Circulation Systems
&
Basic Hydraulics

Water Loss

- Evaporation
- Splash-out
- Drag-off
- Maintenance procedures
- Intentional disposal
- Leaks

Signs and Symptoms of Leaks

- More than 1/4 inch of water is lost in 24 hours
- High water bill
- Algae growth, discolored water, or inability to balance chemicals
- Loose or popping tiles
- Cracking of deck, settling of pool
- Constant running of automatic fill device
- Large amounts of air in the pool
- Wet spots that never dry
- Uneven grass growth around the exterior of the pool

Detecting Water Loss

- Bucket test
- Use of dyes to test for suction leaks
- Pressure testing lines
- Professional instruments which use sound to find leaks

Water Loss Per Inch

V = LWD, where D = 1”

1” = 1/12’ = .0833

Example:

A 25 yard by 25 meter pool loses 2 inches of water per day. How much water must be added to the pool per week to make up for this loss?

(75) (82) (.0833) = 512.295 cubic feet

x 7.48 = 3,832 gpi x 14 = 53,648 gallons

Water Clarity

- 0.25 NTUs - Nephelometric Turbidity Units
- 0.2 Jackson Turbidity Units
  - 0.6 - cloudy pool, 1.0 - unacceptable
- Recirculation system should be capable of returning pool water to acceptable levels within 6 - 8 hours
- Methods for determining clarity:
  - Nephelometer or turbidometer
  - 6 inch black disk
  - Paneled disk
  - Main drain grates
  - Quarter--heads or tails

Consecutive Dilution

Turnovers	5	4	3	2	1
% Water Clarity	99	98	95	84	2
Days to Equilibrium	1	2	3	4	9

Turnover Time

• 6 or 8 hours	Swimming pools
• 2 hours	Training & therapy pools
• 1 hour	Wading pools
• 30 minutes	Spas

- Requirements may vary by State

Relationship between Flowrate and Turnover Time

Flow Rate

360,000 gallons of water

÷ 360 minute required turnover

= 1,000 gpm flow rate

Turnover Time

360,000 gallons of water

÷ 1,000 gpm flow rate

= 360 minutes

= 6 hour actual turnover time

Bather Load & Clarity

Keep the bather load
to total filtered water
(gallons/day) ratio at
1 bather : 1,400 gallons
or less

Bather Load & Clarity

- According to the results of a recent study conducted by John Chadwick in Ontario, Canada; the onset of turbidity is constant and related to the number of bathers -- not just turnover time
- If debris is added to the pool water faster than the filter can remove it -- turbidity will increase

Bather Load & Clarity

- Debris: airborne dirt, dust, plant matter, and pollen; rain water, bathers
- Greatest amount of debris is brought into the pool by bathers

Bather Load & Clarity

Flowrate (gpm) x 60 (min/hr) x 24 hours
= Total filtered gallons per day

Total filtered gallons per day ÷ 1,400 gallons
= Maximum bathers

Bather Load & Clarity

Example: 24,000 gallon pool (20' x 40' x 4')

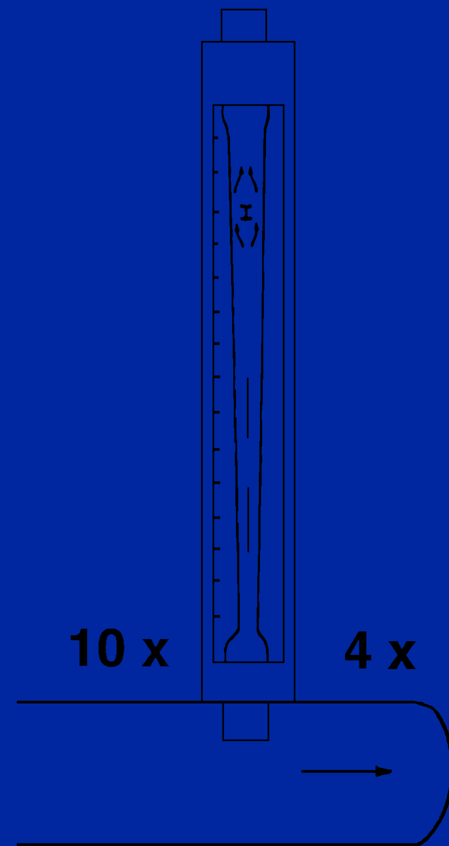
1. 6 hour turnover = 66.6 gpm x 60 x 24 = 95,999 gpd ÷ 1,400 = 68 maximum bathers per day (or turbidity will increase)

2. 250 actual bathers x 1,400 = 350,000 gpd ÷ 24 ÷ 60 = 243 gpm

   24,000 gallons ÷ 243 gpm = 98 min ÷ 60 = 1.64 hours

Flow Meters

- Types
  - Variable area
  - Analog
  - Digital
  - Mercury manometer
- Proper installation
- Maintenance



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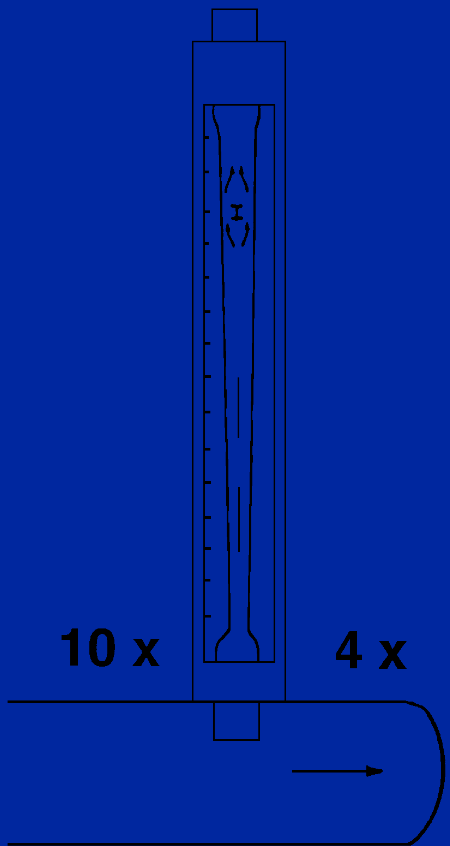
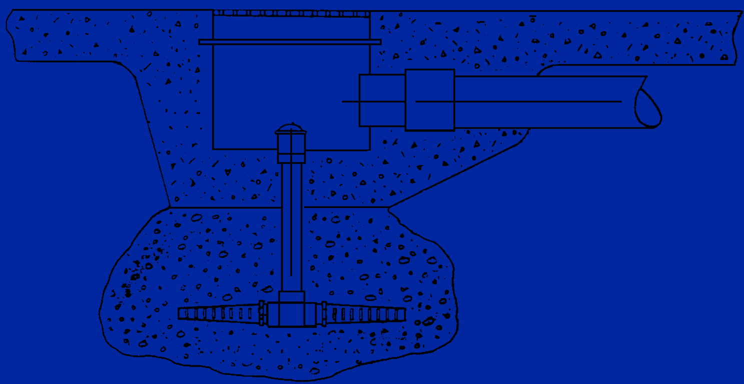


Main Drains

- 2 or more drains
- Anti-vortex drain covers if a single drain is installed
- Plumbed with a T or other design to prevent suction entrapment



Main Drains

- Grate opening size specified by code
- Installed less than 15 feet from the pool walls and no more than 30 feet apart
- Grates 4 x the area of the drain pipe
- Grates removable only with the use of tools
- Not in line with diving boards
- Clearly distinguish grates from the background

