1.128 + 0.002 = 3.33 \text{ m}$$

From Astral catalogue (copy 2004-2005, page 159) we selection the pump for the following specifications :-

- ❖ Pump Name : cast iron pump , 1450rpm
- ❖ Code : 01213
- ❖ Power : 7.5 hp (5.5kw), 3 ph
- ❖ Suction diameter : 3 " (90mm).
- ❖ Discharge diameter : 2 1/2" (75mm).
- ❖ Head : 10 m .
- ❖ Recommended flow rate : 108 m³/hr
- ❖ Protection : IP- 54 motor

10.4.3 Aerating Jets (Entrance Of The Hotel)

In our project we have two Aerating Jet fountains placed on the entrance of the hotel and the figure below explains the situation of this fountains .

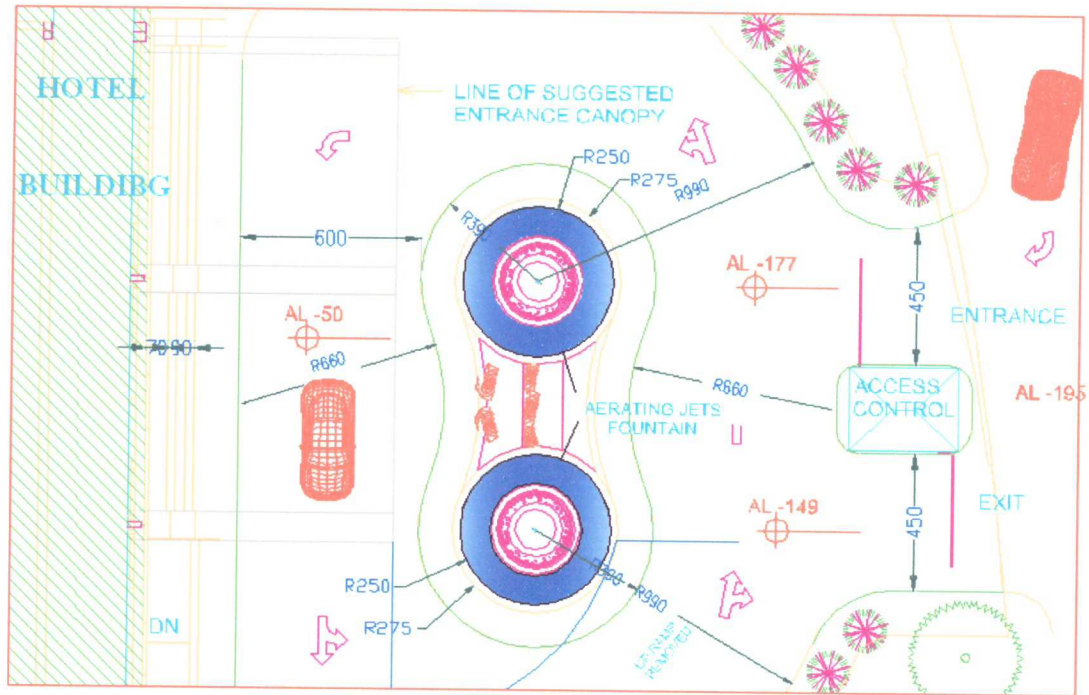


Figure (10.50): Aerating Jets fountains situation

According to PEM catalogue in Appendix C, we selected Aerating Jets with the following specifications :

- ❖ Code : PEM 750-2 series .
- ❖ Flow rate (at 2 m height) : 550 L/min.
- ❖ Nozzle pressure : 4.8 m
- ❖ Outlet diameter : 4"(Φ110 mm) .



Figure (10.51): Aerating Jets, PEM 750-2 series

3) Pipe sizing

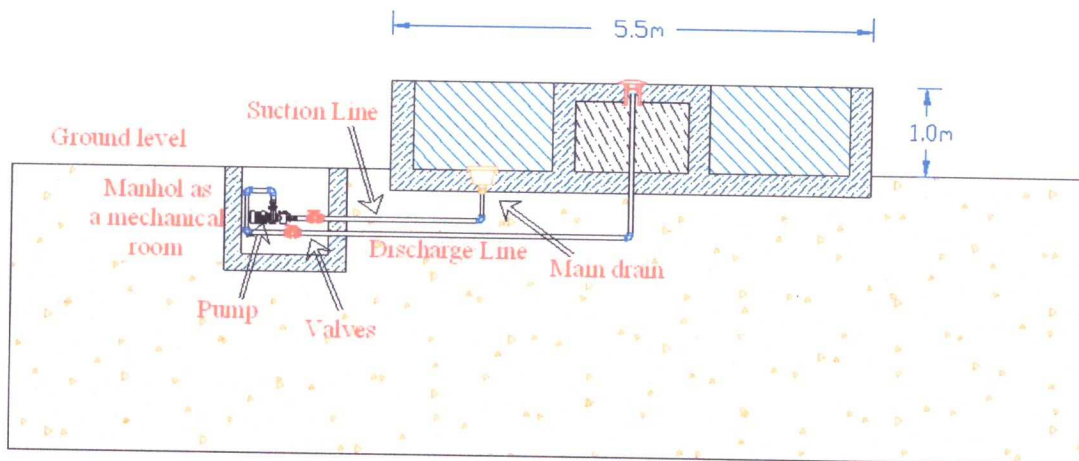


Figure (10.52): piping system

➔ Discharge Pipe from pump to the fountain :

- ❖ Length of discharge pipe : 7.13 m (from AutoCAD drawing).
- ❖ Maximum velocity acceptable = 10ft/sec .
- ❖ Maximum friction loss = 12 ft/100ft .

From PVC tables in Appendix A, At flow rate 550 L/min (33 m³/hr , 145.2gpm) . & with $\Phi 110$ mm, we find :

- ❖ Friction head = 1.1 ft/100ft .
- ❖ Velocity = 3.6 ft /sec.

- Suction Pipe from main drain to the pump :
 - ❖ Length of suction pipe : 2.35 m (from AutoCAD drawing).
 - ❖ Maximum velocity acceptable = 3.3 ft/sec .
 - ❖ Maximum friction loss = 6 ft/100ft .

From Astral catalogue (copy 2004-2005, page 53) we selection the floor main drain for the following specifications :-

- ❖ Main Drain Name : In polyester and fiberglass
- ❖ Code : 20284
- ❖ Recommended flow rate : $33.5 \text{ m}^3/\text{hr} = 147.4 \text{ gpm}$.
- ❖ Outlet connection : $\Phi 110 \text{ mm}$.
- ❖ Main drain dimensions : 355 x 355



Figure (10.53): Aerating Jets fountains main drain

From PVC tables in Appendix A, At 147.4 gpm & $\Phi 110 \text{ mm}$,we find of :
Friction head = 1.17 ft/100ft .

4) Pump selection

- Flow rate of the pump = $33 \text{ m}^3/\text{hr}$
- Total head for the circulation pump = nozzle head + dynamic head + static head

- Nozzle head = 4.8 m .
- Dynamic head = friction head from suction line + friction head from discharge line

$$= (2.35 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (1.17 \text{ ft}/100 \text{ ft}) + (7.13 \text{ m}) * 2 * (3.28 \text{ ft/m}) * (1.1 \text{ ft}/100 \text{ ft})$$

$$= 0.68 \text{ ft} = (0.68 \text{ ft}) / (3.28 \text{ ft/m}) = 0.18 \text{ m}$$

- Static head : the difference between the outlet of the nozzle and the maximum height of water , which designed 2 m .

$$\text{Total head} = 4.8 + 0.18 + 2 = 6.98 \text{ m}$$

From Astral catalogue (copy 2004-2005, page 156), we select the pump with the following specification:

- ❖ Pump Name : Astral Victoria .
- ❖ Code : 23045
- ❖ At a head of 8 m, have a flow rate of $34 \text{ m}^3/\text{hr}$
- ❖ Power : 3.0 hp (2.2 kw), 1 ph
- ❖ Motor protection : IP-55.

APPENDIX

APPENDIX

A

PVC & Steel Pipes Tables



PVC Pipes - Friction Loss and Flow Velocity – schedule 40

Water flow in thermoplastic PVC and CPVC pipes Schedule 40 - friction loss (ft/100 ft, psi/100 ft) and flow velocities at dimensions from 1/2 inch to 16 inches

Friction loss and flow velocity in PVC and CPVC pipes Schedule 40 with water can be found in the table below. The table may be also be used for pipes in other thermoplastic materials where the inner diameter corresponds to [PVC Schedule 40](#).

- 1 ft (foot) = 0.3048 m
- 1 ft/s = 0.3048 m/s
- 1 gal (US)/min = $6.30888 \times 10^{-5} \text{ m}^3/\text{s} = 0.0227 \text{ m}^3/\text{h} = 0.0631 \text{ dm}^3(\text{liter})/\text{s} = 2.228 \times 10^{-3} \text{ ft}^3/\text{s} = 0.1337 \text{ ft}^3/\text{min}$
- 1 psi/100 ft = 2.3 ftH₂O/100 ft = 2288 mmH₂O/100 ft = 22.46 kPa/100 m

Note! Velocity should not exceed 5 feet per second.

The values can be used to calculate pressure loss with the [Equivalent Pipe Length Method](#)

1/2 inches(20mm)				
Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
1	60	1.1	2.1	0.9
2	120	2.3	4.2	1.8
5	300	5.6	23.4	10.5
7	420	7.9	43.1	18.6
10	600	11.3	82.0	35.5

3/4 inches(25mm)

Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
1	60	0.6	0.5	0.2
2	120	0.3	1.0	0.4
5	300	3.2	5.7	2.5
7	420	4.4	10.5	4.6
10	600	6.3	20.0	8.7
15	900	9.5	42.5	18.4
20	1200	12.7	72.3	31.3

1 inches(30mm)

Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
2	120	0.8	0.6	0.2
5	300	1.9	1.7	0.8
7	420	2.7	3.2	1.4
10	600	3.9	6.0	2.6
15	900	5.8	12.8	5.5
20	1200	7.7	21.8	9.4
25	1500	9.7	32.9	14.2
30	1800	11.6	46.1	20.0

1 1/4 inches(40mm)				
Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
2	120	0.4	0.1	0.1
5	300	1.1	0.4	0.2
7	420	1.6	0.8	0.4
10	600	2.2	1.6	0.7
15	900	3.3	3.3	1.4
20	1200	4.4	5.6	2.4
25	1500	5.5	8.5	3.7
30	1800	6.6	11.9	5.1
35	2100	7.7	15.8	6.8
40	2400	8.8	20.2	8.7
45	2700	9.9	25.1	10.9
50	3000	11.1	30.5	13.2

1 1/2 inches(50mm)				
Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
2	120	0.3	0.1	0.03
5	300	0.8	0.2	0.1
7	420	1.1	0.4	0.2
10	600	1.6	0.7	0.3
15	900	2.4	1.5	0.7
20	1200	3.2	2.6	1.1
25	1500	4.0	4.0	1.7
30	1800	4.9	5.5	2.4
35	2100	5.7	7.4	3.2
40	2400	6.5	9.4	4.1
45	2700	7.3	11.7	5.1
50	3000	8.1	14.3	6.2
60	3600	9.7	20.0	8.7

2 inches(63mm)				
Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
5	300	0.5	0.07	0.03
7	420	0.7	0.1	0.05
10	600	1.0	0.2	0.09
15	900	1.5	0.5	0.2
20	1200	2.0	0.8	0.3
25	1500	2.4	1.2	0.5
30	1800	2.9	1.6	0.7
35	2100	3.4	2.2	0.9
40	2400	3.9	2.8	1.2
45	2700	4.4	3.4	1.5
50	3000	4.9	4.2	1.8
60	3600	5.9	5.8	2.5
70	4200	6.8	7.8	3.4
75	4500	7.3	8.8	3.8
80	4800	7.8	9.9	4.3
90	5400	8.8	12.4	5.4
100	6000	9.8	15.0	6.5

2 1/2 inches(75mm)

Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
5	300	0.3	0.04	0.02
7	420	0.5	0.05	0.02
10	600	0.7	0.1	0.04
15	900	1.0	0.2	0.08
20	1200	1.4	0.3	0.1
25	1500	1.7	0.5	0.2
30	1800	2.1	0.7	0.3
35	2100	2.4	0.9	0.4
40	2400	2.7	1.2	0.5
45	2700	3.1	1.4	0.6
50	3000	3.4	1.8	0.8
60	3600	4.1	2.5	1.1
70	4200	4.8	3.3	1.4
75	4500	5.1	3.7	1.6
80	4800	5.5	4.2	1.8
90	5400	6.2	5.2	2.3
100	6000	6.8	6.3	2.7
125	7500	8.6	9.6	4.2
150	9000	10.3	13.4	5.8

3 inches (90mm)				
Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
5	300	0.2	0.02	0.01
7	420	0.3	0.02	0.01
10	600	0.4	0.03	0.01
15	900	0.7	0.07	0.03
20	1200	0.9	0.1	0.05
25	1500	1.1	0.2	0.07
30	1800	1.3	0.2	0.1
35	2100	1.6	0.3	0.1
40	2400	1.8	0.4	0.2
45	2700	2.0	0.5	0.2
50	3000	2.2	0.6	0.3
60	3600	2.7	0.9	0.4
70	4200	3.1	1.1	0.5
75	4500	3.3	1.3	0.6
80	4800	3.5	1.4	0.6
90	5400	4.0	1.8	0.8
100	6000	4.4	2.2	0.9
125	7500	5.5	3.3	1.4
150	9000	6.6	4.6	2.0
175	10500	7.7	6.2	2.7
200	12000	8.8	7.9	3.4
250	15000	11.0	11.9	5.2

