Private Sewage Disposal Systems

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Note: In determining your answers to the CE questions, use only the material presented in the corresponding continuing education article. Using information from other materials may result in a wrong answer.

With the ever-increasing cost of land located in proximity to urban centers, more and more construction is being implemented in outlying areas. Sanitary sewers are not usually available in these remote locations and it becomes necessary for the plumbing engineer to design private sewage systems to handle the wastes from buildings.

Where the concentration of population is not sufficient to economically justify the installation of public sewer systems, installation of a septic tank in conjunction with a subsurface soil absorption field has proven to be an exceptionally satisfactory method of sewage disposal. When properly designed, installed, operated, and maintained, it compares very favorably with the most sophisticated municipal sewage treatment plants.

SEWAGE SYSTEM CRITERIA

The proper disposal of sewage is a major factor affecting the health of the public. When improper or inadequate disposal of sewage occurs, many diseases, such as dysentery, infectious hepatitis, typhoid, paratyphoid, and various types of diarrhea are transmitted through contamination of food and water. To avoid such hazards, any system of sewage disposal must meet the following criteria:

- It must not contaminate any drinking water supply.
- It must not be accessible to insects, rodents, or other possible carriers that might come in contact with food or drinking water.
- It must not be accessible to children.
- It must not violate laws or rules and regulations governing water pollution or sewage disposal.
- It must not pollute or contaminate the waters of any bathing beach, shellfish breeding ground, or any stream used for public or private water supply or for recreational purposes.
- It must not become malodorous or unsightly in appearance.

All these criteria are admirably fulfilled by a public sewage disposal system. Every effort should be made to utilize such facilities if at all possible. When public sewers are not available, some other satisfactory method must be employed.

Any method of sewage disposal is merely an attempt to complete the hydrologic cycle, or as it is popularly called, the ecological cycle. Contaminated water (wastes) of undesirable quality is received and, after processing, returned at an acceptable level of quality. The systems to be discussed are those that return the wastewater to the soil and ultimately to the groundwater (water table).

Two types of systems return wastewater to the soil. They are the cesspool and the septic tank–soil absorption systems.

CESSPOOLS

A cesspool is nothing more than a covered pit with an open-jointed or perforated lining into which raw sewage is discharged. The liquid portion of the sewage is disposed by seepage or leaching into the porous soil surrounding the cesspool. The solids (sludge) are retained in the pit.

A cesspool finds its greatest application in receiving the effluent from one-family homes and it is not recommended even for this use. The raw sewage tends to seal the openings in the pit lining as well as the surrounding soil, thus necessitating frequent visits from the "honey dippers" (cesspool cleaning services). Cloggage may become so severe that complete abandonment of the existing cesspool and the construction of a new pit is often necessary. A cesspool should never be recommended as a substitute for a septic tank with a soil absorption field.

A seepage pit (discussed in another portion of this chapter) should never be confused with a cesspool. Although the construction is the same for both, a seepage pit receives the effluent from a septic tank (where the solids have been liquified), whereas a cesspool receives raw sewage.

SEPTIC TANKS

A septic tank is a liquid-tight structure, with inlet and outlet connections, which receives raw sewage. It is basically a sewage settling tank in which raw sewage is retained for a specified period of time, usually 24 hr. The primary purpose of the septic tank is to act as a settling tank and to break up solids so that the resulting effluent will not clog the pores of the soil in the leaching field. Very little purification is accomplished in the tank; the actual treatment and digestion of harmful waste materials takes place in the ground after discharge from the tank.

Three functions are performed by a septic tank to produce an effluent suitable for acceptance by a subsoil absorption system of sewage disposal: (1) removal of solids, (2) biological treatment, and (3) sludge and scum storage.

Removal of Solids

Clogging of the soil varies directly with the amount of suspended solids in the liquid. The rate of flow entering the septic tank is reduced within the tank so that solids sink to the bottom or rise to the surface of the liquid in the tank. These solids are retained and the clarified effluent is discharged.

Solids and liquid in the tank are exposed to bacterial and natural processes, which decompose them. The bacteria present in the wastes are of the anaerobic type, which thrives in the absence of oxygen. Decomposition of the sewage under anaerobic conditions is termed "septic" and it is from this the tank derives its name.

After such biological action, the effluent causes less clogging of the soil than untreated sewage containing the same quantity of suspended solids.

Sludge and Scum Storage

Sludge is an accumulation of solids at the bottom of the tank. Scum is a partially submerged floating mat of solids that forms at the surface of the liquid in the tank. The sludge is digested and compacted into a smaller volume. The same action occurs with the scum but to a lesser degree. Regardless of the efficiency of the operation of the septic tank, a residual of inert solid material will always remain. Adequate space must be provided in the tank to store this residue during the intervals between cleanings. Sludge and scum will flow out of the tank with the effluent and clog the disposal field in a very short period of time if pumping out of the residue is not performed when required.