Perimeter Overflow Systems

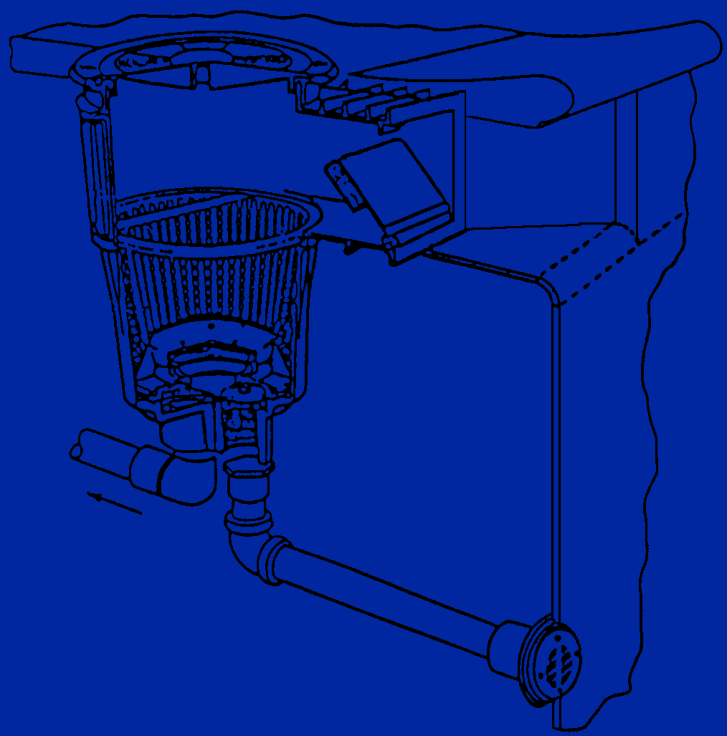
Skimmers

- Installed primarily on outdoor pools, and small pools under 5,000 square feet
- 1 skimmer for each 500 square feet of water surface area, or portion thereof
- 50% or more of water circulates through the skimmers
- Weir automatically adjusts to variations in pool water level over a range of approximately 4 inches

Perimeter Overflow Systems

Skimmers

- Removable and cleanable basket to trap large solids



Skimmers

- Weirs
  - Act as one way valves and prevent debris from floating back into the pool
- Equalizer lines
  - Prevent air from being sucked into the system when pool water level is low. In-take of water into the skimmer lines is diverted to an outlet installed 12-18 inches below the water surface.
- Skimmer baskets
  - Trap and collect floating debris

Skimmers

- Deck covers
  - Hatch which allows access to the skimmer basket from the pool deck
- Flow adjustment plates
  - Allows water flow to be equalized among all the skimmers. Otherwise suction would be greatest in skimmers nearest the recirculation pump and would diminish with distance from the pump.
- Float valves (turtles)
  - Anti-vortex control plates which create a safety by-pass and prevent air lock by diverting water flow through the main drain if water level drops

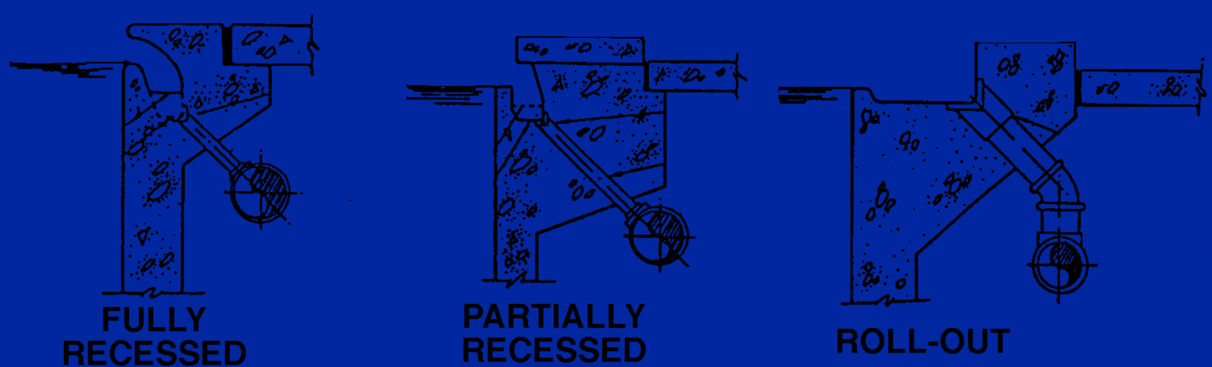
Perimeter Overflow Systems

Gutters

- Extends completely around the pool
- Typically 80 - 85% of water circulates through gutters
- Correct water level must be maintained to allow for removal of floating debris and for continuous overflow of water
- Overflow channel, lip, channel covering or grate, outlet drains, drain grates

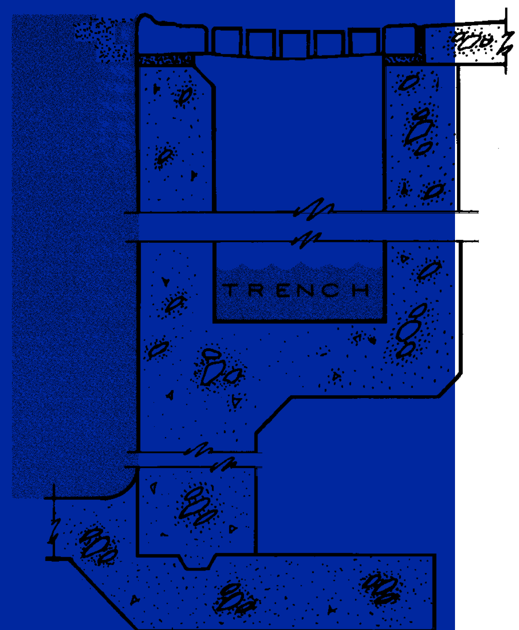
Gutters

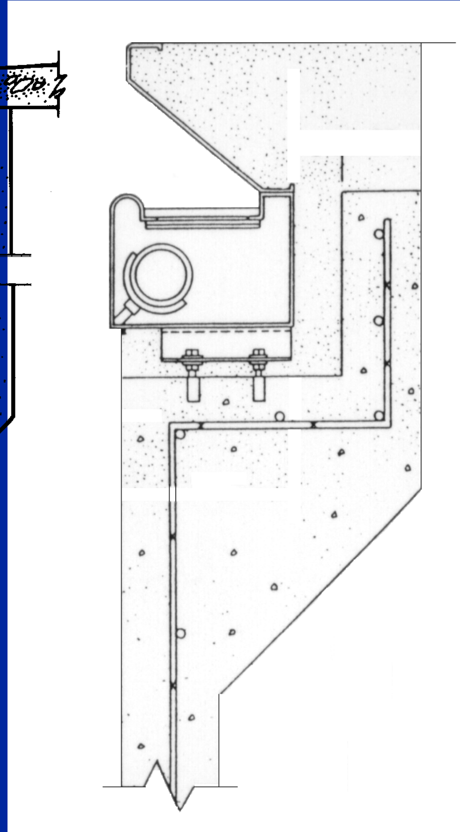
- Fully recessed
- Partially recessed
- Roll-out
- Rim flow
- Water-to-waste



Gutters

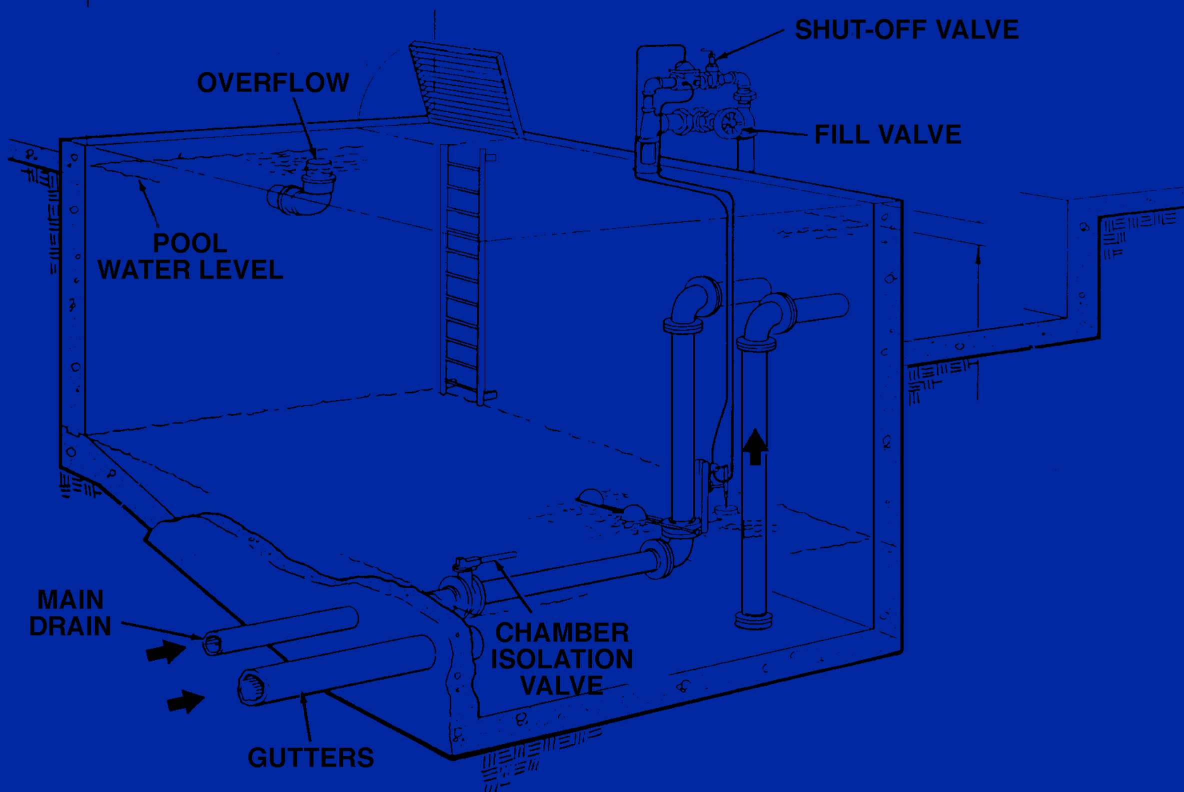
- Pre fabricated or traditional gutters
- Gutter design should be based on:
  - Code requirements
  - Primary facility usage



