Filtration

Filters

- Rapid sand (Sand and gravel)
- High rate sand
  (Multi-cell, horizontal and vertical tanks)
- Vacuum sand
  (Gravity and Hi-rate bi-flow vacuum)
- Diatomaceous Earth
  (Vacuum, Pressure, Regenerative)
- Cartridge

Filtration

- Process of mechanically removing insoluble solid matter from the water
- Filter media
- Filter area
- Filter rate (Design flow rate)
- Turbidity
- Filter run or cycle

Parts of a Filter

- Filter tank
- Freeboard
- Laterals, collection manifold, underdrain
- Manhole
- Drain plug
- Media evacuation port
- Face plate
- Sacrificial anodes
- Media or elements
- Air relief valves
- Clamp assembly
- O-rings, gaskets
- Sight glass
- Valves
- Control consoles
- Influent, effluent and waste lines
- Diffuser or header
- Baffle plate

Filters

- Filter tanks should be positioned to allow accessibility for servicing, disassembly, inspection and proper air circulation
- Air relief valves must be installed on all pressure filter tanks
- Total surface area must be adequate to meet recommended design flow rates
- Sized to maintain clean, clear pool water under all anticipated loads
- Valves and piping should be provided on multi-tank systems to isolate individual filter tanks for maintenance or repair

Filters

- Anchor bolts must be installed to secure filters to the floor and to comply with seismic zone requirements
- Filter tanks must be installed on a level floor or metal shims must be used to level the tanks to prevent face piping leaks
- Install sacrificial zinc anodes to prevent against damage from electrolysis and galvanic corrosion of metal tanks

Rapid Sand Filters

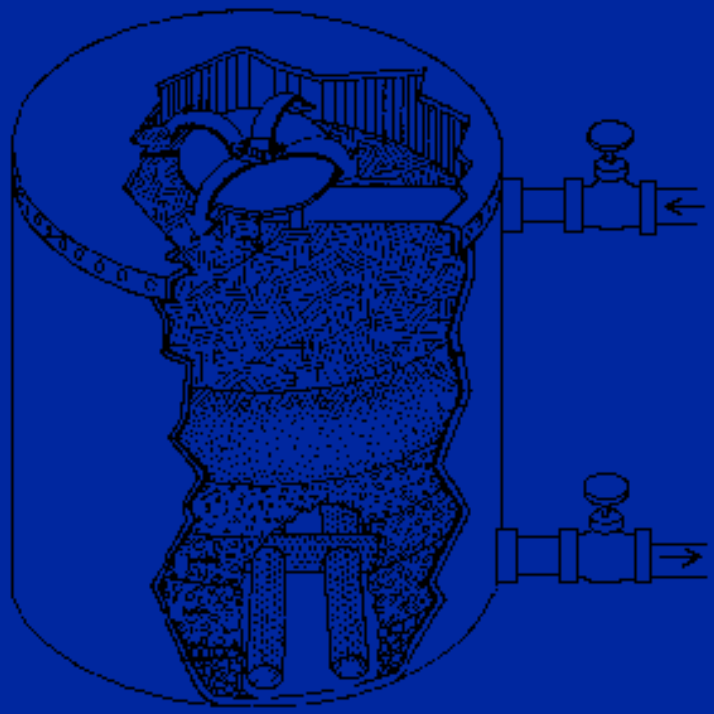
- Series of large tanks
- Multiple layers of sand and gravel
- Graded gravel provides uniform distribution of water and supports the sand
- Depth filtration
- Design flow rate: 1.5 - 5.0 gpm/ft^2 (3.0 gpm/ft^2)
- Backwash rate: 12 - 15 gpm/ft^2
- Each tank is backwashed independently
- Filter aid or flocculants needed (Alum pot)
- Capable of removing 50 - 100 micron particles

Rapid Sand Filters

Example: Layers of media in each 108” diameter tank

Layer	Media	Depth
0	Alum	2”
1	Silica & #30 mesh sand (0.3 - 0.5 mm diameter and uniformity coefficient of less than 1.75)	20”
2	1/8 - 1/4” gravel	4”
3	1/4 - 3/8” gravel	4”
4	3/8 - 3/4” gravel	4”
5	3/4 - 1 1/2” gravel	8”

Rapid Sand Filter - Diagram

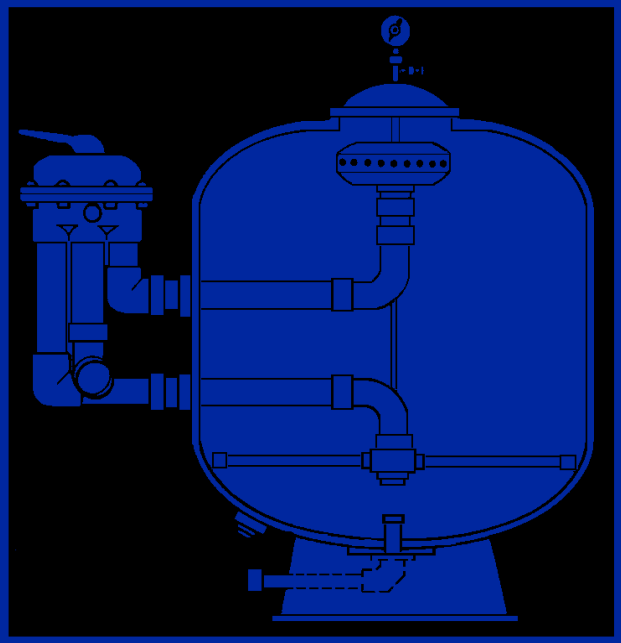


High Rate Sand Filters

- One large or several small tanks
- Pressure systems
- Sold since 1962
- Horizontal or vertical tanks
- Requires less floor space than do rapid sand filters
- Media: permanent single media, usually #20 silica, finer than sand used in rapid sand filters
- Single layer of pea gravel (1/4 - 1/8” diameter) may be used to protect the laterals
- Incoming water flow is directed toward the top of the tank to prevent channeling

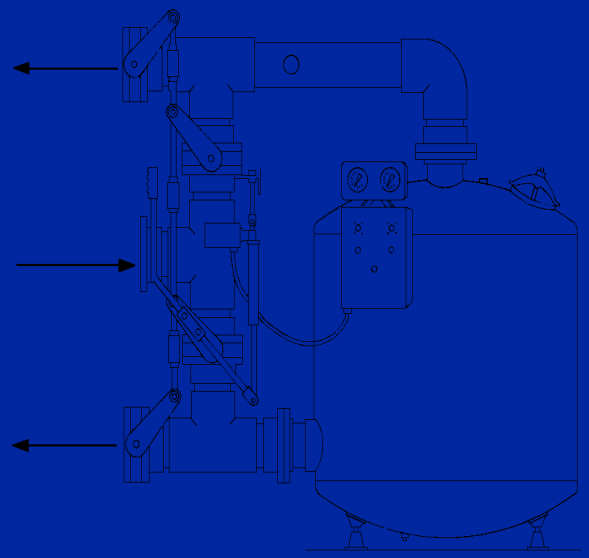
High Rate Sand Filters

- Depth and surface filtration
- Automated operation is possible
- Design flow rate: 12 - 20 gpm/ft^2 (15 gpm typical)
- Backwash rate: 12 - 20 gpm/ft^2
- Backwash and filter at approximately the same rate