4 inches(110mm)				
Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
20	1200	0.5	0.03	0.01
25	1500	0.6	0.04	0.02
30	1800	0.8	0.06	0.03
35	2100	0.9	0.08	0.04
40	2400	1.0	0.1	0.05
45	2700	1.2	0.1	0.06
50	3000	1.3	0.2	0.07
60	3600	1.5	0.2	0.1
70	4200	1.8	0.3	0.1
75	4500	1.9	0.3	0.2
80	4800	2.1	0.4	0.2
90	5400	2.3	0.5	0.2
100	6000	2.6	0.6	0.3
125	7500	3.2	0.9	0.4
150	9000	3.8	1.2	0.5
175	10500	4.5	1.6	0.7
200	12000	5.1	2.1	0.9
250	15000	6.4	3.2	1.4
300	18000	7.7	4.4	1.9
350	21000	9.0	5.9	2.6
400	24000	10.2	7.5	3.3

5 inches(125mm)				
Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
30	1800	0.5	0.02	0.01
35	2100	0.6	0.03	0.01
40	2400	0.7	0.03	0.01
45	2700	0.7	0.04	0.02
50	3000	0.8	0.05	0.02
60	3600	1.0	0.07	0.03
70	4200	1.1	0.1	0.04
75	4500	1.2	0.1	0.05
80	4800	1.3	0.1	0.06
90	5400	1.5	0.2	0.07
100	6000	1.6	0.2	0.08
125	7500	2.0	0.3	0.1
150	9000	2.4	0.4	0.2
175	10500	2.8	0.5	0.2
200	12000	3.3	0.7	0.3
250	15000	4.1	1.1	0.5
300	18000	4.9	1.5	0.6
350	21000	5.7	2.0	0.9
400	24000	6.5	2.5	1.1
450	27000	7.3	3.1	1.3
500	30000	8.1	3.7	1.6

6 inches(140mm)				
Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
50	3000	0.6	0.02	0.01
60	3600	0.7	0.03	0.01
70	4200	0.8	0.04	0.02
75	4500	0.8	0.05	0.02
80	4800	0.9	0.05	0.02
90	5400	1.0	0.06	0.03
100	6000	1.1	0.08	0.04
125	7500	1.4	0.1	0.05
150	9000	1.7	0.2	0.07
175	10500	2.0	0.2	0.1
200	12000	2.3	0.3	0.1
250	15000	2.8	0.4	0.2
300	18000	3.4	0.6	0.3
350	21000	3.9	0.8	0.3
400	24000	4.5	1.0	0.4
450	27000	5.1	1.3	0.6
500	30000	5.6	1.5	0.7
750	45000	8.4	3.3	1.4
1000	60000	11.2	5.5	2.4

8 inches(200mm)				
Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
125	7500	0.7	0.03	0.01
150	9000	0.8	0.04	0.02
175	10500	1.0	0.04	0.02
200	12000	1.1	0.06	0.02
250	15000	1.3	0.07	0.03
300	18000	1.6	0.1	0.05
350	21000	1.9	0.2	0.07
400	24000	2.3	0.2	0.09
450	27000	2.6	0.3	0.1
500	30000	2.9	0.3	0.1
750	45000	3.2	0.4	0.2
1000	60000	4.9	0.9	0.4
1250	75000	6.5	1.5	0.6
1500	90000	8.1	2.2	1.0
2000	120000	9.7	3.1	1.3

10 inches(250mm)				
Volume Flow (gal/min)	Volume Flow (gal/hr)	Velocity (ft/sec)	Friction Head (ft/100 ft)	Friction Loss (psi/100 ft)
200	12000	0.8	0.03	0.01
250	15000	1.0	0.04	0.02
300	18000	1.2	0.05	0.02
350	21000	1.4	0.07	0.03
400	24000	1.6	0.09	0.04
450	27000	1.9	0.1	0.05
500	30000	2.1	0.1	0.06
750	45000	3.1	0.3	0.1
1000	60000	4.1	0.5	0.2
1250	75000	5.1	0.7	0.3
1500	90000	6.2	1.0	0.4
2000	120000	8.2	1.7	0.7
2500	150000	10.3	2.6	1.1

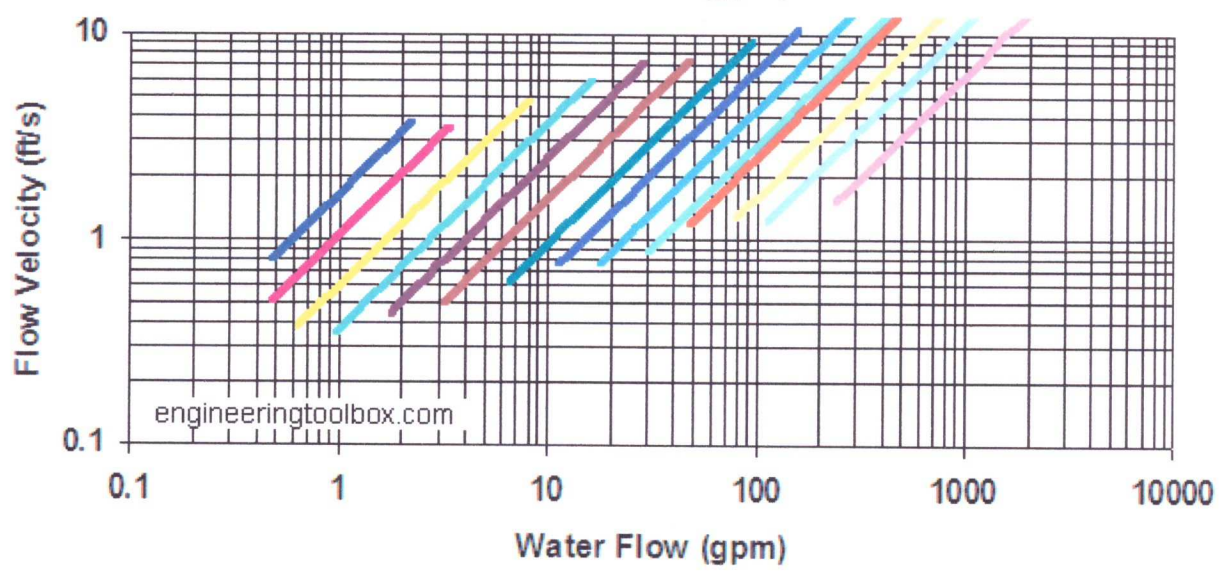
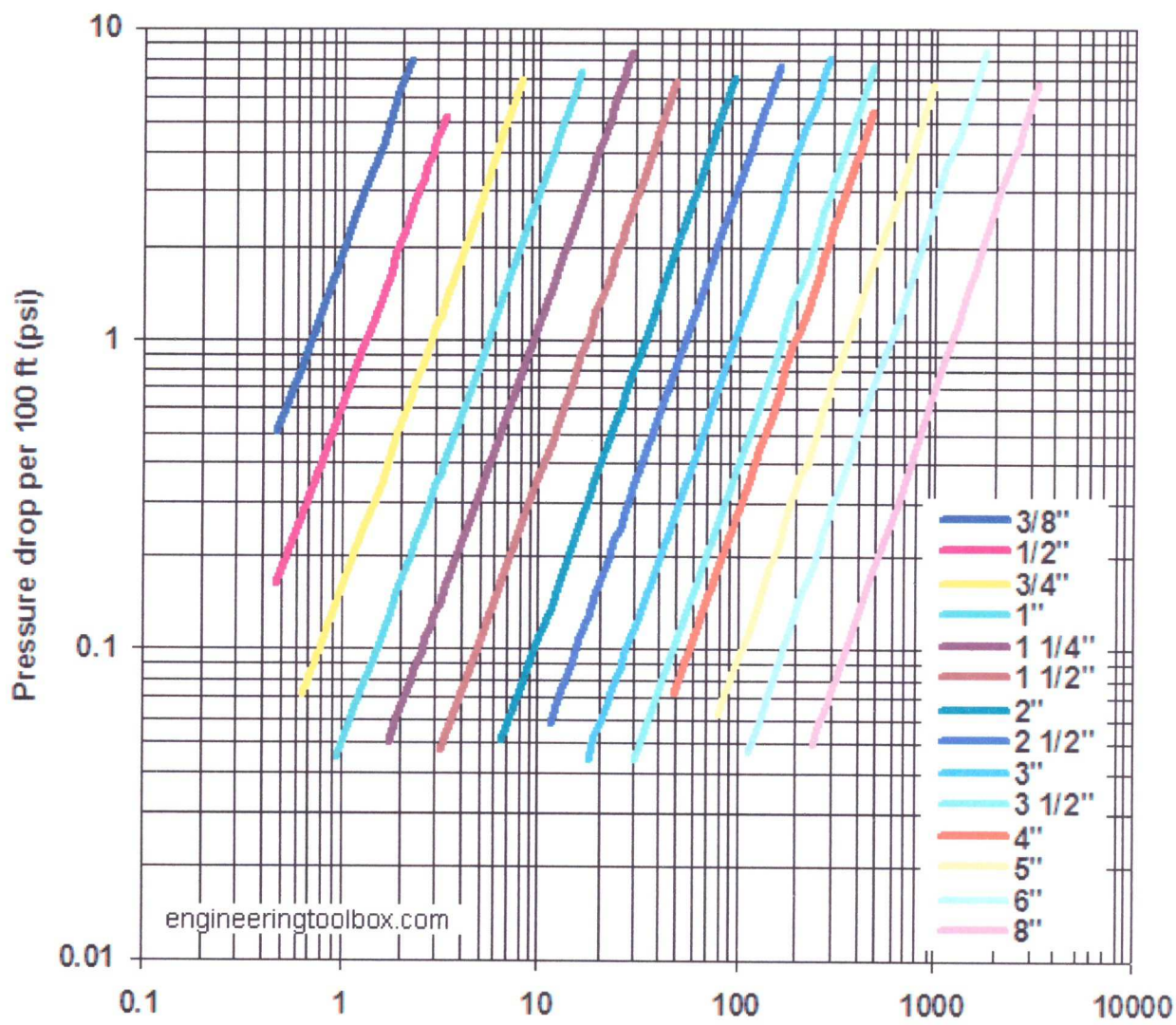


Steel Pipe Schedule 40 - Friction loss and Velocity Diagram

Friction loss and velocity diagrams - in imperial (psi/100 ft, ft/s)

The diagram below indicates friction loss for water flow through [schedule 40 steel pipe](#).

- Fluid : Water
- Pipe : Steel Pipe - Schedule 40
- [Temperature](#) : 20.0 °C (68.0 °F)
- [Density](#) : 998.3 kg/m³ (62.0 lb/ft³)
- [Kinematic Viscosity](#) : 1.004E-6 m²/s (0.01 stokes) (1.08E-5 ft²/s)
- [Pipe Roughness Coefficient](#) : 4.5E-5



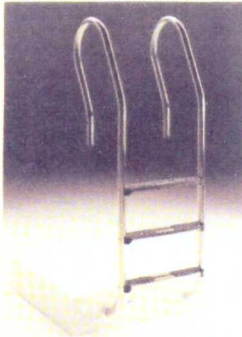
APPENDIX

B

Astral Catalogue, 2004 – 2005

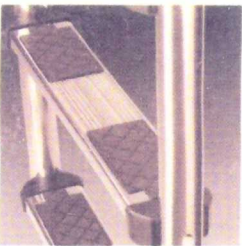
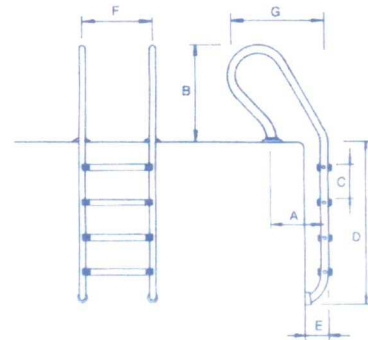
POOL ACCESS - LADDERS

Mixed model ladders



Ladder width 500 mm
Handrails in hand polished stainless seteel (ø 43 mm)
Steps in stainless steel or plastic
Complete with fixing anchors and earth connection

Steps	A	B	C	D	E	F	G
2	350	620	250	710	180	500	522
3	350	620	250	960	180	500	522
4	350	620	250	1210	180	500	522
5	350	620	250	1460	180	500	522

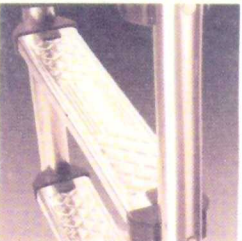


Deluxe model step

Rails and steps in AISI-316

2 steps ladder
3 steps ladder
4 steps ladder
5 steps ladder

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
05484	1	9,7	0,07
05485	1	11,5	0,08
05486	1	12,6	0,09
05487	1	14,8	0,09

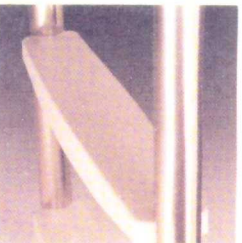


Standard model step

Rails and steps AISI-304

2 steps ladder
3 steps ladder
4 steps ladder
5 steps ladder

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
05496	1	9,7	0,07
05497	1	11,4	0,08
05498	1	15,3	0,09
05499	1	14,8	0,10



Plastic model step

Rails in AISI-304, steps in plastic

2 steps ladder
3 steps ladder
4 steps ladder
5 steps ladder

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
05512	1	9,0	0,07
05513	1	10,7	0,07
05514	1	12,4	0,08
05515	1	14,1	0,09

MODULAR OVERFLOW GRATINGS

GENERAL NOTE FOR ALL TYPES OF MODELS

Made in PP, stabilised against UV rays. Standard white colour.

