CHAPTER 12
SAND FILTRATION

12-1. GENERAL.

Of the two commonly used pool filter systems, the sand system is the easiest to understand. Soil is trapped in the filter bed by a combination of two processes: (1) gelatinous and mucouslike substances and oils tend to cling to the grains of filter sand, and (2) solid particles lodge in the extremely small spaces and voids between the sand particles. As these two dirt collecting mechanisms work together, the filter bed stores more and more dirt and becomes increasingly dense and resistant to flow. Ultimately, adequate flow can no longer be sustained and the filter must be cleaned by backwashing.

12-2. FLOCCULATION.

a. The accumulation of the gelatinous and mucouslike substances referred to above is often described as flocculation. A sand bed does not become an efficient filter until a sufficient accumulation of floc (fine soil) inhibits the passage of very small solids. As a result the sand filter has to operate 8 to 16 hours before attaining its desired efficiency.

b. The formation of Hoc (filter efficiency) can be accelerated by adding aluminum sulphate or potassium alum to the recirculation stream ahead of the filter at the outset of the cycle. This practice is not nearly as widespread as it once was, however, because flocculation materials are not effective except at high pH. Since a high swimming pool water pH is not desirable for disinfection and oxidation reasons, many operators reject the practice. Because the filter bed will Hoc itself in due time, an acceptable practice is to sacrifice the first few hours of efficiency in return for the longer filter cycles which are obtained by letting the Hoc develop from soil in the pool.

12-3. EFFECT OF CHEMICALS.

It is important to note that the dirt holding characteristics of a sand filter are also affected by the chemical treatment of the pool water. Good chlorination practice burns up many unwanted materials which would otherwise collect in the filter bed. Chlorination also breaks down soil barriers already accumulated in the filter medium, thus reopening clogged spaces and passages.

12-4. ANTHRACITE FILTRATION.

Finely crushed hard coal (anthracite) can be used as a filter medium in the same manner as sand is used. It functions in the same way but is backwashed at lower velocities to prevent washing the medium to wastewater during the cleaning cycle.

12-5. SAND FILTER TYPES.

Two types of pressure sand filters, rapid sand and high rate sand, are commonly used in swimming pools today; a third type, referred to as gravity sand, is used occasionally. Rapid sand is the traditional system developed many years ago; high rate sand is relatively recent technology.

12-6. RAPID SAND FILTER CONSTRUCTION.

a. The typical rapid sand filter is a round steel vessel approximately 5 feet in height loaded with a 24-inch-deep bed of sand supported on four layers of gravel graded to uniform size (see figure 12.1). The stratified gravel bed performs two functions in the sand filter:

(1) It serves as a barrier which prevents the sand from washing through the underdrain into the pool during the filter cycle.

(2) It distributes the flow of water uniformly to the underside of the sand bed during the backwash cycle.

b. The size of sand particles in the filter bed is an important consideration. If the sand is too course, the voids between the particles are too large to trap fine solids. If the sand is too fine, the sand bed becomes too dense for dirt to accumulate between the sand grains. The ideal sand particle size for filtering has been established as 0.4 to 0.6 millimeters.

c. A splash plate is positioned above the sand bed to baffle the incoming water and prevent a direct impingement upon the filter bed. A perforated pipe or domelike underdrain is placed in the bottom layer of the coarse gravel to collect the filtered water for recirculation. The space in the filter vessel above the filter bed is referred to as “freeboard” area and is necessary to allow for expansion of the sand bed during backwash procedure.

12-7. RAPID SAND FILTER OPERATION.

a. Typically, the sand filter system on larger swimming pools is a battery of two, three, or four individual tanks manifolded together in order to receive relatively equal portions of the total flow during the filter