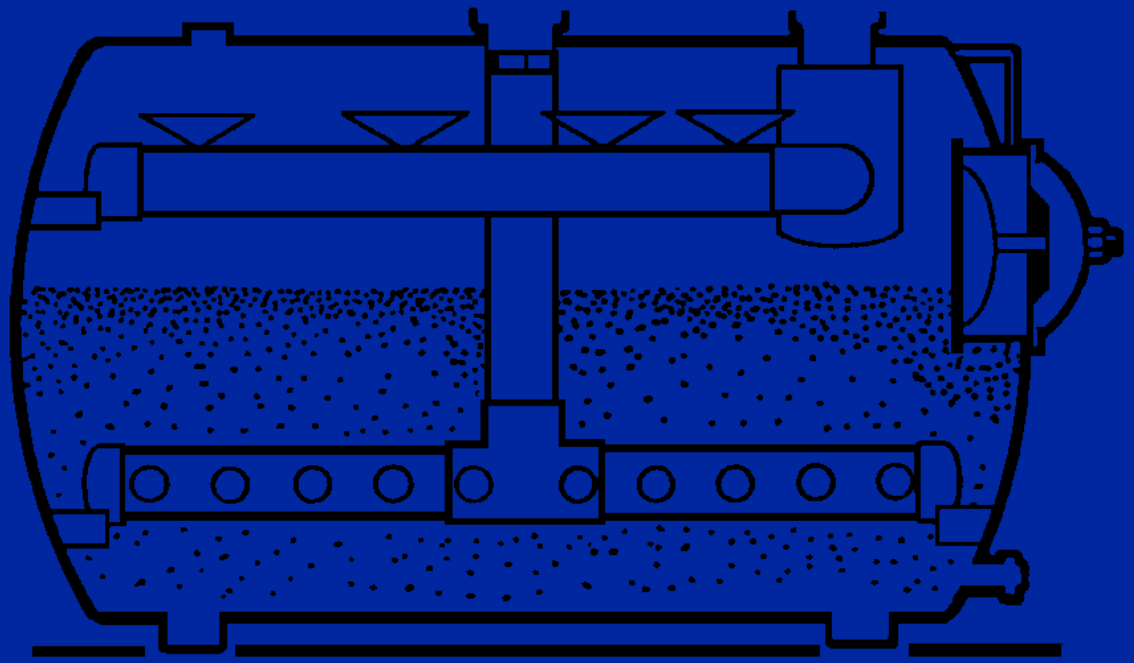


High Rate Sand Filters

- Tanks can be backwashed collectively
- Use of filter aids or flocculants is not recommended
- Capable of removing particles 50 - 100 microns in size, but manufacturers claim retention of particles down to 5 microns on multiple passes



High Rate Sand Filter - Horizontal Tank Diagram

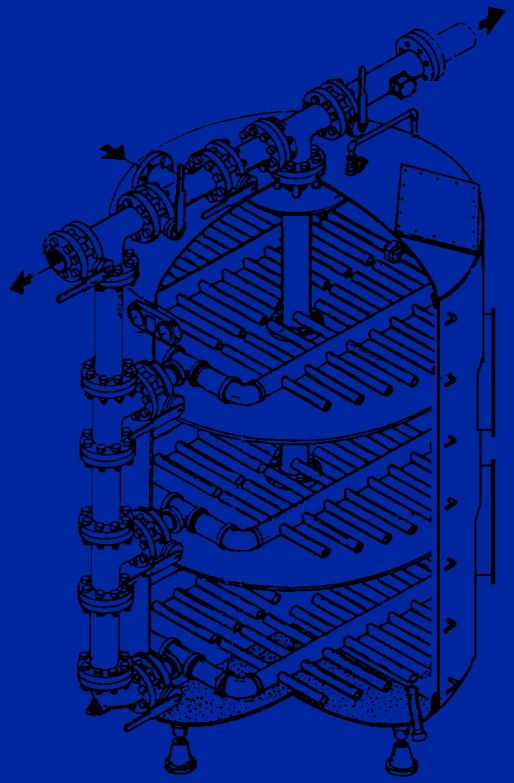


Multi Cell Sand Filters

- Single vertical tank containing 2 or more cells
- Eliminates complex piping and occupies less space in the pump room
- Pressure vessel
- All cells must have equal pressure at all times
- Depth filtration
- Media: Silica, 0.60 - 0.65 mm size with uniformity coefficient of less than 1.6
- Design flow rate: Varies, but 3 - 7.5 gpm/ft^2 is typical
- Backwash rate: 15 gpm/ft^2

Multi Cell Sand Filters

- Cells are usually backwashed separately
- Water is distributed to the top of each cell and out the collector system at the bottom
- Capable of removing particles 50 - 100 microns in size



Vacuum Sand Filters

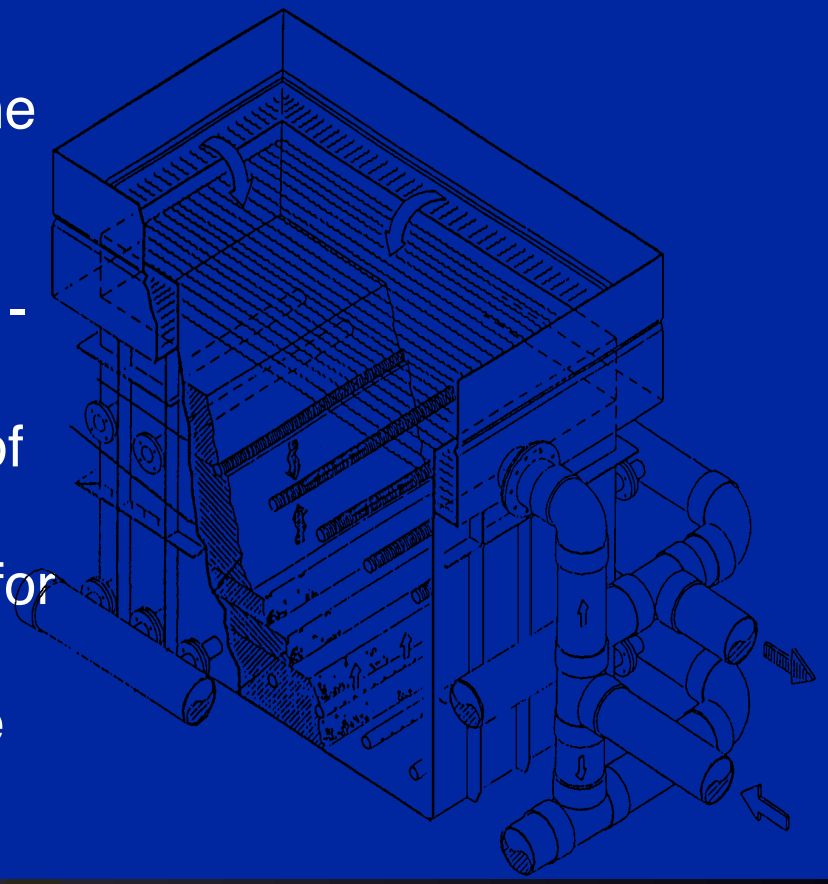
- Open tank
- Design flow rate: 0.5 gpm/ft^2
- Water is returned to the pool by gravity
- Require up to 40% less TDH, and are therefor more energy efficient than pressure systems
- Surge chamber is not necessary
- Dry equipment well can be incorporated into the tank design -- space efficient
- Problem: sand removal for servicing or repairs