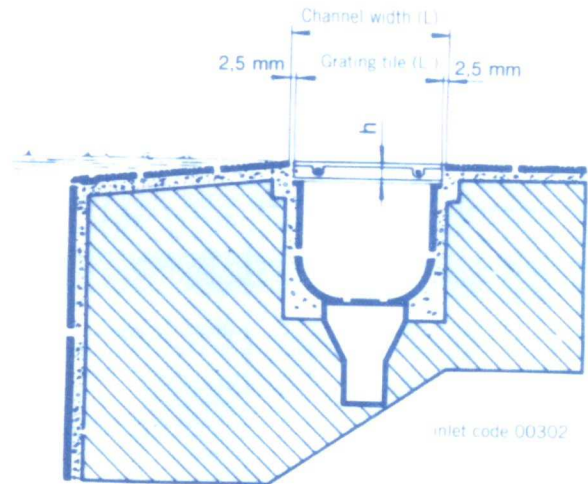
These are supplied as modules of tiles for straight or curved runs (external radius of 1 or 2 metres). The tiles click together with a male-female pressure fit permitting a certain amount of flexibility in assembly which absorbs any expansion which may occur when the tiles are exposed to heat fluctuations.

For all types of gratings it is necessary to construct the channel 5 mm wider than the grating itself, to allow for ease of removal and to allow for expansion.

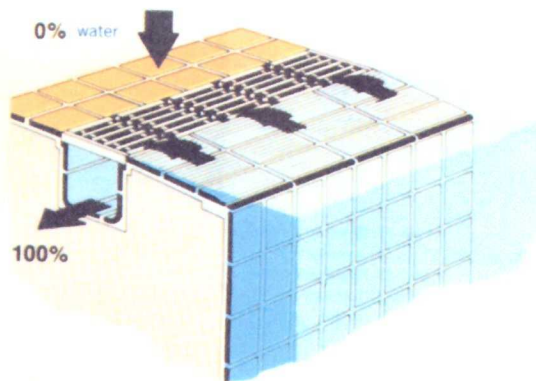
Channel width in mm	Grating width in mm
200.....	195
250.....	245
300.....	295
350.....	345

Height of grating (h) varies according to model.

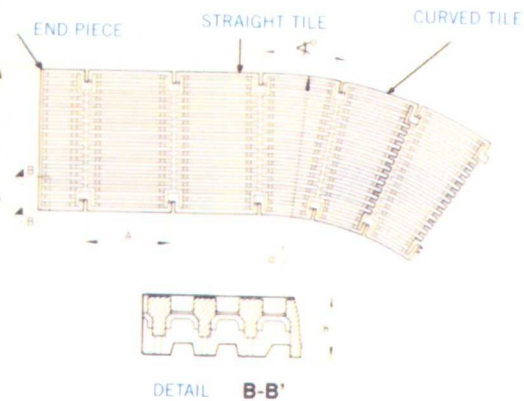
- Longitudinal model h = 24 mm.
- Traversal model h = 22 mm, y h = 35 mm.



LONGITUDINAL GRATING



The longitudinal design of the tiles ensures that any excess water from the pool is not allowed to overflow onto the pool surround keeping this area dry.



	Model		L	L1	h	A	r.1m	r.2m
	STRAIGHT TILE	05581		200	195	24	206	
05582			250	245	24	206		
05583			300	294	24	206		
05584			350	345	24	206		
CURVED TILE			r.1m	r.2m				
	08001	05585	200	195	24	11° 15'	6'	
	07565	05586	250	245	24	11° 15'	6'	
	08002	05587	300	294	24	11° 15'	6'	
END PIECE	06420		200	195	24			
	06421		250	245	24			
	06422		300	294	24			
	06423		350	345	24			

CONCRETE POOLS - SKIMMERS 15 L

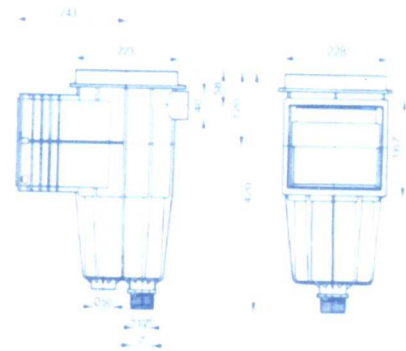
All exposed skimmer parts are UV resistant. Recommended flow 5000 l/h. In white ABS with silent wier flap and flow regulation plug. 1 1/2" female - 2" male suction connections. Ø 50 mm solvent connection also provided. Overflow connection Ø 40 mm. Basket secured to base with bayonet fixing. We recommend installing one skimmer for every 25 m² of water surface area.



With standard throat

Round lid
Square lid

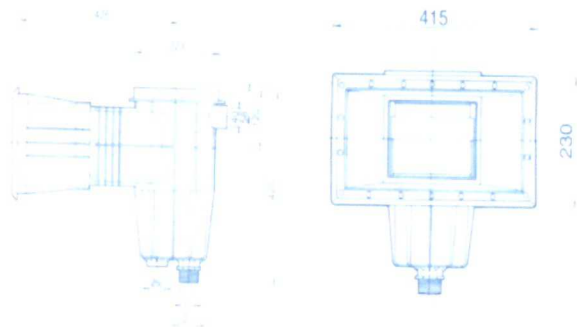
Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00249	1	2.95	0.059
00250	1	3.15	0.059



With wide throat

Round lid
Square lid

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00251	1	4.47	0.12
00252	1	3.00	0.12



44

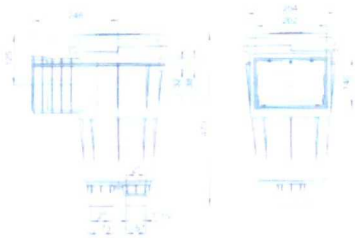
CONCRETE POOLS - SKIMMERS 17.5 L

All exposed skimmer parts are UV resistant. **Recommended flow 7500 l/h.** In white ABS with silent wier flap and flow regulation plug. 1 1/2" female - 2" male suction connections. Ø 50 mm solvent connection also provided. Overflow connection Ø 32 mm. Lid with spring clip fastening system with lid height adjustment to fit surround perfectly. Basket secured to base with bayonet fixing. Weir flap included. We recommend installing one skimmer for every 25m² of water surface area.

With standard throat

	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
Round lid	05589	1	4,20	0,062
Square lid	11306	1	4,20	0,062

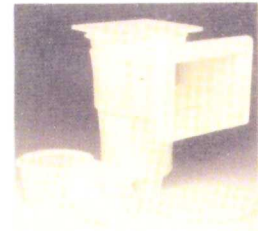
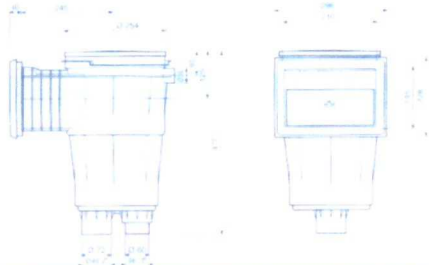
Round lid
Square lid



With standard throat and face plate

	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
Round lid	05280	1	5,10	0,062
Square lid	11302	1	5,20	0,062

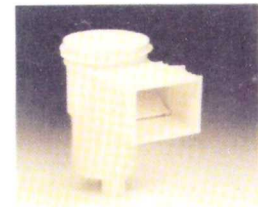
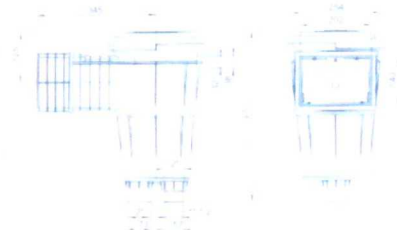
Round lid
Square lid



With extended throat

	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
Round lid	05590	1	4,85	0,077
Square lid	11307	1	5,90	0,077

Round lid
Square lid



CONCRETE POOLS - MAIN DRAINS

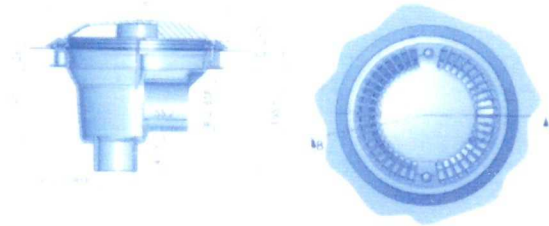
Circular main drain Ø 200 mm with antivortex grille



Made in ABS. Side connection 2" and bottom connection 1 1/2" with knockout. Maximum flow: 13 m³/h

Main drain with antivortex grille

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
27837	1	2,807	0,028



Circular main drain Ø 200 mm with flat grille



Made in ABS. Side connection 2" and bottom connection 1 1/2" with knockout. Maximum flow: 13 m³/h

Main drain with flat grille

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
27839	1	2,651	0,028



Square outlet of 2"



Side connection 2". Body and grille in white ABS. Fixed grille with screws. Maximum flow: 13 m³/h

210 x 210 mm

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00258	4	4,0	0,044

Outlet of 2"



Side connection 2". In S.S. AISI 316. Fixed grille with screws. Maximum flow: 13 m³/h

Side connection 2"

Side connection 2" and bottom connection 1 1/2"

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00268	1	2,56	0,02
26196	1	2,80	0,02

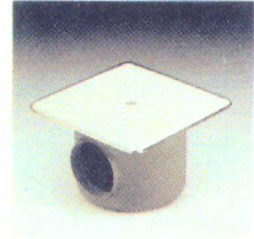
CONCRETE POOLS - MAIN DRAINS

Outlet 2"

Side connection 2". Made in S.S. AISI-316. Antivortex lid. Can be used with liner and prefabricated pools with liner adaptor kit code 00276.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00269	1	1,14	0,01

Side connection 2"



In polyester and fibreglass 355 x 355 mm.

Gel coat finish. Slots < 8 mm. With optional hydrostatic valve.

Solvent socket outlet connection	Grille	Flow	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
Ø 75 mm	AISI-316	18 m ³ /h	20282	1	5	0,047
Ø 90 mm	AISI-316	27 m ³ /h	20283	1	5	0,047
Ø 110 mm	AISI-316	33,5 m ³ /h	20284	1	5	0,047

Max. recommended flow according to UNE-13451-1 standard.

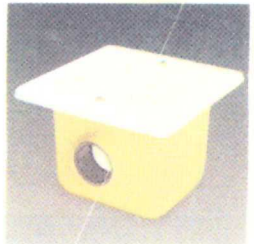


In polyester and fibreglass 355 x 355 mm.

Gel coat finish. With optional hydrostatic valve.

Solvent socket outlet connection	Grille	Flow	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
Ø 75 mm	Plastic	18 m ³ /h	22359	1	4,5	0,034
Ø 90 mm	Plastic	27 m ³ /h	22360	1	4,5	0,034
Ø 110 mm	Plastic	42 m ³ /h	22361	1	4,5	0,034
Ø 125 mm	Plastic	45 m ³ /h	22362	1	4,5	0,034

Max. recommended flow according to UNE-13451-1 standard.



In polyester and fibreglass 512 x 512 mm.

Gel coat finish. Slots < 8 mm. With optional hydrostatic valve.

Solvent socket outlet connection	Grille	Flow	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
Ø 110 mm	AISI-316	42 m ³ /h	20285	1	11,5	0,132
Ø 125 mm	AISI-316	51 m ³ /h	20286	1	11,5	0,132
Ø 140 mm	AISI-316	66 m ³ /h	20287	1	11,5	0,132
Ø 160 mm	AISI-316	95 m ³ /h	20288	1	11,5	0,132
Ø 200 mm	AISI-316	103 m ³ /h	20289	1	11,5	0,132
In UV resistant ABS						
Ø 110 mm	Plastic	42 m ³ /h	28709	1	11,5	0,132
Ø 125 mm	Plastic	51 m ³ /h	28710	1	11,5	0,132
Ø 140 mm	Plastic	66 m ³ /h	28711	1	11,5	0,132
Ø 160 mm	Plastic	95 m ³ /h	28712	1	11,5	0,132
Ø 200 mm	Plastic	103 m ³ /h	28713	1	11,5	0,132

Max. recommended flow according to UNE-13451-1 standard.



CONCRETE POOLS - ABS INLETS

Return inlet

In white ABS UV resistant, 3 adjustable positions. (100%, 65%, & 35%). Max. flow complies with UNE 13451-1: 13500 l/h.

Connection: External Ø 63 mm

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
15863	24	3,4	0,020



Concrete floor inlet

Return / Suction. Adjustable flow. Made in white ABS, screw in S.S. Max. flow complies with UNE 13451-1: 12000 l/h

2" external thread, Ø 50 mm solvent internal
To glue onto Ø 63 PN 6, Ø 50 mm solvent internal

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00303	24	5	0,020
20140	20	4,4	0,021

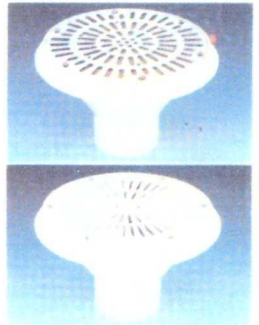


3" Concrete floor inlet

Made in PVC plastic. Suction. Adjustable flow by way of grille rotation. Flow surface area: 0.015 m². Exterior Ø 295 mm. Flow (0.4 m/s.) 20000 l/h. Max. flow complies with UNE 13451-1: 2600 l/h (0.5 m/s.)