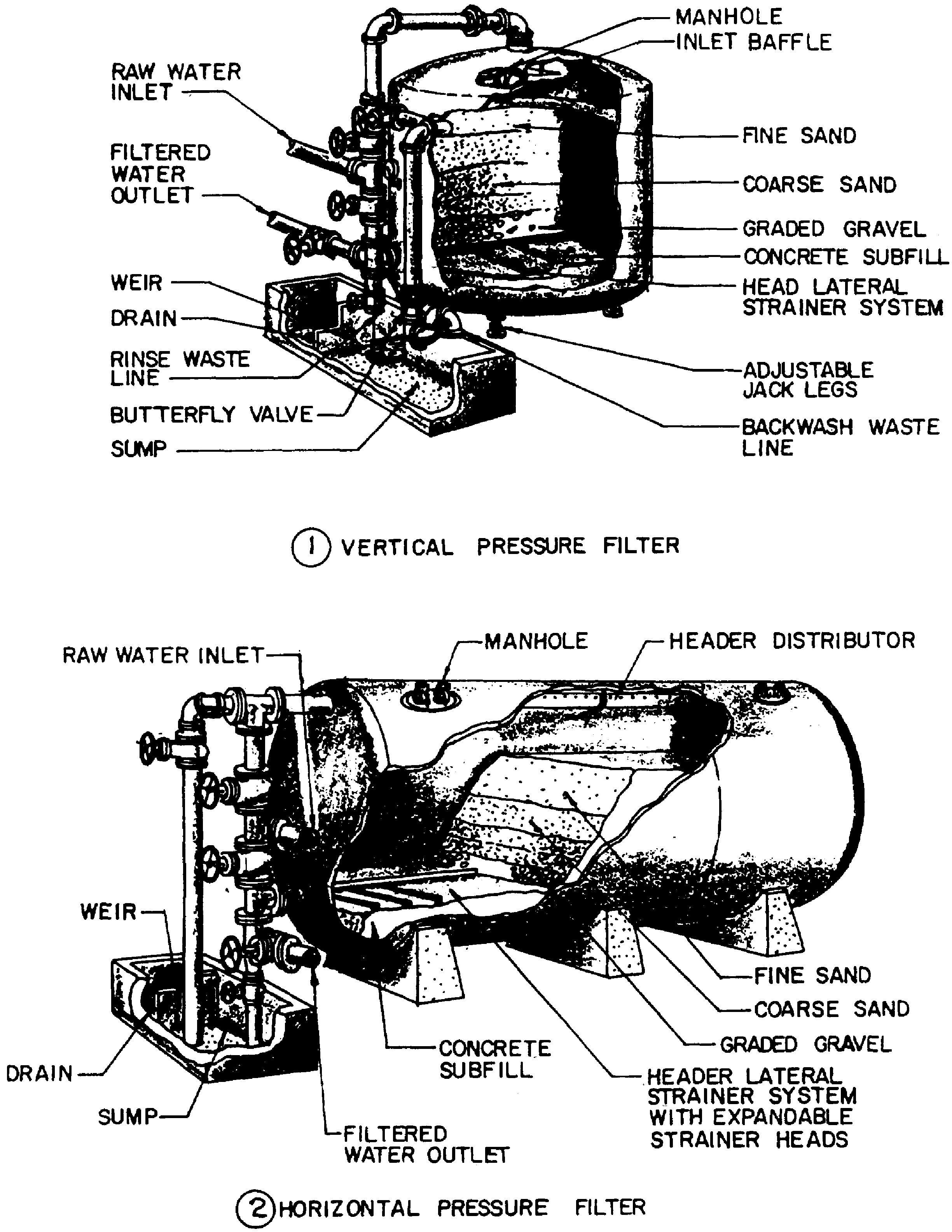

Figure 12.1. Manually operated pressure type rapid sand filters

cycle. This multiple cell arrangement provides an important accommodation to the backwash cycle. Since the sand filter must be backwashed at approximately four times the rate used during the filter cycle, the recirculation pump can provide the necessary backwash velocity only if the filter cells are backwashed one at a time. If the sand filter was a single vessel, a separate pump much larger than the one used for recirculation would be required for efficient backwash.

b. The diameter of the filter vessel is governed by the size of the pool and is specifically determined by the flow rate per square foot of surface area of the sand bed. The use of sand as a filter was introduced in the processing of public drinking water supplies, so the technology of sand filtration was quite naturally developed by public health agencies and the water works industry. During the development stage water was traditionally filtered at a rate of 3 gallons per minute per square foot (gal/min/ft^2) of sand bed surface area. Thus, if a given system requires a total flow of 600 gal/min, a filter system has to contain 200 square feet of sand surface area. Today it is still common practice to use 3 gal/mm/ft^2 as a standard of design and operation of swimming pool sand filters.

12-8. HIGH RATE SAND FILTER CONSTRUCTION.

