Model Decentralized Wastewater Practitioner Curriculum

Septic Tanks

Module Text

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Septic Tanks

I. Overview

The purpose of the septic tank is to provide an environment for the first stage of treatment in onsite and decentralized wastewater systems by promoting physical settling and flotation, anaerobic digestion. Additionally, the tank allows storage of both digested and undigested solids until they are removed.

A. Physical Processes

Septic tanks provide separation of solids from wastewater by settling of heavier solids and flotation of fats, greases, and lighter solids. The solids content of the wastewater is reduced by 60-80% within the tank. The settled solids are called sludge, the floated solids are called scum, and the liquid layer in between is called the clear zone (Figure 1). Although the liquid in the clear zone is not highly treated, it is greatly clarified compared to the wastewater entering the tank, the larger particles having migrated to either the sludge or scum layers. Another important function of the tank is storage of these accumulated solids. The tank should be large enough to hold solids until maintenance (i.e., tank pumping) is performed.

The effluent, or wastewater that leaves the septic tank, should come from the clear zone to minimize the solids loading on the downstream components of the system. The baffle, tee or effluent screen at the outlet is designed to draw from the clear zone retaining floatable or settleable solids in the tank. The settling process requires time to occur, so the tank must be large enough to retain the wastewater in a turbulence-free environment for many hours. Typical detention times are 2-4 days. Excessive flow and turbulence can disrupt the settling process. Tank volume, size, shape and inlet baffle configuration are designed to minimize turbulence.

B. Biological and Chemical Processes

Anaerobic and facultative biological processes in the oxygen-deficient environment of the tank provide partial digestion of some of the wastewater components. These processes are slow, incomplete, and odor producing. Septic solids include both biodegradable and nonbiodegradable materials; although many of the solids will decompose, some solids will accumulate in the tank. Gases (hydrogen sulfide, methane, carbon dioxide and others) result from the anaerobic digestion in the tank and may create safety hazards for improperly equipped service personnel. The gases accumulate in bubbles in the sludge that, as they rise, may resuspend settled solids. This will elevate the total suspended solids (TSS) concentration in the clear zone and ultimately send more suspended solids to downstream system components. This scenario often results when active digestion occurs during warm temperatures. Attempts to reduce discharge of re-
suspended solids led to the development of tank features such as gas deflectors. Effluent screens now help to perform this function.

Figure 1. Cross section of a two-compartment septic tank showing sludge, clear zone and scum layers

The anaerobic digestion processes in tanks are affected by temperature in the tank and by substances that have an adverse impact on biological organisms. Higher temperatures will enhance the rate of biological processes and inhibiting substances will reduce it. Some factors that affect the way a tank functions include:

- Strength (concentration) of the incoming wastewater
- pH
- Introduction of harsh chemicals, drain cleaners, paint, photo processing chemicals or other inappropriate substances into the waste stream which may affect pH and biological activity
- Introduction of fats, oils and grease (FOG)
- Highly variable flow patterns that affect detention time
- Introduction of pharmaceuticals (especially those for chemotherapy and dialysis; long term use of antibiotics, etc.)
- Introduction of process wastewaters, including backwash from a water softener, and
- Lack of maintenance resulting in excess accumulation of solids, reducing effective volume and reducing detention time.

User education and care are important factors in maximizing the effectiveness of septic tank processes.
II. Design

The goal of this section is not to provide enough information for the reader to become a designer of septic tanks, but to prepare the septic system practitioner to ask the right questions and demand quality.

A. Tank Sizing

New tanks have a rated volume based upon the depth from the bottom of the tank to the invert of the outlet (Figure 2). Overtime, the rated volume stays the same but the effective volume is decreased as solids and scum accumulate. Septic tanks should be large enough to retain the wastewater in a calm, turbulence-free environment for sufficient settling. The average length of time that the wastewater spends in the tank is called detention time. Detention time is a function of the effective volume and the rate of flow into the tank.

![Figure 2. Effective volume of a new tank](image)

The minimum recommended detention time to allow adequate settling of solids is two days. The tank should also have sufficient volume to accommodate storage of sludge and scum. Finally, if wastewater is recirculated from an advanced treatment device back to a treatment tank, the increased hydraulic load and reduced hydraulic detention time must be addressed in tank sizing. In general, for residential systems the tank size required is set by local code. The local health department uses the above concepts and then adds a safety factor in determining required tank size.

It is common to estimate daily flow by assuming an average daily water use of 75 gallons per person. Local regulatory codes may use a larger or smaller figure, but the concept of sizing based on expected flow is implicit in nearly every wastewater regulation. This figure accounts for peak flows. The actual average water use in most households is between 45 and 65 gallons per person per day. Since it is impractical to size the system...
based on the **actual** number of people that occupy a residence, sizing is based on the **potential** occupancy of a residence indicated by the number of bedrooms. For a three-bedroom house, allowing for two people per bedroom, calculate daily flow as follows:

\[
3 \text{ bedrooms} \times 2 \text{ persons/bedroom} \times 75 \text{ gallons/person/day} = 450 \text{ gallons/day}
\]

Then we multiply by the detention time of 2 days:

\[
450 \text{ gallons/day} \times 2 \text{ days} = 900 \text{ gallons}
\]

So the minimum tank clear space volume is 900 gallons. We have not yet provided any space for solids storage. A good rule of thumb is to allow an additional one-third to one-half of the minimum tank volume for solids storage. So:

\[
900 \text{ gallons} \times \frac{1}{3} = 300 \text{ gallons}
\]

And

\[
900 \text{ gallons} + 300 \text{ gallons} = 1200 \text{ gallons}
\]

Therefore a 1200-gallon tank should be chosen to provide adequate detention time and solids storage for this three-bedroom home. Some regulations allow a 1000-gallon single compartment tank for this size home. Others use an even greater margin of safety and require larger tanks for a three-bedroom house. The larger volume allows even more settling time and produces cleaner effluent, thus protecting downstream components.

While not as common, some jurisdictions use the type and number of plumbing fixtures to size septic tanks. While modern fixtures often conserve more water than their predecessors, the presence of dual showerheads and large capacity tubs can offset the advantages of low-flow fixtures by increasing total water use. Some jurisdictions require additional tankage when garbage disposals are used in a facility served by a septic system. The use of a garbage disposal increases the solids loading to the tank and may result in increased maintenance. For septic tanks serving non-residential facilities, flow rates are established by local codes or widely accepted engineering principles. For example, a system serving a restaurant may be sized by the number of seats in the facility or by the number of meals served per day.

When lift pumps precede a septic tank, the rapid discharge entering the tank can create turbulence that may disturb the quiescent zone of the tank and cause excessive flow rates that affect the hydraulic detention time in the tank. This may result in a high suspended solids concentration in the effluent from the tank. When any pump precedes a septic tank (such as when an advanced treatment unit recirculates a portion of the effluent back to the septic tank for denitrification) the flow from such a pump must be attenuated. Using small dose volumes, low flow rates, and a two-compartment septic tank can achieve this. The pump discharge must be plumbed into the sewer piping from the house and not directly into the septic tank. Another approach is to install an additional tank (a surge
tank) to receive the pump discharge and subsequently direct the flow into the gravity sewer leading from the house to the main septic tank.

B. Tank Geometry

Septic tank design allows for a quiescent zone in order to slow the velocity of the wastewater stream and optimize the settling of solids. In order to achieve this, the distance between the inlet and outlet should be maximized. A length to width ratio of at least 3:1 is preferable with a recommended liquid depth of 3 feet. The practice of industry in some areas is to utilize tanks with length to width ratios in the range of 1.5:1 to 2.5:1, but 3:1 is preferable. For a given volume, shallower tanks result in increased surface area. This configuration will attenuate flow and promote settling of solids. The outlet pipe is typically about 2 inches lower than the inlet pipe elevation and a freeboard or air space exists above the liquid level to allow venting of gases between compartments and out through the vent stack on the plumbing system of the house.