Septic tanks are eminently effective in performing their purpose when adequately designed, constructed, operated, and maintained. They do not accomplish a high degree of bacteria removal. Although the sewage undergoes some treatment in passing through the tank, infectious agents present in the sewage are not removed. The effluent of a septic tank cannot be considered safe. In many respects, the discharged liquid is more objectionable than the influent because it is septic and malodorous. This should not be construed in any way as detracting from the value of the tank because its primary purpose is simply to condition the raw sewage so that it will not clog the disposal field.

Continued treatment and the removal of pathogens are accomplished by percolation through the soil. Disease-producing bacteria will die out after a time in the unfavorable environment of the soil. Bacteria are also removed by physical forces during filtration through the soil. This combination of factors achieves the eventual purification of the septic tank effluent.

Septic Tank Location

The location of the septic tank should be chosen so as not to cause contamination of any well, spring, or other source of water supply. Underground contamination can travel in any direction for considerable distances unless effectively filtered. Tanks should never be closer than 50 ft to any source of water supply and, where possible, greater distances are preferable. They should be located where the largest possible area will be available for the disposal field and should never be located in swampy areas subject to flooding. Ease of maintenance and accessibility for cleaning are important factors to be considered. When it is anticipated that public sewers will be available in the future, provisions should be made for the eventual connection of the house sewer to such a public source.

Tank Capacity

Studies have proven that liberal tank capacity is not only desirable from a functional viewpoint but is good economical design practice. The liquid capacities recommended in Table 21-1 make allowances for all household appliances including garbage grinders.

Table 21-1 Liquid Capacity of Tank, gal
(provides for use of garbage grinders, automatic clothes washers, and other household appliances)

Number of Bedrooms	Recommended Minimum Tank Capacity	Equivalent Capacity per Bedroom
2 or less	750	375
3	900	300
4[a]	1000	250

a For each additional bedroom, add 250 gal.

Tank Material

Septic tanks must be watertight and constructed of materials not subject to excessive corrosion or decay. Acceptable materials are concrete, coated metal, vitrified clay, heavyweight concrete blocks, or hard-burned bricks. Properly cured precast and cast-in-place, reinforced concrete are believed to be acceptable everywhere. Local codes should be checked as to the acceptability of the other materials. Steel tanks conforming to U.S. Department of Commerce Standard 177-62 are generally acceptable. Precast tanks should have a minimum wall thickness of 3 in. and should be adequately reinforced to facilitate handling. When precast slabs are used as covers, they should be watertight, at least 3 in. thick and adequately reinforced. All concrete surfaces should be coated with a bitumastic paint or similar compound to minimize corrosion.

Tank Access

Access should be provided to each compartment of the tank for cleaning and inspection by means of a removable cover or a 20-in. minimum size manhole. When the top of the tank is more than 18 in. below grade, manholes and inspection holes should be extended to approximately 8 in. below grade. They can be extended to grade if a seal is provided to prevent the escape of odors.

Tank Inlet

The invert elevation of the inlet should be at least 3 in. above the liquid level in the tank. This will allow for momentary surges during discharge from the house sewer into the tank and also prevent the backup and stranding of solids in the piping entering the tank.

A vented inlet tee or baffle should be provided to direct the influent downward. The outlet of the tee should terminate at least 6 in. below the liquid level but in no case should it be lower than the bottom of the outlet fitting or device.

Tank Outlet

The outlet fitting or device should penetrate the liquid level just far enough to provide a balance between the sludge and scum storage volumes. This will assure usage of the maximum available tank capacity. A properly operating tank divides itself into three distinct layers: scum at the top, a middle layer free of solids (clear space), and sludge at the bottom layer. While the outlet tee or device retains the scum in the tank, it also limits the amount of sludge that can be retained without passing some of the sludge out with effluent.

Data collected from field observation of sludge accumulations indicate that the outlet device should extend to a distance below the liquid level equal to 40% of the liquid depth. For horizontal cylindrical tanks the percentage should be 35. The outlet device or tee should extend up to within 1 in. of the top of the tank for venting purposes. The space between the top of the tank and the baffle permits gas to pass through the tank into the building sanitary system and eventually to atmosphere where it will not cause a nuisance.

Tank Shape

Available data indicate that for tanks of a given capacity and depth, the shape of a septic tank is unimportant and that shallow tanks function equally as well as deep ones. It is recommended, however, that the minimum plan dimension be 2 ft and the liquid depth range from 30 to 60 in.

Scum Storage Space

Space is required above the level of the liquid in the tank for the accumulated scum, which floats on top of the liquid. Although there is some variation, approximately 30% of the total amount of scum will accumulate above the liquid level and 70% will be submerged. In addition to the scum storage space, 1 in. should be provided at the top of the tank for free passage of gas through the tank back to the inlet and building drainage system.

For tanks with vertical walls, the distance between the top of the tank and the liquid level should be approximately 20% of the liquid depth. For horizontal cylindrical tanks, the liquid depth should be 79% of the diameter of the tank. This will provide an open area at the top of the tank equal to 15% of the total cross-sectional area of the tank.