Grille in S.S. AISI 304
Grille in white ABS

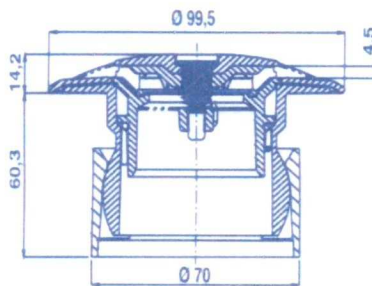
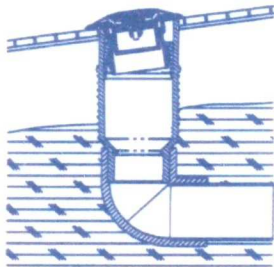
Code	Standard Packing	Standard Weight kg	Standard Volume m ³
08317	1	-	-
11796	1	-	-



Adjustable angled bottom inlets


Angled body in PVC. Lid in ABS. Regulating screw in POM. Max. flow: 14000 l/h
Allows 8° adjustment.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
22353	24	4,1	0,022



CONCRETE POOLS - ABS INLETS




Reducing conduit (Net'n'Clean oscillating nozzle) 

Conduit with adjustable internal diameter for solvent welding inlets 22353. Connections are Ø 63 mm male and Ø 50 mm female solvent socket. Made in white PVC.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
21248	12	7,3	0,032




Concrete vacuum point 

To glue inside Ø 63 mm 6 bar pipe and Ø 50 mm solvent internal. Made in white ABS. Plug thread 1 1/2". Can be installed with wall conduits 15661 & 15660.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00300	24	3,62	0,020



Concrete vacuum point 

2" external thread, Ø 50 mm, solvent internal. Made in white ABS. Plug thread 1 1/2". Can be installed with wall conduits 15658 & 15659.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00301	24	3,8	0,020
06594	-	-	-

2" ext. thread, 1 1/2" solvent internal. Plug thread 1 1/2"




Concrete vacuum point

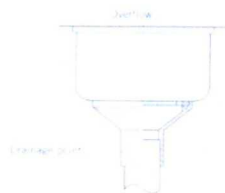
To glue inside Ø 50 mm 10 bar pipe. Made in white ABS. Plug thread 1 1/2". Can be installed with wall conduits 15658 & 15659. End connection 07958 and push fit connection 01393.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
24415	60	3,72	0,02



Overflow channel drainage point 

Body and grille in ABS. Screws in S.S. To be glued to external Ø 63 mm. Owing to its design this inlet is particularly suitable for overflow channels.



Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00302	12	3,1	0,016

CONCRETE POOLS - WALL CONDUITS

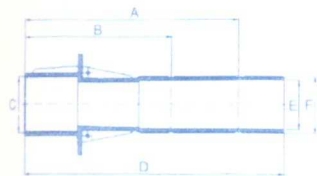
New range of 300 mm conduits for Ø 2" inlets and "Multiflow", that can be easily be cut to required lengths depending on pool shell thickness. Made in ABS. They all have 2 holes for positioning within the pool shell.

Rear external 2" male thread and Ø 50 mm solvent internal

	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
2" front internal thread for 2" male thread inlet	15658	15	4,3	0,040
Ø 59.3 mm solvent internal for inlets suitable for gluing in to Ø 63 mm 6 bar pipe & dichro light "MINI" Ø8554	15661	15	4,2	0,040

Rear external Ø 63 mm male thread and Ø 50 mm solvent internal

	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
2" front internal thread for 2" male thread inlet	15659	15	4,2	0,040
Ø 59.3 mm. solvent internal for inlets suitable for gluing into Ø 63 mm 6 bar pipe & dichro light "MINI" Ø8554	15660	15	5,6	0,040



DIMENSIONS	MODELS			
	15658	15661	15659	15660
A	250	250	250	250
B	175	175	175	175
C	2"	Ø 59.3	2"	Ø 59.3
D	300	300	300	300
E	Ø 50	Ø 50	Ø 50	Ø 50
F	2"	2"	Ø 63	Ø 63

PVC wall conduit- Length 300 mm

PVC grey colour.

	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
2" female & male connection	00323	6	3,0	0,011
2" ext. thread pipe connection, solvent int. Ø 50 mm	00324	6	3,0	0,011

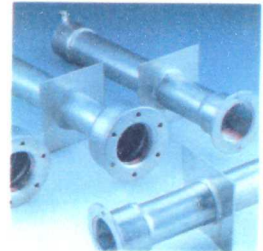
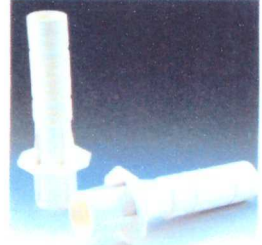
Stainless steel wall conduits

Made in S.S AISI-304. Both ends with internal thread of 1/2". Earth connection.

	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
Length 240 mm.	00327	1	0,7	0,003
Length 340 mm.	00328	1	0,8	0,005



DIMENSIONES	MODELOS	
	00327	00328
A	240	340
B	1/2"	1/2"
C	74	74
D	1/2"	1/2"
E	35	35



FOR LINER AND PREFABRICATED POOLS - MAIN DRAINS

All main drains made in plastic are provided with UV protected grilles.

- According to UNE 13451-1 standard, in public pools:

- Water passing speed 0.5 m/seg
- Maximum suction velocity 1.5 m/seg
- Minimum distance between drains: >2 m
- Recommended use of WARNER security system to detect any irregularities and effect automatic shut-down of pumps



Mini drain

Side connection with 2" internal threads. Made in white ABS with grille fixed to flange. Suction velocity of grille 0.5 m/sec and max. flow 11 m³/h. Bottom connection with plug or for fitting the hydrostatic relief valve & drainage tube. Slots < 8 mm. Complies with valid standard. M5 threaded screws and brass inserts to secure flange and grille. Can be used in concrete spas and small pools.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
27814	1	2,64	0,013

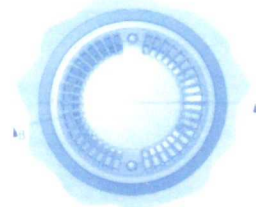


Circular main drain Ø 200 mm with antivortex grille

Made in ABS. Side connection 2" and bottom connection 1 1/2" with knockout. Maximum flow: 13 m³/h.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
27125	1	3,543	0,028

Main drain with **antivortex grille**

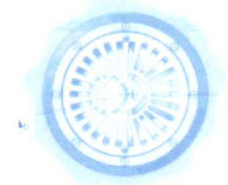


Circular main drain Ø 200 mm with flat grille

Made in ABS. Side connection 2" and bottom connection 1 1/2" with knockout. Maximum flow: 13 m³/h.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
27838	1	3,391	0,028

Main drain with **flat grille**



FOR LINER AND PREFABRICATED POOLS - MAIN DRAINS

Drains of \varnothing 280 mm for liner. PARKER model



Made totally in white ABS, with self adhesive gaskets and screws. 2" side connections which can be plugged from the inside for pressure testing. 1 1/2" bottom connection with plug for fitting the hydrostatic relief valve & drainage tube. Suction velocity 0.5 m/sec. Recommended max. flow: 13 m³/h. Installed flush with floor bottom for total drainage.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00270	4	5.71	0,044
07880	4	5.71	0,044

With self tapping screws



Drain of \varnothing 210 mm



Side connection 2". Body and grille in ABS, with self-adhesive gaskets, flange, and screws. Maximum flow: 13 m³/h

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00271	4	4.0	0,028

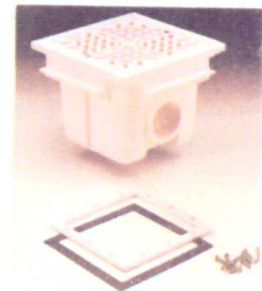


Drain of 210 x 210 mm.



Side connection 2". Body and grille in ABS, with self-adhesive gaskets, flange, and screws. Maximum flow: 13 m³/h

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00273	4	5.5	0.043



Drain \varnothing 50 mm. int., \varnothing 63 mm. est.

Body in white ABS with stainless steel grille. Complete with self adhesive gaskets, flange, and screws. Maximum flow: 7 m³/h

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00274	4	4.0	0,023



Drain of 2"



In S.S. AISI 316, with fixed grille and screws. Includes gaskets, flange, and fixing screws. Maximum flow: 13 m³/h

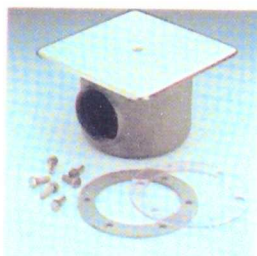
Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00275	1	2.27	0.02
26197	1	4.23	0.04

Side connection 2"

Side connection 2", bottom connection 1 1/2"



FOR LINER AND PREFABRICATED POOLS - MAIN DRAINS



Liner adaptor kit

For drain 00269. Complete with gaskets, flange, and screws. Frame in AISI-316

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00276	40	9,7	0,01

Drain not included



In polyester and fibreglass 355 x 355 mm.

Gel coat finish. With gaskets, flange, and screws. Slots < 8 mm. Recommended flow 20 m³/h (0,3 m/s). Recommended max. flow: 33,5 m³/h (0,5 m/s.). With optional hydrostatic valve.

Solvent socket outlet connection	Grille	Flow	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
Ø 75 mm	AISI-316	18 m ³ /h	20074	1	6,5	0,047
Ø 90 mm	AISI-316	27 m ³ /h	20075	1	6,5	0,047
Ø 110 mm	AISI-316	33,5 m ³ /h	20290	1	6,5	0,047



In polyester and fibreglass 355 x 355 mm.

Gel coat finish. Grille in UV resistant ABS. With gaskets, flange, and screws. Recommended max. flow: 27 m³/h (0,5 m/s.). With optional hydrostatic valve. Grille 257 x 257 mm.

Solvent socket outlet connection	Grille	Flow	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
Ø 75 mm	Plastic	18 m ³ /h	22416	1		0,034
Ø 90 mm	Plastic	27 m ³ /h	22417	1		0,034
Ø 110 mm	Plastic	42 m ³ /h	22418	1		0,034
Ø 125 mm	Plastic	45 m ³ /h	22419	1		0,034



In polyester and fibreglass 512 x 512 mm.

Gel coat finish. With gaskets, flange, and screws. Slots < 8 mm. Recommended flow 62 m³/h (0,3 m/s). Recommended max. flow: 103 m³/h (0,5 m/s.). With optional hydrostatic valve. Grills in AISI-316

Solvent socket outlet connection	Grille	Flow	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
Ø 110 mm	AISI-316	42 m ³ /h	20076	1	1,4	0,132
Ø 125 mm	AISI-316	51 m ³ /h	20077	1	1,4	0,132
Ø 140 mm	AISI-316	66 m ³ /h	20078	1	1,4	0,132
Ø 160 mm	AISI-316	95 m ³ /h	20079	1	1,4	0,132
Ø 200 mm	AISI-316	103 m ³ /h	20291	1	1,4	0,132
Grille in UV resistant ABS plastic:						
Ø 110 mm	Plastic	42 m ³ /h	28722	1	1,4	0,132
Ø 125 mm	Plastic	51 m ³ /h	28723	1	1,4	0,132
Ø 140 mm	Plastic	66 m ³ /h	28724	1	1,4	0,132
Ø 160 mm	Plastic	95 m ³ /h	28725	1	1,4	0,132
Ø 200 mm	Plastic	103 m ³ /h	28726	1	1,4	0,132

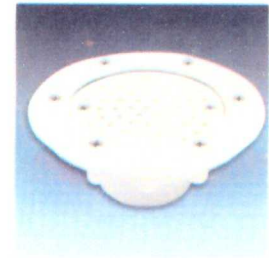
FOR LINER AND PREFABRICATED POOLS - ABS INLETS

Adjustable liner return inlet



With gaskets, flanges, and screws. 3 adjustable positions (100%, 65% & 35%) Max. flow complies with UNE 13451-1: 13.5 m³/h.
External connection Ø 63 mm.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
15864	12	4,2	0,02



Floor return inlet



For return. Made in white ABS, with gaskets, flanges, and screws. Adjustable flow. Max. flow 12 m³/h.

2" external thread Ø 50, internal solvent

00340

12

5,4

0,020

Solvent external Ø 63 PN 6, Ø 50 internal solvent

20139

12

5,4

0,021

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00340	12	5,4	0,020
20139	12	5,4	0,021



3" adjustable floor suction inlet



For suction. Made in white ABS, with gaskets, flanges, and screws. Adjustable flow by way of grille rotation.
Flow surface area: 0,015 m². Flow at 0,4 m/s: 20 m³/h.

Max. recommended flow:
26 m³/h. (0,5 m/s)

Grille in S.S. AISI-304
Grille in white ABS

08316

1

-

-

11795

1

-

-

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
08316	1	-	-
11795	1	-	-



Liner floor inlet BCN03



Adjustable liner floor inlet. For glueing into PN6 and PN10 pipe. In white ABS with self tapping screws or with metal inserts according to model type. With flange in plastic or stainless steel.
Maximum flow 9,5 m³/h

Plastic flange with self-tappers PN6
Plastic flange with metal inserts PN6
S.S. flange with self-tappers PN10
S.S. flange with metal inserts PN10

28230

12

3,25

0,031

28231

12

3,55

0,031

28501

12

4,24

0,031

28502

12

4,54

0,031

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
28230	12	3,25	0,031
28231	12	3,55	0,031
28501	12	4,24	0,031
28502	12	4,54	0,031



Liner return inlet

External thread 1 1/2". Made in S.S. AISI-316. Ø 20 mm eyeball. Complete with gaskets & screws.
Recommended flow: 4,5 m³/h

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
16327	1	0,5	0,001



Panel pool adapter

1 1/2" external thread. Made in S.S. AISI-316. Allows installation in both concrete and prefabricated pools. Water flow may be adjusted by the central screw. To be used with 16331.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
26171	1	0,2	0,001



Liner return inlet

Made in S.S. AISI-316. Ø 20 mm eyeball. Can be used with wall conduits 00344, 00345, & panel adapter 26171. Complete with gaskets & screws.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
16331	1	0,3	0,001



Adjustable return inlet

2" external thread. Made in S.S. AISI-316. Allows installation in both concrete and prefabricated pools. Water flow may be adjusted by the central screw. Max. recommended flow: 14m³/h

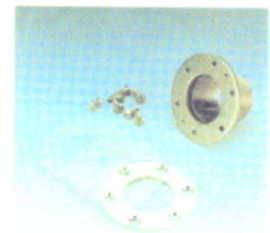
Code	Standard Packing	Standard Weight kg	Standard Volume m ³
15839	1	0,9	0,002



Liner suction inlet

Made in S.S. AISI-316, with gaskets, flange & screws. 1 1/2" BSP threads.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
16330	1	0,5	0,001



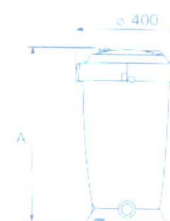
CARTRIDGE FILTERS

Cartridge filters, Terra series

Made in PP and fibreglass. Supplied with pressure gauge and manual air vent. Higher filtration capacity. Easy maintenance. 2" BSP outlet (Supplied with 2-1/4" red bush). Filtration velocity 1.8 m³/h x m². Maximum working pressure: 2.5 Kg/cm².