C. Tank Compartments

Single compartment tanks have only one main chamber for settling and solids detention. Two-compartment tanks typically contain a wall placed transversely across the tank with an opening to allow flow from the clear zone of the first compartment into the second. A narrow, horizontal slot or multiple holes at about mid-level in the clear zone has been found to provide the best solids detention in the first compartment (See Figure 3). The tank division is commonly placed to provide about $\frac{2}{3}$ to $\frac{3}{4}$ of the total volume in the first compartment. See Figure 1 for an illustration of this. A two-compartment configuration has generally been found to provide better removal of solids than a single compartment, but some research based on settling theory suggests that, at least for lower total volumes in the range of 1000 gallons, a single compartment is better. However, field sampling data shows the two compartment configuration provides better effluent quality. The second compartment has the potential to improve the efficiency of solids removal if tank maintenance is neglected. In some areas two septic tanks of the same size (e.g. 2-1000 gal. tanks) are installed in series to provide the two-chamber effect.

Tank geometry for small systems such as individual home systems and other systems designed for flows up to a few hundred gallons per day is generally set by the local code. Septic tanks for larger systems should be designed by an engineer or a certified design professional.
A less common tank design is a meander tank with one or more baffle walls arranged longitudinally in the tank. The flow enters one corner of the tank and travels the length of the tank where it moves across the tank to the next long chamber, changes direction, and travels toward the outlet. Here it may exit or be directed again into another longitudinal chamber and flow in the other direction once again. The objective of this circuitous flow path is to, increase the length-to-width ratio, reduce short circuiting, reduce inlet and outlet turbulent zones, and improve the overall tank effectiveness. One of the challenges of this design is to provide appropriate access ports for effective solids removal (Figure 4).
D. Vehicular Traffic

Standard concrete septic tanks are not intended to be installed under vehicular traffic loads. However, concrete tanks designed for traffic loading or special situations are available. Among the applicable industry standards address designing load requirements for concrete tanks is ASTM C-857: Standard Practice for Minimum Structural Design Loading for Precast Concrete Utility Structures. Table 1 lists design criteria from Section 4 of the ASTM standard.

Table 1. Design loads for concrete utility structures (ASTM C-857).

<table>
<thead>
<tr>
<th>Designations</th>
<th>Maximum Loads</th>
<th>Typical Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-16</td>
<td>16,000 lbf/wheel</td>
<td>Heavy Traffic</td>
</tr>
<tr>
<td>A-12</td>
<td>12,000 lbf/wheel</td>
<td>Medium Traffic</td>
</tr>
<tr>
<td>A-8</td>
<td>8,000 lbf/wheel</td>
<td>Light Traffic</td>
</tr>
<tr>
<td>A-0.3</td>
<td>300 lbf/ft²</td>
<td>Pedestrian Walkways</td>
</tr>
</tbody>
</table>

When designing an onsite system which may be subject to some form of live load factors due to potential vehicular traffic, a designer must follow established engineering analysis including such items as: soil type, depth to groundwater, bedding materials, backfill materials, potential lateral earth pressures, and vertical loads. When designing onsite systems which have potential vehicular traffic, designers would benefit from referring to AASHTO C98-HB-16 Standard Specification for Highway Bridges 16th Edition. The International Association of Plumbing and Mechanical Officials (IAPMO) Standard for Prefabricated Septic Tanks (IAPMO PS 1-2004) states that “septic tanks and covers shall be designed for an earth load of not less than five hundred (500) pounds per square foot when the maximum coverage does not exceed three feet” (Section 4.7 of the standard).

When considering use of tanks other than concrete in vehicular traffic areas, consult with the manufacturer or a structural engineer.

E. Tank Appurtenances

1. Tees and Baffles

Baffles are structures made of various materials placed around the inlet or outlet pipe. These devices serve to direct incoming flow to or draw flow from the clear zone. Baffles extend only part of the way to the top or to the bottom of the tank (Figure 5).

Curtain baffles (Figure 6) are partial walls usually constructed of the same material as the tank itself that extend across the short dimension and down into the clear zone of the tank near the inlet or outlet port. In the past, curtain baffles and pipe tees used as baffles were made of concrete or vitrified clay which had a tendency to deteriorate over time in the
septic tank environment. With the availability of composite materials, curtain baffles are not often used in modern tank construction and have been replaced by tees made of PVC as shown in Figure 5. As the name implies, these are T-shaped pipes attached to inlet and/or outlet pipes.

![Concrete and fiberglass tanks with PVC pipe tees as baffles](image)

**Figure 5. Concrete and fiberglass tanks with PVC pipe tees as baffles**

The use of a baffle or tee at the inlet varies by regulatory jurisdiction. Where they are used, the devices direct incoming wastewater flow downward to the level of the clear zone, dissipating the energy of the incoming flow to prevent turbulence and disruption of the segregated solids in the tank. They may also prevent short-circuiting of flow across the top of an accumulated scum layer to the outlet.

![Concrete curtain baffle](image)

**Figure 6: Concrete curtain baffle**

Outlet ports of septic tanks may be fitted with sanitary tees with drop pipes or with effluent screens. These are designed to retain floating solids in the tank. Outlet tees should extend far enough above the wastewater surface and deep enough into the clear zone to keep the scum layer from entering the outlet port. The scum layer can float several inches above the water level so extending the outlet baffle above the top of the
outlet pipe 4-6 inches is recommended. It should penetrate to about 40% of the liquid depth. Access openings or risers should be located so that the inlet and outlet devices can be inspected and serviced.

2. Effluent screens

Effluent screens are designed to help keep solids in the tank. These devices trap suspended solids, reduce the TSS concentration in septic tank effluent, and help protect the soil absorption field or other downstream treatment unit. They typically replace the outlet baffle in the final compartment of the tank. Several types of effluent screens are available including multiple plates assembled with slots between, slotted cylinders, and multiple perforated tubes assembled together. Others may be fitted with an alarm or used in conjunction with a pump for pressurized applications (Figure 7). Although it is easier to install effluent screens in a new septic tank, several types can be retrofitted to existing tanks. In addition to models that can be placed directly into concrete baffles, installation options include (1) replacement of PVC outlet tee or baffle with the effluent screen and housing; (2) placement in a sump outside the tank; and (3) placement within the pump vault of a pumped system.

![Effluent Screens Image](image)

**Figure 7.** Left: Some of the many proprietary effluent screens available. Center: Effluent screen with alarm float. Right: Pressure filter to be used with a pump.

Choose and install effluent screens with ease of serviceability in mind since all will require service. Cleaning frequency depends on the overall size of the unit, screen opening size, and use. A screen in the second compartment of a two-compartment tank should require less service than a unit in a single compartment tank. Some effluent screens have shut-off mechanisms or secondary screens to keep solids from moving out of the tank when the screen is being cleaned. If such a device is not included, some solids may be discharged downstream when the screen is removed, thereby reducing its overall effectiveness. One method of preventing such solids discharge is to pump down the tank level before removing the screen for cleaning.
In choosing and installing an effluent screen, the following factors must be considered:

- Effluent screens are designed to reduce solids discharge, not necessarily BOD discharge.
- The screen case should act as an outlet tee.
- Screens should allow solids of no greater than 1/16” to 1/8” to pass through the cartridge, depending on system design and regulatory specifications.
- The filter cartridge should be secured in place and should not allow bypass of unfiltered solids if the screen openings become clogged.
- The effluent screen housing should be sized and placed so that it does not interfere with normal pumping of the tank.
- The estimated wastewater flow from the house should be matched with the surface area of the filter. (i.e., as the design flow increases, more surface area must be provided.
- An access opening at grade over the screen should be provided for screen removal and cleaning as needed. (See Figure 8)
- The design should include a mechanism to prevent solids bypass during cleaning.

**Figure 8:** Left: Housing for effluent screen located directly under tank opening. Right: Cutaway tank showing position of effluent screen relative to attached riser.