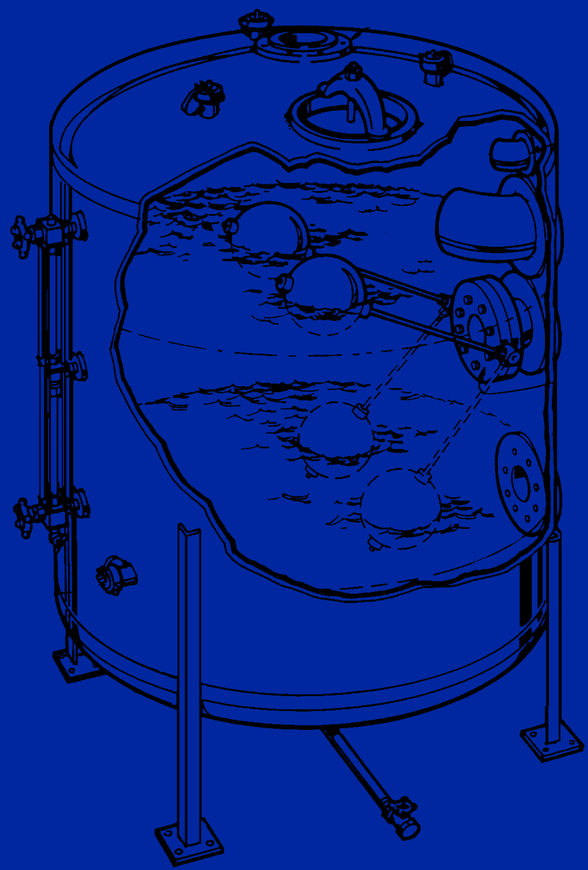


Surge Chambers

- Hold the water displaced by swimmers in reserve



Balancing Tank



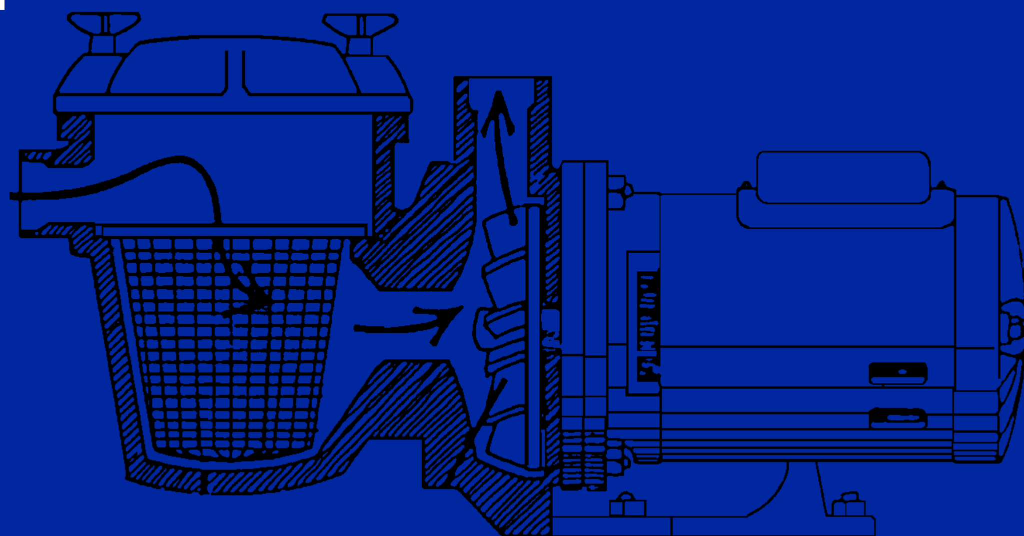
- Surge chamber
- Surge trench
- Balancing tank
- Vacuum filter tank
- In-pool surge

Surge Chambers

- Helps establish hydraulic equilibrium in the pool
- Capacity: 1 gallon per one square foot of pool water surface area
- Static and dynamic surge
- Automatic fresh water make-up flow control (with manual override) provided to maintain proper pool water operating level

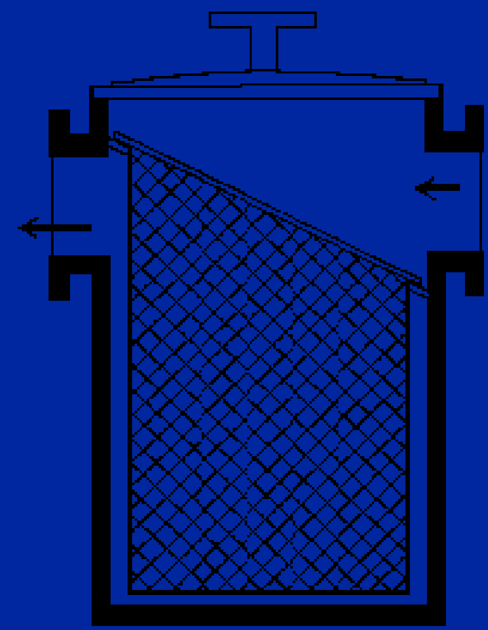
Hair & Lint Strainer

- Installed upstream or on the suction side of the pump on pressure systems
- Strains out large debris that could damage the impeller



Hair & Lint Strainer

- Properly sealed to prevent air intake
- Suction side vacuum gauge and discharge side pressure gauge help identify need to clean out the strainer
- Clean prior to backwashing filters
- Spare strainer baskets, gaskets or o-rings should be available



Identification of Components

- All piping, filters and components which are part of the pool mechanical operating system must be labeled, tagged or color coded
- Schematic diagrams of the circulation system should be permanently affixed to the pump room wall
- Operating manuals from the manufacturer should be available for reference

Commonwealth of Pennsylvania

Color Coding

Potable water	Dark blue
Filtered water	Aqua
Skimmer or gutter lines	Olive green
Main drain line	Black
Alum	Orange
Chlorine	Yellow
Soda ash	White
Acid	Pink
Backwash waste	Dark brown
Sewer	Dark gray
Deck drains	Light brown
Compressed air	Dark green
Gas	Red

Hydraulics

- The study of liquids in motion and at rest
- Pool pumps must overcome all of the resistances to flow (friction losses) created by moving water through pipes and equipment.
- Higher the velocity, the greater the resistance (feet of head)
- Remove resistance (friction loss or pressure), and you will have more flow.
- Less horsepower (and therefor less energy) will be required to achieve the desired flow if friction losses are reduced.