Compartments

Although a number of arrangements are possible, compartments refer to the number of units in series. They can be separate units connected together or sections enclosed in one continuous shell with watertight partitions separating the individual compartments.

A single-compartment tank gives acceptable performance, but available research data indicate that a two-compartment tank with the first compartment equal to ½ to ⅔ of the total volume provides better suspended solids removal. Tanks with three or more equal compartments perform about on an equal basis with a single-compartment tank of the same total capacity. The use of a more than two-compartment tank is therefore not recommended. All the requirements of construction stated previously for a single-compartment tank apply to the two-compartment tank. Each compartment should be provided with an access manhole and venting between compartments for the free passage of gas.

Figure 21-1 illustrates all the salient features of a typical two-compartment septic tank.

Cleaning of Tanks

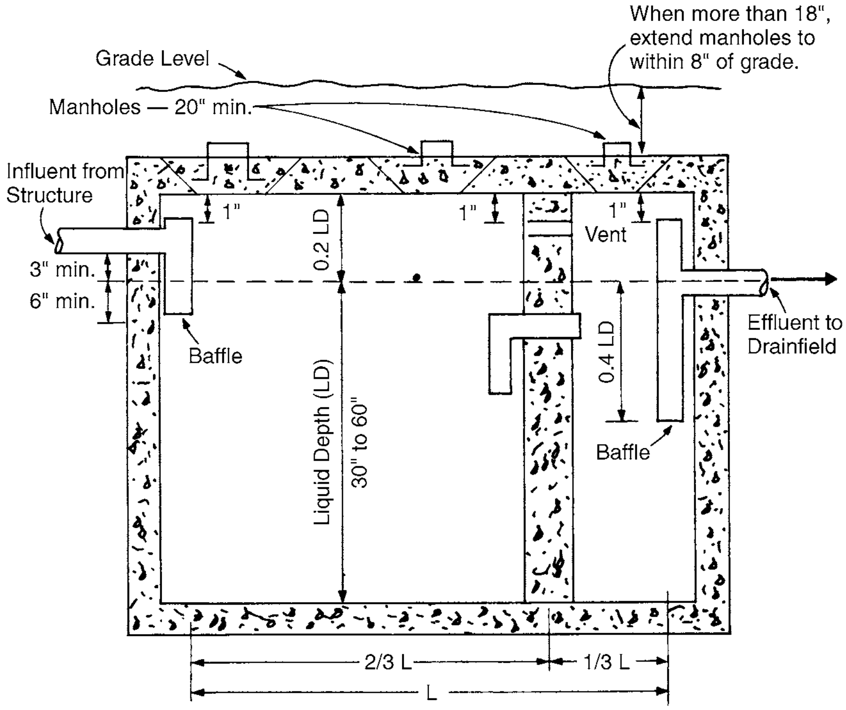
Before too much sludge or scum is allowed to accumulate, septic tanks should be cleaned to prevent the passage of sludge or scum into the disposal field. Tanks should be inspected at least once a year and cleaned when necessary.

Cleaning is usually accomplished by pumping the contents of the tank into a tank truck. A small residual of sludge should be left in the tank for "seeding" purposes. Tanks should never be washed or disinfected after cleaning.

Chemical Additives

The operation of a septic tank is not improved in any way whatsoever by the addition of chemicals; and such additions are not recommended. Some products that claim to "clean" septic tanks contain sodium hydroxide or potassium hydroxide as the active agent. Such compounds may result in sludge bulking and a sharp increase in alkalinity, which may interfere with digestion. The effluent may severely damage the soil structure of the disposal field and cause accelerated

Figure 21-1 Precast Septic Tank



clogging even though some immediate temporary relief may be experienced shortly after application of the product.

On the other hand, ordinary household chemicals in general use around the home will not have a harmful effect on the operation of a septic tank. Small amounts of chorine bleach or small quantities of lye or caustic are not objectionable. If tanks are sized as recommended herein, the dilution of the lye or caustics in the tank will be enough to minimize any harmful effects. Soaps, detergents, bleaches, drain cleaners, etc., will have no appreciable adverse effect on the system. However, since both the soil and the organisms might be susceptible to large doses of chemicals, moderation is recommended.

Toilet paper substitutes, paper towels, newspaper, wrapping paper, rags, and sticks should not be introduced into the septic tank. They may not decompose and are likely to lead to clogging of the disposal field.

Backwash from a household water-softening unit has no adverse effect on the operation of a septic tank, but may cause a slight shortening of life of the disposal field installed in a structured clay type soil.

Septic Tanks for Nonresidential Buildings

Table 21-1 gives the liquid capacity of tanks on the basis of the number of bedrooms. When designing a septic tank for other types of buildings, Table 21-2 may be used to estimate the quantity of sewage flow. The quantities listed are merely the best averages presently available and should be modified in localities or establishments where available information indicates a need to do so.