3. **Access Risers**

Structurally sound and watertight risers are required over each tank access port in order to provide access for inspection and maintenance of tank appurtenances such as effluent screens and/or pumps. Risers and their lids may be made of concrete or composite materials such as polyethylene, PVC, ABS, or polypropylene (Figure 9). Riser construction and installation will be discussed in more detail in the Tank Construction section.
Access risers leading into septic tanks have traditionally been buried six to twelve inches beneath the ground in order to prevent unauthorized access to a tank. The practice of burying risers was viewed as a safety precaution to keep children from entering the potentially deadly environment. There are now several alternative methods used to prevent unauthorized access such as securing the riser lid with non-standard screws or using lids which accommodate padlocks (Figure 10).

Figure 9: Access risers constructed of various materials

Figure 10. Padlocked riser lid for preventing unauthorized access to a septic tank.
III. Tank Construction

A. Materials

Historically, many different materials have been used to construct septic tanks. Materials used in the past include redwood planks, bricks and mortar, and coated metal. Currently, tanks are constructed using one of three materials: precast concrete, fiberglass reinforced plastic (FRP), and rotationally molded polyethylene/polypropylene resin (poly).

Reinforced concrete tanks have traditionally been used for onsite systems. This is reflected in the amount of information available regarding them relative to tanks made of other materials. Concrete tanks are readily available, generally lower in cost than alternative materials and have, for the most part, proven to be reliable. Use of tanks fabricated from FRP and rotationally molded polyethylene is becoming more common. Figure 11 shows pictures of tanks constructed of these materials. Most local codes specify where and how each tank may be used. The reader is referred to those sources for further information on requirements for their use in specific locations.

![Image of tank construction materials]

Figure 11. Materials used for tank construction: precast concrete, fiberglass reinforced plastic, and polyethylene/polypropylene (clockwise from top left).

B. Structural Soundness
All septic tanks must be structurally sound in order to prevent collapse. They must be able to withstand handling and transport after manufacturing, and not be susceptible to damage during installation. Additionally, tanks must be capable of supporting anticipated soil loads as well as a 2500 pound wheel load, and be able to withstand both internal and external hydraulic pressure. Regardless the materials used in the production of septic tanks, structural integrity depends on good design, use of quality materials, proper manufacturing methods and careful construction techniques.

C. Manufacturing

1. Precast concrete septic tanks

Precast tanks are widely accepted, readily available, and have proven long-term reliability. The factors described in this section impact design, production and maintenance of structurally sound, quality precast concrete tanks.

Precast Concrete Mix Design

Concrete mix designs are based upon the nature of the structure being manufactured. For septic tanks, critical elements which impact mix design are the following:

- Low water to cement ratio; typically, less than 0.45. (The water to cement ratio is calculated by dividing the water in one cubic yard of the mix [in pounds] by the cement in the mix [in pounds]. So if one cubic yard of the mix has 235 pounds of water and 470 pounds of cement, the mix is a 0.50 water to cement ratio). Excessive water reduces the final compressive strength of concrete
- The need to achieve a minimum compressive strength of 4,000 psi after 28 days
- Use of quality aggregates that have a consistent gradation, low moisture content and are free from deleterious substances
- Appropriate use of chemical admixtures to improve mix flowability, water-reduction, air entrainment, and resistance to corrosion/degradation; and
- Selection of the proper cement from five primary types on the basis of “which individual characteristics best fit the regional conditions and operation of each manufacturer” as stated in the NPCA Septic Tank Manufacturing Best Practices Manual.

Precast Concrete Structural Reinforcement

In concrete tanks, steel mesh, rebar or special fibers provides structural reinforcement. In addition to proper mix, casting and curing techniques, proper placement of reinforcement is essential to prevent spauling and shrinkage cracks and to provide the tensile strength that concrete alone lacks. Precast concrete tanks are usually reinforced by embedding placing wire or rebar in the concrete form or mold prior to pouring the concrete (Figure 12). Fiber reinforcement entrained in the concrete mix may also be used to provide strength, but is not considered a substitute for wire or rebar as of this writing.
Figure 12. Top Left: Tank form with reinforcing wire in place before concrete is poured. Top Right: Cutaway tank showing rebar in top and sidewall. Bottom: Reinforcing steel properly placed (and supported using a “chair”) in the tank form before pouring the unit.

Manufacturing Practices for Precast Concrete Tanks

To properly manufacture quality precast concrete, the producer must follow up-to-date industry practices, including the following:

1. Proper maintenance of manufacturing forms or molds, including at least:
   - Removal of excess form oil
   - Removal of rust
   - Elimination of voids to prevent concrete mix from spilling from the form
   - Maintenance of tolerances to prevent improperly fitting structures
2. Proper selection and placement of reinforcement.
3. Proper vibration techniques which ensures the uniform distribution of the concrete mixture throughout the entire form or mold.
4. Utilization of proper curing techniques to maintain correct moisture content and temperature. Proper curing is essential in developing strength, durability and watertightness.

Joint Design for Precast Concrete Tanks

To ensure structurally sound precast tanks with watertight joints, it is recommended that only interlocking joints be used. Interlocking joints have the effect of increasing overall structural strength of mid-seam tanks. The most common types of interlocking joints used in septic tank construction are tongue-and-groove and lap joints. Non-interlocking joints are acceptable on top seam tanks provided that the top piece (“lid”) is properly secured to the structure with appropriate sealing materials. Figure 13 illustrates top seam and midseam tanks.

Figure 13. Top seam (left) and midseam (right) tanks.

Another method of manufacturing precast concrete tanks utilizes a seamless design, sometimes referred to as monolithic construction. Manufacture of such a tank involves a two stage operation. The joint where the two successive pours mate, is called a “cold joint” and it will leak without proper precautions. During the first stage, all but the lid of the tank is cast. Once the original casting has reached sufficient concrete strength it is stripped from its form. Rebar protruding from the first casting is incorporated into the lid casting. A waterstop sealant or solid waterstop (a thin sheet of metal, rubber, plastic or other materials inserted across a joint to obstruct the seepage of water through the joint) must be cast into the joint between the first and second casting in order to create a watertight joint.

Sealing Materials for Precast Concrete Tanks

Materials used to seal multiple-piece precast tanks typically consist of blended sealant compounds listed as butyl rubber-based or asphalt-based (bituminous). (Fuel/oil resistant
sealants are also available for use on grease traps or in situations where petroleum products may be part of the waste stream.) Both types of sealant compounds should conform to ASTM Standard C-990 and AASHTO M198-75B standards that specify relative amounts of butyl rubber and fillers used in production. The federal standard SS-S-210(210A) provides information on the ratio of hydrocarbon to filler (typically cellulous or limestone) and temperature ranges for effective use.

Compressibility in cold temperatures (i.e., ambient temperature below 40°F) is a critical characteristic of a sealant compound. Bituminous (tar-based) mastic is widely used in warmer climates but is not appropriate in colder areas since it tends to crack under those conditions. In any climate, installation at low temperatures can render any seal ineffective. If tank sections are to be joined at temperatures below 40°F, measures should be taken to keep the sealant warm such as storing it in the cab of the delivery truck prior to use.

Quality mastic should not excessively compress when squeezed between the thumb and forefinger and when stretched, should not shred or snap. Currently, there are no standards for mastic size and the actual measurement of nominal one-inch mastic can vary in size to some extent. Because of this, a critical factor when evaluating the sealing potential of a sealant is the cross-sectional volume. Cross-sectional volume is defined as the geometrical shape of the sealant [i.e., .75” (H) x 1.0” (W)]. Industry experience has shown that a sealant’s cross-sectional height must be compressed a minimum of 30% to create a good seal with 50% compression being desirable.

The seams to be joined should be clean and dry. If this is not the case, mastic manufacturers can provide information on primers to be used with their products. These are typically of three general types:

- Liquid rubber
- A water based product that dries to a ‘sticky’ state, and
- An all-season type that can be applied to wet or dry surfaces.