Keep Velocity Down

- Install larger filters
  - As filters get dirty, pressure increases
  - Every 1 psi of pressure increase adds 2.31 feet of head resistance to flow
- Plan efficient plumbing layouts
  - Reduce the number of valves, plumbing Ts and elbow fittings
  - Two 45° elbows have less resistance to flow than one 90° elbow fitting

Valves

- Regulate the amount of flow, direction of flow and segregate equipment
- Common pool valve types:
  - Gate
  - Butterfly
  - Ball
  - Slide
  - Unitrol
  - Automatic
  - Float
  - Multiport

Pipe Sizing

- Pipes should be sized properly to carry water safely and efficiently through the system
- 7.0 ft/sec is the maximum allowable velocity for optimum hydraulic efficiency

Velocity

- Velocity is the speed at which water travels through the pipes and equipment
- Velocity is directly related to friction loss
- Friction loss increases with velocity
- Velocity is created at the expense of pressure (pressure loss)
- If velocity is reduced, available pressure will increase

Velocity & Resistance

Example: 360,000 gallon pool

Flowrate	Pipe Diameter	Velocity	Friction loss per 100 feet of pipe
750 gpm (8 hours)	6 inches	8.5 fps	7.12 FOH
	8 inches	4.8 fps	1.74 FOH
1,000 gpm (6 hours)	6 inches	11.34 fps	12.04 FOH
	8 inches	6.38 fps	2.97 FOH

Velocity & Resistance

- Example: 360,000 gallon pool (continued...)
- As flowrate increases 25% from 750 gpm to 1,000 gpm, velocity increases 33% and resistance increases 70%
- When pipe size is increased by 2 inches in diameter from 6 to 8 inches, velocity decreases 56% and resistance decreases by 75%

Pipe Sizing

- Velocity = (0.32 x Flowrate in gpm) ÷ Pipe area in square inches
- NSPI Recommended Maximum Velocity

Discharge pipe	10 feet per second
Suction pipe	8 feet per second

- Many State codes permit a maximum velocity of 6 fps in suction piping

Pipe Sizing Example

Pool volume:	360,000 gallons
Turnover:	6 hours
Flowrate:	1,000 gpm
Suction pipe:	8 inch diameter

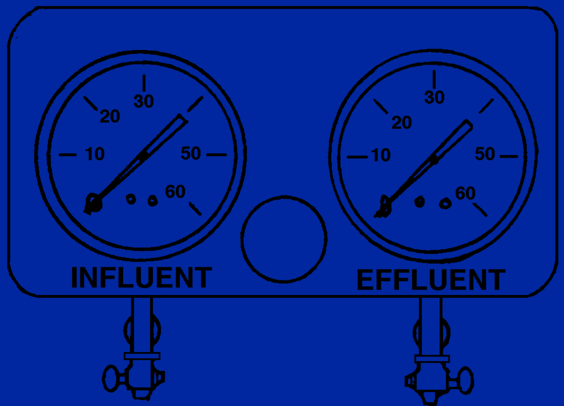
Area $= \pi r^2 = 3.14 \times 4^2 = 50.24\ in^2$

Velocity $= (0.32 \times 1{,}000\ gpm) \div 50.24\ in^2$

$= 6.37\ fps$

Pressure and Vacuum Gauges

- Influent pressure gauge before pressure filters
- Effluent pressure gauge after each filter
- Vacuum gauge after vacuum filters
- Vacuum gauge on suction side of pump
- Pressure gauge on discharge side of pump
- psi
  Pounds per square inch
- Hg
  Inches of mercury

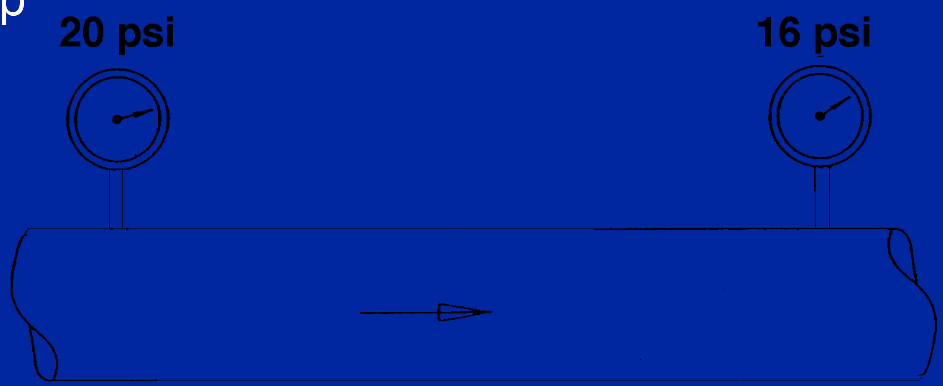


Using Gauges to Identify Problems

- Dirty Filter
  - Vacuum: Down from start-up reading
  - Influent: Up
  - Effluent: Down
- Blocked suction line, clogged hair & lint strainer
  - Vacuum: Up from start-up reading
  - Influent: Down
  - Effluent: Down
- Defective pump seal, clogged impeller
  - Vacuum: Down from start-up reading
  - Influent: No change
  - Effluent: No change

Using Gauges to Identify Problems

- Restricted return line, partially closed valve
  - Vacuum: Down from start-up reading
  - Influent: Up
  - Effluent: Up
- Partially closed valve opened
  - Vacuum: Up from start-up reading
  - Influent: Up
  - Effluent: Up



Hydraulic Terminology

- **Suction**
  Plumbing system before the pump that brings water into contact with the impeller

- **Discharge**
  Plumbing system after the pump that delivers pressurized water to the pool

Hydraulic Terminology

- **Suction lift**
  Distance from the water level to the eye of the pump impeller

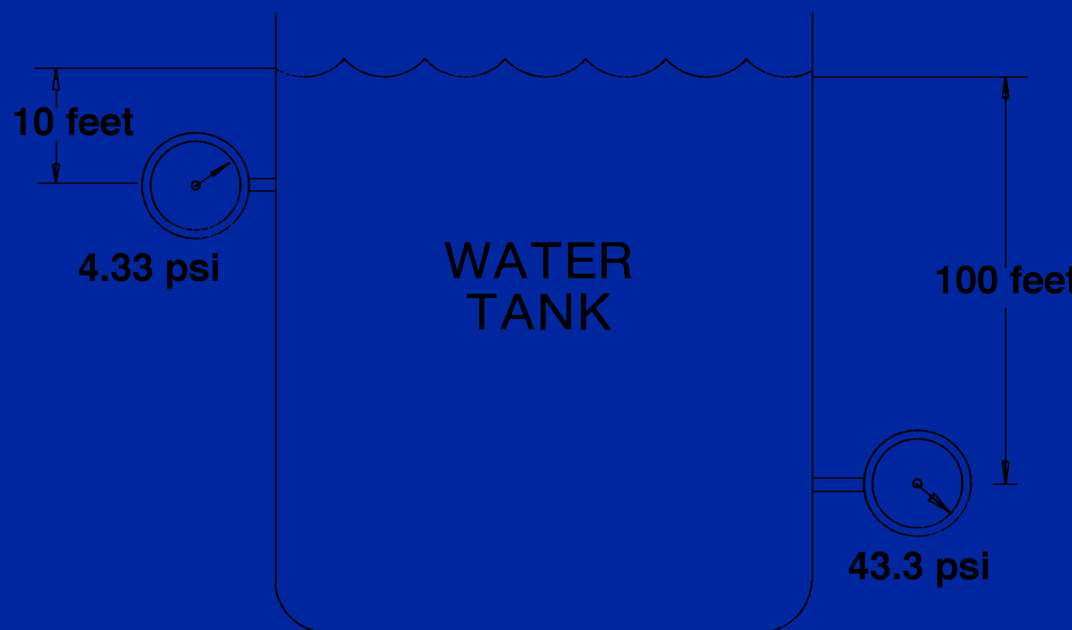
- **Discharge head**
  Total vertical distance between the pump discharge and the pool

Hydraulic Terminology

- **Head**
  Pressure expressed in feet
- **TDH**
  Total dynamic head consists of all the suction lift, discharge head and friction losses in a plumbing system

Pounds Per Square Inch (PSI)

- 43.3 psi ÷ 100' = 0.433
- 1 foot of head = 0.433 psi



Relationship between

PSI & Feet of Head

- 43.3 psi ÷ 100' = 0.433
- 1 foot of head = 0.433 psi

- 100' ÷ 43.3 psi = 2.31 feet of head
- 1 psi = 2.31 feet of head

Inches of Mercury (Hg) and Feet of Head

- Atmospheric pressure on the surface of water pushes water up a suction pipe when a pump exhausts air, creating a vacuum
- Mercury weighs 13.6 times more than water
- 13.6 ÷ 12 = 1.13’ mercury = 1’ water
- 30" of mercury (perfect vacuum at sea level) = 33.9 feet of head
- 33.9 feet of head ÷ 30" of mercury = 1.13
- 33.9 feet of head ÷ 14.7 psi = 2.31

Inches of Mercury (Hg) and Feet of Head

- If a closed evacuated tube is placed in a dish of mercury at sea level, air pressure pushing down on the mercury will cause the mercury to rise 30 inches
- If a closed evacuated tube is placed in a pool of water, air pressure pushing down on the water will cause the water to rise 33.9 feet

Friction

- Friction loss - head loss due to resistance created in the plumbing system
- Friction is resistance created by water rubbing against the surface of every pipe, fitting, and piece of equipment in the system
- Water coming into contact with equipment surfaces brakes and slows down the whole flow of water
- Energy consumed to overcome resistance to flow is the friction loss

Atmospheric Pressure

- Pressure created by the weight of air
- Atmospheric pressure decreases with altitude
- Suction lift decreases 1 foot of head (or .433 psi) per 1,000 feet of altitude above sea level.
- Atmospheric pressure at:
  - Sea level = 14.7 psi
  - 1,000 feet = 14.27 psi
  - 2,000 feet = 13.83 psi
  - 3,000 feet = 13.4 psi...
- This has a negative effect on a pump's ability to lift water. Therefore, pump size must be increased with altitude.

