CHAPTER 8

RECIRCULATION AND FILTRATION SYSTEMS

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- Calculate pool volume.
- Understand the flow of water to and from the pool.
- Calculate the flow rate of a swimming pool.
- List the flow rates for the various types of filters.
- Explain why “backwashing” is necessary for proper recirculation and filtration.
- Compare the different types of filtration systems.
- Explain the purpose of flocculants.

Before any water treatment, chemical adjustment, or evaluation of a problem, the pool operator must know how much water is in the pool. This is determined by calculating the volume of water in the pool.

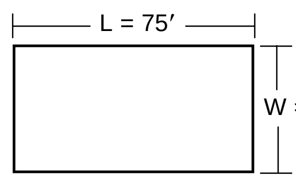
To determine the amount of water in your pool, use formulas that match the shape of the pool. The first step in calculating volume is to calculate area. Once the surface area of a pool is known, it is multiplied by depth to determine volume.

Calculating the Area of Pools

Regularly Shaped Water Bodies

Rectangles – The area of a rectangle is found by multiplying the length (L) by the width (W).

Area = length × width



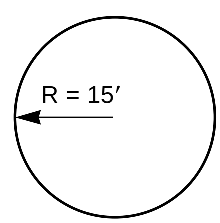
Example:

L = 75 feet — Area = 75 ft. × 40 ft.

W = 40 feet — Area = 3,000 sq. ft.

Circles – The area of a circle is 3.14 (π) times the radius (half the diameter) times the radius.

Area = πr^2 OR **3.14 × radius × radius**



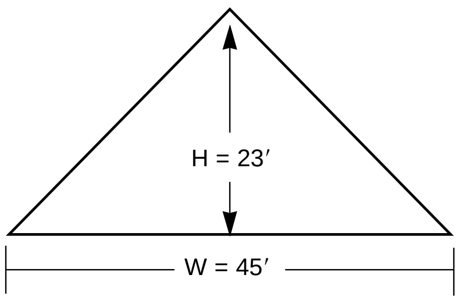
Example:

r = 15 feet — Area = 3.14 × 15 ft. × 15 ft.

Area = 706.5 sq. ft.

Triangles – To find the area of a triangle, multiply the width at the base (W) by the height (H), and divide by 2.

$$\text{Area} = \frac{W \times H}{2}$$



Example:

W = 45 ft.

H = 23 ft.

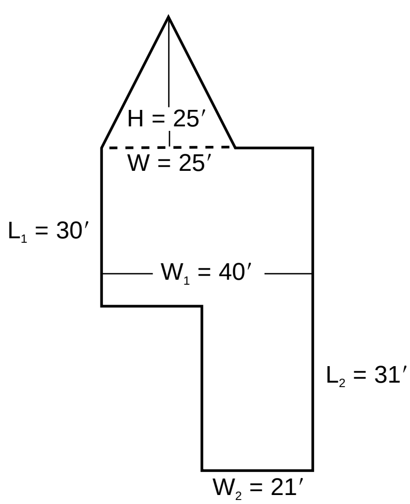
$$\text{Area} = \frac{45 \text{ ft.} \times 23 \text{ ft.}}{2}$$

Area = 517.5 square feet

Irregularly Shaped Sites

Irregularly shaped pools often can be reduced to a combination of rectangles, circles and triangles. Calculate the area of each and add them together to obtain the total area.

$$\text{Area} = \frac{(W \times H)}{2} + (L1 \times W1) + (L2 \times W2)$$



Example:

W = 25 feet	W_1 = 40 feet
H = 25 feet	L_2 = 31 feet
L_1 = 30 feet	W_2 = 21 feet

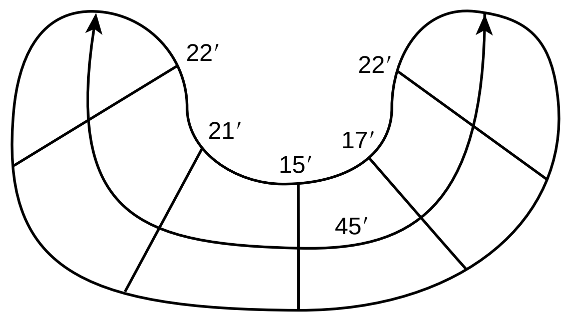
$$\text{Area} = \frac{(25 \text{ ft.} \times 25 \text{ ft.})}{2} + (30 \text{ ft.} \times 40 \text{ ft.}) + (21 \text{ ft. x } 31 \text{ ft.})$$

Area = 312.5 sq. ft. + 1,200 sq. ft. + 651 sq. ft.