	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
Terra 50 Recommended flow: 8,4 m ³ /h. Filtration surface: 4,7 m ² .	18218	1	7,5	0,086
Terra 75 Recommended flow: 12,5 m ³ /h. Filtration surface: 7 m ² .	18219	1	8,8	0,100
Terra 100 Recommended flow: 16,5 m ³ /h. Filtration surface: 9,3 m ² .	18112	1	9,7	0,120
Terra 150 Recommended flow: 25 m ³ /h. Filtration surface: 14 m ² .	18220	1	11,2	0,130

Code	A
18218	450
18219	570
18112	690
18220	810

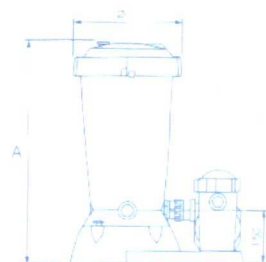
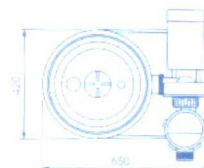


Monobloc cartridge filters, Terra series

Made in PP and fibreglass. Supplied with pressure gauge and manual air vent. Higher filtration capacity. Easy maintenance. 2" BSP outlet (Supplied with 2-1/4" red bush). Filtration velocity 1.8 m³/h x m². Maximum working pressure: 2.5 Kg/cm².

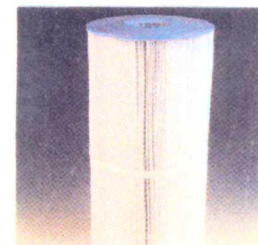
	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
Terra 50 Recommended flow: 8,4 m ³ /h. Filtration surface: 4,7 m ² . AstraMax pump 3/4 HP 230 V 1~	18549	1	-	-
Terra 75 Recommended flow: 12,5 m ³ /h. Filtration surface: 7 m ² . AstraMax pump 1 HP 230 V 1~	18550	1	-	-
Terra 100 Recommended flow: 16,5 m ³ /h. Filtration surface: 9,3 m ² . AstraMax pump 1,25 HP 230 V 1~	18551	1	-	-
Terra 150 Recommended flow: 25 m ³ /h. Filtration surface: 14 m ² . AstraMax pump 1,25 HP 230 V 1~ Filtration velocity 1,2 m ³ /h/m ²	18552	1	-	-

Code	A
18549	585
18550	705
18551	825
18552	945



Replacement cartridges

	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
For Terra 50	19785	1	1,4	0,017
For Terra 75	19786	1	1,7	0,024
For Terra 100	19787	1	2,2	0,032
For Terra 150	19788	1	2,8	0,039



Height of filter bed 1 m

BOBBIN WOUND FILTERS



Atena model



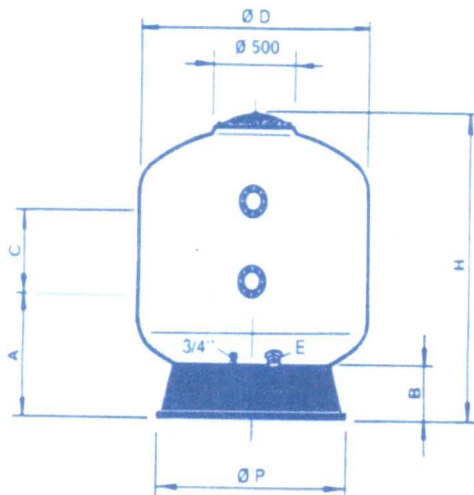
Collectors & diffusers in PVC polypropylene. Lid Ø 500 mm. Complete with pressure gauge panel, manual air vent, water purge, and sand dump port.
Standard colour: grey

Maximum working pressure: 2.5 Kg/cm²



• ALTERNATIVE HEIGHTS AVAILABLE UNDER SPECIAL ORDER

Diameter Ø mm	Filtration velocity m ³ /h/m ²	Outlet Ø mm	Flow m ³ /h	Code	Standard Packing	Standard Weight kg	Standard Volume m ³
1,050	20	63	17	11511	1	120	1,9
	30-40	75	25-34	11517	1	120	1,9
1,200	20-30	75	22-33	11512	1	154	2,7
	40	90	45	11522	1	154	2,7
1,400	20	75	30	11513	1	173	3,7
	30	90	46	11518	1	173	3,7
	40	110	61	11523	1	173	3,7
1,600	20	90	40	11514	1	235	5,0
	30-40	110	60-80	11519	1	235	5,0
1,800	20	90	50	11515	1	270	6,4
	30	110	76	11520	1	270	6,4
	40	125	101	11524	1	270	6,4
2,000	20	110	62	11516	1	295	8,7
	30	125	94	11521	1	295	8,7
	40	140	125	11525	1	295	8,7



Ø (mm)	1,050	1,200	1,400	1,600	1,800	2,000
FLANGE Ø (mm)	-	-	-	-	-	-
Height of the filtering sand (m)	1	1	1	1	1	1
H (mm)	1.650	1.790	1.767	1.847	1.887	2.050
B (mm)	200	230	240	260	280	300
A (mm)	540	570	585	680	720	790
C (mm)	545	640	610	515	465	510
Ø P (mm)	755	940	1.085	1.265	1.370	1.550
E (mm)	90	90	90	140	140	140
Filtration area (m ²)	0,86	1,13	1,54	2,01	2,54	3,14
Volume (l)	1.050	1.500	2.000	2.600	3.400	4.400
Sand 0.4 - 0.8 mm (Kg)	1.050	1.375	1.825	2.450	3.100	3.800
Gravel 1 - 2 mm (Kg)	300	300	500	750	750	1.150
Total weight in operation (Kg)	2.000	2.700	3.700	4.900	5.100	7.900

Maxim pumps 2,860 r.p.m.



Pump body and support in heat resistant plastic. Double protected shaft with IP-54 motor. 8 litre capacity strainer. 4" strainer connection 3" / 90 mm male thread union connections.



230 V valid for voltages between 220 & 240 V

3 phase
(3.5 HP) 230/400 V III

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
08003	1	32	0,184

m.c.a.	8	10	12	14	16	19,5
m/h	56	50	42	34	23	0

3 phase
(4.5 HP) 230/400 V III

08004	1	34	0,184
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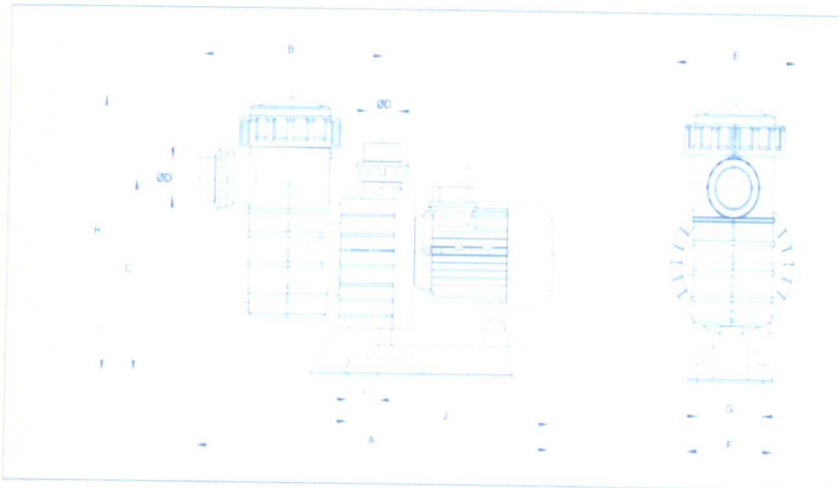
m.c.a.	8	10	12	14	16	19,5
m/h	74	66	57	46	30	0

3 phase
(5.5 HP) 230/400 V III

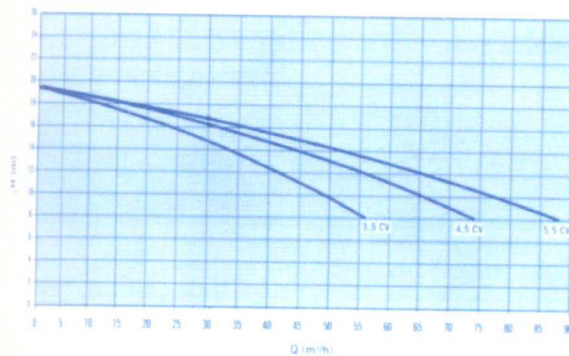
08005	1	37	0,184
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m.c.a.	8	10	12	14	16	19,5
m/h	88	78	67	53	34	0

DIMENSIONS



Performance curves

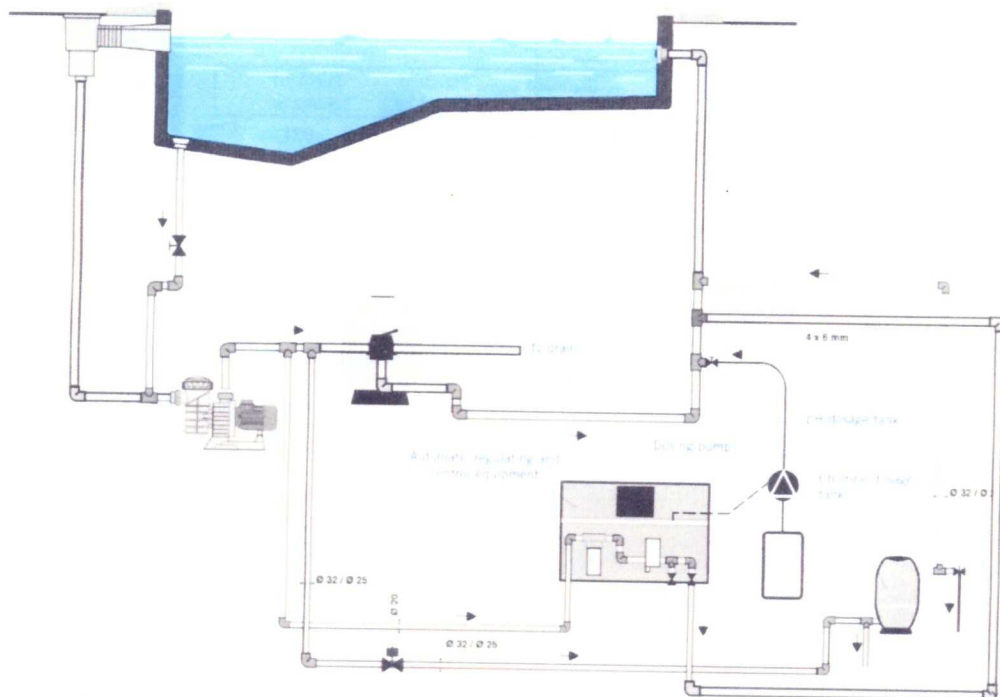


TECHNICAL CHARACTERISTICS

Model	Type	Voltage	A	B	C	Ø D	E	F	G	H	I	J
08003	3.5	230/400	815	430	385	3"	287	200	140	530	65	468
08004	4.5	230/400	815	430	385	3"	287	200	140	530	65	468
08005	5.5	230/400	847	430	385	3"	287	200	140	530	65	500

DOSING TANKS

INSTALLATION diagram of chlorine/bromine dosing tanks and automatic regulating and control equipment



Compact dosage tank

Trichlor and bromine tablet dosing tanks with automatic safety valve

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
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Compact dosage tank 40 l.
 Trichlor (for pools from 200 to 500 m³)
 Bromine (for pools from 150 to 300 m³)
Compact dosage tank 60 l.
 Trichlor (for pools from 500 to 1000 m³)
 Bromine (for pools from 300 to 450 m³)

16631	1	14.0	0.128
16632	1	18.0	0.185



Safety valve kit

PVC body with metal safety valve suitable for trichlor/bromine dosage tanks. Opening pressure reading 2.5-3 bar (Kg/cm²)

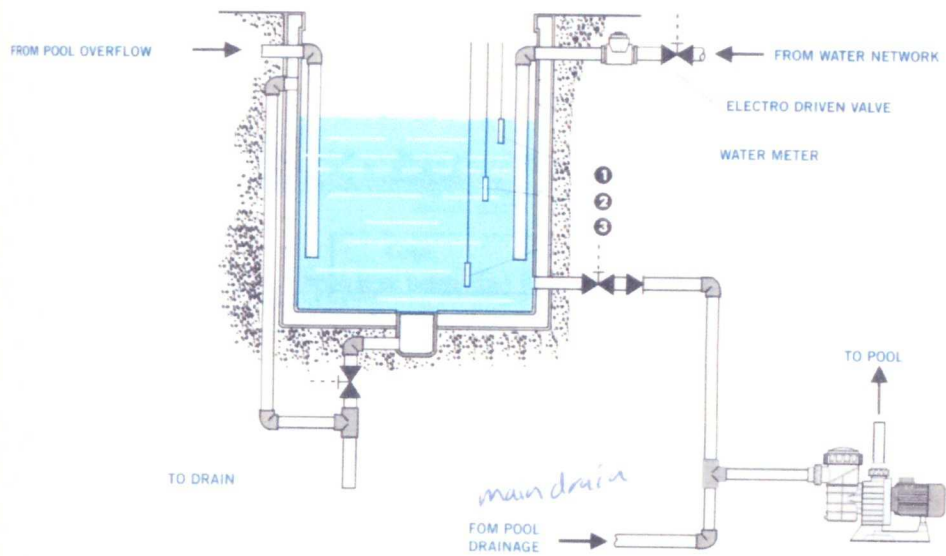
Code	Standard Packing	Standard Weight kg	Standard Volume m ³
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For 40 l dosage tank
 For 60 l dosage tank

16633	1	0.4	0.002
16634	1	0.4	0.002

CONTROL SYSTEMS

BALANCE TANK INSTALLING DIAGRAM



- ① Maximum water level signal in BALANCE TANK for starting the pumping system and electrodriven valve shut down.
- ② Minimum water level signal in COMPENSATION TANK for opening and shutting the electrically operated valve for make up water.
- ③ Minimum level signal in COMPENSATION TANK for shutting down the pumping system.