Cavitation

- Violent collapse of air vapor bubbles at the eye of the impeller when they come into contact with the high pressure water produced by the pump
- Air bubbles form along the impeller vanes when pressure at the eye of the impeller is lower than the vapor pressure of water
- Pump is starved for water - it’s trying to discharge more water than is coming in

Cavitation

- Excessive vacuum on the suction side of the pump
- Minor cavitation:
  - Noise (rumbling, grinding marbles)
  - Vibration
  - Erratic operation of pressure gauges
  - Air bubbles visible in hair and lint strainer
- Severe cavitation:
  - Impeller destroyed (Swiss cheese impeller)
  - Will not move water efficiently

Cavitation

- To reduce turbulence and prevent cavitation:
  - Do not restrict or undersize suction pipe
  - Do not throttle down a valve on the suction piping to reduce flow
  - Do not install elbows or tees immediately before the suction port
  - Install a straight section of pipe at least 4 times the diameter of the pipe immediately before the suction port of the pump
  - Do not permit flows high than the pump's peak efficiency
  - Do not permit suction lift higher than that recommended by the manufacturer

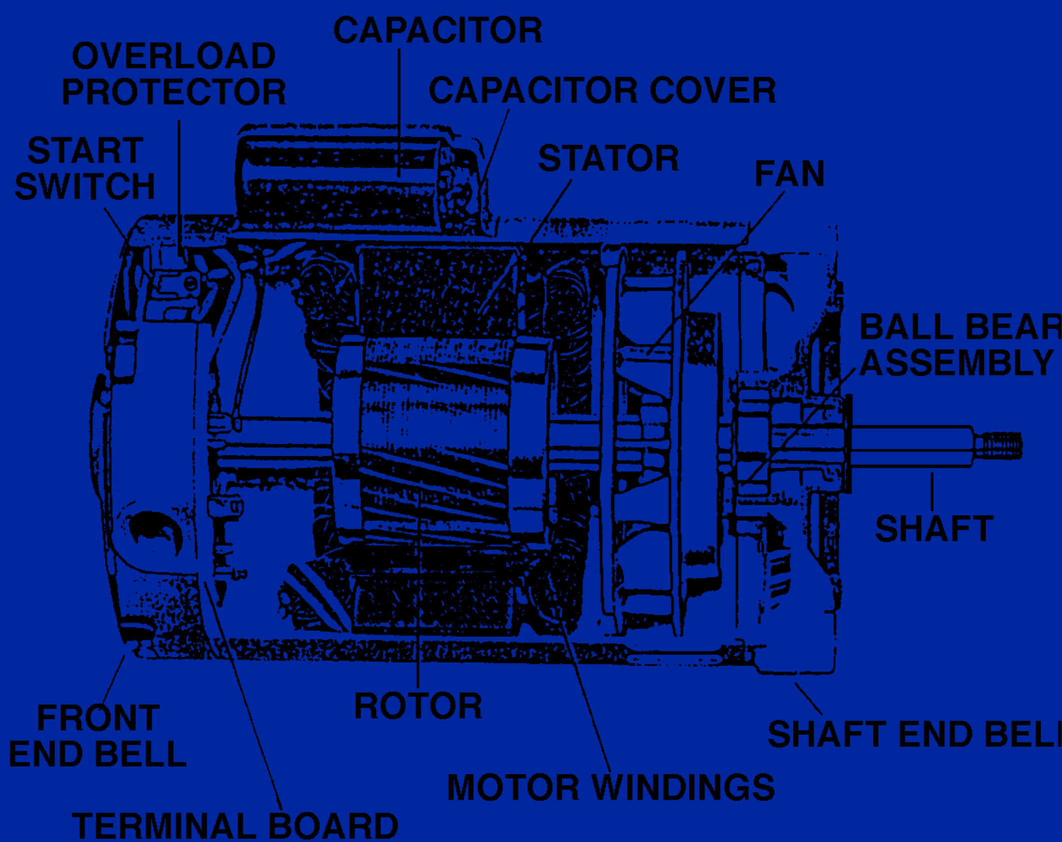
Cavitation

- To eliminate cavitation problems:
  - Reduce the friction loss on the suction side of the pump
  - Throttle a valve on the pump discharge line to restrict the outgoing flow to equal the incoming flow (temporary solution)
  - Downsize the pump

Motors

- End frames (2)
- Ball bearing assembly
- Lock plate
- Fan
- Shaft
- Rotor
- Capacitor and capacitor cover
- Bearing
- Stator assembly with motor windings inside
- End cover or shield
- Terminal board
- Contacts
- Start switch
- Overload protector

Motor Diagram



Motors

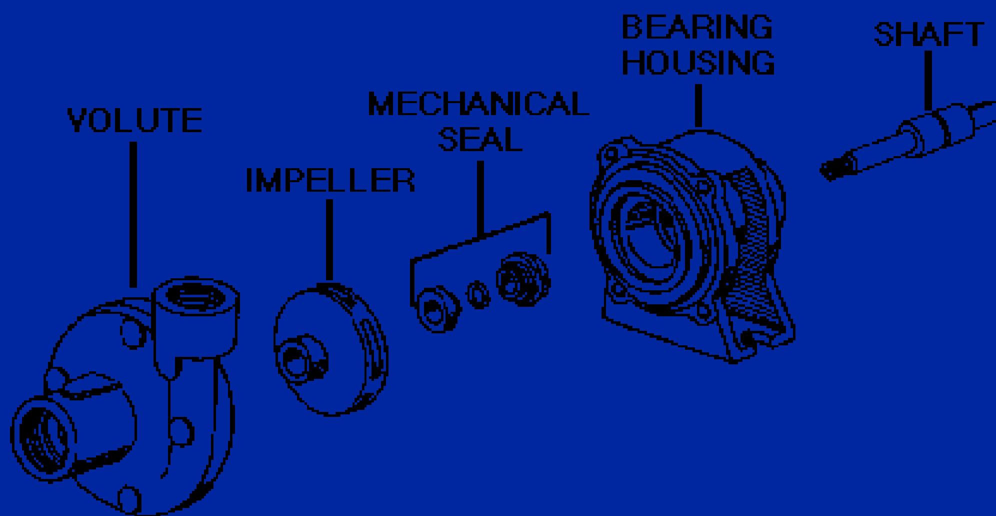
- **Stator**
  Surrounds the rotor and contains the electrical windings
- **Windings**
  Alternating current or voltage flows along the windings (phase) governed by the capacitor
- **Overload protector**
  Protects motor from electrical overloads
- **Rotor**
  Current creates magnetic force that pulls the rotor and turns the shaft
- **Fan**
  Moves air through motor and cools rotor and stator

Motors

- **Shaft**
  Extends from the motor to the pump and turns the impeller
- **Ball-bearing assembly**
  Allows the shaft to rotate quietly
- **Impeller**
  Open or closed face circular blade with vanes
- **Vanes**
  Push water from the eye (center) of the impeller in an outward direction to the volute or diffuser (pump housing)

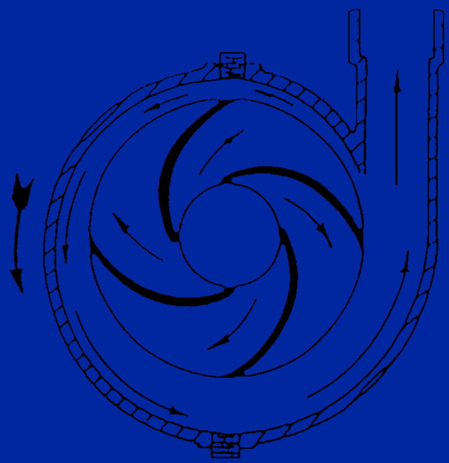
Pumps

- Seal plate
- O-rings
- Shaft seal
- Impeller
- Diffuser
- Clamp
- Tank body/volute
- Base and shock pad