Total area = 2,163.5 sq. ft.

Another way is to establish a line down the middle of the pool for the length, and then measure from side to side at several points along this line. pools with very irregular shapes require more side-to-side measurements. The average of the side measurements can be used as the width. The area is then calculated as a rectangle.

$$\text{Area} = \frac{L \times (a + b + c + d + e)}{\text{number of side-to-side measurements}}$$



Example:

L = 45 feet	c = 15 feet
a = 22 feet	d = 17 feet
b = 21 feet	e = 22 feet

$$\text{Area} = \frac{45 \text{ ft.} \times 22 \text{ ft.} + 21 \text{ ft.} + 15 \text{ ft.} + 17 \text{ ft.} + 22 \text{ ft.}}{5}$$

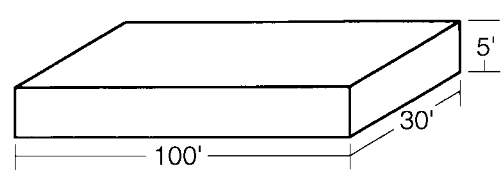
Area = 873 square ft.

Calculating Volume of Pools

To treat bodies of water, you must determine the volume of the water. Volume of water is determined by multiplying the surface area by the depth. Irregularly shaped pools will often be a combination of shapes. Similar to what you did in the previous examples for finding the area of irregularly shaped pools, reduce the pool to a combination of rectangles, circles and triangles. Determine the area, and multiply the area by the depth to calculate the volume. With irregularly shaped pools, add the volume of each section together to obtain the total volume.

Pools Shaped Like Cubes or Boxes – The volume of a cube or box is found by multiplying the length (L) by the width (W) by the depth (D).

$$\text{Volume} = \text{length} \times \text{width} \times \text{depth}$$



Example:

l = 100 feet w = 30 feet d = 5 feet

Volume = 100 ft. x 30 ft. x 5 ft.

Volume = 15,000 cubic ft. (feet3)

One cubic foot = 7.48 gallons of water. Therefore, 15,000 x 7.48 = 112,200 gallons of water in this rectangular pool.

For accurate calculations, divide the pool into various areas according to depth. If the slope of an area is constant, an average of the shallow depth and deepest depth may be used. To calculate volume in varying sloped pools, determine the volume in sections that do have constant slopes and add together.

Example:

$$\textbf{Volume} = \textbf{length} \times \textbf{width} \times \frac{(\textbf{depth}_1 + \textbf{depth}_2)}{2}$$

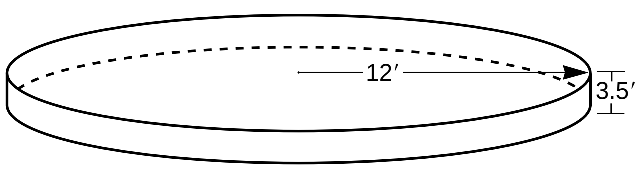
$$40 \times 20 \times \frac{(6+3)}{2} = 3{,}600 \text{ cubic ft.}$$

3,600 cubic ft. × 7.48 gallons/cu. ft. = 26, 928 gallons

Shaped Like Cylinders

The volume of a cylindrical pool or spa is found by multiplying the depth by the area of the circle at the base. The area of the circle is the radius (half the diameter) times the radius times 3.14.

Volume = depth x 3.14 x radius x radius



Example:

depth = 3.5 feet radius = 12 feet

Volume = 3.5 ft. × 3.14 × 12 ft. × 12 ft.

Volume = 1,582.5 cubic ft (feet3)