The typical high rate sand filter is a round pressure vessel with a special influent baffle in the top of the tank, a bed of filter sand, and a mechanical underdrain system to collect the filtered water for recirculation. The underdrain is often designed to serve as a barrier to the migration of the sand bed and as a backwash water distributor without the requirement of the stratified gravel bed which was traditionally used in the rapid sand systems.

12-9. HIGH RATE SAND FILTER OPERATION.

a. The total plant size and hydraulic characteristics of the high rate system differs substantially from the rapid sand filter. Instead of operating at the traditional flow rate of 3 gal/min/ft^2, it operates at flow rates of 15 to 25 gal/mm/ft^2 of filter surface area. Because the total flow requirements of a given pool can be satisfied through a sand bed of considerably smaller surface area than in the case of rapid sand systems, the physical plant of the high rate filter is much smaller as well. It is therefore possible, for example, to adequately filter a 90,000-gallon pool through a single high rate filter tank 48-inches in diameter, whereas a rapid sand system for the same pool would require the use of a battery of three filter tanks, each 72 inches in diameter. Appendices F, Sizing a Rapid Sand Filter and G, Sizing a Diatomite Filter show the steps and assumptions for these calculations.

b. The high rate system provides an effluent of excellent quality, which appears largely due to its increased dirt holding capacity. The high flow rate drives the dirt load deeper into the filter bed, thus increasing the dirt-holding capacity of the medium. In the typical rapid sand system the primary soil load is confined to the top 2 to 4 inches of the sand bed, whereas the high rate filter collects soil through the entire depth of the sand bed.

c. The high rate filter system is normally backwashed at or near its filter flow rate of 15 to 25 gal/min/ft^2.

12-10. GRAVITY SAND FILTER.

The gravity sand system is an early swimming pool design that has been largely outdated by the pressure system which can be installed and operated in a much smaller area. Although the sand bed functions as a filter medium in the same manner in both systems, the gravity plant requires a much larger ground space than its equivalent pressure plant. Also, the backwashing procedure requires increases in both manual labor and water waste.

12-11. BACKWASH THEORY.

Backwashing cleans the filter by reversing the flow and causing the water to course upward through the bed. The backwash water action tends to slightly expand the bed, causing the sand particles to tremble and scrub against each other allowing the collected soil to break free and wash out of the filter vessel to a point of disposal. In rapid sand filter systems the backwash cycle is normally continued until the backwash effluent is observed to be free of soil, a period of about 8 to 10 minutes per cell. In high rate filters, backwash is accomplished in about 2 minutes because of the greater velocity of the backwash water.

12-12. BACKWASH OPERATION.

a. Backwashing the high rate filter is simple because there is generally only one tank in the system. However, the operator should understand the backwash function in the older rapid sand systems, based on several important observations

b. The accumulation of foreign material in a swimming pool filter causes the soil to clump to some extent. Hair or lint often serves as a structure, and balls of organic material (mud balls) form and become imbedded in the top layer of sand. If backwash velocities are insufficient to wash the clumps to waste, they will work their way deeper into the filter bed creating channels which ultimately permit unfiltered water to take a path of least resistance through the medium.

c. Another undesirable result of insufficient backwash velocities is termed calcification. If the bed is not disturbed enough to expand slightly, it may eventually become encrusted with a cementlike mass and become impervious to the flow of water. This phenomenon is particularly likely to occur if pH and total alkalinity of the pool water are permitted to become unreasonably high.

d. Both an inadequate backwash velocity and a backwash rate which substantially exceed 15 $gal/min/ft^2$ (25 $gal/mm/ft^2$ for high rate sand filters) are undesirable. In some circumstances the full capacity of the recirculation pump will cause the sand and gravel bed to tumble and partially invert the sand layer and the layer of small gravel immediately beneath it. If this condition occurs, channeling can take place similar to that caused by the mud-balling described above. The condition can be corrected only by removing and reloading the first two strata of media.

e. As indicated in the above discussions, backwashing of the rapid sand filter system involves much more than a mere reversal of flow. The operator must establish the backwash flow rate with care to avoid the problems which result from either inadequate or excessive flow rates. In addition, the operator must comply with any discharge flow restrictions in the facility National Pollutant Discharge Elimination System (NPDES) permit. State and/or local authorities should be consulted for compliance advice.

12-13. EQUIPMENT INSPECTION.

Regardless of the protection methods used, the bed or the rapid sand filter should be periodically inspected. If signs of mud-balling or calcification are observed, the bed should be soaked with corrective chemicals such as acids and detergents.