Centrifugal Pump

- Impeller generates water movement at a high velocity
- Volute or diffuser slows water, and converts velocity to pressure
- Pump delivers water flow and artificially creates pressure
- When the motor is wired correctly, impeller will rotate in a clockwise direction



How to Read a Pump Description

7 1/2 hp, 4 x 3, 500 gpm @ 40’ TDH

• 7 1/2 hp	Pump horsepower
• 4	Size of suction connection
• 3	Size of discharge
• 500 gpm	Output in gallons/minute
• 40 TDH	Total dynamic head resistance at the most efficient point

Pump Sizing Example

System components: 1 skimmer, 1 main drain, 1 pump, hi-rate sand filter, 250,000 BTU gas heater, 70’ of 1.5” diameter schedule 40 PVC pipe, 12 1.5” 90 degree ells, 2 1.5” tees, 1 1.5” check valve, 2 1.5” gate valves, 1 1.5” 3-way valve, 3 inlet fittings @ 10 FOH

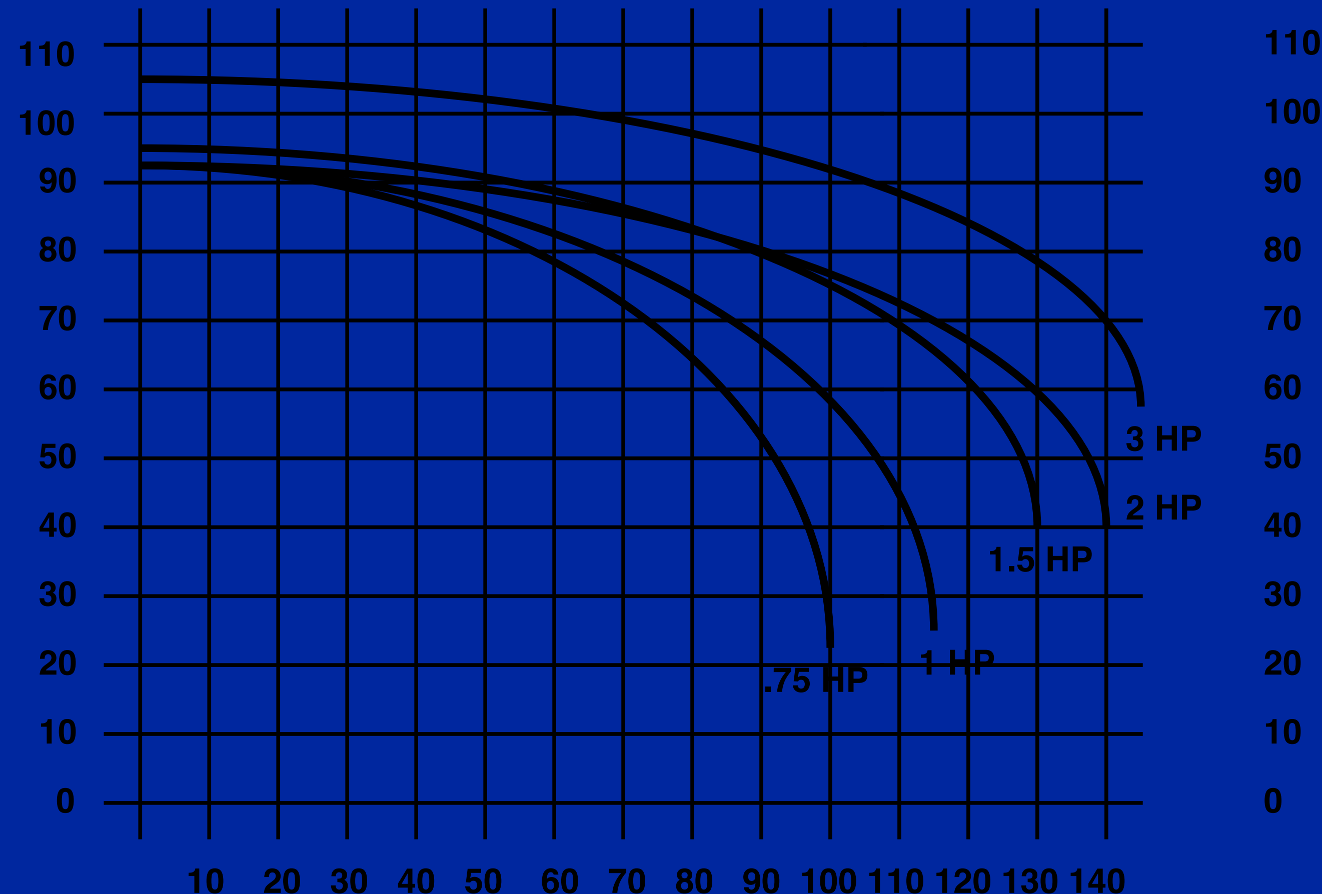
0.216 FOH	Friction loss per foot of pipe
x 214 feet	Total feet of pipe (70’ of 1.5” sch 40 PVC = 70’ 1.5” 90 degree ells = 12 @ 8’ = 96’ 1.5” tees - 2 @ 13’ = 26’ 1.5 swing check valve = 15’ 1.5” gate valves = 2 @ 1.5’ = 3’ 1.5” 3-way valve = 4’)

Pump Sizing Example

= 46.22 FOH	Friction loss of pipe and fittings
+ 46 FOH	Total friction losses (Skimmer and main drain = 2 FOH Filter = 6 FOH Dirty filter = 25 FOH Heater = 3 FOH Inlet fittings = 10 FOH)
= 92.22 FOH	Total system head
60 gpm	Required flowrate

Pump Performance Curve

Read GPM on Horizontal and TDH on Vertical Axis



Pump Sizing Using Gauges

How to calculate TDH of a pool circulation system when you don’t know the length of pipe or conversion factors to express friction losses from components as equivalent lengths of pipe in feet

- Multiply the influent pressure (immediately after backwashing) in psi x 2.31 = ______ feet of head
- Multiply the vacuum reading on the pump suction line in Hg x 1.13 = ______ feet of water
- Add the feet of head and feet of water to determine total dynamic head = ______ TDH
- Determine the minimum required flowrate by dividing water volume by turnover in minutes = ______ gpm
- Refer to the manufacturer’s pump curve, and find the intersection of TDH and flowrate

Cost of Pump Operation

- For residential pools, longer running times do not necessarily mean higher energy bills
- Less resistance and lower energy consumption can be achieved through slower turnover rates
- Pool pumps draw approximately 1,000 watts per hour per unit of horsepower
- A 2 hp pump running 4 hours per day will cost the same as a 1 hp pump running 8 hours per day

Cost of Pump Operation

- Example: 24,000 gallon residential pool

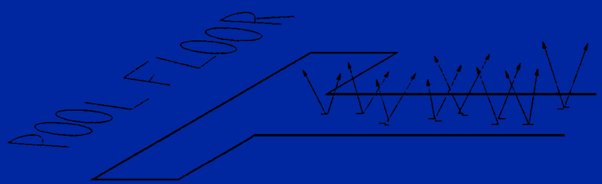
Turnover Time	Flowrate	Pump Size	Energy Cost @ 10¢ per kilowatt hour
4 hours	100 gpm	2 hp	20¢/hour x 4 hours = 80¢
8 hours	50 gpm	1 hp	10¢/hour x 8 hours = 80¢