The retention period of the sewage in a septic tank should be 24 hr. Table 21-2 gives the gallons per person per day (24 hr). The required liquid capacity of the tank can then be determined by multiplying the values given in the table by the estimated population.

Tables 21-3 and 21-4 give daily gallonages in terms of fixtures for country clubs and public parks, respectively.

SUBSURFACE SOIL ABSORPTION SYSTEM

Criteria for Design

The first step in the design of a subsurface soil absorption sewage disposal system is to determine whether the soil is suitable for the absorption of the septic tank effluent. If it is, the next step is to determine the area required for the disposal field. The soil must have an acceptable percolation rate and should have adequate clearance from groundwater. In general, two criteria must be met:

1. The percolation rate should be within the range shown in Table 21-5 or Table 21-6.
2. The maximum elevation of the groundwater table should be at least 4 ft below the bottom of the trench or seepage pit. Rock formation or other impervious strata should be at a depth of more than 4 ft below the bottom of the trench or seepage pit.

Table 21-3 Sewage Flow from Country Clubs

Type of Fixture	Gallons per Day per Fixture
Showers	500
Baths	300
Lavatories	100
Toilets	150
Urinals	100
Sinks	50

Table 21-4 Sewage Flow at Public Parks
(during hours when park is open)

Type of Fixture	Gallons per Day per Fixture
Flush toilets	36
Urinals	10
Showers	100
Faucets	15

Table 21-2 Quantities of Sewage Flows

Type of Establishment	Gallons Per Person Per Day (unless otherwise noted)
Airports (per passenger)	5
Apartments–multiple family (per resident)	60
Bathhouses and swimming pools	10
Camps:	
Campground with central comfort stations	35
With flush toilets, no showers	25
Construction camps (semi-permanent)	50
Day camps (no meals served)	15
Resort camps (night and day) with limited plumbing	50
Luxury camps	100
Cottages and small dwellings with seasonal occupancy	50
Country clubs (per resident member)	100
Country clubs (per non-resident member present)	25
Dwellings:	
Boarding houses	50
additional for non-resident boarders	10
Luxury residences and estates	150
Multiple-family dwellings (apartments)	60
Rooming houses	40
Single-family dwellings	75
Factories (gallons/person/shift, exclusive of industrial wastes)	35
Hospitals (per bed space)	250
Hotels with private baths (2 persons per room)	60
Hotels without private baths	50
Institutions other than hospitals (per bed space)	125
Laundries, self service (gal/wash, i.e., per customer)	50
Mobile home parks (per space)	250
Motels with bath, toilet, and kitchen wastes (per bed space)	50
Motels (per bed space)	40
Picnic parks (toilet wastes only) (per picknicker)	5
Picnic parks with bathrooms, showers, and flush toilets	10
Restaurants (toilet and kitchen wastes per patron)	10
Restaurants (kitchen wastes per meal served)	3
Restaurants, additional for bars and cocktail lounges	2
Schools:	
Boarding	100
Day, without gyms, cafeterias, or showers	15
Day, with gyms, cafeterias, and showers	25
Day, with cafeterias, but without gyms or showers	20
Service stations (per vehicle served)	10
Swimming pools and bathhouses	10
Theaters:	
Movie (per auditorium seat)	5
Drive-in (per car space)	5
Travel trailer parks	
Without individual water and sewer hookups (per space)	50
With individual water and sewer hookups (per space)	100
Workers:	
Construction (at semi-permanent camps)	50
Day, at schools and offices (per shift)	15

If these two primary conditions cannot be met, the site is unsuitable for a soil absorption system and some other seepage disposal system must be employed.

Percolation Tests

Percolation tests help to determine the acceptability of the site and establish the size of the disposal system. The length of time required for percolation tests varies for different types of soil. The safest method is to make tests in holes that have been kept filled with water for at least 4 hrs and preferably overnight. Percolation rates should be determined on the basis of test data obtained after the soil has had the opportunity to become wetted or saturated.

Enough tests should be made in separate holes to assure the validity of results. The percolation test as developed at the Robert A. Taft Sanitary Engineering Center has proven to be one of the best in the country and is given here in its entirety:

Procedure for Percolation Tests

1. Number and Location of Tests. Six or more tests shall be made in separate test holes spaced uniformly over the proposed absorption field site.
2. Type of Test Hole. Dig or bore a hole, with horizontal dimensions of from 4 to 12 in. and vertical sides to the depth of the proposed absorption trench. In order to save time, labor, and volume of water required per test, the holes can be bored with a 4-in. auger.
3. Preparation of a Test Hole. Carefully scratch the bottom and sides of the hole with a knife blade or sharp-pointed instrument, in order to remove any smeared soil surfaces and to provide a natural soil interface into which water may percolate. Remove all loose material from the hole. Add 2 in. of coarse sand or fine gravel to protect the bottom from scouring and sediment.
4. Saturation and Swelling of the Soil. It is important to distinguish between saturation and swelling. Saturation means that the void spaces between soil particles are full of water. This can be accomplished in a short period of time. Swelling is caused by intrusion of water into the individual soil particle. This is a slow process, especially in clay-type soil, and is the reason for requiring a prolonged soaking period.