Hi-rate Bi-Flow Vacuum Sand Filters

- Single rectangular stainless steel tank
- Tanks can be fabricated in modular sections for access to existing pump rooms
- Stacked multiple cells minimize floor space in the pump room, giving 2 square feet of filter area for each 1 square foot of tank size
- Can be installed above deck (open tank), at deck level (open tank), or below deck (using a vented closed tank system)
- Distribution system around the perimeter at the top and bottom of the tank (holes facing tank)

Hi-rate Bi-flow Vacuum Sand Filters

- Collection laterals across the center of the tank connected to external header pipes
- Design flow rate: 6.25 - 15 gpm/ft^2
- Backwash rate: 40% of the filtration flow rate
- Uses 50% less water for backwashing
- Automatic gas release system



Hi-rate Bi-flow Vacuum Sand Filters

- Media: Graded silica sand 24” above and 32” below the center laterals, particle size 0.45 - 0.55 mm and uniformity coefficient not to exceed 1.45
- Sand media is supported by:
  - 1 top layer of #12 support sand
  - 1 upper layer of 1/8 - 1/4’ roofing gravel
  - 1 lower layer of 1/2 - 3/4” roofing gravel
- Manufacturer claims that due to “electrostatic interaction of dirt and sand particles at accelerated filter rates, and the effect of a negative pressure environment in the media bed” colloidal sized particles can be filtered out

Clinoptilolite

- Zeolite family of volcanic minerals
- Can be used instead of sand in sand filters
- Marketed by British Zeolite Co. of West Sussex, UK
- Granular
- Extremely porous
- Capable of removing particles down to 5 microns in size
- Life expectancy 5 - 7 years
- When a layer of 10% sodium chloride (table salt) is added to the filter bed an ionic reaction occurs which causes the absorption and removal of ammonia as the water passes through the filter, thereby reducing chloramine formation

Diatomaceous Earth Filters

- Single tank
- Pressure, vacuum or regenerative systems
- D.E. - Fossilized skeletal remains of single celled sea plants (diatoms), mined and refined
- Respiratory protection required when handling D.E.
  Contains amorphous (non crystalline) D.E. and crystalline silica
- Elements:
  - Disks, flat or curved leaves, flex tube, or cylinders
  - Composed of grids and septa (“skin and bones”)
- Grid support (metal or plastic)
- Septa (usually woven synthetic fabric) that D.E. is deposited on

Diatomaceous Earth Filters

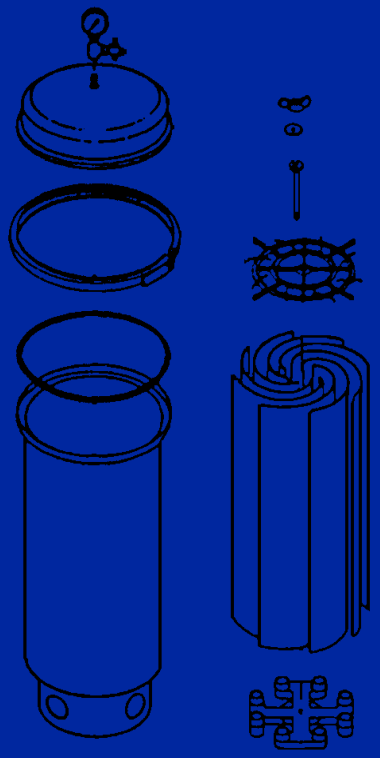
- Surface, rather than depth, filtration
- Filter elements must be pre coated with D.E.
  - 1.5 - 2.5 ounces of D.E. per square foot of filter surface area (or 1 pound for each 10 square feet)
  - 1 pound coffee can holds approximately 2 ounces of D.E.
- Design flow rate: 1.5 - 2.0 gpm/ft^2 (commercial), 2.5 - 3.0 gpm/ft^2 (residential)
- Filter rates up to 2.5 gpm/ft^2 may be allowed if D.E. is body fed continuously from a slurry pot at a rate of at least 0.1 lb/24 hours per square foot of filter area

Diatomaceous Earth Filters

- As dirt blocks the filter cake pores:
  - The cake compacts
  - Permeability is reduced
  - Resistance to flow increases
  - Influent pressure increases
  - Bridging occurs -- media builds up between the elements
- Water or compressed air are used to remove used D.E. from the elements
- Disassembly and manual cleaning of elements is necessary when filter cycles decrease

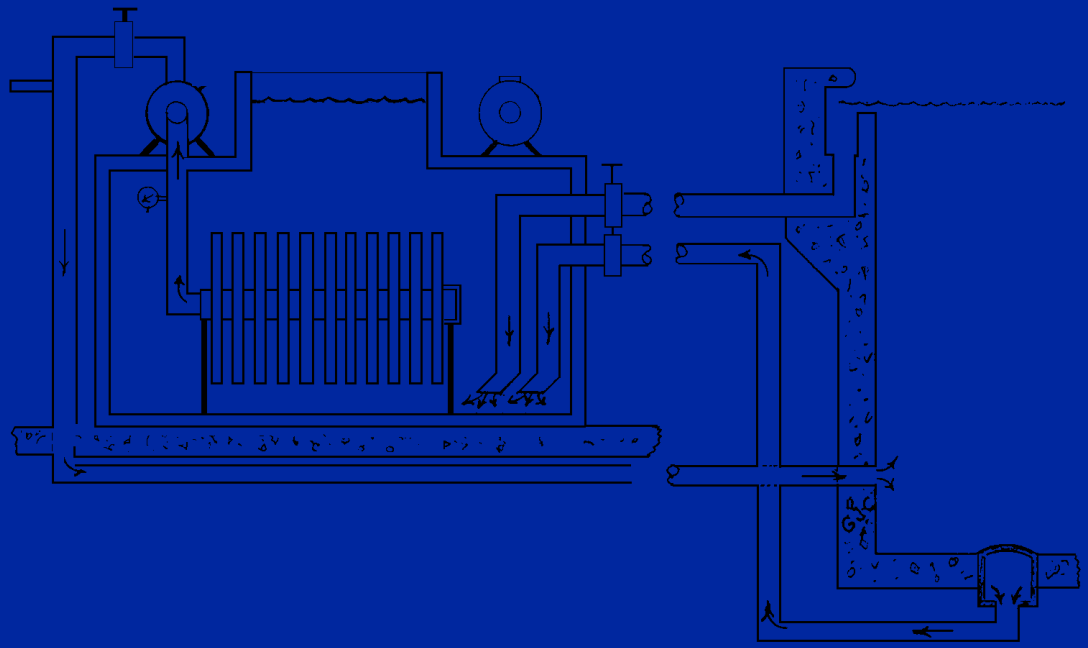
Diatomaceous Earth Filters

- Capable of removing 3 - 5 micron sized particles
- Separation tanks and D.E. disposal problems