Mastics should be applied in a continuous bead. Opinions vary on how to join two pieces of mastic: the ends can be overlapped and kneaded together or the two ropes can be carefully butted up to one another. Ultimately it is critical to ensure a good joint seal. When placing mastic in a seam, a higher rope is better than a wider one. For extra assurance for watertightness after assembling the tank halves, a butyl rubber wrap (approximately 1/8” thick and 4-12” wide) can be applied to the seam (Figure 14).
Concrete tanks should reach a 28-day compressive strength of 4000 psi before they are delivered to a site for installation. They should be designed to comply with standards from the American Society for Testing Material (ASTM) and the National Precast Concrete Association (NPCA). Structural strength of precast concrete may be ascertained through engineering design analysis, compressive strength loading, or other acceptable engineering practice. Although vacuum testing would also be an effective method for testing the structural soundness of a precast structure, it is not recommended due to the risk of injury when drawing negative air pressure in excess of seven inches of mercury. Vacuum testing is more appropriately used for watertightness testing (discussed in Section IV), where the goal is to hold negative air pressure at a lower figure of four inches of mercury for five minutes.

Access Risers for Precast Concrete Tanks
Access risers for use with concrete tanks are available in a variety of materials. Typically, rises for precast concrete tanks are manufactured from precast concrete, polyethylene, polypropylene or ribbed PVC. No matter what material is used, the riser must be structurally sound and watertight.

Concrete risers may be cast into concrete tanks with a “cold joint”. The riser itself is produced separately and allowed to cure. It is then placed into the tank or tank lid form, and the structure is poured (Figure 15). This cold joint may require further sealing (mastic or other appropriate sealants) to ensure watertightness. Riser section joints should also be wrapped as shown in Figure 15. Polyethylene, polypropylene and PVC risers can also be cast directly into concrete tanks (Figure 16). Because of concerns regarding an effective bond between concrete and some of these materials, supplemental seals should be used to ensure watertightness. If additional riser sections are added, joints should again be wrapped. Note that cast-in-place risers are the best choice in high groundwater conditions and in cold climates where frost heave might otherwise cause separation of a riser that was added after the tank is produced.

Figure 15. Left: Concrete riser being cast into the top half of a mid-seam tank section. Center: Cast-in concrete riser in lid for a top-seam tank. Right: Concrete riser sections with supplemental wrap for watertightness.
Figure 16. Left: Polypropylene riser being cast into a concrete tank. Right: Finished tank with cast-in riser.

When concrete risers are attached to a tank after it is made, a tongue and groove connection in combination with mastic or other appropriate sealant (Figure 17) is more likely to remain undisturbed and watertight compared to a mortared seam (Figure 18). If additional concrete riser sections are added, these should also be made with tongue and groove joints and sealed with mastic (Figure 19). Wrapping seams as shown in Figure 15 provides additional protection especially in high water table- and freezing/thawing soil conditions.

Figure 17. Groove fitting (left) for concrete riser (right).

Figure 18. Although the seams shown here are above average, mortared seams around concrete risers may not remain watertight over time.
Figure 19. Applying sealant to concrete riser sections.

Polyethylene and polypropylene risers are typically connected to a precast tank using an adapter ring cast into the tank (Figure 20). Another option is to mechanically attach a flange to the tank top using butyl rubber and stainless bolts. The riser is then sealed in place using appropriate adhesives. One such procedure is illustrated in Figure 21 and other proprietary adaptors and methods are available.

It is essential to note that no matter what materials are used, access riser joints on tanks installed in areas where freezing and thawing soil conditions occur will require supplemental sealing to remain watertight.

Figure 20. Cast-in-place PVC adapter for attaching access riser
Figure 21. Procedure for attachment of bolt-in-place riser to concrete tank: Flange is mechanically attached to tank using butyl rubber and stainless bolts. Riser is then attached using appropriate adhesives.

Pipe Penetrations for Precast Concrete Tanks

Inlet and outlet pipe penetrations are a common potential point of leakage, particularly if the tank or piping settles or shifts after installation. These connections should be mechanically sealed to the tank so that they are watertight and flexible. Although bituminous seal, mastic, or concrete grout have been used for many years, newer flexible gasket and boot fittings are available that can be cast in place at the time of tank manufacture and provide a much more reliable seal (Figure 22). Rubber boot seals are particularly desirable because they are flexible and retain a seal during backfilling and settling.

Figure 22. (Left to right) Rubber boot-type pipe seal with stainless steel band clamp, cast-in-place friction fit seal and PVC insert seal.

2. Rotationally molded polyethylene/polypropylene septic tanks

Polyethylene/polypropylene (“poly”) tanks are a relatively new innovation. Some early poly tanks were prone to deflection and splitting. Newer model tanks have a ribbed design to enhance structural stability (Figure 23). These tanks are lighter than concrete tanks. However, they are more prone than concrete tanks to float out of the ground in areas of high water tables and precise installation practices must be followed when using them. (These practices are discussed in Section V. Installation.) Manufacturers of non-concrete tanks state that they are not subject to rust or corrosion and are resistant to the chemicals and gases present in sewage and soil. Although there are no uniform standards for manufacture of plastic septic tanks per se, their use in the onsite industry dictates that they meet the same requirements for structural stability and watertightness as all other septic tanks. As time passes, industry standards for manufacturing will undoubtedly evolve.
Poly tanks are rotationally molded in one piece. Sufficient, high-quality raw material and careful attention to manufacturing practices are essential for structural soundness and watertightness. Walls of these tanks are typically $\frac{1}{4}''$ thick, and defects in wall thickness will compromise the integrity of the tank. As with tanks made of other materials, access riser joints and pipe penetrations must be properly sealed to make sure they do not leak. Rubber and plastic pipe seals are routinely used in the production of poly tanks and access risers are typically made of the same poly materials as the tank itself (Figure 24).

**Figure 23:** Rotationally molded one-piece polyethylene tanks showing ribbed construction.

**Figure 24.** Rubber pipe seal and riser connection on a poly tank.

While one-piece design implies that they should be watertight, it is imperative that they (and tanks of all other materials) be tested via appropriate methods. Most local codes specify where and how these tanks may be used; the reader is thus advised to review the strength requirements included in local and state codes when assessing the use of any tank in onsite systems.

3. Fiberglass reinforced plastic (FRP) septic tanks
Fiberglass reinforced plastic (FRP) tanks are also relatively new compared to precast concrete tanks. Like the poly tanks discussed in the previous section, FRP tanks are lightweight; thus, the same concerns regarding flotation and installation must be addressed. More information on this is provided in Section V. Installation. Manufacturers of FRP tanks advocate their use on the basis that they are not subject to rust or corrosion and are resistant to the chemicals and gases present in sewage and soil. There are established industry standards that address materials such as plastic laminates, rigid plastic, and cured reinforced resins. These may have a bearing on the production of FRP tanks. Specific standards for using FRP in the manufacturing of septic tanks are being considered by industry groups. Clearly, their use in the onsite industry dictates that they meet the same requirements for structural stability and watertightness as all other septic tanks. The reader is again advised to review the strength requirements included in local and state codes when assessing use of these tanks in onsite systems.

Some FRP tanks are produced in one piece. Others are produced in two pieces using an injection molding process (Figure 25). As stated previously, sufficient, high-quality raw material and careful attention to manufacturing standards are essential for structural soundness and watertightness. It is possible (though not common) for FRP tanks to leak as a result of shipping damage, a substandard batch of adhesive, uneven application of adhesive or stress placed on the midseam during installation.
Two-piece FRP tanks are often shipped unassembled and must be permanently fastened together before placement. The assembly process must be carefully done so that the joint will not leak or separate. Generally, this is achieved using appropriate adhesives and stainless steel bolts. The bolts are primarily used to hold the halves in place while the adhesive cures (Figure 26). As with tanks made of other materials, pipe penetrations and access riser joints must be properly sealed to make sure they do not leak. Rubber and plastic pipe seals are routinely used in the production of these tanks. Figure 27 illustrates the attachment of a PVC riser onto an FRP tank.
D. Overall Quality of Precast Concrete, FRP, and Poly Septic Tanks

Aside of the wastewater source, the septic tank is the first component of any septic system. As such, it is important that high-quality watertight tanks be used. If you are unsure about the quality of a tank, consult with a qualified structural engineer regarding potential problems with structural integrity. Ultimately, a hydrostatic or vacuum test of the tank after installation will indicate the status of watertightness.

