

INTRODUCTION

The solids in raw household wastewater will quickly clog all but the most porous gravel formations. To enhance soil absorption, raw wastewater is discharged to a septic tank where solids are retained. A septic tank is a watertight chamber that:

- separates the settleable and floatable solids,
- promotes the growth of anaerobic bacteria necessary to decompose the solids, and
- provides storage for the resulting sludge and scum.

The septic tank reduces the velocity of wastewater and permits the settling of materials heavier than the liquid. Concurrently, scum, grease and other materials lighter than the water float to the top. A vertical section of a properly operating tank would show it divided into three distinct layers; scum at the top, a middle zone of generally clear water relatively free of solids called the “clear space”, and a bottom layer of sludge.

Septic tanks are designed to handle all the normal daily flow a household or business produces and should have sufficient capacity for a minimum detention of at least 2-3 times the daily wastewater flow. For this reason, design should be based upon the maximum capacity of a home rather than its number of inhabitants at any particular time. Minimum capacities for septic tanks are shown in Table V-1. The design should allow for the inclusion of laundry and garbage grinder wastes.

It is desirable to install larger tanks whenever possible. Tanks larger than the minimum have the advantage of more solids separation into the scum and sludge layers, and more solids storage. The larger capacity provides less carryover of solids, resulting in prolonged life of the soil absorption unit. Larger tanks also require less frequent cleaning and allow for future expansion of the home, which provides a positive cost-benefit return. Design flow capacity does not allow for roof drainage, other surface water, footing drainage, sump pump, or any other subsurface drainage, so these must be excluded from the system.

Table V-1. Minimum Septic Tank Capacities Based on the Number of Household Bedrooms.

Number of Bedrooms ¹	Septic Tank Capacity (gallons) ²	
	Minimum	Recommended
3	1,000 ³	1,350
4	1,200	1,800
5	1,500	2,250

¹ For each additional bedroom add 150 gallons to the recommended value.

² Volume held by the tank below the liquid level (invert of the outlet pipe).

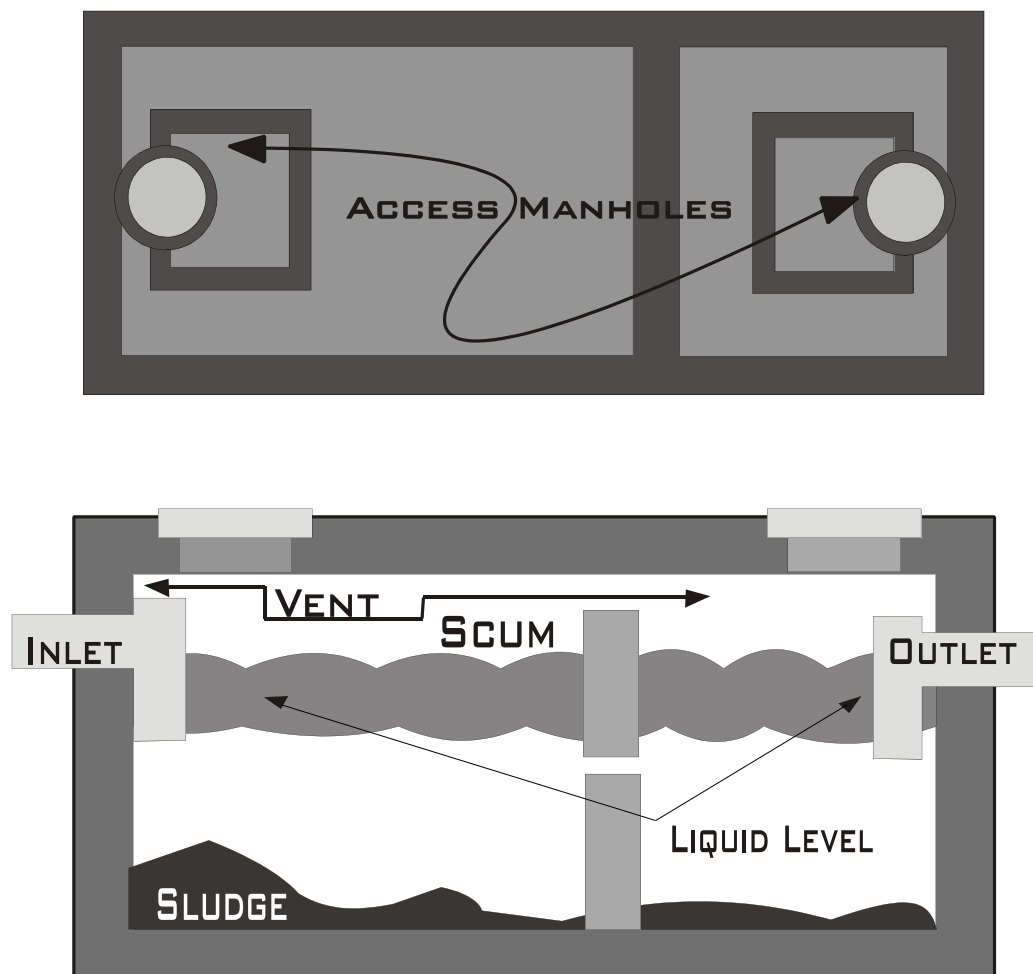
³ Minimum tank size is 1,000 gal.