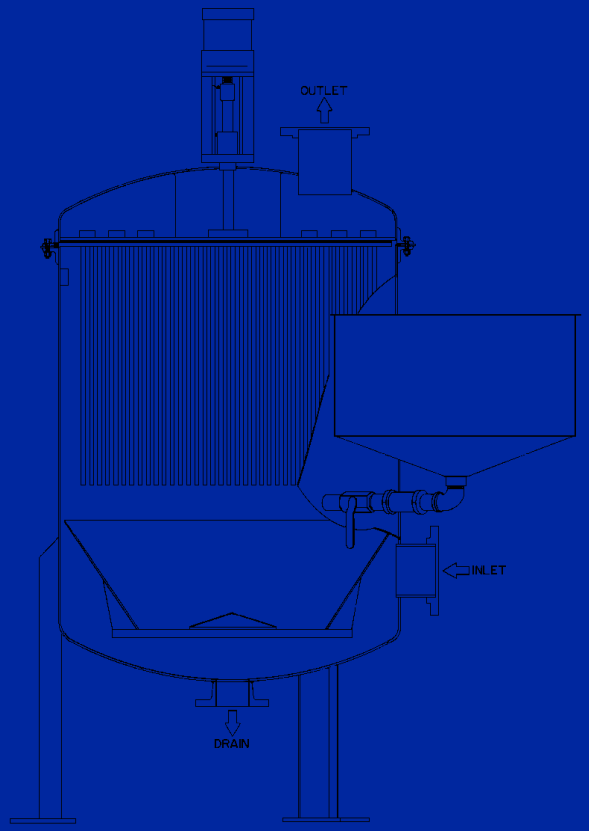
Vacuum D.E. Filter

- Vacuum tanks can eliminate the need for surge chambers



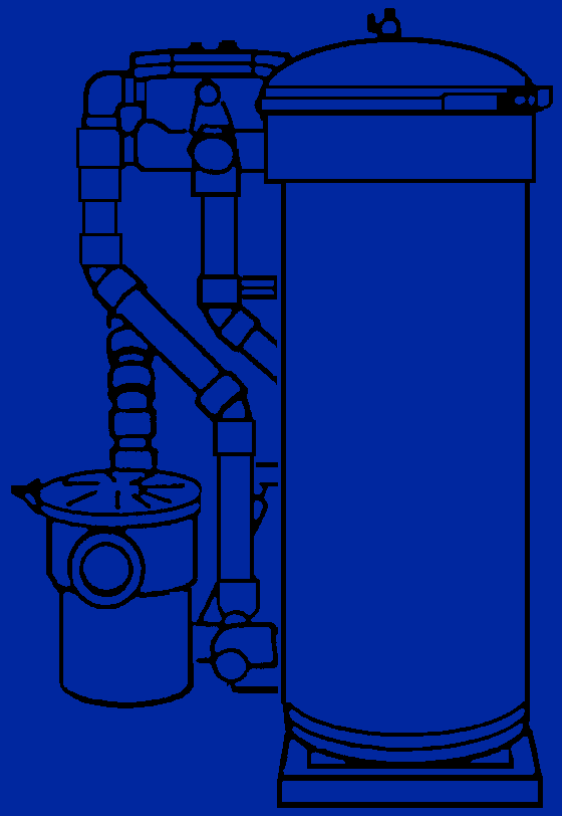
Regenerative D.E. Filter

- Regenerative, or bump D.E. systems, allow D.E. to be removed from and redistributed onto the tubular elements, also redistributing the dirt in the filter cake, and extending the filter run (manual or automatic)



D.E. Separation Tank

- Separates the used D.E. from the water during backwashing or filter cleaning
- D.E. will clog sewers and septic systems
- High bacterial content
- Dispose of D.E. collected in the separation tank according to local regulations



Cellulose Fiber

- Filtration media introduced in 1992 as a substitute for diatomaceous earth because of:
  - Health concerns (suspected carcinogen and silicosis lung disease) of working with D.E.
  - Environmental concerns
- Pulverized cellulose wood pulp
- Non toxic -- FDA approved additive in cheese and bakery products
- Biodegradable
- Non abrasive
- Can remove finer, smaller particles than D.E., and can trap algae spores, suspended calcium and other hard metals (copper, iron), and oils

Cellulose Fiber

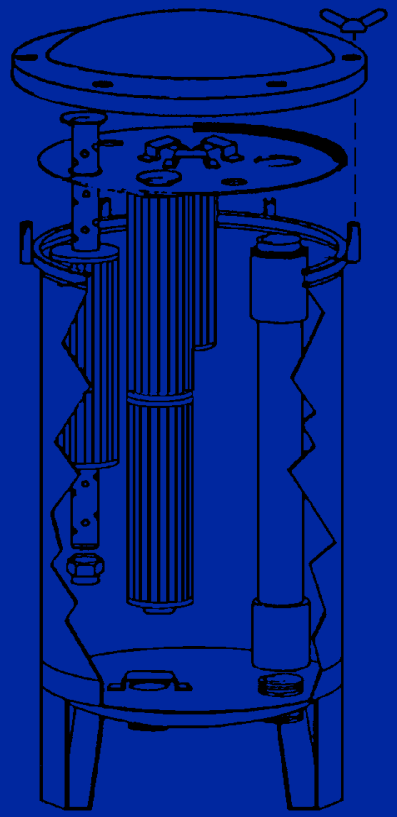
- Remove and thoroughly clean D.E. filter elements before converting to cellulose
- Pre coat elements with 0.0625 pounds of cellulose fiber per square foot of filter surface area (1/4 - 1/8 the amount of D.E. typically used)
- Can also be used as a filter aid for sand and cartridge filters -- add powder gradually until a 1 psi influent pressure increase is seen
- Potential problems:
  - Short filter cycles -- may load faster because smaller sized particles and oils can be removed
  - Rapid pressure increase if oversaturated water causes calcium to deposit on top of the cellulose
  - Algae blooms inside filter tanks

Cartridge Filters

- Pressure filtration
- Cartridges - Pleated synthetic fibrous material attached to a cylindrical core
- Stainless steel filter tank
- Since 1970's, only surface filtration
- Large filter surface area in a small space
- Design flow rate: 0.375 (commercial) - 1.0 (residential) gpm/ft^2
- Capable of removing 15 -25 micron sized particles

Cartridge Filters

- Do not add D.E.
  - Causes tears in the cartridges
  - Reduces surface area and causes very short filter runs
- Do not add alum
  - Clogs the pores in the fibrous material
  - Destroys the cartridge



Cartridge Filters

- Not backwashed -- cartridges are removed and cleaned manually
- Once cleaned, cartridges never recover their entire surface -- they lose 25-35% of their filtering capacity after each cleaning
- Cartridge have a limited lifespan -- occasional replacement is required

Backwashing & Filter Cleaning

High Rate Sand Filters

- Turn off the heater.
- Turn off the circulation pump.
- Close the valves on the pump suction and discharge lines to isolate the hair & lint strainer. Remove the hair & lint strainer for cleaning. Replace with a spare strainer basket, and seal properly. Set the dirty strainer basket aside for cleaning.
- Reopen the valves surrounding the hair & lint strainer to allow water to flow from the pool for filter backwashing.
- Close the valve on the pool return line to keep debris from the filter from returning to the pool.