A quality concrete tank should have the following characteristics:

- Reasonably smooth surface
- No honeycombing or cracks
- No efflorescence (the changing of crystalline compounds to a whitish powder through loss of water) that may indicate a very old tank or a bad pour
- No exposed rebar or wire (inside or outside)
- Smooth, well-made tongue-and-groove or lap joint with properly applied mastic

A quality poly tank should have the following characteristics:

- Uniform wall thickness
- No pin holes
- No deformation of tank or riser openings

A quality FRP tank should have the following characteristics:

- Properly sealed mid-seam (if two-piece)
- No imperfections in lay-up
- Uniform wall thickness
- No de-lamination
- No cracks or dings from handling

Additionally, tanks made from any of these materials should have:

- Flexible, watertight pipe seals at all pipe penetrations
- Cast-in-place or mechanically-attached riser with tight fitting lid

Although high-quality, structurally-sound, watertight tanks are regularly being produced from all materials, Figures 28 through 36 help identify potential problems with various tanks. Keep in mind that a tank may have cosmetic deficiencies that do not affect performance in any way. Likewise, a tank may have an attractive appearance and still have structural deficiencies. Ultimately, hydrostatic or vacuum testing should be employed to measure tank quality. These tests are discussed in Section IV: Watertightness Testing.
Figure 28. Uneven surface on concrete tanks may be “bug-holes” (trapped air bubbles between the form and the concrete that produced voids in the hardened structure). Whether this tank leaks or not will be proven by testing, not surface appearance.

Figure 29: The variation in color may be discoloration from form release agents, variations in vibration, or an indication of multiple concrete pours into the form. Testing for watertightness is an essential practice, regardless of appearance.
Figure 30: Honeycombing as a result of a concrete form which leaked. Since two separate forms are required to make the top and bottom pieces, both leak. Dark lines around the honeycomb are caused by form oil interacting with the cement paste. The tiny bug-holes are from air bubbles trapped along the form surface.

Figure 31. Excessive form leakage or insufficient vibration can cause this. In the case of form leakage, the creamy cement paste drips out and leaves behind the stones. Insufficient consolidation looks the same but is caused by not vibrating the concrete into one solid mass.
Figure 32. Exposed reinforcement-wire is an indication of potential weakness. Again, watertightness testing is essential.

Figure 33: This seam will be difficult to seal properly since the joint’s tolerance was not properly maintained during manufacture. The condition is often the result of a poorly maintained tank form.

Figure 34. Use of proper adhesives and recommended fasteners do not guarantee a watertight FRP tank. Watertightness testing is essential.
Figure 35: FRP tank with a weak seam (left) and a poly tank with a hole (right). Both problems were revealed via hydrostatic testing.

Figure 36. Deformation of a rotationally molded poly tank.
IV. Watertightness Testing

There are many reasons to ensure that all septic tanks are watertight. Leakage from the tank releases minimally treated sewage into subsurface soils and/or groundwater. Sewage injected deeply in the soil profile is much less likely to be adequately treated as it moves down through the soil. In areas of relatively shallow water tables or where tanks are located in low areas, groundwater or surface water can leak into the tank. Inflow of groundwater can disrupt settling, treatment, and storage of solids (i.e., the important functions of the tank) as well as the function of downstream components of the wastewater treatment system. Possible locations on a septic tank where leakage can occur include:

- Weep holes at the base of the tank. (Weep holes are used in some precast concrete tanks to release forms from tanks and to prevent collection of rainwater during storage prior to installation. If used, these should be sealed appropriately prior to installation.)
- Mid-seam joint
- Inlet/outlet pipe penetrations
- Top-seam joint
- Tank top/access riser joint
- Access riser/lid joint
- Any damaged, improperly-formed location or area where material is too thin.

New tanks can be tested for watertightness by filling with water (hydrostatic testing) or by vacuum testing. In both cases, the tank should be tested in the ready-to-use state. Inlets and outlets should be plumbed with the appropriate pipes, which can then be plugged for the test.

A. Hydrostatic Testing

Be careful when performing hydrostatic tests on plastic and fiberglass tanks as they gather much of their strength from the soil support. For all mid-seam tanks, keep the backfill near the mid-seam, but leave the seam itself exposed to monitor the test.

The following is a suggested water testing procedure for tanks. Note that this test does not evaluate the tank’s ability to withstand external pressures: that issue must be assured through adequate engineering design.

1. Plug the inlet and outlet pipes with a watertight plug, pipe and cap or other seal. Seal the pipes away from the tank to test any pipe connections that may be of concern.
2. If testing a mid-seam tank, ensure that the seam is exposed for the water test.
3. Fill the tank to the top.
4. If the tank has a riser, add water into the riser to a maximum of 2-inches above the tank/riser seam. Care must be taken not to overfill as the top section of a two-piece tank may become buoyant.

5. Measure and record the level of the water.

6. Let the tank sit for 24 hours. Any obvious leakage during this time should be evaluated and remedied by the application of a suitable sealing compound.

7. If the test reveals leaks that cannot be repaired, the tank is considered unacceptable.

8. Refill concrete tanks to original level after 24 hours as they will absorb some water.

9. Check again after 24 hours. If less than 1 gallon is lost in a concrete tank, the leak test is considered acceptable.

Tables 2 and 3 provide information for calculating volumes in square and round risers.

**Table 2. Depth change equivalent to one gallon in round risers of various interior diameters.**

<table>
<thead>
<tr>
<th>Riser Diameter (Inches)</th>
<th>Depth (Inches) Equal to One Gallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>0.91</td>
</tr>
<tr>
<td>24</td>
<td>0.51</td>
</tr>
<tr>
<td>30</td>
<td>0.33</td>
</tr>
<tr>
<td>36</td>
<td>0.23</td>
</tr>
</tbody>
</table>

**Table 3. Depth change equivalent to one gallon in square risers of given interior dimensions.**

<table>
<thead>
<tr>
<th>Riser Dimensions (Inches)</th>
<th>Depth (Inches) Equal to One Gallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 x 18</td>
<td>0.71</td>
</tr>
<tr>
<td>24 x 24</td>
<td>0.40</td>
</tr>
<tr>
<td>36 x 36</td>
<td>0.18</td>
</tr>
</tbody>
</table>

When performing hydrostatic testing in cold climates, there are a few important points to consider. First, water is its densest at about 4 degrees C (just above freezing), so water put into a tank at 10-20 degrees C (typical of groundwater) and left in the tank overnight at freezing temperatures will drop the level in the tank a substantial amount (about 2% or 3 gallons in a 1500 gal tank). A 'loss' of 3 gallons in the risers will look like a leak. Additionally, water used in the test will freeze and expand by approximately 9%. If the site is not occupied quickly the tank may crack as a result of the test itself.

**B. Vacuum Testing**
Vacuum testing of tanks (Figure 37) requires less time than hydrostatic testing and can be performed without having water available on the site. Testing should be done on the tank in its ready-to-use state (i.e., pipes in the inlet and outlet, risers with lids, etc.) In this test all pipe penetrations, manholes and risers are sealed airtight and a special insert is sealed on one of the tank manholes. Using a pump, air is evacuated through this insert to a standard vacuum level and the reading on a vacuum gage is recorded. Local codes, ASTM standard C-1227, or the National Precast Concrete Association (NPCA) standard can be used to determine the target vacuum for the size, shape and tank material being used. Be careful not to exceed the recommended vacuum level. It is possible to damage or implode a tank.