Septic tanks are constructed with baffles or sanitary tees on both the inlet and outlet pipes. Baffles or tees retain floating scum and minimize the disturbance of the settled sludge or floating scum as wastewater enters and leaves the tank. Septic tank design should include provisions for two openings through the top that are large enough for clean out and repair. These should be located to permit easy access to the tank inlet and outlet devices. It is important that the openings themselves are accessible and have covers that exclude water. Section views showing details for a concrete septic tank are in Figure V-1.

TANK MATERIALS AND SHAPES

Three types of materials have proven to be acceptable for long-term use of a tank: concrete, polyethylene plastic, and fiberglass. Although tanks have been made from metal, the corrosive atmosphere and contents cause rapid disintegration. The metal is soon compromised, leaving nothing but a rust-lined underground void, subject to collapse and obviously leaking. Simply stated, metal tanks should never be allowed in a wastewater treatment system.

Figure V-1. A Two Compartment Septic Tank: a. Top View, b. Side Section View



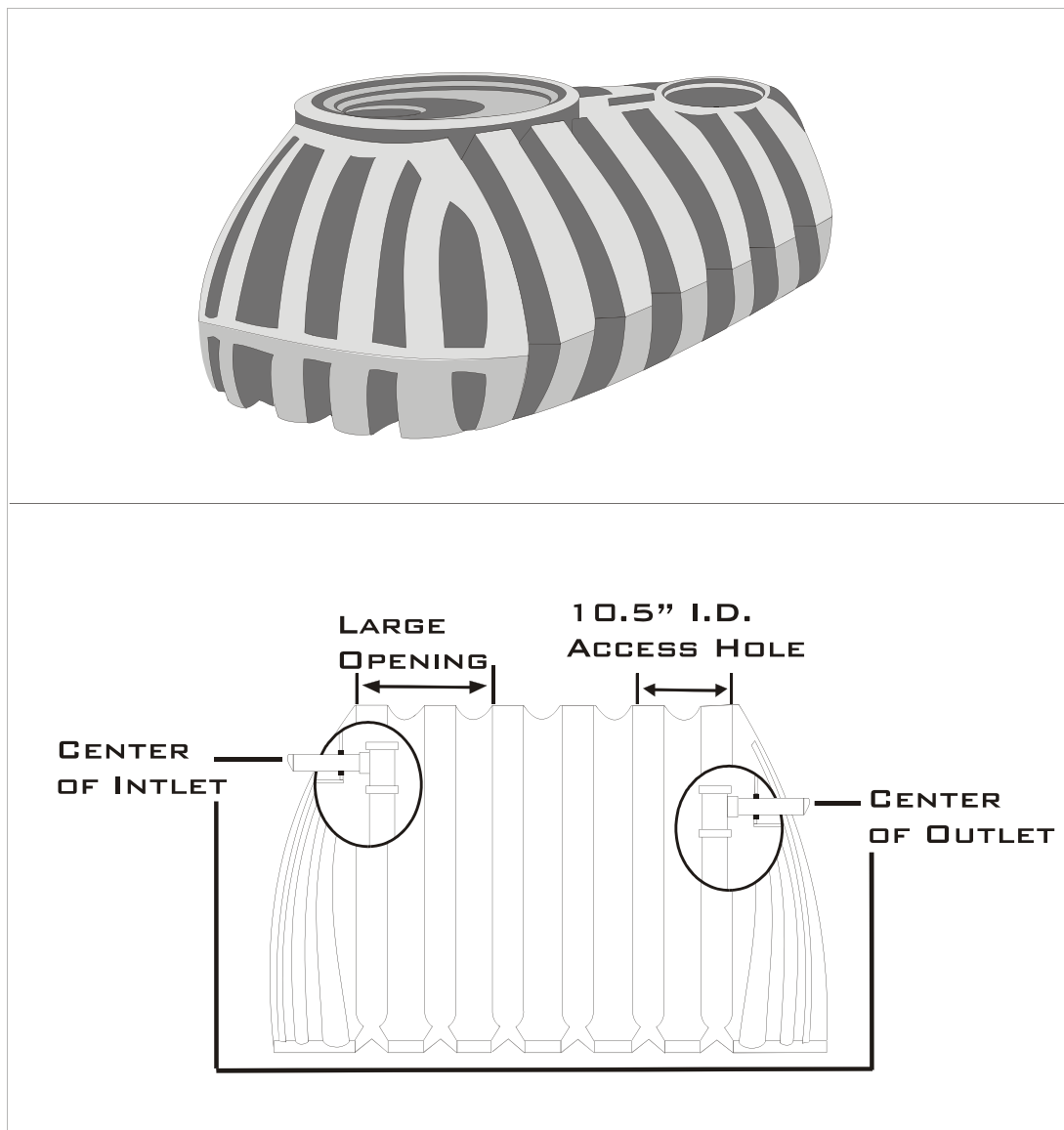
Box-like concrete septic tanks are the most common. Properly reinforced and mixed, concrete forms a pre-cast tank that is strong, durable, stable, and modest in cost. The metal reinforcement used in the sidewalls must be positioned in the form so that the metal is always covered by at least an inch of concrete. If the rebar or wire mesh is exposed, not only is the concrete strength compromised, but the metal deterioration (as discussed previously) further weakens the tank. Any exposed reinforcement is a valid reason to reject that the tank.