Backwashing & Filter Cleaning

High Rate Sand Filters

- Open the valve on the discharge line.
- Open and close the appropriate valves on the filter influent and effluent lines in order to reverse the flow of the water through the filter tank.
- Turn on the circulation pump.
- Stand next to the sight glass on the discharge line and watch for the improved clarity of water going to waste.
- After approximately 2 to 10 minutes, water running through the sight glass will clear. When this occurs, shut off the circulation pump.
- Close the valve on the discharge line.

Backwashing & Filter Cleaning

High Rate Sand Filters

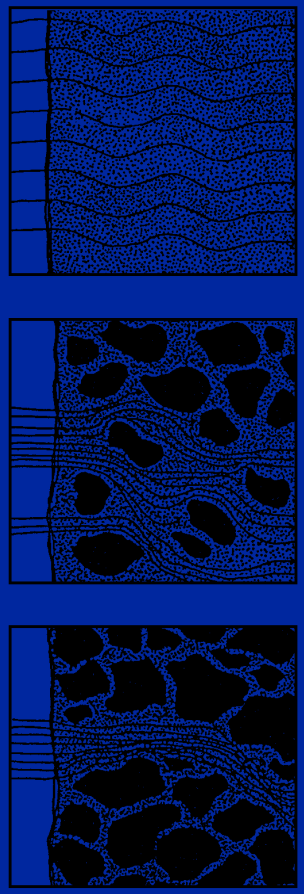
- Open the valve on the return line to allow filtered water to return back to the pool.
- Open and close the appropriate valves on the filter influent and effluent lines in order to return the flow of the water through the filter tank from top to bottom.
- Turn on the recirculation pump.
- Turn the heater back on.
- Manually bleed the air from filter tank by opening the valve at the top of the tank.
- Record the flow rate and pressure differential.
- Add fresh water to the pool to make-up for the water sent to waste during the backwashing procedure.

Channeling & Mudball Formation

On a seasonal or yearly basis, clean the sand inside the filter tank by adding a commercial sand cleaning solution or sodium bisulfate.

Mudballs and channels which form inside the sand should be destroyed.

Some manufacturers also recommend that the top 6 inches of sand be removed and replaced with fresh #20 silica on a yearly basis.



Sand Filter Inspection

Open the filter tank and observe, dig with a trowel or poke (being careful not to damage the filter tank or components) and look for:

- Flatness of the media bed
- Channeling (holes)
- Media migration
- Contamination caused by improper backwashing or improper chemical balance

Backwashing & Filter Cleaning

Pressure D.E. Filters

- Turn off the heater, then the circulation pump.
- Open the hair & lint skimmer. Remove the skimmer basket, empty the basket of debris, then replace the skimmer basket and reseal.
- Open the manual air relief valve and bleed off the air trapped in the filter tank to reduce pressure.
- Close the valves on the influent and effluent lines.
- Drain the water out of the filter and to the diatomaceous earth separation tank. Used D.E. should be considered a biological waste product and should be handled carefully and disposed of properly and according to local regulations.

Backwashing & Filter Cleaning

Pressure D.E. Filters

- Clean the filter elements if necessary:
  - Carefully remove the filter elements one at a time.
  - Rinse out the inside of the filter tank.
  - Rinse the elements with fresh water using a high pressure nozzle.
  - Soak the elements in a trisodium phosphate (TSP) and water solution (1 cup of TSP to 1 gallon of water) for 4 to 8 hours to remove grease and oils, and to avoid setting stains.
  - Soak the elements in a solution of sodium bisulfate and water (10 parts of water to 1 part acid) for 4 to 8 hours.

Backwashing & Filter Cleaning

Pressure D.E. Filters

- Clean the filter elements if necessary: (continued...)
  - Remember, always add acid to water, not water to acid.
  - Soak the elements in sodium bicarbonate (baking soda) and water for 2 to 4 hours to neutralize the acid.
  - Rinse the elements with fresh water.
  - Inspect for tears in the fabric of the elements.

Backwashing & Filter Cleaning

Pressure D.E. Filters

- Replace the elements inside the filter tank, being careful to realign them properly.
- Inspect band ring and the o-ring for wear prior to reassembling the tank. Replace if necessary.
- Replace the filter lid and clamp assembly strictly according to the manufacturer's directions.
- Fill the filter tank with fresh water.
- Turn on the recirculation pump. (Keep the air release valve open).
- Recharge by slowly adding D.E. mixed with water to the filter.
- Turn the heater back on.
- Record the flowrate and pressure gauge readings.

Backwashing & Filter Cleaning

Cartridge Filters

- Turn off the heater.
- Shut off the pool circulation pump.
- Close the valves on the pump suction and discharge lines to isolate the hair & lint strainer.
- Remove the hair & lint strainer for cleaning. Replace with a spare strainer basket, and seal properly. Set the dirty strainer basket aside for cleaning.
- Release the air pressure by opening the valve at the top of the filter tank.
- Open the valve under the filter tank to drain the water out of the filter tank.

Backwashing & Filter Cleaning

Cartridge Filters

- Open the filter tank. Remove the gasket and carefully remove the filter cartridges, and set them aside for cleaning.
- Rinse out the inside of the filter tank. Close the drain plug.
- Install the spare set of cartridges in the filter tank being careful to align them on the manifold fittings.
- Replace the gasket over the cartridges, and reseal the filter tank, carefully following the manufacturer's directions.
- Refill the filter tank with water by opening the valve on the suction side of the pump.
- Turn on the recirculation pump.

Backwashing & Filter Cleaning

Cartridge Filters

- Manually bleed the air from filter tank by opening the valve at the top of the tank.
- Turn the heater back on.
- Record the flow rate and pressure differential.
- Clean the dirty cartridges with a commercially prepared filter cartridge cleaning solution, or:
  - Separate each pleat in the cartridges and rinse the cartridges with fresh water using a high pressure nozzle.

Backwashing & Filter Cleaning

Cartridge Filters

- Soak the cartridges in a trisodium phosphate (TSP) and water solution (1 cup of TSP to 1 gallon of water) for 4 to 8 hours to remove grease and oils, and to avoid permanently setting the stains. Soak the cartridges in a solution of sodium bisulfate and water (10 parts of water to 1 part acid) for 4 to 8 hours.
- Remember, always add acid to water, not water to acid.
- Soak the cartridges in sodium bicarbonate (baking soda) and water for 2 to 4 hours to neutralize the acid.
- Rinse the cartridges with fresh water.

Backwashing & Filter Cleaning

Cartridge Filters

- Store the clean cartridges in a dark location to prevent algae growth.
- Store the spare cartridges in a barrel of water, or in dark colored garbage bags to prevent their drying out and rapid deterioration.

Filter Sizing

- Pool dimensions: 75' x 45' x 4.75'
- Volume: 120,000 gallons
- Required turnover: 6 hours
- High rate sand

  120,000 gallons ÷ 360 minutes = 333 gpm

  ÷ 15 gpm/ft^2 = 22.22 ft^2 x 1.25 = 27.8 ft^2
- D. E.