Figure 37. Vacuum testing: Top Right: Seal on outlet pipe. Top left: seal plate and gage on top of riser. Vacuum testing equipment includes a device to pull the vacuum (bottom left), plates to seal risers and gages (bottom right) to measure vacuum achieved

Specifically, as of August 2003, the NPCA standard states: “The recommended [vacuum test] procedure is to introduce a vacuum of 4 inches of mercury. Hold this pressure for 5 minutes. During this initial 5 minutes, there is an allowable pressure equalization loss of up to a half-inch of mercury. If the pressure drops, it must be brought back to 4 inches and held for a further five minutes with no pressure drop.”
If a tank will not hold the vacuum, leaks must be located and repaired. The test can then be repeated. If the tank cannot be repaired and rendered watertight, it should be replaced. Note that vacuum testing of concrete tanks draws seams together for a positive mastic seal, assuming there are no other problems. With any tank, collapse, deflection, deformation, or cracking indicate a poor quality tank. It is important to test the entire system: tank, pipe sleeves, risers, inspection ports and lids.

C. Testing Existing Tanks

It is more difficult to check watertightness in an existing septic tank. Adequate testing requires a period of several hours to a day or more without inflow to the tank and sealing off inlet and outlet pipes. Seal the line at the distribution box (or other appropriate place in the case of secondary treatment units) and at the clean-out between the building and the tank. Apply vacuum or water as desired. If there are no leaks, the entire system passes in one step. If there are leaks, successive tests will locate the source or sources. Although actual testing of existing tanks may be impractical, much can be discerned by a thorough inspection of a tank both before and after it has been pumped out. Most tanks built using older methods of construction (such as built-in-place block or brick tanks) would typically not be watertight or structurally sound and probably cannot reasonably be repaired. In some cases it may be possible to do more to check existing tanks. If the soil around the tank is saturated, the tank contents can be pumped down and observations made over the next few hours to detect leakage into the tank around pipe penetrations, seams or through breaks in the tank. Caution should be exercised, however, as high groundwater may cause empty tanks to become buoyant and float out of the ground. Alternately, excessive soil pressure may collapse a tank. In some cases, it may be necessary to excavate completely around the tank to make a visual inspection for leaks. If there is any doubt about the integrity of the existing tank, it should be replaced.
V. Installation

A. Safety

Maintaining a safe working environment during installation is essential. All excavations should comply with OSHA standards and must be done so that they are protected from sidewall collapse. Once a tank is in the hole, people should never be in the hole between the tank and the excavation walls. If this is necessary, excavate back the sidewalls to prevent collapse or use trench boxes for support. As a boom truck or other machine handles the tank, workers must stay clear of the unit and never be directly under the tank. Lifting slings must always be placed in grooves of concrete tanks or attached to lifting rings of FRP tanks (Figure 38). Lifting slings must be placed at the appropriate location on poly tanks.

Figure 38: Left: Concrete tank with grooves for lifting slings. Right: FRP tank with lifting rings on seam flange.

B. Planning and Excavation

The first step in tank installation is to be sure the building stub-out elevation is consistent with that required to install the tank and soil treatment system at the correct elevations. Tanks should be kept as shallow as possible to minimize soil pressure and potential groundwater infiltration, and (where site conditions or regulations dictate) to keep the soil treatment system as shallow as possible. The tank inlet must be set to provide a slope of between 1% and 2% (i.e., 1/8” to ¼” drop per foot of run) on the building collection pipe from the stub-out to the tank. The tank dimensions must be known so that the excavation can be made to the proper depth assuring that the tank inlet will be set at the proper elevation. Proper compaction of the underlying soils and bedding materials is critical to eliminate later settling which will ultimately occur in all tank installations, regardless of the material used for construction. Potential tank settling is measurable, predictable and preventable. Proper evaluation of the original soil, bedding materials, depth to
groundwater, backfill materials, and potential stress loads reduces the likelihood of later settling.

C. Bedding Material

The depth of the excavation should take into consideration the fact that tanks should be bedded with a layer of granular material (washed stone or coarse sand). This is helpful to fully support the bottom of the tank and distribute the weight evenly (Figure 39). Avoid over-excavating the hole to maintain relatively undisturbed soil under the granular material. In the event of over-excavation, clean, granular material should be used to re-establish the correct elevation. Ensure that there are no native rocks under the tank that could rupture the structure. This is important for all types of tanks. Note that in some cases, naturally occurring soil may serve as suitable bedding material. The reader should check local regulations regarding this.

Figure 39: Granular bedding in a tank excavation.

D. Setting the Tank and Joining Seams

Workers must be safely positioned while tanks are being set (Figure 40). Compliance with OSHA standards is critical. The tank must be set level to provide the proper drop from inlet to outlet. Level of the tank should be carefully checked as it is set in the excavation.
Figure 40. All workers should be safely positioned relative to suspended tanks during installation.

Installing two-piece concrete or FRP tanks requires that sealing materials be properly applied to a clean, smooth surface so that the joints will be watertight (Figures 41 and 42). Seams may be sealed at the point of manufacture or in the field. For more information on materials and techniques for joining concrete and FRP tank seams, see Section III. Construction. Watertightness testing of all tanks (one-or two-piece, made of any material) is critical since tanks may be damaged during transport and handling.

Figure 41. Proper seal being made; Left: mastic seal properly in groove. Right: top piece being carefully placed.
Figure 42. Seams of two-piece FRP tanks must be clean and smooth, and then must be carefully mated using proper adhesives and stainless bolts. Watertightness testing after installation is critical to check for damage from transport and handling.

E. Backfilling the Installation

All tanks should be backfilled with successive tamped “lifts” or depth increments of uniform gradation (Figure 43) with no deleterious material or stones larger than 2 ½ inches in diameter. Crushed rock or pea gravel of ½ inch diameter is preferred if native materials are not appropriate. Each layer should be uniform, no greater than 24 inches thick and nearly equal height around the perimeter of the tank. Compaction under the haunch (bottom curvature of some tanks) is best done in 6” to 12” layers. When installing non-concrete tanks, it is critical to simultaneously fill the tank with water to just above the backfill level to avoid uneven or excessive pressures on the tank walls during the installation process and to minimize the risk of the tank shifting position. A tamping tool may be necessary to provide good contact against and between tank ribs (Figure 42). Backfill with granular material to at least the midseam of the tank. Flowable fill or native soil free of deleterious material may be used above midseam. Note: Never try to backfill an empty fiberglass or poly tank as it may collapse.
F. Installation in High Water Table Conditions

Under some soils and site conditions, granular backfill may create a void area where subsurface water can collect, creating hydrostatic pressure on the exterior of a tank where high groundwater conditions are not otherwise present. If groundwater to grade is possible, a concrete collar over the midseam (Figure 44) or the installation of “deadmen” (steel cables attached to heavy concrete blocks) may be required for counteract buoyancy. Note that the use of a concrete collar with poly tanks may have an adverse affect on tank integrity because of chemical interaction between the materials.

Trenching leading to and from the tank excavation should include earthen dikes or mounds to prevent the free flow of groundwater into the tank excavation. Failure to include such water diversions may result in the creation of a “French Drain”, which channels water directly to the tank excavation. When installing in areas with high water tables it may be necessary to incorporate a separate drain tile system (such as a curtain drain) to divert water away from the septic system.