Electronic operating panel for overflow pool balance tank

2 water sensors control panel. Water level sensor with 2 m. cable.

* SENSOR- 3 Minimum safety level for pump operation: The pump stops functioning if water level doesn't reach the minimum set level.

* SENSOR- 2 Water make up level: Gives the electro driven valve signal opening signal to maintain correct water level in pool. Electro driven valve signal in 220 V II & 24 V II.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
12061	1		

3 water level sensors control panel

* SENSOR- 3 Minimum safety level for pump operation: The pump stop functioning if water level reaches the minimum set level.

* SENSOR- 2 Water make up level: Gives the electro driven valve signal opening signal to maintain correct water level in compensation tank. Electro driven valve signal in 220 V II & 24 V II.

* SENSOR- 1 Pump start level: The pump starts operation when water level in balance tank reaches the overflow level (pipe burst or check valve failure).

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
12062	1		

Buoys

Plastic float

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
20259	1		
20260	1		
20261	1		
20262	1		

26 x 34 - 1"
33 x 42 - 1 1/2"
40 x 49 - 1 1/2"
50 x 60 - 2"

Ref.	A (mm)	Float Ø (mm)
20259	386	180
20260	591	220
20261	596	220
20262	699	300

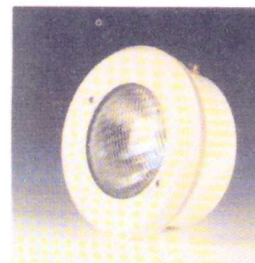
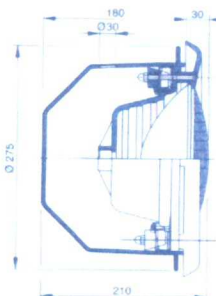
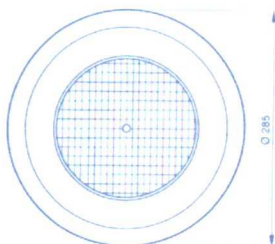
UNDERWATER LIGHT FOR CONCRETE POOLS

"PS" Underwater light

Supplied with niche. Made of PS and lamp housing in PP + fibreglass. 300 W & 12 V bulb.

Without cable
With white ABS rim
With stainless steel rim

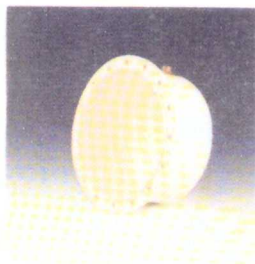
Code	Standard Packing	Standard Weight kg	Standard Volume m ³
07833	4	11,20	0,090
07831	4	12,25	0,090



"PS" lights niche

Made of polystyrene with packing glands for U/W Astral lights 07831 & 07833.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00355	6	7	0,068

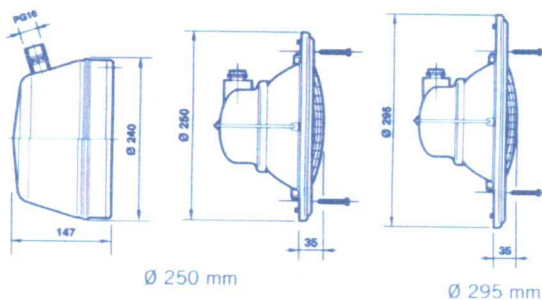


Stainless Steel light U/W light

Totally in S.S. 18/8/2 AISI-316. and supplied with niche, 2,5 m cable & 300 W and 12 V bulb. Threaded gland connection PG16 with converter PG16 to M25. Rim screwed directly to niche with screws. (An accessory 00368) is available for mounting it on liner and prefabricated pools.

Ø 250 mm rim
Ø 295 mm rim

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
00358	1	3,7	0,02
00359	1	3,9	0,02



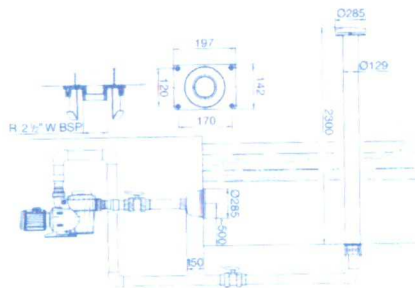
ORNAMENTAL WATER FEATURES

Mushrooms Ø 285 mm



In AISI-316 Stainless Steel. Column Ø 129 mm. Height 2.3 m.

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
19966	1	24,8	0,273



Feature code	Base cover	Anchor		Suction		Pump	Control Box		
		Concrete	Liner	Concrete	Liner		Manual Switch	Pneumatic Switch	
19966	19979	19983	15833	19987	20091	05090	19990	07537	07867

Note: The pneumatic switch includes: control box, wall conduits and switch.

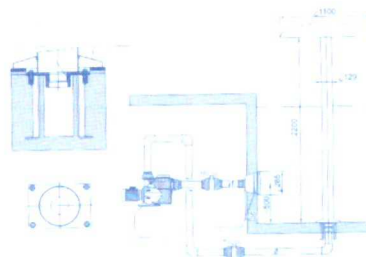
Umbrellas



In AISI-316 Stainless Steel. Umbrella in polyester

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
22750	1	30	0,450
22751	1	85	1,900
22752	1	110	2,400
22753	1	130	3,500
22754	1	-	-
22755	1	-	-

Umbrella, Ø 1100 mm
 Umbrella, Ø 1500 mm
 Umbrella, Ø 2000 mm
 Umbrella, Ø 2500 mm
 Column Ø129 mm
 Column Ø254 mm



Note: The pneumatic switch includes: control box, wall conduits and switch.

Umbrella Ø	Top	Column	Base Cover	Anchor		Suction		Pump	Control Box		
				Concrete	Liner	Concrete	Liner		Manual Switch	Pneumatic Switch	
1100	22750	22754	19979	19983	15833	19987	20091	05090	19990	07537	07867
1500	22751	22755	19980	19984	19986	19987 x 2 u	20091x2	08003	19991	-	-
2000	22752	22755	19980	19984	19986	19987 x 2 u	20091x2	08003	19991	-	-
2500	22753	22755	19980	19984	19986	19987 x 2 u	20091x2	08004	19992	-	-

ORNAMENTAL WATER FEATURES

Wall suction point

In AISI-316 Stainless Steel. Ø = 285 mm. Suction point for water features.

Concrete pool

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
19987	1	2.9	0.018



Wall suction point

In AISI-316 Stainless Steel. Ø = 285 mm. Suction point for water features.

Prefabricated and liner pool

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
20091	1	2.9	0.018



Anchors

In AISI-316 Stainless Steel. Includes base for embedding, screws, washers and earth connection. Connection 2 1/2" BSP.

Rectangular anchor
Ø254 mm anchor
600 mm wide anchor
1 m wide anchor

Code	Standard Packing	Standard Weight kg	Standard Volume m ³
19983	1	2.1	0.012
19984	1	9.8	0.113
19985	1	6.4	0.039
20135	1	10.8	0.076



Liner pools

In AISI-316 Stainless Steel. Includes base for embedding, fixing plate, 3 gaskets and earth connection. Connection 2 1/2" BSP.

Rectangular anchor



Code	Standard Packing	Standard Weight kg	Standard Volume m ³
15833	1	2.5	0.007



Liner pools

Anchor Ø 254 mm

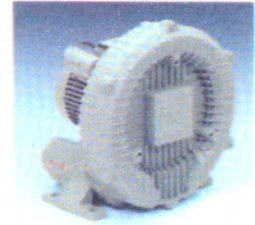
Code	Standard Packing	Standard Weight kg	Standard Volume m ³
19986	1	11	0.400



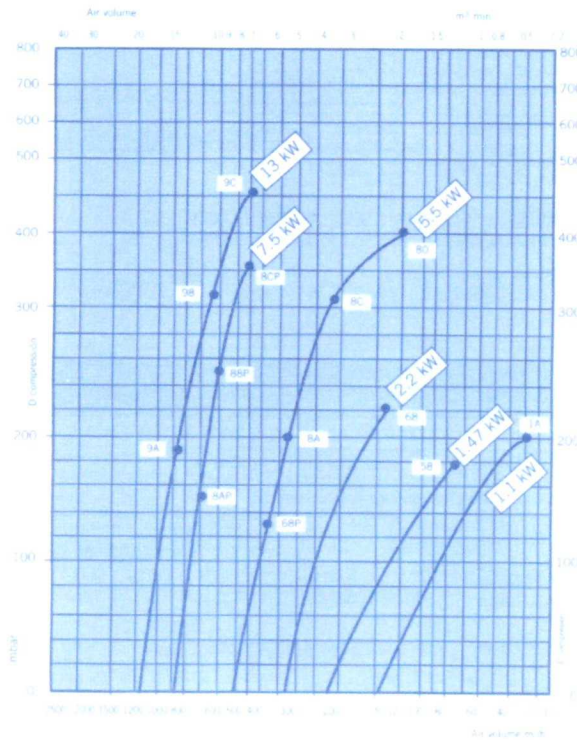
AIR BLOWERS

Turbo blower for non-stop use

kW	Max air volume m ³ /h	Max compression Mbar.	Ø connection	Code	Standard Packaging Unit	Standard weight Kg.	Standard Volume m ³
1.1 mono	-	-	2"	09094	1	18	0.057
1.1	150	180	2"	04029	1	18	0.057
1.47	216	200	2"	04030	1	25	0.091
2.2	300	200	2"	04031	1	30	0.091
5.5	480	270	2 1/2"	16701	1	68	0.130
7.5	850	250	2 1/2"	16702	1	72	0.130



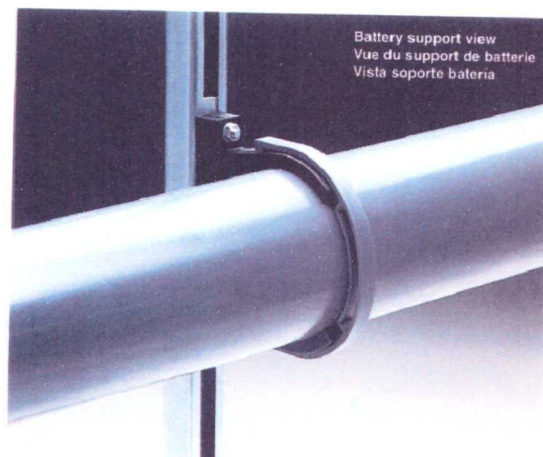
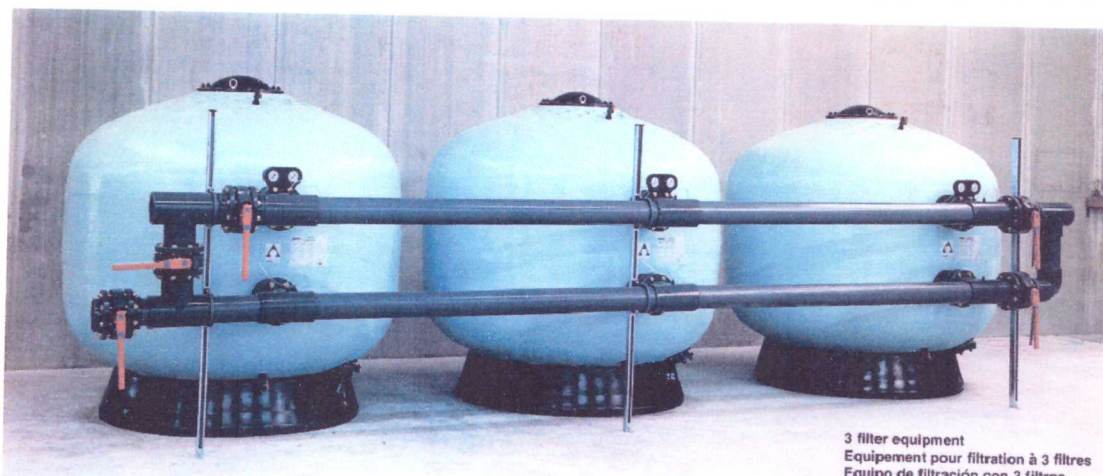
COMPRESSORS/BLOWERS SELECTION CHART, THREE PHASE MOTOR 50 Hz.



Air blowers

	Code	Standard Packaging Unit	Standard weight Kg.	Standard Volume m ³
0.74 kW Flow 65 m ³ /h a HA of 1 m water head	04089	1	3.5	0.028
1.10 kW Flow 133 m ³ /h a HA of 1 m water head	04028	1	3.5	0.028





N.º 075

WE RESERVE THE RIGHT TO CHANGE ALL OR PART OF THE FEATURES OF THE ARTICLES OR CONTENTS OF THIS DOCUMENT, WITHOUT PRIOR NOTICE.

NOUS RÉSERVONS LE DROIT DE MODIFIER TOTALEMENT OU EN PARTIE LES CARACTÉRISTIQUES DE NOS ARTICLES OU LE CONTENU DE LE DOCUMENT, SANS PRÉ-AVIS.