  120,000 gallons ÷ 360 minutes = 333 gpm

  ÷ 2 gpm/ft^2 = 166.5 ft^2 x 1.25 = 208 ft^2
- Cartridge

  120,000 gallons ÷ 360 minutes = 333 gpm

  ÷ .375 gpm/ft^2 = 888.88 ft^2 x 1.25 = 1,111 ft^2

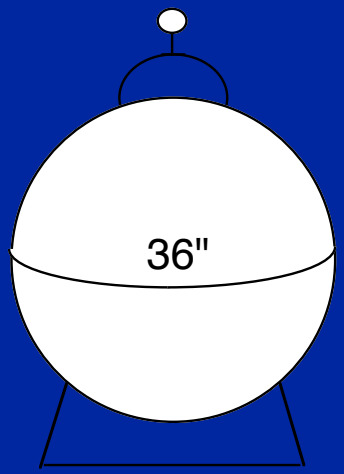
Filter Sizing Example

High Rate Sand Filter

360,000 gallons ÷ 360 minutes = 1,000 gpm

1,000 gpm ÷ 15 gpm/ft^2 = 66.66 ft^2

66.66 ft^2 ÷ 7.065 ft^2 = 9.43 36-inch diameter filter tanks



Area = pi x radius squared

(3.14) (1.5') (1.5')

= 7.065 sq. feet

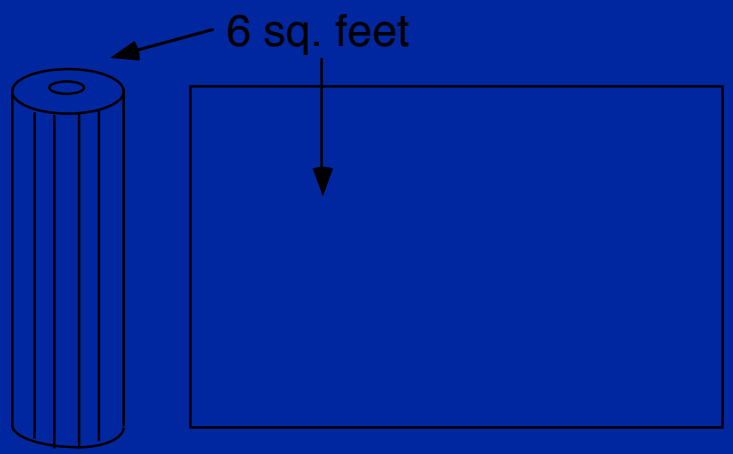
Filter Sizing Example

Cartridge Filter

360,000 gallons ÷ 360 minutes = 1,000 gpm

1,000 gpm ÷ 0.375 gpm/ft^2 = 2,666 ft^2

2,666 ft^2 ÷ 6 ft^2 = 444 6-square foot cartridges



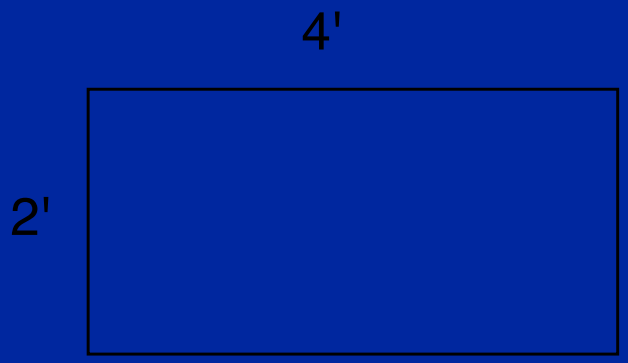
Filter Sizing Example

D.E. Filter

360,000 gallons ÷ 360 minutes = 1,000 gpm

1,000 gpm ÷ 2 gpm/ft^2 = 500 ft^2

500 ft^2 ÷ 16 ft^2 = 31.25
2’ x 4’ rectangular elements



Area = 2' x 4' = 8 sq. feet
8 sq. feet x 2 element sides
= 16 sq. feet per element

Filter Selection

- Type of media
- Cost of purchase, operation and replacement
- Pool size and required flow rates
- Filter surface area and space requirements in the pump room
- Plumbing requirements
- Filtering capability -- size of particle the filter is able to remove from the water and clarity achieved
- Ability to get the filter into an existing room
- Availability of water for backwashing
- Water disposal restrictions
- Time requirements and ease of maintenance

Improved Clarity

- Flocculants
- Clarifiers
- Sequestering Agents
- Chelating Agents
- Magnetic Water Conditioners
- De-Foamers
- Enzymes
- Absorbent Foam
- Nanofiltration

Flocculants & Clarifiers

- Flocculants and clarifiers make colloidal (Koll-oyd-al) particles stick together or coagulate so that the particles become large enough to be filtered out or heavy enough to settle
- Colloidals are particles smaller than 1 micron in size which are suspended in water
- Colloids are small enough to pass through pool filters, too light to settle on the bottom of the pool, and make water murky or cloudy

Clarifiers

- Organic polymers
- Natural polymer chitin often extracted from sea organisms
- Positively charged repeating polymer links attract negatively charged colloidal particles. The electric charge is neutralized, and the polymer coils up into a large particle which can be filtered.
- Use 2 - 2.5 ounces /10,000 gallons
- Biodegradable

Flocculants

- Aluminum sulfate (Alum) when added to water forms a floc or gelatin like substance--aluminum hydroxide
- Causes a sudden drop in pH and total alkalinity
- If pH is in range of 7.2 - 7.6, a white precipitate forms
- Coagulant or Settling Agent:
  - Broadcast 2 ounces per 100 ft^2 of pool water surface area
  - Alum will feel sticky and will cause eye and skin irritation

Flocculants

- Filter Aid:
  - Introduce 2 ounces per square foot of filter surface area
  - Used on rapid sand filters. Do not use with D.E. or cartridge filters or vacuums.
  - Fills in spaces between grains of sand and forms a gelatinous mat above the top sand layer
  - Alum pot
  - May pass through filter media if not pre dissolved, if pH is out of range, or if fed in too close to the filter

Sequestering Agents

- Increase the ability of water to hold metals in solution
- Preventative treatment. Keeps minerals from:
  - Oxidizing and staining
  - Causing scale build-up
  - Precipitating (coming out of solution) calcium and magnesium salts when pH and water temperature rise
  - Discoloring or clouding the water
  - Attaching to and discoloring bathers' hair

Chelating Agents

- Pronounced “key-lating”
- Remove metals from the water
- Cures mineral staining problems
- Organic water soluble molecule that bonds and reacts with metal ions to keep them from precipitating

Sequestering & Chelating Agents

EDTA

- Ethylenediamine - tetracetic acid (also DTPA, HEDTA and NTA)
- Prevent staining by tying up reactive sites on metal ions keeping them from combining with other substances and precipitating

Polymers

- Also used as clarifiers
- Negatively charged (anionic) polymers interfere with metallic crystal formation, preventing calcification and scale formation

HEDP

- Hydroxyethylidene (or 1,1-diphosphonic acid)
- Like EDTA, block reactive sites on metal ions preventing them from combining with other substances and precipitating
- Negatively charged (anionic) electrolyte capable of distorting crystal formation and therefore preventing scale formation