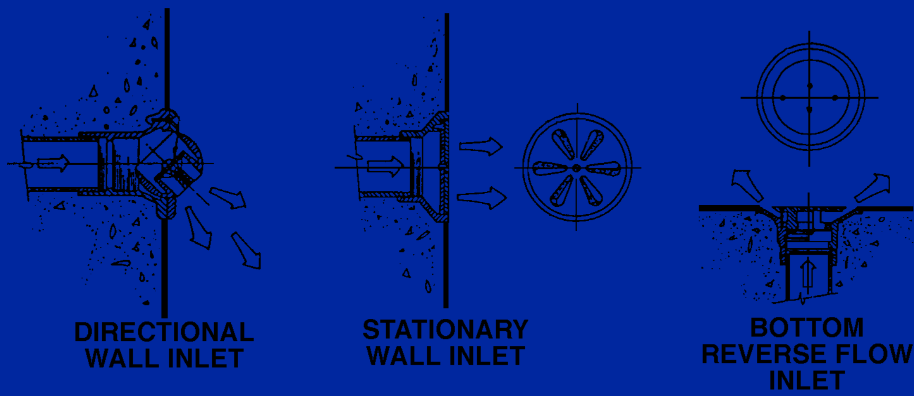
Proper Pump Installation

- Pump is properly secured to its base
- Installed to avoid cavitation
- Operating quietly
- Installed over a shock pad to prevent vibration
- Self-priming, or if flooded suction, located to avoid need for priming
- Installed at the highest point of the suction run
- Properly sized according to the manufacturer’s pump performance curve
- Installed to allow adequate room for servicing and ventilation

Inlets

- Directional wall inlets
- Stationary wall inlets
- Bottom reverse flow inlets
- Tile tube
- Plumbed to provide uniform distribution of water throughout the pool





Sparge System

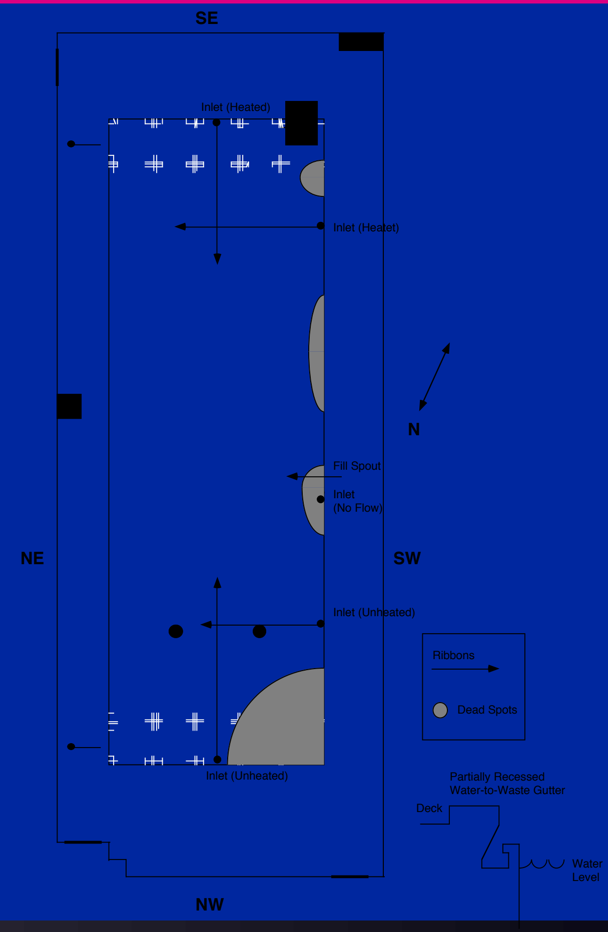
- Releases compressed air into the bottom of a diving pool through special inlets
- Raises the water surface
- Creates a softer impact surface for divers in training
- Prevents divers from being as severely injured if they hit the water incorrectly
- Creates ripples on the water surface to help divers know where they are in relation to the water
- Psychologically assists divers to take more risks without fear of injury

Sparge System

- Users should be warned that the current generated by the sparge system could wash them over and possibly down the wall of the pool
- Water level rises 3 - 4 inches above the normal water surface, and may flood the decks of deck level (rimflow) gutter pools
- Accomplished divers performing vertical dives should not use sparge systems because of the upward force of the air-water mix below -- they are designed to be used for a surface cushion effect when landing flat on new dives.

Testing Pool Circulation Patterns

- Dye tests and ribbon tests are used to confirm proper inlet operation, a uniform circulation pattern, and absence of dead spots
- Dye tests
  - Sodium fluorescein
  - Crystal violet
- Ribbon Tests



Ribbon Testing

- Cut plastic ribbon into strips 6 or more feet in length -- one ribbon for each pool inlet
- Use wire cutters to cut wire into 3 inch pieces
- Poke a wire through one end of each ribbon
- Place both ends of the wire into the inlet
- Observe ribbon movement and inlet operation. Note:
  - Inlets that don't work
  - Inlets where the water stream is weak
  - Inlets pointed in the wrong direction
  - Inlets in need of adjustment

Sodium Fluorescein Dye Testing

- Read the MSDS sheet for sodium fluorescein provided by the chemical distributor.
- Clear the pool of bathers, and allow the water to settle for a few minutes. Make sure the water is at the proper level.
- Put on protective goggles and disposable latex gloves to prevent skin contact with the dye.
- Empty the container of dye into the gutter drain, surge chamber, or skimmer basket nearest the pump.
- Use 3 ounces (a small Dixie Cup full) per 100,000 gallons of pool water.

Sodium Fluorescein Dye Testing

- If your pool has water-to-waste rather than recirculating gutters:
  - Turn off the circulation pump
  - Isolate the hair & lint strainer
  - Remove the strainer lid
  - Empty the dye into the basket
  - Replace the lid and o-ring
  - Open the valves to permit normal water flow through the hair & lint strainer
  - Turn the circulation system back on

Sodium Fluorescein Dye Testing

- Start the video camera and record for reference.
- Wait one to three minutes. Water dyed a bright, fluorescent yellow-green color will enter the pool.
- Number your inlets on a diagram, and record the order of color introduction.
- Document: the inlet pattern, any inlets that don't work, inlets where the water stream was weak, inlets pointed in the wrong direction, or inlets in need of adjustment.
- Observe the circulation pattern. Look for circulation "dead spots" where the water does not change color.
- After 10 minutes, or when the dye reaches all areas of the pool, stop the test.

Sodium Fluorescein Dye Testing

- The water soluble dye should disappear completely within 1 to 4 hours.
- It won't hurt bathers to swim in the pool while the dye is still present. The dye won’t stain their skin or bathing suits.
- If you spill any powdered dye on the deck, just dilute it and wash it down the deck drains.
- If you get full strength powdered dye on yourself, scrub with soap and water (-- it may take a day or so to remove all traces of color).
- Do not breathe or swallow the dye.
- If you spill dye on your clothes, just wash normally in the washing machine with detergent and water.

Crystal Violet Dye Testing

- Read the MSDS sheet for crystal violet provided by the chemical distributor.
- Clear the pool of bathers, and allow the water to settle for a few minutes. Make sure the water is at the proper level.
- Put on appropriate personal protective gear to prevent skin contact with the dye.
- Since the purple color produced by crystal violet will not appear in the presence of chlorine, all traces of chlorine must be removed from the pool prior to starting the test.

Sodium Thiosulfate

To remove chlorine from pool water, add sodium thiosulfate to the pool at a concentration of 1 ounce per 1 ppm per 10,000 gallons of pool water.

Example:
To remove 2.5 ppm of chlorine from a 150,000 gallon pool, 2.34 pounds of sodium thiosulfate would be needed.

$(1\ \text{oz})(2.5\ \text{ppm})(15) = 37.5\ \text{oz} \div 16 = 2.34\ \text{lbs}$

Crystal Violet Dye Testing

- After the chlorine has been removed from the pool, pre mix crystal violet with water (25 grams per 2 gallons of water)
- Use 25 grams, about one ounce, of crystal violet for each 67,500 gallons of pool water which will be dyed.
- Empty the container of dye into the gutter drain, surge chamber, or skimmer basket nearest the pump.
- Start the video camera and record the test for future reference.
- Wait one to three minutes. Water dyed a purple color will enter the pool through one of the return inlets.