   In the conduct of the test, carefully fill the hole with clear water to a minimum depth of 12 in. over the gravel. In most soils, it is necessary to refill the hole by supplying a surplus reservoir of water, possibly by means of an automatic syphon, to keep water in the hole for at least 4 hrs and preferably overnight. Determine the percolation rate 24 hrs after water is first added to the hole. This procedure is to ensure that the soil is given ample opportunity to swell and to approach the condition it will be in during the wettest season of the year. Thus, the test will give comparable results in the same soil, whether made in a dry or wet season. In sandy soils, containing little or no clay, the swelling is not essential, and the test may be made as described under item 5C, after the water from one filling of the hole has completely seeped away.

Table 21-5 Absorption Area Requirements for Individual Residences[a]
(provides for garbage grinder and automatic clothes washing machines)

Percolation Rate (time required for water to fall 1 in.), in minutes	Required Absorption Area, in ft²/bedroom[b], standard trench[c], seepage beds[c], and seepage pits[d]
1 or less	70
2	85
3	100
4	115
5	125
10	165
15	190
30[c, e]	250
45[c, e]	300
60[c, e, f]	330

a It is desirable to provide sufficient land area for an entire new absorption system if needed in the future.
b In every case, sufficient land area should be provided for the number of bedrooms (minimum of two) that can be reasonably anticipated, including the unfinished space available for conversion as additional bedrooms.
c Absorption area is figured as trench bottom area and includes a statistical allowance for vertical side wall area.
d Absorption area for seepage pits is figured as effective side wall area beneath the inlet.
e Unsuitable for seepage pits if over 30.
f Unsuitable for absorption systems if over 60

Table 21-6 Allowable Rate of Sewage Application to a Soil Absorption System

Percolation Rate (time for water to fall 1 in.), in minutes	Maximum Rate of Sewage Application (gal/ft²/day)[a] for Absorption Trenches[b], Seepage Beds, and Seepage Pits[c]
1 or less	5.0
2	3.5
3	2.9
4	2.5
5	2.2
10	1.6
15	1.3
30[d]	0.9
45[d]	0.8
60[d, e]	0.6

a Not including effluents from septic tanks that receive wastes from garbage grinders and automatic washing machines.
b Absorption area is figured as trench bottom area, and includes a statistical allowance for vertical sidewall area.
c Absorption area for seepage pits is effective sidewall area.
d Over 30 unsuitable for seepage pits.
e Over 60 unsuitable for absorption systems.

5. Percolation Rate Measurement. With the exception of sandy soils, percolation rate measurements shall be made on the day following the procedure described under item 4, above.
   A. If water remains in the test hole after the overnight swelling period, adjust the depth to approximately 6 in. over the gravel. From a fixed reference point, measure the drop in water level over a 30-min. period. This drop is used to calculate the percolation rate.
   B. If no water remains in the hole after the overnight swelling period, add clear water to bring the depth of water in the hole to approximately 6 in. over the gravel. From a fixed reference point, measure the drop in water level at approximately 30-min intervals for 4 hrs, refilling 6 in. over the gravel as necessary. The drop that occurs during the final 30-min period is used to calculate the percolation rate. The drops during prior periods provide information for possible modification of the procedure to suit local circumstances.

C. In sandy soils (or other soils in which the first 6 in. of water seeps away in less than 30 min, after the overnight swelling period), the time interval between measurements shall be taken as 10 min and the test run for 1 hr. The drop that occurs during the final 10 min is used to calculate the percolation rate.

Absorption Area

For locations where the percolation rates and soil characteristics prove to be satisfactory, the next step is to determine the required absorption area from Table 21-5 for residences or from Table 21-6 for other types of buildings. As noted in the tables, soil in which the percolation rate is slower than 1 in. in 30 min is not suitable for seepage pits and a rate slower than 1 in. in 60 min is not satisfactory for any type of soil absorption system.

There are three types of soil absorption systems:

1. Absorption trenches
2. Seepage beds
3. Seepage pits

The selection of the system will be affected by the location of the system in the area under consideration. A safe distance must be maintained between the site and the source of any water supply. No specific distance can be absolutely safe in all localities because of the many variables involved in the underground travel of pollution. Table 21-7 can be used as a guide for establishing minimum distances between various components of a sewage disposal system.