1,582.5 cu. ft. × 7.48 gallons/cu. ft. = 118,371 gallons

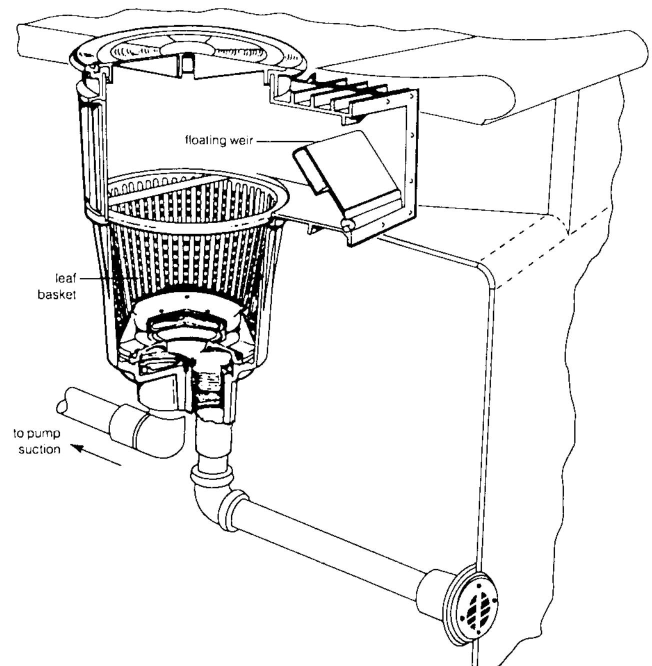
Pool Filter Systems and Operation

Public swimming pools, spas, wading pools, wave pools, etc. are required to have the water recirculated continuously, 24 hours a day. A series of **drains** and **skimmers** move the water from the pool through the **hair and lint strainer, pump, filter, heater,** and return the water back to the pool through small openings, called **inlets**, in the pool wall and sometimes in the floor.

Skimmers

The pool is designed so that the water level and cleanliness level remain fairly constant. Water is delivered to the filters either drawn through several openings in the pool wall called s**kimmers** or from an overflow system in the gutter that extends around the pool perimeter. These devices are designed for moving water at a specific rate along the piping to the pump.

Frequently clean the skimmers and grates in the overflow gutters to ensure that larger debris is removed before reaching the hair and lint skimmer. Many of these surface skimmers are the connection points for the vacuum cleaning systems for the pool. On the skimmer opening is a moving part called the weir or gate. The weir keeps larger floating materials confined in the skimmer so they can be easily removed.



Skimmer system

Filtration

The physical removal of dirt and debris from pool water is called filtration. Only pool water should be returned to the filtration equipment from the skimmers and main drains of the pool, i.e., no water from the decks, drinking fountains, or any type of dehumidifying equipment is allowed to drain back into the pool water.

Pool water travels within a closed loop of piping through the hair and lint strainer where the larger debris in the water is removed before reaching the pump. Water is said to be under **suction** from the pool, through the hair and lint strainer, then into the pump and attached impeller. After the pump, water is said to be under **pressure** when moving through the filter, heater and piping back to the pool.

The chemical feeder of disinfectants is attached to the filtration system. The pool filter not only helps clean the water of algae and smaller particulate matter, but also mixes the disinfectant with the water. Without a clean and properly functioning filtration system water clarity is impaired.

Turnover rate

All of the water in the pool must be filtered within a specified time period. This is called the **turnover rate**. The clarity of typical public swimming pool water is optimal when the turnover rate is between 6-8 hours. Other pools have different rates dependent upon their size, type and volume. For example, spa pools and wading pools usually have a turnover rate of 1 hour or less, while for wave pools it is 4 hours or less.

For a swimming pool, there may need to be several turnovers during the 24 hour period since only 68% of the contaminants are removed in 6-8 hours. In two turnover periods (12-16 hours) approximately 96% of debris is removed. Only a very small amount of material remains after 24 hours (less than 0.5% is not removed).

To calculate the turnover rate of a pool in gallons per minute (gpm), use the following formula with the specific volume of your pool.

Required flow rate in gallons per minute = volume/divided by time

For example, if a pool has a volume of 36,000 gallons and the required turnover rate is 6 hours:

$$\text{FLOW RATE} = \frac{\text{VOLUME}}{\text{(HOURS) x (60 min./hr)}}$$

$$\text{Flow Rate} = \frac{\text{36,000 gal}}{\text{6 HRS x 60 min./hr}}$$

$$\text{Flow Rate} = \text{100 G.P.M.}$$

Therefore, if 100 gallons of water per minute (gpm) passes through the filter, all the water in the pool will be recirculated in 6 hours.

Filter area

Each type of filtration system allows water to pass through the filtering media at a specific rate —**filter rate**—measured in gallons per minute (gpm) per square foot of filter area. For example, a high rate sand filter could have a filter rate of 12 to 20 gpm per square foot of effective filter surface area. See Table One. A cartridge system, by comparison, would have a flow rate of 0.375 gpm per square foot of surface area.

Sand filter system.

Filters are sized according to the volume of water that needs to be filtered within the specified turnover rate. A pool volume of 36,000 gallons with a desired turnover rate of 6 hours, or 100 gpm, would need a *high rate sand filter* with approximately 7 square feet of filter surface area. First, divide the pool volume by the **desired turnover rate** to determine flow rate (36,000/6 hrs x 60 min/hr = flow rate). Next, divide the flow rate by the appropriate filter flow rate per square foot (from Table One.) to determine the size of the filter surface area needed, i.e., 100 gpm flow rate divided by 15 gpm/sq. ft. = 6.67 or 7 sq. ft. of filter surface area.