Source of Metals Found in Pool Water

- Fill water
- High velocity of water stripping metals from the pipes
- Ionizers
- Metal based algaecides
- Aggressive water conditions:
  - Unadjusted water balance (low pH, total alkalinity and calcium hardness)
  - Incorrectly adding too much acid
  - Adding acidic products prior to the pump, filter or heater

Stain Finder

Metal	Source	Color
Aluminum	Pool fittings & hardware	White or yellow
Cadium	Source water, plaster, calcium hypochlorite	White powder or crystals
Cobalt	Fiberglass accelerator	Red, blue, violet, gray or brown
Copper	Algaecides, pipes, ionizers, heat sinks, heat exchangers	Aqua, blue, black, purple, brownish red or yellow
Iron	Well water, source water, galvanized pipe	Brown, dark red, blue-gray, greenish white
Magnesium	Source water	White powder or crystals
Manganese	Well water	Rose, black, green, purple
Nickel	Heater headers, plated hardware	Green, brown or black
Titanium	Paint, chlorine generator electrodes	White

Removing Metal Stains

- Sequestering and chelating agents
- Acid washing
- Non drain acid wash
- “The Catfish”
- Pumice stones
- Fine grit sandpaper
- Hydrogen peroxide

Acid Washing

- Read the Material Safety Data Sheets (MSDS) for all the chemicals you will use during the procedure.
- Purchase and wear the personal protective gear recommended in the MSDS sheets, including:
  - Protective clothing that covers all areas of exposed skin
  - Full face shield or goggles
  - Half mask respirator with fresh acid cartridges
  - Rubber boots and gloves
- Visually inspect the pool, looking for: discoloration, mineral staining, ghosting, plaster etching or mottling, chipped tile, broken steps, cracks, scaling, and other problems which can be corrected while the pool is empty.

Acid Washing

- Drain the pool to the sanitary sewer or other approved location
  - Closely inspect the entire surface of the empty pool
  - Tap the walls and pool bottom looking for loose plaster or hollow spots
  - Sand off any excessive calcium build-up
  - Make sure the pool is dry and you have taken all appropriate safety precautions to avoid electrocution if you're working with an electrical sander
- Rinse down the whole pool with water from a garden hose using a high pressure nozzle.

Acid Washing

- Mix water and tri sodium phosphate (TSP) in a plastic sprinkling can.
- Add about 1/4 cup of tile soap to the mixture.
- Pour the TSP mixture from the deck down, a small area at a time.
- Scrub with an industrial pool deck brush to remove the oil residue and scum that has built up over time. After completing the pool walls, scrub the pool bottom in a similar manner. Be careful not to slip and fall.
- Rinse the entire pool with fresh water again.

Acid Washing

- Make sure that the area you're working in is extremely well ventilated.
  - Acid fumes are heavier than air and will have a tendency to collect in the bottom of the pool.
  - Don't work alone.
  - Both you and your partner should be knowledgeable in first aid procedures for acid burns, and respiratory emergencies in case one of you is overcome by fumes.
- Prepare a mild acid and water solution.
  - Add acid at a ratio of no more than 1 part muriatic acid to 4 parts of water.
  - Remember to add the acid to the water already in the bucket, not water to the acid.

Acid Washing

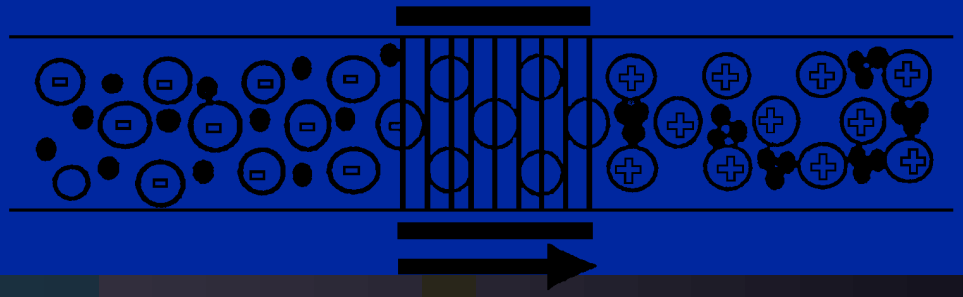
- Using a long handled brush, scrub a small area at a time until the surface feels like fine sand paper.
  - Rinse frequently.
  - Keep the rinse water on at all times
  - Move the sump pump around to avoid leaving an impression known as a pump "foot print" on the pool bottom.
- Neutralize the acid, and dispose of the neutralized solution in an approved manner.
- After completing the acid wash, rinse the pool several times with fresh water.

Acid Washing

- Pour sodium carbonate (soda ash) down the main drains to help neutralize any acid that may have gotten into the drains and recirculation lines.
- Neutralize the acid on the pool shell, by again scrubbing the entire surface with a mixture of TSP and water, as previously described.
- Rinse the surface one final time with fresh water.

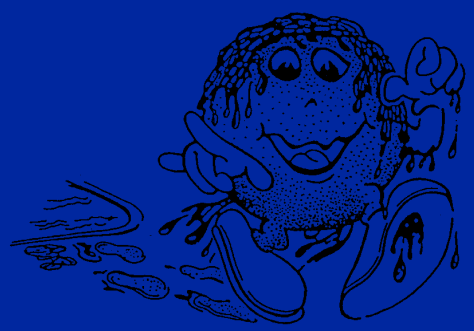
Magnetic Water Conditioners

- Acts as a wetting agent, reduces surface tension, increases ionic activity, increases sanitizer effectiveness
- Reduces pH fluctuation (bounce)
- Clarifies water by coagulating oils, lotions and debris so they can be filtered out
- Removes (chelates) carbonate scale
- Ruptures algae cell walls
- Controversial -- exaggerated claims



Oils

- Promote bacterial growth
- Retard sanitizer effectiveness
- Cloud water
- Form scum lines
  ("bathtub rings" at the water line)
- Clog cartridge and D.E. filters
- Contribute to mudball formation in sand filters



Enzymes

- Definition - protein-like substances formed in plant and animal cells that act as an organic catalyst to start or speed up chemical reactions
- Synthetic enzymes are now available
- Digest and convert oils in pool water to carbon dioxide and water
- Similar process used to clean up ocean oil spills
- Effective against all organic compounds (body wastes, sap, pollen, small dirt particles...)