Crystal Violet Dye Testing

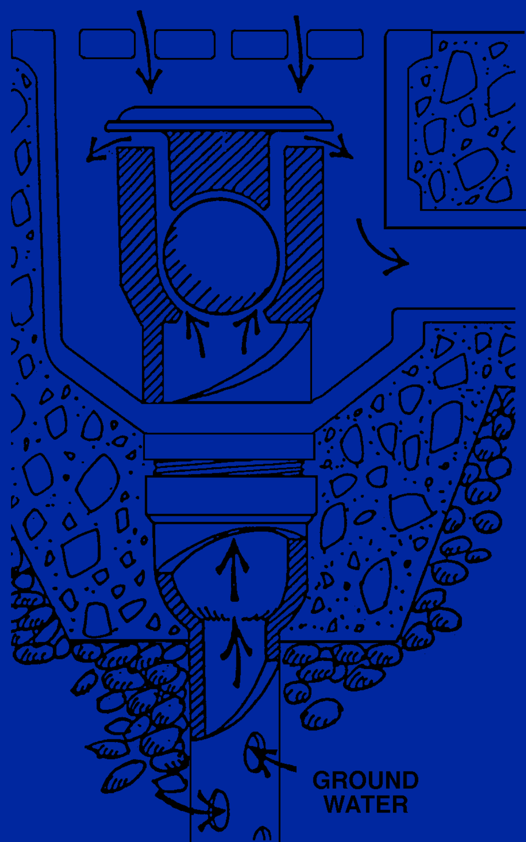
- Number your inlets on a diagram, and record the order of color introduction.
- Document: the inlet pattern, any inlets that don't work, inlets where the water stream was weak, inlets pointed in the wrong direction, or inlets in need of adjustment.
- Observe the circulation pattern. Look for circulation "dead spots" where the water does not change color, and record.
- After 10 minutes, or when the dye reaches all areas of the pool, stop the test.
- To remove the dye once the test is completed, turn on the chlorinator and inject chlorine.

Water Supply

- Supplied by means of a permanently installed pipe and fill line
- Potable water from an approved source
- No direct physical connection between the the pool and water supply permitted
- Backflow protection
- Air gap separation or vacuum breakers
- Fill spouts
- Auto fill valves

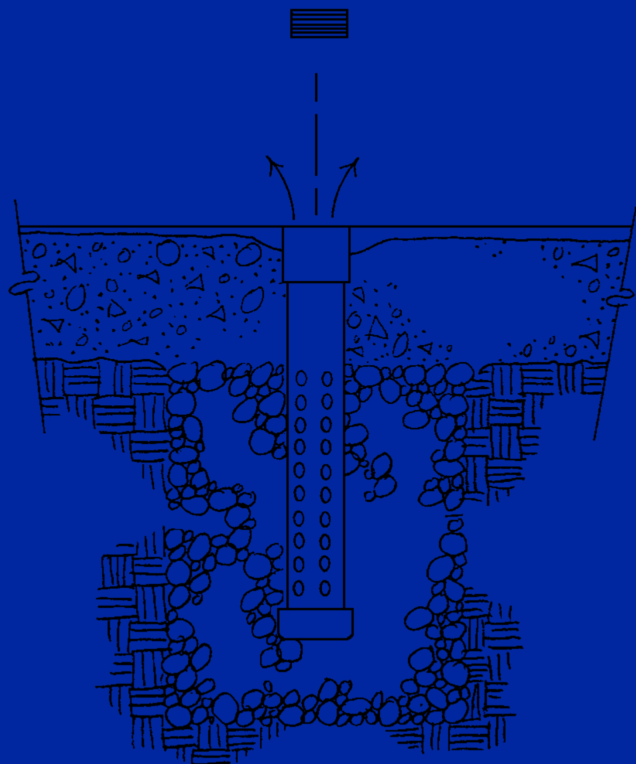
Hydrostatic Relief Valves

- Protective device installed on in-ground pools to stabilize against outside pressure
- Prevents pool from floating out of the ground



Hydrostatic Relief Valves

- Pools can float when the upward force of buoyancy exceeds the structural weight of an empty pool



Hydrostatic Relief Valves

- Why pools pop to seek equilibrium
  - Ground freezes and thaws
  - High ground water tables
  - Irrigated and heavily landscaped areas surrounding pool
  - Poor drainage
  - Pools built on flat ground next to a hillside
  - Expansive soil conditions (clay)

Hydrostatic Relief Valves

- Allows ground water to seep into an empty pool
- Automatic (spring loaded or check valve) or manual plugs
- Location: flush with pool floor or in bottom of main drain
- Valves are connected to perforated or slotted water collection tubes that extend down into a gravel pit beneath the pool

Hydrostatic Pressure

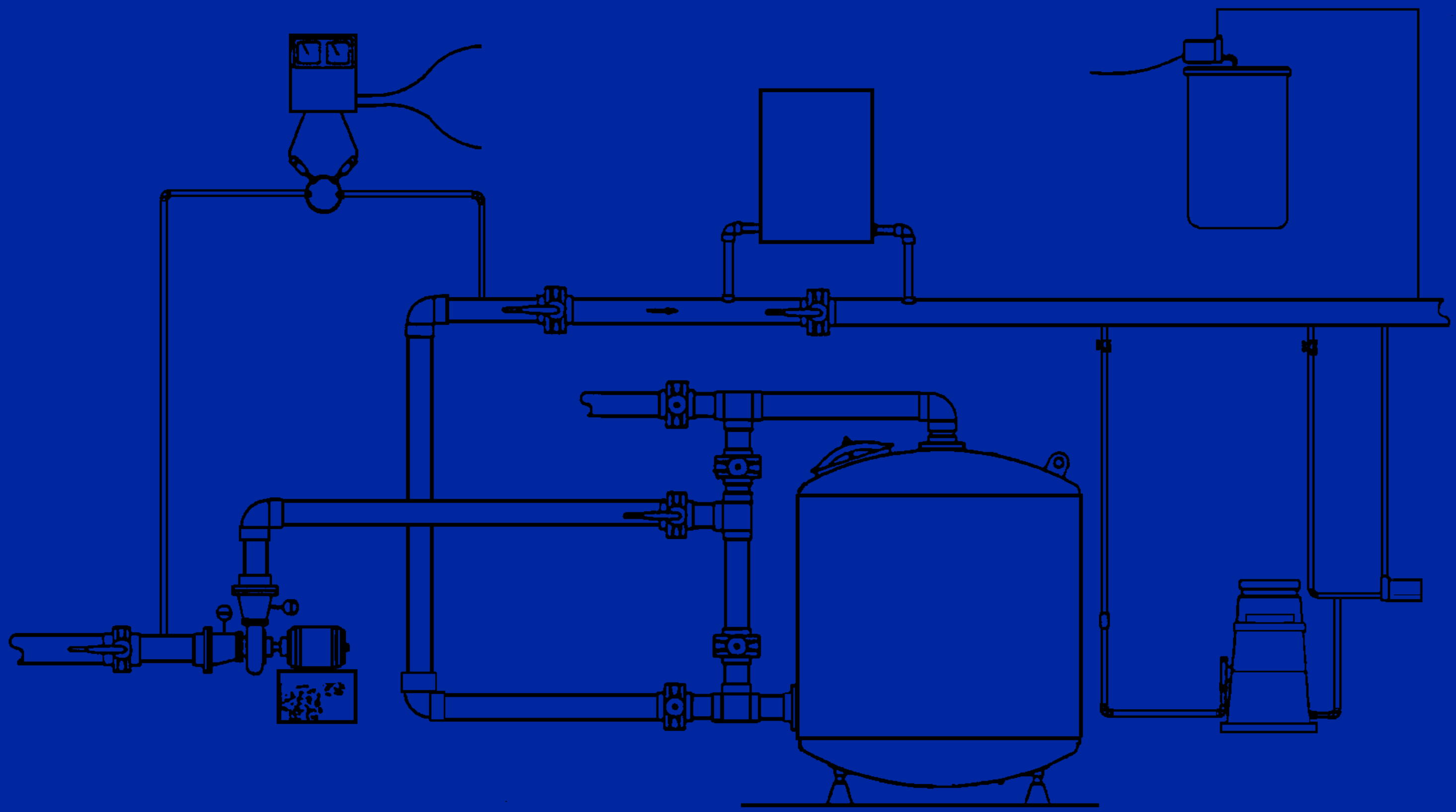
To lessen the likelihood of pool popping:

- Do not drain the pool during a rainy season or immediately after heavy rains
- Check the ground water table elevation - check local flood maps
- Make sure a hydrostatic relief valve is installed and will operate if needed
- Drain the pool slowly
- Allow a sump pump to run continuously to pump out ground water during repairs when the pool is empty
- Drill several holes in the bottom of the pool and monitor water level
- Don’t keep a pool empty longer than is absolutely necessary
- Liability release forms

Hydrostatic Relief

- Where the presence of water hazards (springs, tidal waters...) is known prior to construction:
  - Install a gravity flow underdrain system
  - Build on pilings
  - Install viewing and pumping wells next to the pool

Pool Circulation System Diagram



Tour of Pump Room