NOB RESERVAMOS EL DERECHO DE CAMBIAR TOTAL O PARCIALMENTE LAS CARACTERÍSTICAS DE NUESTROS ARTICULOS O CONTENIDO DE ESTE DOCUMENTO, SIN PREVIO AVISO.

REP. DE LA R. ESPAÑA, CONDOMINIO INDUSTRIAL "SOCIEDAD ANONIMA S.A." - RESOLUCIÓN DE LOS RESERVADOS

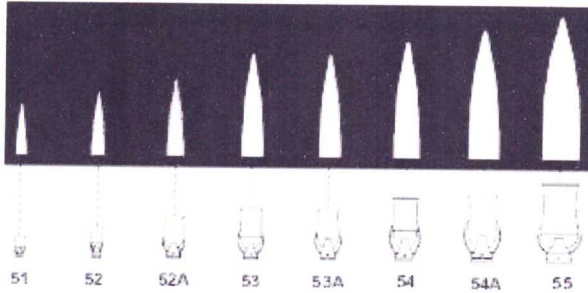
APPENDIX
C

PEM Catalogue

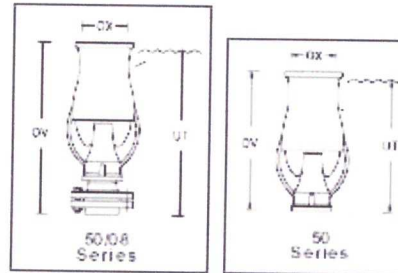
PEM 50 Series Cascade Jets will provide highly visible frothing and foaming White Water spray effects. PEM 50 Series Jets are one piece bronze castings. PEM 08 Adjustment Flanges are of cast bronze and are stainless steel fitted. PEM Series Cascade Jets require a linear inflow, a constant waterlevel and might be subject to pool surging.

For PEM 50 Series Cascade Jets see page 547 of this catalog

#505-5000 PEM 50 SERIES CAST BRONZE CASCADE JETS



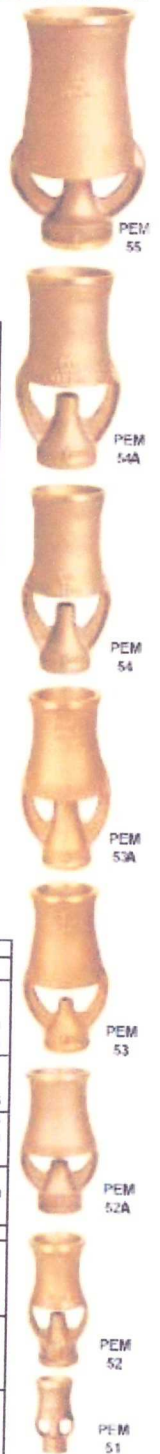
PEM 54 and 53 Fountain Spray



PERFORMANCES are based on 'UT' and 'UT 0.8' dimensions, showing immersion of the jets. The effect diameter at base is approximately 30% - 35% of spray height.

To change appearance of spray effects, change 'UT' or 'UT 0.8'; decrease = lighter, increase = heavier. (proportional) 'FL' and 'MC' values below.

PEM #	51	52	52A	53	53A	54	54A	55								
PEM #	505-5110	505-5120	505-5130	505-5140	505-5150	505-5170	505-5180	505-5190								
PEM #	5108	5208	52A08	5308	53A08	5408	54A08	5508								
PEM #	505-5210	505-5220	505-5230	505-5240	505-5250	505-5270	505-5280	505-5290								
T	12"	34"	114"	112"	112"	2"	212"	3"								
OXJet	30mm 2"	60mm 2.625"	104mm 4.125"	120mm 4.75"	120mm 4.75"	140mm 5.5"	160mm 6.5"	190mm 7.68"								
OXJet	38mm 1.500"	51mm 2.000"	70mm 2.755"	76mm 3.000"	76mm 3.000"	102mm 4.000"	120mm 4.724"	152mm 6.000"								
SS	6mm 0.250"	8mm 0.315"	8mm 0.315"	10mm 0.390"	16mm 0.630"	16mm 0.630"	18mm 0.700"	22mm 0.875"								
OV	95mm 3.750"	140mm 5.500"	191mm 7.519"	229mm 9.000"	229mm 9.000"	260mm 11.000"	300mm 11.811"	366mm 14.400"								
OV 0.8	141mm 5.550"	190mm 7.480"	236mm 9.291"	280mm 11.030"	280mm 11.030"	342mm 13.420"	346mm 13.700"	425mm 16.740"								
UT	90mm 3.500"	134mm 5.280"	185mm 7.280"	220mm 8.500"	229mm 9.000"	269mm 10.500"	287mm 11.270"	341mm 13.500"								
UT +0.8	135mm 5.320"	184mm 7.250"	230mm 9.050"	270mm 10.700"	270mm 10.590"	330mm 12.990"	336mm 13.220"	400mm 15.740"								
PERFORMANCES:																
V	FL MC		FL MC		FL MC		FL MC		FL MC		FL MC		FL MC		FL MC	
m	l	m	l	m	l	m	l	m	l	m	l	m	l	m	l	m
0.5	34	10.5	39	7.1	65	6.4	99	2.9	93	2.2						
1.0	46	16.6	76	11.1	100	7.9	122	6.6	114	3.1						
1.5	57	21.6	88	15.2	117	9.5	135	9.9	137	4.3	292	7.6	396	7.0	500	6.1
2.0	66	27.4	103	19.5	131	14.0	160	12.6	156	6.5	320	9.3	425	9.5	560	8.1
2.5			114	23.4	142	17.1	174	15.2	182	7.7	354	11.1	490	13.0	600	9.3
3.0			125	27.2	153	19.8	190	16.1	209	9.2	380	13.4	530	16.0	645	10.7
4.0					174	24.0	224	23.4	235	12.0	400	19.1	560	22.0	743	14.6
5.0									269	15.0	440	23.5	640	27.0	844	17.4
6.0									292	16.0	468	26.9	700	32.0	930	19.9
8.0											570	33.0	850	41.0	1132	34.6
10.0											720	39.0	1050	55.0	1390	46.0
12.0													1190	64.0	1552	57.0
15.0															1960	75.0
Fl	G	Fl	G	Fl	G	Fl	G	Fl	G	Fl	G	Fl	G	Fl	G	Fl
2	10.1	42	17.5	30	23.0	22	27.8	15	26.1	6						
3	11.7	52	19.3	34	26.9	25	29.4	20	31.4	11						
4	13.5	62	21.1	43	29.9	28	32.3	27	34.9	13	71.4	21	96	19		
5	15.7	72	23.3	51	30.9	31	35.7	33	37.8	17	77.2	25	105	22	133	20
6			25.7	61	32.5	40	39.9	37	42.7	20	85.9	30	114	25	143	25
8			29.4	77	36.5	54	46.5	50	46.6	25	93.6	36	127	37	157	32
10			33.1	83	40.4	65	50.2	60	54.8	30	100.4	45	141	48	171	36
15							67.4	63	67.7	44	107.0	57	163	77	211	46
20									77.9	57	129.2	90	185	96	246	66
30											164.0	110	245	135	330	134
40													315	166	410	174
50															524	229

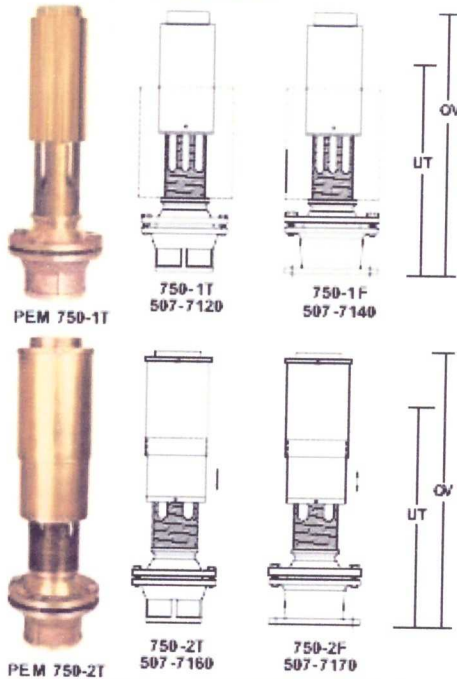


PEM 750 SERIES

4" AERATING JETS

#507-7100

Sleeve UP-Spray down & heavier.
Sleeve DOWN-Spray up & lighter.



PEM 750-1 Series Aerating Jets are made of brass, bronze and copper, stainless steel fitted. PEM 750 Aerating Jets are waterlevel dependent. The narrow columnar White Water spray effect is adjustable as to appearance and spray height by altering the water to air ratio with the lowering or raising of the lower part of the air intake sleeve. Best, solid White Water spray effects are within the lower 2/3 range of UT. The UT immersion of PEM 750-1 is affected by the air sleeve adjustment. The UT immersion of PEM 750-2 will not be affected by the new for 1992 water to air ratio adjustment. These jets have to be protected from pool surging. Debris strainers for 750-1 are made of bronze and brass, are required where floating debris is encountered. (Not available as standard for PEM 750-2 but can be custom made, please enquire). Ballswivel mounting permits directional adjustment (up to 17 degrees off centreline).

PEM #	750-1AT 507-7110	750-1T 507-7120	750-1AF 507-7130	750-1F 507-7140	750-2T 507-7160	750-2F 507-6170
T	4"	4"	4" Flange	4" Flange	4"	4" Flange
OX	35mm 1.375"	35mm 1.375"	35mm 1.375"	35mm 1.375"	102mm 4.000"	102mm 4.000"
OV	635mm 25.0"	635mm 25.0"	635mm 25.0"	635mm 25.0"	690mm 27.170"	690mm 27.170"
OD	210mm 8.270"	210mm 8.270"	229mm 9.000"	229mm 9.000"	210mm 8.270"	229mm 9.000"
UT	553mm 21.750"	553mm 21.750"	553mm 21.750"	553mm 21.750"	588mm 23.280"	588mm 23.280"
OD (Strainer)		229mm 9.000"		229mm 9.000"		
SS	20mm 0.750"	20mm 0.750"	20mm 0.750"	20mm 0.750"	25mm 1.000"	25mm 1.000"



PEM 750-1
Micrometric air sleeve adjustment permits fine control of spray effect appearance as well as of spray height.

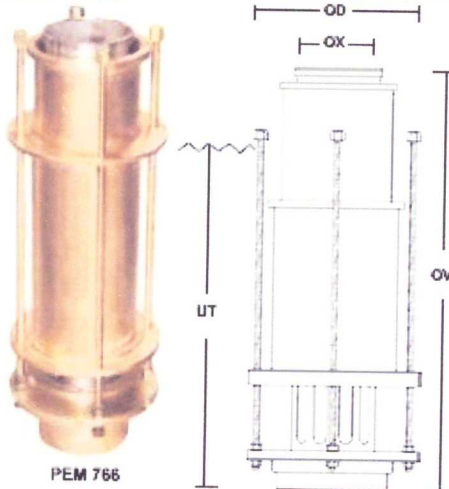
PERFORMANCES :

V	750-1		750-2	
	FL	MC	FL	MC
m	L	m	L	m
2	360	5.9	5.50	4.8
3	470	7.2	6.50	5.5
5	640	10.5	8.70	10.0
10	900	19.1	11.60	15.5
15	1100	28.2	14.30	22.0
20	1250	36.5	17.00	31.0
25	1410	46.5	19.20	42.0
30	1580	56.5	21.50	51.5
40	1830	73.8	26.30	76.0
50			31.00	99.0
Ft	G	Ft	G	Ft
6	125	21	154	17
10	170	24	172	19
15	192	30	207	25
20	188	41	232	30
30	230	58	288	47
40	262	74	330	60
50	288	87	378	73
60	365	146	456	130
100	410	166	588	169
150	542	308	730	288

PEM 760

6" & 8" AERATING JETS

#507-7400



PEM 760 Aerating Jets are waterlevel dependent and produce a narrow, solid, columnar White Water spray effect. The spray effect is adjustable as to appearance (density) and height by a proportioning of the pond water to air ratio drawn in by the jet. The adjustment does not affect the UT as in most smaller aerating jets. The ratio adjustment can be effected from above waterlevel by turning the lift bolts (4) with a wrench, clockwise (1/2 turn each, one after the other) to lower the spray, counter clockwise to raise the spray. These jets must be protected from pool surging. Best, solid, spray effects are within the lower 2/3 of the shown spray heights. PEM 760 Aerating Jets are made of brass and bronze, stainless steel fitted.

DIMENSIONS :

PEM #	766 507-7440		768 507-7460	
	6"		8"	
T	152mm/6.000"		200mm/8.000"	
OX	32mm/1.250"		45mm/1.750"	
OV	813mm/32.000"		914mm/36.000"	
OD	350mm/13.780"		400mm/15.750"	
UT	660mm/26.000"		760mm/30.000"	

PERFORMANCES :				
V	766		768	
	FL	MC	FL	MC
m	L	m	L	m
3	1404	6	2200	6
6	2000	11	3000	12
10	2500	18	3900	20
15	3000	27	4900	30
20	3500	36	5700	40
30	4200	54	7000	60
50	5100	90	8300	100
Ft	G	Ft	G	Ft
10	360	18	600	20
20	530	36	900	40
50	780	90	1300	100
80	960	144	1600	160
100	1200	180	1900	200
150	1580	270	2150	300

NOTE
Pressures greater than shown might damage jets.

The performances shown are for undisturbed, linear inflow into jet at given UT immersion and shown sleeve adjustment position. Performances are extremely variable due to different UT immersions and air to water ratio adjustment. Maximum height with exclusion of pond water can reach up to appr. within 20% of nozzle pressure. Minimum height with entry ports fully open can be appr. less than 50% of shown values. For directional adjustment combine Jet with 08-10 Adjustment Flange. Riser pipe for PEM 768 must be flow sized with reduction at jet.