Table One. Filter flow rates for various types of filters

Vacuum sand filter	0.5 gpm/sq. ft.
Rapid sand filter	3.0 gpm/sq. ft.
High rate sand filter	12-20 gpm/sq. ft. (15 gpm/sq. ft. ideal)
D.E. filter(s)	2.0 gpm/sq. ft.
Cartridge filter	0.375 gpm/sq. ft.

Filter Media and Backwashing

The ability of the filter to trap and hold particulate matter from the pool water is dependent upon the size and type of media (filter substrate). A finer, smaller material such as diatomaceous earth (D.E.) will trap a greater amount of debris compared to sand media or the paper mesh of a cartridge filter.

When the filter media is clean there is little resistance against the water. However, when the filter gets dirty, the flow rate slows and filtering becomes less efficient, possibly causing cloudy water, algae build up, and more contaminants remaining in the pool water. Cleaning the filter media by mechanical or physical methods is called **backwashing**.

Backwashing sand filter systems usually involves reversing the flow of water through the filters by turning a valve or control lever to a backwash position. The reverse flow loosens the dirt in the filter media and rinses the debris to waste (eliminated from the system). In a diatomaceous earth (D.E.) filter system, the filter grids would be washed of D.E. powder during the backwash procedure and require recoating before reuse. Cartridge filters must have the entire mesh or woven element replaced with a cleaned or new unit.

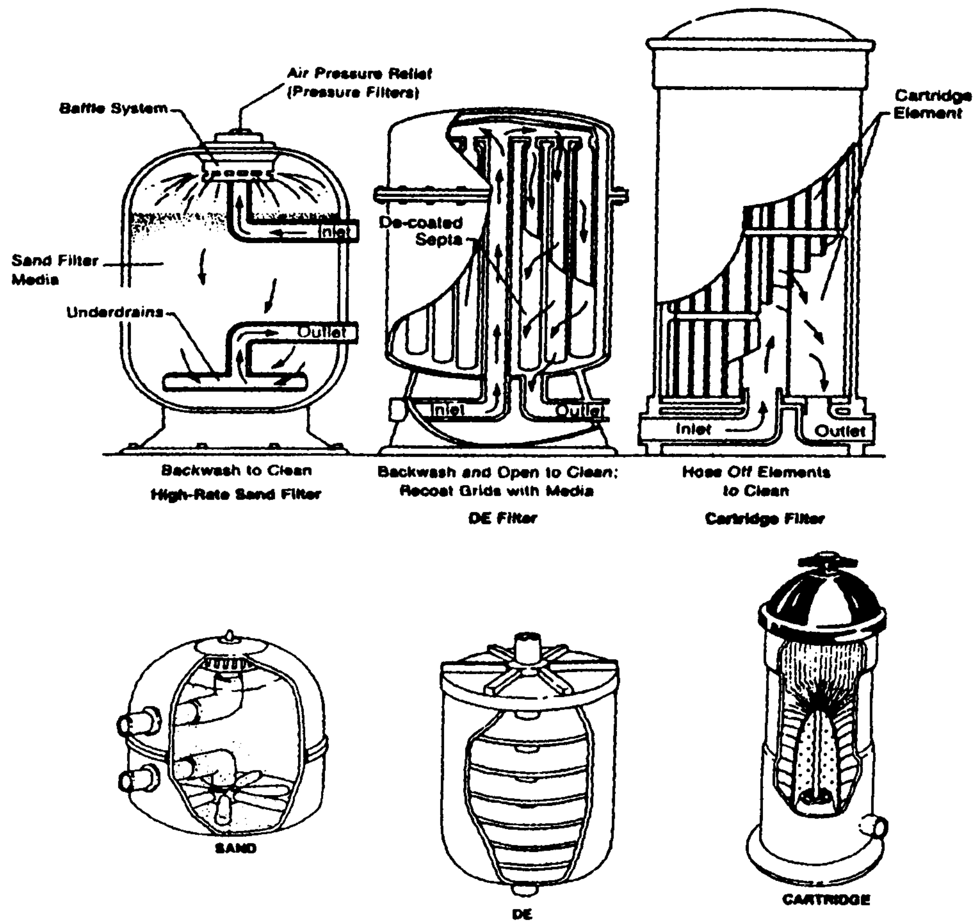
Backwashing requires that a specific flow rate is maintained during the procedure. Usually the rate is 12 to 15 gpm/sq.ft. for sand filters. Backwashing should be performed when the:

- incoming (influent) pressure is 10-12 psi greater than the pressure on a clean filter,
- flow rate decreases due to resistance in the dirty filter,
- pool water becomes cloudy and debris remains in the water.