Table 21-7 Minimum Distance Between Components of Sewage Disposal System

	Horizontal Distance (ft)				
Component of System	Well or Suction Line	Water Supply Line (pressure)	Stream	Dwelling	Property Line
Building sewer	50	10[a]	50	–	–
Septic tank	50	10	50	5	10
Disposal field and seepage bed	100	25	50	20	5
Seepage pit	100	50	50	20	10
Cesspool[b]	100	50	50	20	15

a Where the water supply line must cross the sewer line, the bottom of the water service within 10 ft of the point of crossing shall be at least 12 in. above the top of the sewer line. The sewer line shall be of cast iron with leaded or mechanical joints at least 10 ft on either side of the crossing.

b Not recommended as a substitute for a septic tank. To be used only when found necessary and approved by the health authority.

Seepage pits should never be installed in areas of shallow wells or where there are limestone formations and sinkholes with connection to underground channels through which pollution could travel to water sources.

Absorption Trenches

The drain pipe for a soil absorption field may be 12-in. lengths of 4-in. agricultural drain tile, 2–3 ft lengths of open-joint vitrified clay sewer pipe, or perforated nonmetallic pipe. Individual laterals should not exceed 100 ft in length and the trench bottom and piping should be level. Use of more and shorter laterals is recommended because if a breakdown should occur in any one lateral, most of the field would still be operative. The space between laterals should be at least twice the depth of gravel to prevent overtaxing the percolative capacity of the adjacent soil.

The depth of the absorption trenches should be at least 24 in. to provide the minimum required gravel depth and earth cover. Additional depth may be required for ground contour adjustment, for extra aggregate specified under the pipe, or for other design purposes. The minimum distance of 4 ft between the bottom of the trench and the water table is essential to minimize groundwater contamination. Freezing is an extremely rare occurrence in a well-constructed system that is kept in continuous operation. It is of course extremely important that the pipe be completely surrounded by the gravel to provide for free movement of the wastewater.

The required absorption area is based upon the results of the percolation tests and may be selected from Table 21-5 or 21-6.

Example 21-1

For a three-bedroom house and a percolation rate of 1 in. in 15 min, the necessary absorption area will be 3 bedrooms × 190 ft^2 per bedroom (Table 21-5) = 570 ft^2. For 2-ft-wide trenches with 6 in. of gravel below the drain pipe the total length of trench will be: 570 ÷ 2 = 285 ft. If this length is divided into three portions (3 laterals), the length of each lateral will be 285 ÷ 3 = 95 ft. If this length is too long for the site, the number of laterals must be increased. Using 5 laterals, the length of each lateral will be 57 ft. If the trenches are separated by 6 ft, the width of the field will be 2-ft-wide trenches × 5 trenches = 10 ft plus 6 ft between trenches × 4 spaces = 24 ft. The total field will then be 57 ft in length by 34 ft. in width for a total area of 1938 ft^2 plus the additional land required to keep the field an acceptable distance from property lines, wells, etc.

Construction

Careful construction is extremely important in achieving a satisfactory soil absorption system. Care must be exercised so as not to seal the surfaces on the bottom and sides of the trenches. Trenches should not be excavated when the soil is wet enough to smear or compact easily. Open trenches should always be protected from surface runoff to prevent entrance of silt and debris. All smeared or compacted surfaces should be raked to a depth of 1 in. and loose material removed before placing gravel in the trench.

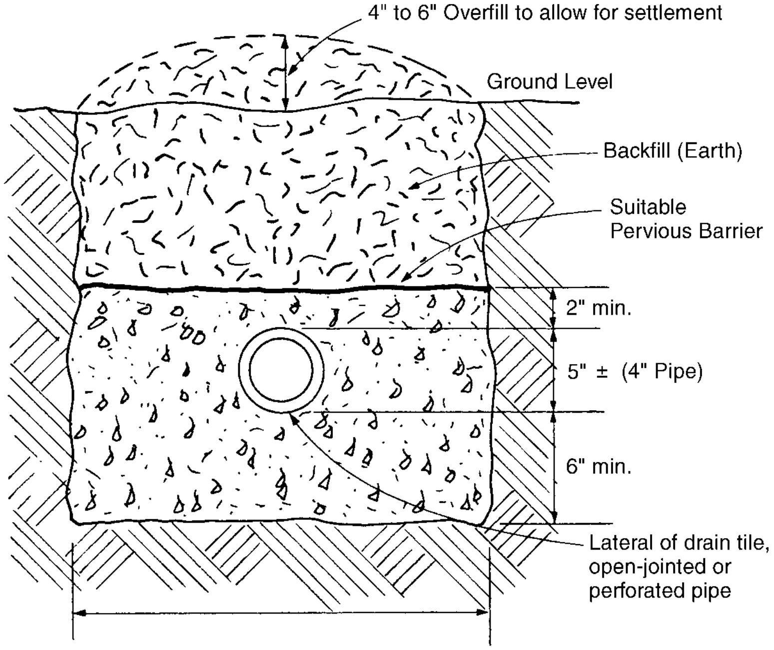
The pipe should be completely surrounded by clean, graded gravel ranging in size from ½ to 2½ in. Cinders, broken shells, or similar materials are unsuitable as they are too fine and will lead to premature clogging of the soil. The gravel should extend at least 2 in. above the top of the pipe, at least 6 in. below the bottom of the pipe and fill the entire width of the trench. The top of the gravel should be covered with untreated building paper or a 2-in. layer of hay, straw, or similar pervious material to prevent the earth backfill from clogging the gravel. If an impervious covering is used, it will interfere with evapotranspiration at the surface. This is an important factor in the operation of a disposal field and, although evapotranspiration is not generally taken advantage of in the calculations, it provides an added factor of safety.