Enzymes

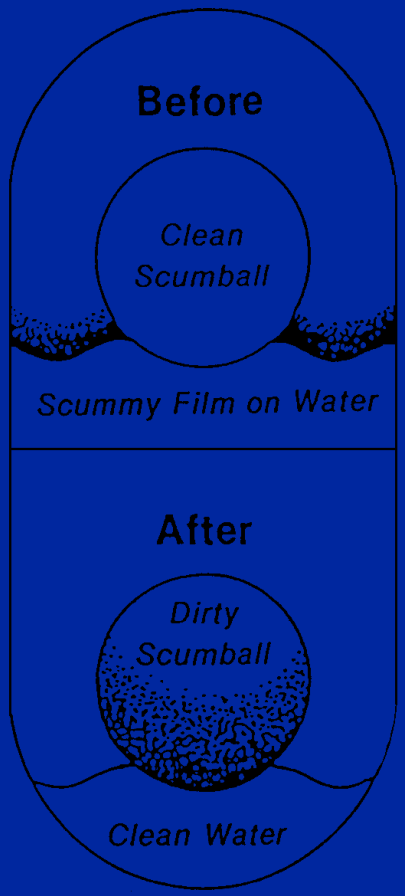
- Can also be used to remove detergents from vandalized pools, spas and fountains
  (Doris Day and James Garner movie “The Thrill of It All”)
- Enzymes are used to destroy rather than mask odors
- Takes approx. 5 days to remove the oils
- No way to test water for enzyme concentrations
- Dose:
  - Initial: 1 to 2 ounces per 1,000 gallons of pool water
  - Maintenance: 1/2 ounce per 1,000 gallons of pool water per week

Absorbent Foam

- Absorbs oils from the water
- Patented molecular structure and cell design
- Molecular wicking permits foam to absorb up to 32 times its weight in oil
- “Scum” balls, mitts for cleaning scum line, cartridge filter block, bags, skimmer sock, floating lilies

Absorbent Foam

- When foam is saturated, it turns a dark color and sinks
- To clean: Remove the foam, squeeze out the oils and re use or replace



De-foamers

- Wetting agents that prevent foaming, or that neutralize and dissipate suds in aerated spas, fountains and hydrotherapy pools
- Hide, rather than solve, the problem
- Causes of foaming in pools:
  - Soft water
  - Quaternary ammonia algaecides
  - Body lotions and suntan oils
  - Tile cleaners
  - High TDS
  - Air pollution
  - Body fats (sweat glands) and oils (skin)

Nanofiltration

- Removes particles to 0.001 microns in size, or any impurities with molecular weighs over 200
- Rejects 10% of total water product
- Operates at higher pressure than ultra fine and micro filtration systems
- Forces water under pressure at 100 -140 psi through semi permeable membranes
- Reduces unacceptably high levels of:
  - TDS, sodium, chlorides, calcium, magnesium, copper, iron, lead and other heavy metals; cyanuric acid, nitrates, phosphates, algae spores, dissolved organics (prevents THM formation)

Vacuuming

- Routine daily maintenance
- Debris heavier than water settles on the bottom of the pool after a period of quiescence
- Best time to vacuum a pool:
  - Before opening for the day
  - After the debris in the pool has had a chance to settle for two or more hours
- Brushing vs. vacuuming a pool

Vacuuming

- Select the most appropriate type of vacuum:
  - Cost of purchasing and maintaining the vacuum
  - Type and size of pool
  - Time involved, and maintenance staff costs
  - Disposal of debris
  - Water requirements
  - Thoroughness of cleaning the pool
  - Durability

Vacuums

- In-Line
- Portable (With or without a filter)
- Automatic: Pressure Side
  (Uses a booster pump and collects debris in an on-board bag)
- Automatic: Pressure side sweeps
- Automatic: Suction Side
- Robots
- Rechargeable
- Hand Pump (Slurp)
- Pop-up (In- Floor)

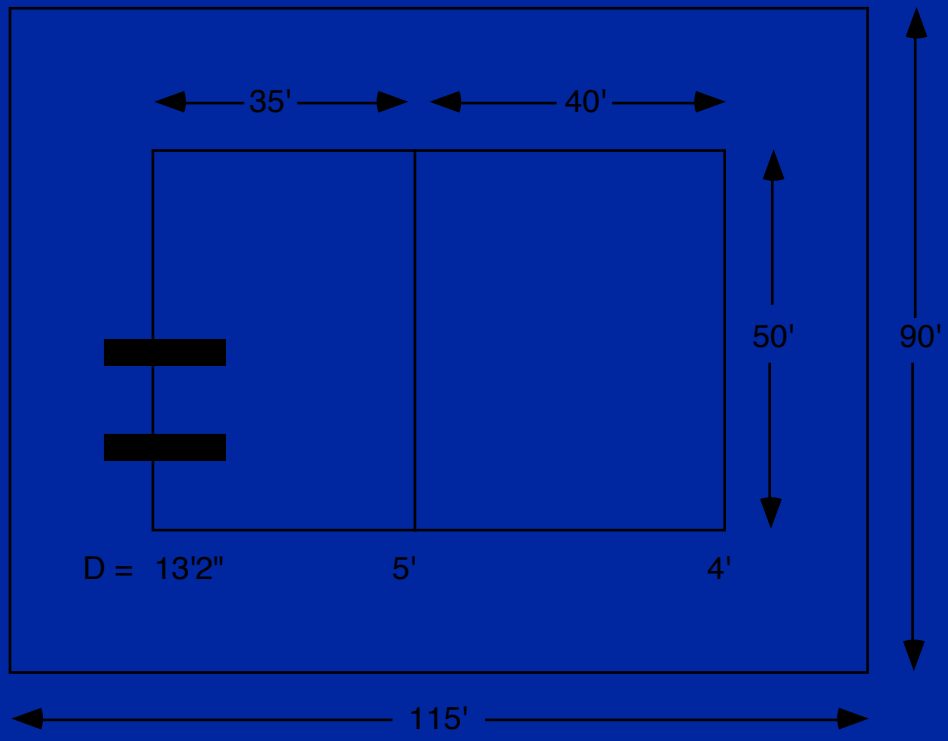
Bather Capacity Limits

- Patron safety
- Equipment is sized to permit sanitary operation of the facility based on reasonable patron use

Methods of Determining Bather Load

- Square footage of pool water surface area (CA, VA, WY, OR)
- Flowrate (FL, AK)
- Gallons of water in the pool (LA, AR)
- Variation of the APHA standard in which the pool is divided into shallow, deep, diving, and deck areas (Most states)
- Not specified (HI, KY, ME, MT, NH, OH, TN)
- No bathing codes (KS, MS)
- Spas
  - Usually 1 bather for each 10 square feet of surface area
  - Linear feet of seating tier in spas (1:3')

Bather Load Example



The dimensions of a commercial swimming pool are 25 yards in length by 50 feet in width. Depth ranges from a minimum of 4 feet to a maximum of 13'2". Fifty-three percent, or a section of the pool 40 feet by 50 feet in area, is 5 feet or less in depth. Two diving boards are installed in the pool. The deck surrounding the pool measures 90 feet by 115 feet.

Bather Load Example

California (187)

1 bather for each 20ft^2 of water surface area

Florida (103)

1 bather for each 5 gpm of water circulated

Louisiana (372)

1 bather for each 500 gallons of water in the pool

Bather Load Example

Pennsylvania (315)

- 1 bather per 10 ft^2 of water surface area less than 5 feet deep
- 1 bather per 25 ft^2 of water surface area greater than 5 feet deep
- 3 patrons per 300 ft^2 of water surface area reserved around each diving board or platform and not included in computing the deep area
- 1 additional patron per 50ft^2 in excess of the minimum deck area required (4 feet, 6-8 feet behind diving boards) as long as the maximum number does not exceed $P = B \div 0.25$, where P = the maximum number of patrons permitted through the gate as long as sufficient lounging area is available, and B = the maximum number of bathers permitted in shallow, deep and diving areas.