THE PEM COLLECTION 2005, EDITION 2



PEM 876C-S to 85m in Artificial Lake at Jebel Hafeet, Al Ain, U.A.E.
Created by Engineering Marketing Est., Abu Dhabi, U.A.E.

For more information about projects shown, please contact the creators named.
Most creators have video clips available upon request (High speed internet service required)

PEM FOUNTAIN CO. Richmond Hill, ON, Canada,
Fax: 905-884-8941 - www.pemfountain.ca
E mail: sales@pemfountain.ca

This Picture courtesy of Engineering Marketing Est. Abu Dhabi

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2005 by PEM Fountain Co., Div. of Imperial Infusion Co. Ltd. Canada

THE PEM COLLECTION

Pictures courtesy of Anders Soergel, Anleka, Sweden

#13 - 1
1 x PEM 54-08
5 x PEM 53-08



#13 - 2 20 x PEM x 1611



#13 - 3 PEM 16 - 7



#13 - 4
5 x PEM x 1615 & 4x PEM 02-6

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CREATIONS by : ANLEKA, Landskrona, Sweden , Fax: 46-418-450333, www.anleka.se

THE PEM COLLECTION



16 - 1 PEM 29's



16 - 2 PEM 54 & PEM 53's



16 - 3 PEM 776



16 - 4 PEM 107B



16 - 5 PEM 108 - 375's



ITT

Gunite Equipment

Components for Gunite Applications



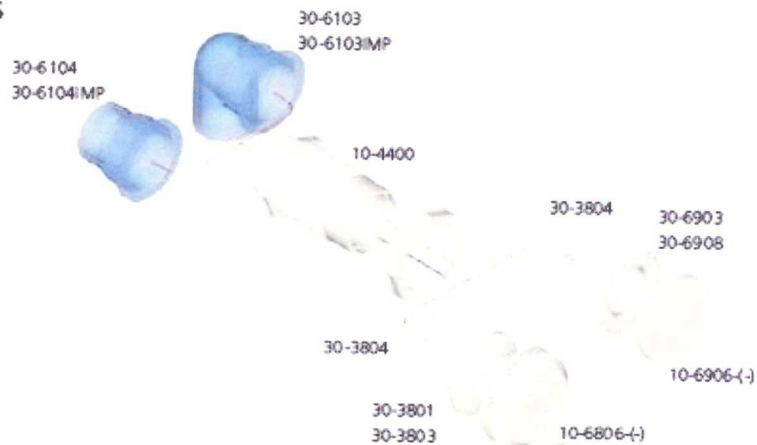
ITT HydroAir has a wide range of articles suitable for gunite applications.

Gunite applications are special compared to acrylic installations. The main difference is the thick walls that demand extended fittings.

The shown products are designed and commonly used for gunite applications. However, our extensive jet and fitting range can be used for gunite as well.

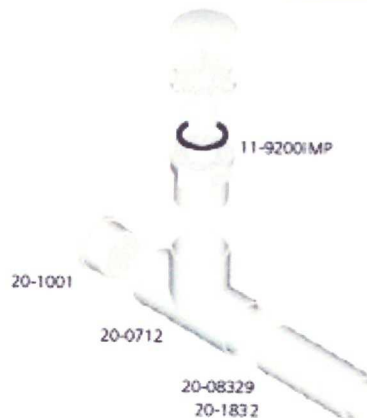
For further information you can always visit our website on www.hydroair.dk or contact our Customer Service.

Suctions



Air Jet

High volume air jet with 16 side outlets.



ITT HydroAir

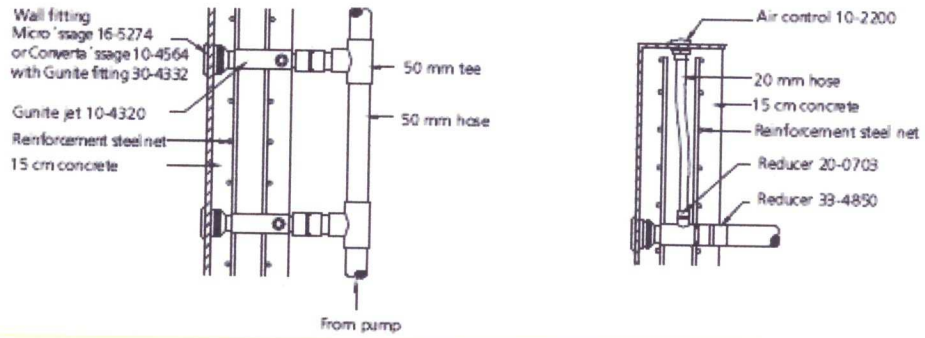


ITT

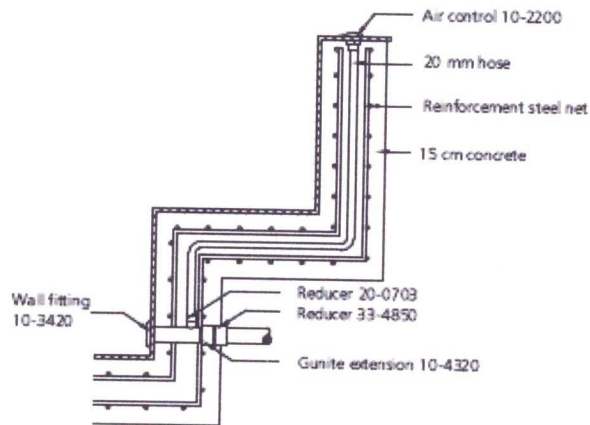
Gunite Equipment

Useful Guidelines for Gunite Installations

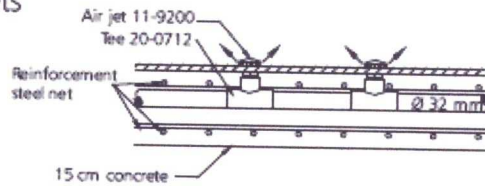
Therapy Jets



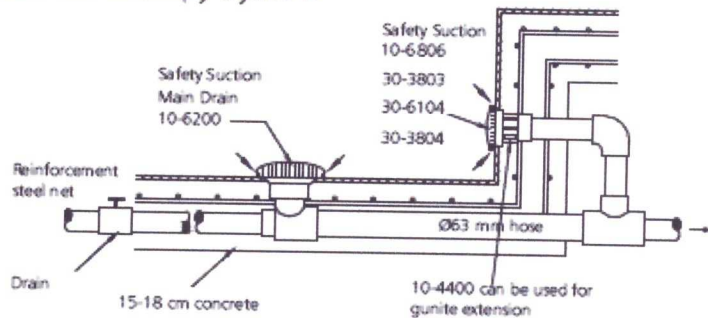
Therapy Jets



Air Channels / Air Jets



Suction for Therapy System



Conversions and equivalents

Number				Force					
10 ⁻⁶	is	micron	μ	millionth	1 N	= 0.225 lbf	1 lbf	= 4.448 N	
10 ⁻³	is	milli	m	thousandth		= 1 kg m/s ²			
10 ³	is	kilo	k	thousand	1 kN	= 0.1004 tonf	1 tonf	= 9.964 kN	
10 ⁶	is	Mega	M	million					
10 ⁹	is	Giga	G	billion - US					
10 ¹²	is	Tera	T	billion - European					
Length				Pressure/stress					
1 mm	=	0.0394 in	1 in	=	25.40 mm	1 N/mm ²	= 0.0647 tonf/in ²	1 tonf/in ²	= 15.44 N/mm ²
1 m	=	3.28 ft	1 ft	=	0.3048 m		= 145.04 lbf/in ²		= 15.44 MN/m ²
	=	39.37 in		=	30.48 cm	1 kN/m ²	= 0.145 lbf/in ²	1 lbf/in ²	= 0.0689 bar
1 km	=	0.62 mile	1 mile	=	1.61 m	1 bar or atmosphere	= 14.5 lbf/in ²		= 68.948 mb
						1 atmosphere	= 199 kN/m ²		
						1 atm-sphere	= 760 mm of mercury		
						1 m head	= 1.42 lb/in ²	= 29.9 in/Hg	= 33.5 ft of water
								1 lb/in ²	= 2.3 ft head
Area				Power					
1 mm ²	=	0.00155 in ²	1 in ²	=	645.2 mm ²	1 W	= 1 J/s	1 hp	= 745.7 W
1 m ²	=	10.76 ft ²	1 ft ²	=	0.093 m ²	1 hp metric	= 735 W		= 0.746 kW
1 ha	=	2.47 acre	1 acre	=	4046.9 m ²	1 kW	= 3412 Btu	1 Btu	= 0.293 W
	=	10.000 m ²		=	0.405 ha		= 1.341 hp	1 hp	= 2545 Btu
						1 kW/m ²	= 317 Btu/ft ²	1 Btu/ft ²	= 3.15 W/m ²
						1 kW/m ³	= 15.5 Btu/Imp gal	Btu/Imp gal	= 64.5 W/m ³
Volume				Temperature					
1 m ³	=	35.31 ft ³	1 ft ³	=	0.0283 m ³	1°C	= 1.8°F	1°F	= 0.55°C
	=	1000 litre		=	28.32 litre water	1°C	= 1°C on absolute scale from -273°C		
	=	1000 Kg water		=	62.4 lb water	°C	= 5/9 (°F-32)	°F	= (°C × 9/5) + 32
	=	220 Imp gal water		=	6.24 Imp gal				
	=	264 US gal water		=	7.48 US gal				
Capacity				Heat					
1 litre	=	0.220 Imp gal	1 Imp gal	=	4.546 litre	1 cal	= 4.187 J	1 Btu	= 252 cal
	=	0.264 US gal	1 US gal	=	3.785 litre	1 kcal	= 1.164 W		= 1.055 kJ or kW-sec
1 US gal	=	0.83 Imp gal	1 Imp gal	=	1.2 US gal		= 3.968 Btu		= 0.252 kcal
	=	8.33 lb water		=	10 lb water	1 W	= 3.412 Btu		= 0.293 W
1 cc	=	0.035 fl oz	1 fl oz	=	28.35 cc	1 kWh	= 3412 Btu/h	1 Therm/h	= 100 000 Btu/h
							= 859.6 kcal/h		= 29.3 kWh
							= 3.6 MJ		= 25.2 Mcal/h
						1 GJ	= 10 ⁹ joules	= 1 ton Refrigeration	= 12000 Btu/h
							= 275 kW	= 9.5 Therms	= 75 ton Refrigeration
Mass/weight				Heat per unit area					
1 gm	=	0.035 oz	1 oz	=	28.35 g	1 kW/m ²	= 317 Btu/ft ²	1 Btu/ft ²	= 3.155 W/m ²
1 kg	=	2.205 lb	1 lb	=	0.454 kg		= 0.27 cal/cm ²		= 0.27 cal/cm ²
1 tonne	=	0.984 ton	1 ton	=	1.016 tonne		= 3.6 kJ/m ²		or Langley
	=	2204.6 lb		=	2240 lb				= 2.7 kcal/m ²
1 kg water	=	0.220 Imp gal	1 lb water	=	0.10 Imp gal				
	=	0.264 US gal		=	0.12 US gal				
Mass per unit measure				Thermal coefficient - value					
1 kg/m	=	0.672 lb/ft	1 lb/ft	=	1.488 kg/m	1 W/m ² /°C	= 0.176 Btu/ft ² /°F	1 Btu/ft ² /°F	= 5.678 W/m ² /°C
1 kg/m ²	=	0.205 lb/ft ²	1 lb/ft ²	=	4.882 kg/m ²				
1 kg/m ³	=	0.0624 lb/ft ³	1 lb/ft ³	=	16.019 kg/m ³				
Velocity acceleration				Illumination					
1 m/s	=	3.28 ft/s	1 ft/s	=	0.3048 m/s	1 lux	= 0.093 ft candle	1 lumen/ft ²	= 10.76 lux
1 km/h	=	0.62 mph	1 mph	=	1.61 km/h		or lumen/ft ²	= lumen/m ²	
	=	0.91 ft/s		=	0.447 m/s				
g	=	9.81 m/s ²	=	32.2 ft/s ²					
sound/air	=	335 m/s	=	1100 ft/s					
1 Hz	=	1 c/s	=	1 cycle/sound					
Flow				Clarity or turbidity					
1 litre/s	=	2.12 ft ³ /min	1 ft ³ /min	=	0.472 litre/s	1 JTU	= 1 ppm	=	1mg SiO ₂ /litre distilled water
1 m ³ /min	=	35.314 ft ³ /min		=	0.028 m ³ /min	1 ppm	= 1 mg/litre		
1 m ³ /h	=	35.314 ft ³ /sec	1 cusec	=	375 Imp g/min	1 μm	= 1 millionth m	micron	
	=	0.589 ft ³ /min	1 ft ³ /min	=	1.699 m ³ /h	1 nanometer	= 1 millionth mm	micro-mm	
	=	220 Imp gal/h	1 Imp gal/h	=	4.546 litre/h	1 nm	= 10 ⁻⁹ m		
	=	264 US gal/h	1 US gal/h	=	3.785 litre/h	1 Ångstrom	= 10 ⁻¹⁰ m		
1 m ³ /m ² /min	=	20.45 I gal/ft ² /min	=	24.54 US gal/ft ² /min	1 μμ	= 10 ⁻¹² m	micro-micron		
	=	1226.77 I gal/ft ² /h	=	1472.12 US gal/ft ² /h	25 μm	= 0.025 mm	= 1 thousandth of an inch		
1 m ³ /m ² /h	=	0.34 I gal/ft ² /min	=	0.41 US gal/ft ² /min					
	=	20.45 I gal/ft ² /h	=	24.54 US gal/ft ² /h					

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