Manufacturers generally provide detailed instructions to be followed when installing their tanks. The reader is directed to the tank source for additional information.
G. Pipe Penetrations

For all types of tanks, pipe penetrations must remain watertight after backfill: thus it is critical to assure that there is no movement of the inlet and outlet pipe during the backfill process. Movement of this pipe during or after backfilling can alter the working liquid elevation in the tank and can damage or displace the effluent screen and case. Tamp the backfilled soil under the pipe to give it a firm foundation (Figure 45). The section of pipe across the excavation from tank to undisturbed soil should be rigid (Schedule 40 PVC or stronger) to reduce deflection. Pipe seals formed with mortar, mastic, and some rigid plastic seals are likely to be sufficiently stressed during the backfill operation that they may leak and allow root penetration. Attempting to bond wet mortar to dry concrete or PVC is not an effective pipe seal (Figure 46). As illustrated in Section III. Construction, mechanically-fastened, flexible boot seals can overcome this problem and are highly recommended.
Figure 45: Tamped (compacted) backfill under an outlet pipe to prevent settling or movement.

Figure 46: Using mortar to seal pipe joints is NOT a recommended practice.

H. Access Risers

There are varied opinions about whether riser lids should be accessible at the surface or buried under a few inches of soil. Some homeowners object to the aesthetic appearance of exposed lids and unless the lids have childproof or locking fasteners, they can pose a safety or vandalism hazard. There are devices that can be used to locate lids buried under a few inches of soil: small screw-type plastic or metal markers that are installed flush with the ground or fastened to the lid. These can later be located with a metal detector. However in practicality, there is no substitute for safe access at grade. The presence of risers provides the homeowner a constant reminder of the location of the tank and may trigger more frequent maintenance. Risers should extend to the final finished grade (or 1-3” above) and the ground should be sloped away to prevent surface water collection or
inflow around the riser as shown in Figure 47. Information on connecting access risers to tanks is included in Section III. Construction.

Figure 47. Proper final grade slopes away from the tank and risers.
VI. Operation and Maintenance

In most cases, owners are also the operators of septic tanks. They should be provided with basic information about how to assure that their systems are properly operated and maintained.

A. Pumping

If a tank is operating properly, solids are retained and take up increasingly more volume. At some time they must be removed. (If there is little accumulation of solids, either the household is extremely conservative with water use and waste generation or there is a problem causing solids to pass through the tank.) When there is little clear zone left, proper solids separation will no longer occur, detention time for settling is further reduced and solids will wash out of the tank, eventually clog the soil treatment area and cause system failure.

Solids are removed from septic tanks using vacuum tanker trucks operated by a licensed service provider. Research on solids accumulation shows the interval depends on tank size, number of people in the house, and the nature of the sewage (which in turn depends on household habits and lifestyles). Many publications and maintenance programs recommend a three to five year pumpout interval. This interval is probably reasonable but checking sludge levels at the time of service can provide a better estimate of the necessary pumpout interval.

The most reliable method for determining the need to pump is regular inspection of the tank including measurement of sludge and scum thickness. If we use regular inspection as a method for determining pumpout needs, a good rule of thumb is to pump before the top of the sludge layer reaches a level 9 to 12 inches below the bottom of the outlet baffle, or when the bottom of the scum layer reaches a level 3 inches above the bottom of the outlet baffle (Figure 48). Some local regulations, guidelines, and practices regarding when a tank should be pumped may be based on total scum thickness, total sludge thickness, or proportion of tank volume occupied by solids. A typical guideline is pumping when sludge levels reach 25-33% of tank liquid capacity. When inspecting two-compartment tanks or systems with two tanks in series, it is important to open and evaluate both of the compartments and tanks. Although solids may accumulate at a much slower rate in the second compartment, it will still need to be pumped at some time and is usually pumped at the same time as the first compartment.
Figure 48. Determining minimum clear space between scum and outlet (3” minimum) and between sludge and outlet (9” minimum).

There are many devices that can be used to either determine sludge and scum accumulations periodically or to monitor levels on a continuous basis. Figure 49 shows a proprietary device (the Sludge Judge™), one made using clear PVC pipe and one constructed of a small paddle on a stick or an L-shaped rod for measuring scum levels.

Figure 49. Tools for measurement of sludge depth (left and center) and one for measuring scum levels (right).

There is some evidence that when tanks are pumped every year or even more frequently, they sometimes do not develop normal scum and sludge layers. Pumping too frequently may prohibit development of a normal population of beneficial microbes. From the perspective of system longevity, it may be best to err on the side of pumping too often
rather than not enough; however, excessive pumping increases the burden on septic disposal facilities unnecessarily and adds unnecessary cost for the owner. Decision-making based on actual tank conditions observed during inspection is recommended.

Table 4 shows the average pump-out intervals required based on actual monitoring of tanks in two studies. This approach is not used much because people have not been trained to do it and many septic tanks are buried without risers. Gaining access to the tank is thus laborious and disruptive. There is a general belief that if you are going to the trouble to gain access to the tank, you may as well pump it and be done with it. The presence of access risers at or close to the surface makes regular tank inspection more feasible.

Table 4. Shaded entries show average required pump-out intervals from two tank monitoring studies. (Bounds, 1997)

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<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Number of occupants</td>
<td>2   3   4   5</td>
<td>2   3   4   5</td>
</tr>
<tr>
<td>Pump-out interval (yrs)</td>
<td>22  11  7  4</td>
<td>25  14  9  5</td>
</tr>
<tr>
<td>Capacity (Gallons)</td>
<td>1500</td>
<td>1500</td>
</tr>
<tr>
<td>Number of occupants</td>
<td>5   6   7   8</td>
<td>5   6   7   8</td>
</tr>
<tr>
<td>Pump-out interval (yrs)</td>
<td>9   7   5  4</td>
<td>12  9   6  4</td>
</tr>
</tbody>
</table>

Tanks that are not designed, installed, and used correctly may float out of the ground when they are pumped during seasons of high groundwater. If a tank must be pumped under high groundwater conditions, consider placing a uniformly distributed static load over the tank until it can be refilled with water immediately after pumping. The static load should be sufficient to ballast the tank without causing structural damage. In addition, tanks may collapse from external soil pressure (Figure 50). This can be costly since the tank must be re-excavated and replaced. To prevent flotation or collapse, it is best to pump at a time during the year when the seasonal water table is below the tank.
When inspecting septic systems, damaged tees and baffles are sometimes observed in older tanks. Concrete baffles and clay and concrete tees used as baffles may deteriorate in the moist, corrosive atmosphere of a tank. Deteriorated or missing baffles must be replaced as soon as the condition is discovered. This is usually done by replacing the original unit with a PVC or other plastic baffle tee. It is recommended that an effluent screen be added as part of any outlet baffle replacement operation. A failed outlet baffle can usually be replaced by inserting a section of 3” PVC into the outlet pipe and adding necessary fittings inside the tank to either use a 3” baffle tee or fit to a selected outlet filter.

At the time of pumping or inspection, access risers and lids should be checked for leakage or any structural damage. Any leaks should be repaired or patched but structural damage indicates the need for replacement.

**B. Effluent Screens**

Effluent screens should be removed and cleaned upon inspection. Safety dictates always wearing gloves when performing this task. Observations should be made regarding past or present elevated liquid level in the tank caused by a screen clogging or other downstream conditions. If the liquid level is elevated, the tank must be pumped down before removing the screen to avoid passing the solids out into the soil treatment system as the screen is removed. Some screens have a secondary device to prevent solids bypass. Screens can either be replaced with new ones or they can be rinsed off with a hose stream over the inlet opening of the tank so all material removed in cleaning goes back into the tank (Figure 51). Never allow the screen cleanings to be left on the ground surface.
Figure 51: Effluent screens should be rinsed off into the inlet end of the septic tank.

In most cases, the effluent screen is cleaned when the tank is pumped, but it should be inspected at a frequency of at least every one to two years. Observations show that frequency of cleaning the screen is less when the screen is placed in the second compartment of a two-compartment tank than if placed in a single compartment tank. Other factors that can increase the frequency of maintenance include:

- High content of fats, greases, and oils
- Presence of hair or laundry lint
- Presence of excessive solids through use of garbage grinder or excessive toilet tissue
- High water usage and peak flows.