If tile pipe is used, the upper half of the joint openings should be covered. Drain tile connectors, collars, clips or other spacers with covers for the upper half of the joints may be used to assure uniform spacing, proper alignment, and protection of the joints. They are available in galvanized iron, copper, and plastic.

The problem of root penetration can be avoided by the use of a liberal quantity of gravel around the pipe. There should be at least 12 in. of gravel beneath the pipe when a trench is within 10 ft of large trees or dense shrubbery.

Backfilling of the trench should be hand tamped and the trench should be overfilled at least 4 to 6 in. This will prevent settlement to a point lower than the surface of the adjacent ground where storm water could collect and cause premature saturation of the absorption field and possible complete washout of the trench. Machine tamping or hydraulic backfilling should never be permitted. Figure 21-2 illustrates a typical absorption trench.

Figure 21-2 Section through Typical Absorption Trench



Seepage Beds

The use of seepage beds in lieu of standard trenches has been around for over twenty-five years. Common design practice for soil absorption fields is for trenches with widths varying from 12 to 36 in. When trenches are wider than 3 ft they are called seepage beds. Typically rectangular in shape, seepage beds are compact and used when less land is available for system design. Dry climates prove to be a better environment for use than climates having wet, humid conditions. Keep in mind, seepage beds do not have the sidewall area to provide oxygen to the center of a bed and long-term performance depends on the condition of the sidewall area. Slopes greater than 5% are not suitable for this absorption system application. Care must be taken during construction so as not to destroy soil structure by compacting the soil in the bottom of the bed. Additionally, the Federal Building Administration has sponsored studies indicating that seepage beds are a satisfactory method for disposing of the effluent from septic tanks in soils that are satisfactory for soil absorption systems. The studies have demonstrated that the empirical relationship between percolation tests and the bottom area of trenches is applicable for the design of seepage beds.

The three main elements of a seepage bed are the same as those of trenches:

1. The absorption surface
2. The gravel layer
3. The distribution system.

The advantages of seepage beds are (1) a wide bed makes more efficient use of land than a series of long narrow trenches with wasted land between the trenches and (2) efficient use can be made of a variety of modern earth-moving equipment already at the site, which will result in lower costs for the system.

Design Criteria for Seepage Beds

The following criteria should be adhered to in the design of seepage beds:

1. The amount of bottom absorption area shall be the same as for trenches, shown in Table 21-5 or 21-6.
2. Percolation tests should be performed as previously outlined.
3. The bed should have a minimum depth of 24 in. to provide a minimum earth backfill cover of 12 in.
4. The bed should have a minimum of 12 in. depth of gravel extending at least 2 in. above and 6 in. below the pipe.
5. The bottom of the bed and the distribution tile or perforated pipe should be level.
6. The drain lines for distributing the effluent from the septic tank should be spaced no greater than 6 ft apart and no greater than 3 ft from the bed sidewalls.

Distribution Boxes

Although many codes specifically require the use of a distribution box in a soil absorption system, research and field tests have conclusively demonstrated that they offer practically no advantages and can be a source of serious problems in many installations. As a result of its study of distribution boxes, the Public Health Service set forth the following conclusions in the report to the Federal Housing Administration:

1. Distribution boxes can be eliminated from septic tank-soil absorption systems in favor of some other method of distribution without inducing increased failure of disposal fields. In fact, evidence indicates that distribution boxes as presently used may be harmful to the system.
2. Data indicate that on level ground, equal distribution is not necessary if the system is designed so that an overload trench can drain back to the other trenches before failure occurs.
3. On sloping ground a method of distribution is needed to prevent excessive buildup of head and failure of any one trench before the capacity of the entire system is utilized. It is doubtful that distribution boxes as presently used give equal distribution. Rather, they probably act as diversion devices sending most of the liquid to part of the system.

Because of the above findings, it is recommended that distribution boxes be eliminated in all disposal field systems where they are not specifically required by local codes.

Seepage Pits

Where absorption fields are impractical, seepage pits may be applicable. The capacity of a seepage pit should be computed on the basis of percolation tests made in each vertical stratum penetrated. The weighted average of the results should be used to obtain the design figure. Soil strata in which percolation rates are in excess of 30 min/in. should not be included in computing the absorption area.

Effective Area of Seepage Pit

The effective area of a seepage pit is the vertical wall area of the pervious ground below the inlet. The area of the bottom of the pit is not considered in calculating the effective area nor is any impervious vertical areas. Table 21-8 is a compilation of vertical surface area for various pit diameters and depths. The bottom of the pit must always be at least 4 ft above groundwater table.