High Rate Sand Filter

In high rate sand filters, to be effective, the filter needs a specific sand size to filter particulate matter in the pool water. The sand is packed around a series of finger-like projections called laterals or elements housed in a tank into which the water enters. The incoming water from the pool enters through these laterals and is discharged upward where it is reflected off the top of the tank cover and flows downward. This downward flow of the water inside the tank helps to prevent channeling and migration of the sand. Should channeling occur, the water will pass through the channel without being properly filtered.

An open space between the top of the tank and the top of the sand inside the tank is called the **freeboard**. The freeboard is usually 12 inches or more and must exist for the sand to "tumble and fluff-up," causing the debris to loosen for backwash removal.



Examples of Pool Filter Systems.

On the outlet (effluent) pipe, a pressure gauge is mounted. This gauge measures the pressure in the system of the "clean and filtered" water emerging from the filter, which should be lower than the influent gauge reading. Typically, the difference between the influent and effluent pressure gauges should not be more than 12-15 psi. Some filter equipment may have a higher differential based on the pool design.

Backwashing of the high rate sand filter for a time period of 2-3 minutes is recommended. Once the water discharge is clear, the backwashing is complete. Reposition the lever or handle of the backwash valves to a "filter run" position. If sand is found entering the pool through the inlets of the pool wall, there may be either a cracked or broken lateral, or the lever on the filter for backwashing may not be properly set in place.

Filter aids, or **flocculants**, are sometimes used for trapping surface dirt on the sand. Flocculants may not be recommended for use by the filter manufacturer since the filter will have an increased pressure from the restricted (clogged) surface. The use of D.E. powder in the filter is not recommended as a routine method of cleaning the pool of debris. D.E. may offer a temporary relief, while masking a significant filter problem. The filter size, pump impeller, or the entire circulation system may need to be re-evaluated to determine if it meets the cleaning demands of the pool size and volume of use.

Vacuum Sand Filters

The vacuum sand filter is not used as much as in previous years due to the inefficiency of the system. However, many older, community pools may have this type of filtration equipment. Filter rates are low at about 0.5 gallons of water per square foot of surface area, therefore more space is required for this open tank, gravity system. These systems allowed the operator to observe flocculation and possible channeling of the sand. Most vacuum sand systems have been replaced with newer high rate sand filters.

CHAPTER 8

Review Questions

Recirculation and Filtration Systems

Write the answers to the following questions, then check your answers with those in the back of the manual.

1. Calculate the pool volume in gallons if a 25’ x 50’ pool has a shallow end of 3 ft. and a deep end of 7 ft.

2. Explain the flow of water away from the pool and back into the pool. Underline key components of the system.

3. Calculate the flow rate in gallons per minute (gpm) of a 40,000 gallon pool requiring a 6 hour turnover. Also calculate for a pool requiring an 8 hour turnover rate.

$$\text{Flow rate} = \frac{\text{volume}}{\text{hours} \times 60 \text{ minutes/hour}}$$

4. What is the “filter flow rate” of a high rate sand filter? Is there an ideal filter flow rate? If so, what is it?

5. D.E. filters have a filter flow rate of 2.0 gpm / square ft. How much D.E. filter area is needed in a 36,000 gallon pool for a 6 hour turnover rate?

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D.E. filter(s)	2.0 gpm / sq. ft.
Cartridge filter	0.375 gpm / sq. ft.

$$\frac{\text{Pool volume in gallons}}{\text{turnover rate (60 min/hr)}} = \text{Flow rate gpm}$$

$$\frac{\text{Flow rate gpm}}{\text{Filter flow rate/sq. ft.}} = \text{square feet of filter area}$$

6. List 3 conditions that indicate that a pool should be backwashed.

7. Should flocculants be added to the pool frequently? Why or why not?

8. Are vacuum sand filters economical? Why or why not?

9. How do you calculate the area of the following?
   Circle:
   Triangle:
   Rectangle:
   Circle:
   Area :
   Triangle:

10. How do you calculate the area of an irregularly shaped pool?

11. How do you calculate the volume of water in a spa shaped like a cylinder?