There is some evidence that when backwash from water softening units is plumbed into the septic system, increased effluent screen maintenance may be required. More research is needed in this area. Clogging of screens should not be considered an indication of a problem with the screen unit since the purpose of a screen is to catch suspended solids. Rather, premature clogging may be an indicator of other problems such as:

- Reduced detention time due to excessive flows
- Neglecting to pump out the septic tank as needed
- Excessive flushing of grease or oil down the kitchen drain
- Use of a garbage grinder
- Excessive toilet paper use

If a screen requires servicing more frequently than anticipated by design, either the effluent screen or the wastewater characteristics should be evaluated to find the cause for premature clogging. This may indicate leaks in the fixtures, excess water use, poor wastewater quality, or that the screen is not adequately sized for that application.

C. Myths and Additives
There are many myths about substances that can help start biological activity or “improve performance” of septic tanks. Dead chickens and dead cats used to be favorite recommendations. They do nothing to enhance the function of the tank. Another myth is that a few inches of solids should be left in the tank when it is pumped to “start the tank up again”. There will be sufficient bacteria left in the tank even after a thorough pump-out, as well as bacteria carried in the incoming wastewater, to begin digestion again. However, the tank should not be washed or excessively cleaned during pump-out.

One of the most frequently asked questions about septic tanks is “what about septic tank additives?” Some chemical additives are corrosive and can actually harm the tank or its normal biological processes. Repeated use of drain cleaners, antiseptic products, medicines and laundry bleach by homeowners can upset the bacteriologic balance in the septic tank. Biological additives (bacteria and enzymes) are not likely to harm the tank, but evidence as to their usefulness in residential septic tanks has not yet been conclusively shown in carefully controlled studies. Studies show no significant positive effect associated with additives. In these studies, there was some minor reduction of the scum layer. This may mean that the floatable solids moved into the soil treatment area. Thus, the additives may actually defeat the purpose of the tank i.e., to retain solids and protect the soil treatment system. Some people promote the addition of yeast to a new or recently pumped tank. While this is harmless, it is not needed.

Another potential drawback of additives is that some advertise, “Never pump your septic tank again”. With these products the homeowner may be deluded into ignoring proper inspection and maintenance of their septic tank. Pumping is not just for solids removal; it provides an opportunity to observe potential problems and identify needed repairs. There is no substitute for proper operation, inspection, and maintenance of a tank to keep the system working as intended.

D. Recommendations to Owners

Some materials should never be put into a septic system. Coffee grounds, cat litter, cooking fats, and cigarette butts do not decompose in the septic tank and can cause rapid accumulation of solids. Paints, paint chips, solvents, some drain cleaners, and house and yard chemicals are not digested in the tank. They may actually disrupt bacterial digestion and they may pass from the tank and contaminate groundwater. Disposable diapers, female sanitary products, condoms, and other items that are nonbiodegradable may cause rapid accumulation of solids in the tank. Even paper products such as paper towels, facial tissues, sanitary wipes, etc., add to solids build up in the tank. In the absence of an effluent screen, some of these may exit the tank, posing a danger of plugging the outlet pipe, an effluent pump, dispersal system orifices or part of the soil absorption system. Items that should not be put into the tank include:

- Greases/fats/cooking oils
- Coffee grounds
- Cat litter
- Paints and chemicals
- Disinfectants
- Inorganic material (kitty litter, etc.)
- Disposable diapers
- Paper towels
- Female hygiene products
- Condoms
- Toilet wipes and similar materials
- Cigarette butts

There has been some debate about which type of toilet paper “works” best with septic tanks. Some arguments claim that if the paper doesn’t decompose, it causes excessive solids accumulation. Others claim that if paper does break down in the tank, nonbiodegradable cellulose fibers can flow into the soil absorption field or next treatment component and cause clogging; still others argue that colored toilet paper causes more clogging problems than white paper. The subject certainly warrants further research. In any case, it is best to exercise moderation in the use of toilet paper and to avoid disposing of excessive amounts of “non-contaminated” paper and facial tissue (e.g., tissue used in removing makeup, etc.) in the toilet.

Hair (particularly long hair) can cause thickening and matting of the scum in the tank by entangling other solids. It may also contribute to premature clogging of effluent screens. Using drain strainers on sinks, tubs, and showers and cleaning them frequently can minimize hair in the tank.

Laundry wastewater raises another set of concerns, particularly because modern households do much more laundry than households of several decades ago. Laundry lint, which often has a high proportion of nonbiodegradable fibers, has been suggested to cause problems by matting the scum layer in septic tanks and by exiting the tank and clogging absorption systems. Several filters for intercepting laundry lint in the house plumbing are currently on the market. They are relatively inexpensive and are a simple way of avoiding a costly problem. Powdered laundry and dishwasher detergents may contain fillers and bulking agents that can add solids to the tank and clog soil absorption fields. Washing numerous consecutive loads of laundry in a short period of time can cause turbulence that may wash solids out of the tank and cause hydraulic overloading of the soil absorption system.

The use of garbage disposals adds unnecessary solids to the waste stream and encourages homeowners to introduce food scraps that result in increased BOD and FOGs. If garbage disposals are used, more frequent solids removal may be needed.

As stated previously, plumbing water softener backwash water into a system is a subject of much discussion. The effects of doing so are not well understood and more study is needed in order to provide accurate guidance to practitioners and homeowners. In the interim, careful monitoring of systems receiving backwash water is warranted.
VII. Inspections and Troubleshooting

A trained and experienced service provider can perform troubleshooting relatively easily through an inspection of the septic tank. The process requires removal of the lids over the inlet and outlet portions of the tank. The service provider will first note the liquid level in the tank by either looking directly at the water level in or behind the outlet baffle or tee. The water should be at the level of the invert (bottom inside lip) of the outlet pipe if no water has recently flowed into the tank. If the water level is not elevated above the invert, the sludge and scum levels can be measured. Refer to the section on Operation and Maintenance (Section VI). If the water level is below the invert, there is a leak in the tank that should be located and repaired.

If the level is above the outlet invert, there is a blockage in the outlet pipe or effluent screen or a back up from the soil treatment system. Pipe blockages can be a result of many different things: root intrusion, crushed pipes, deteriorated clay or concrete pipes, or a pipe with a “belly” that prohibits gravity flow. If the soil treatment system seems normal, investigate for a line blockage. It may be possible to run a plumber’s snake through the line from the tank (after pumping the tank) or it may be necessary to expose and cut into the pipe outside the tank to get a snake into the line. Any of this can be an unpleasant job if there is effluent backed up in the line. It is a good practice to have a vacuum truck at the site to remove effluent as needed. Additionally, gloves and eye protection should always be worn.

Odor from and around septic tanks may be noticed in some systems. Odor around older systems may be caused by deterioration of tank components, broken tank tops, or submergence of the inlet that prevents proper venting of the tank through the plumbing roof stack. Odor may also be detectable from a new tank that has not developed normal biological processes yet or a tank that has been recently pumped. Normal odor may come from the roof stack. This may be especially prevalent during times of still air and particularly during temperature inversions that may occur early morning or late evening. Possible remedies for stack odor include extending roof vents higher to an elevation above the roof ridge or installing activated carbon filters on the top of vent pipes to filter odor.
VIII. Abandonment Procedures for Tanks

In the event that a septic tank is no longer used (alternate connection to city sewer, tank replacement during system upgrade or repair, etc.), the tank must be properly abandoned. Local codes may list specific requirements for this activity and must be followed. In the absence of specific code requirements, the following procedures are recommended. The goal is to render the area of the old tank safe and free of environmental or public health impacts.

The tank must first be completely emptied of its contents using vacuum tanker trucks operated by a licensed service provider. Three common processes for dealing with the empty tank are listed below:

- Remove and dispose of the tank at an approved site (normally a landfill)
- Crush the tank completely and backfill
- Fill the tank with granular material or some other inert, flowable material such as concrete

The abandoned tank must present no collapse or confined-space hazard. The reader is directed to check with local authorities for recommended or approved procedures.
References