Table 21-8 Vertical Wall Areas of Seepage Effective Strata Depth Below Flow Line (below inlet)

Diameter of seepage pit (feet)	1 foot	2 feet	3 feet	4 feet	5 feet	6 feet	7 feet	8 feet	9 feet	10 feet
3	9.4	19	28	38	47	57	66	75	85	94
4	12.6	26	38	50	63	75	88	101	113	126
5	15.7	31	47	63	79	94	110	126	141	157
6	18.8	38	57	75	94	113	132	151	170	188
7	22.0	44	66	88	110	132	154	176	198	220
8	25.1	50	75	101	126	151	176	201	226	251
9	28.3	57	85	113	141	170	198	226	251	283
10	31.4	63	94	126	157	188	220	251	283	314
11	34.6	69	101	138	173	207	212	276	311	346
12	37.7	75	113	151	188	226	264	302	339	377

Example: A pit of 5-foot diameter and 6-foot depth below the inlet has an effective area of 94 square feet. A pit of 5-foot diameter and 16-foot depth has an area of 94 + 157, or 251 square feet.

When more than one pit is required to obtain the necessary absorption area, the distance between the walls of adjacent pits should be equal to three times the diameter of the largest pit. For pits 20 ft or greater in depth the minimum spacing between walls should be 20 ft.

Construction of Seepage Pit

All loose material should be removed from the excavated pit. The pit should be backfilled with clean gravel to a depth of 1 ft above the pit bottom to provide a sound foundation for the pit lining. Material for the lining may be clay or concrete brick, block, or rings. Rings should have weepholes or notches to provide for seepage. Brick and block should be laid dry with staggered joints. Brick should be laid flat to form a 4-in. wall. The outside diameter of the lining should be 12 in. less than the diameter of the pit to provide a 6-in. annular space between the lining and pit wall. This annular space should be filled with clean, coarse gravel to the top of the lining.

Flat concrete covers are recommended. They should be supported by undisturbed earth and extend at least 12 in. beyond the excavation. The cover should not bear on the lining for support. A 9-in. capped opening in the pit cover is convenient for pit inspection. All concrete surfaces should be coated with a bitumastic paint or similar product to minimize corrosion.

All connecting piping should be laid on a firm bed of undisturbed soil throughout their length and at a minimum grade of 2% (¼ in./ft). The pit inlet pipe should extend at least 1 ft into the pit with a tee or ell to direct the flow downward to prevent washing and eroding of the sidewalls. When more than one pit is utilized they should be connected in series.

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Expiration date: Continuing education credit will be given for this examination through **June 30, 2018**.

CE Questions — "Private Sewage Disposal Systems" (CEU 248)

1. What is the maximum rate of sewage application to a soil absorption system if the percolation rate is five minutes?
   a. 2.5 gal/ft^2/day
   b. 2.2 gal/ft^2/day
   c. 1.6 gal/ft^2/day
   d. 1.3 gal/ft^2/day

2. The bottom of a seepage pit must always be at least ________ above the groundwater table.
   a. 2 feet
   b. 4 feet
   c. 6 feet
   d. 8 feet

3. Which of the following is a covered pit with an open-jointed or perforated lining into which raw sewage is discharged?
   a. seepage pit
   b. septic tank
   c. cesspool
   d. drainage ditch

4. What is the minimum recommended septic tank capacity for a five-bedroom house?
   a. 750 gallons
   b. 900 gallons
   c. 1,000 gallons
   d. 1,250 gallons

5. A seepage pit should be located ________ minimum from a water supply line.
   a. 50 feet
   b. 20 feet
   c. 10 feet
   d. 5 feet

6. A________ is a liquid-tight structure, with inlet and outlet connections, which receives raw sewage.
   a. seepage pit
   b. septic tank
   c. cesspool
   d. drainage ditch

7. A private sewage disposal system must not ________.
   a. contaminate any drinking water supply
   b. be accessible to children
   c. become malodorous or unsightly in appearance
   d. all of the above

8. What is the estimated quantity of sewage flow from a day school with gyms, cafeterias, and showers?
   a. 5 gal/person/day
   b. 10 gal/person/day
   c. 15 gal/person/day
   d. 25 gal/person/day

9. ________ is a partially submerged floating mat of solids that forms at the surface of the liquid in a septic tank.
   a. scum
   b. sludge
   c. sewage
   d. effluent

10. The depth of an absorption trench should be at least ________ to provide the minimum required gravel depth and earth cover.
   a. 12 inches
   b. 24 inches
   c. 36 inches
   d. 48 inches

11. Which of the following is an acceptable material of construction for a septic tank?
   a. concrete
   b. hard-burned bricks
   c. vitrified clay
   d. all of the above

12. When a trench for a soil absorption field is wider than 3 feet, it is called a ________.
   a. seepage pit
   b. absorption trench
   c. seepage bed
   d. cesspool