Concrete septic tanks are very heavy, requiring special trucks for transport and placement. If struck or dropped, the concrete may crack. A cracked tank will leak and must be rejected. The tank forms should be filled with a single pour. If the form is partially filled and the concrete hardens before the rest of the fill, a “cold joint” is created. Cold joints are prone to seeping or leaking and are not acceptable in septic tanks. It is a good idea to fill a tank with water and check for leaks before placement in the ground.

A two-piece septic tank with a horizontal joint around the middle (also called a clam shell tank) is designed as two boxes that fit together, rim to rim. One box forms the bottom half and the other box (with the inlet and outlet in opposite ends and the hatch or hatches in the top) is the top half. The bottom half is placed in the excavation, a rubber or asphalt sealer is fitted completely around the rim before the top half is lowered into place on the sealer. This design divides the weight between the two halves, making it easier to handle and position. However, the potential for leakage is great along the seam where the two halves meet. This tank can only be checked for leakage **after** it has been placed. Should leaks be detected, it is necessary to pump out the water and reseal before testing again. Leakage has been a real disadvantage of the two-piece design, and its use has fallen out of favor.

Fiberglass and polyethylene plastic tanks are so similar that both are discussed here as “plastic tanks”. Plastic tanks are manufactured by molding and are usually round or capsule-shaped (horizontal cylinder). Because the entire tank is formed as a single piece, there are no seams to seal, and the material is resistant to impact damage. These tanks’ great advantage as well as their disadvantage, is their light weight. The lightness allows these tanks to be transported in an ordinary pick-up. The tank can be set in place with only a backhoe or hand-carried by a few people. These tanks are life-savers in situations where a heavy truck cannot gain access to place a concrete tank. Figure V-2 shows an example of a polyethylene plastic septic tank.

Due to their lightness, plastic tanks **must** be installed according to the manufacturer’s instructions. This usually involves setting the tank on a carefully leveled and compacted sand or small gravel bed in the bottom of the excavation. Sand or fill is tamped around the tank as it is filled with water. Failure to observe the procedures stipulated by the manufacture can result in a tilted or deformed tank, or one that literally floats out of the ground. Plastic tanks are deeply ribbed for reinforcement and for a better “grip” by the soil. Although plastic tanks are readily available for many uses, only those specifically designed for use as septic tanks can be used for this purpose.

Figure V-2. Example of Polyethylene Plastic Tank

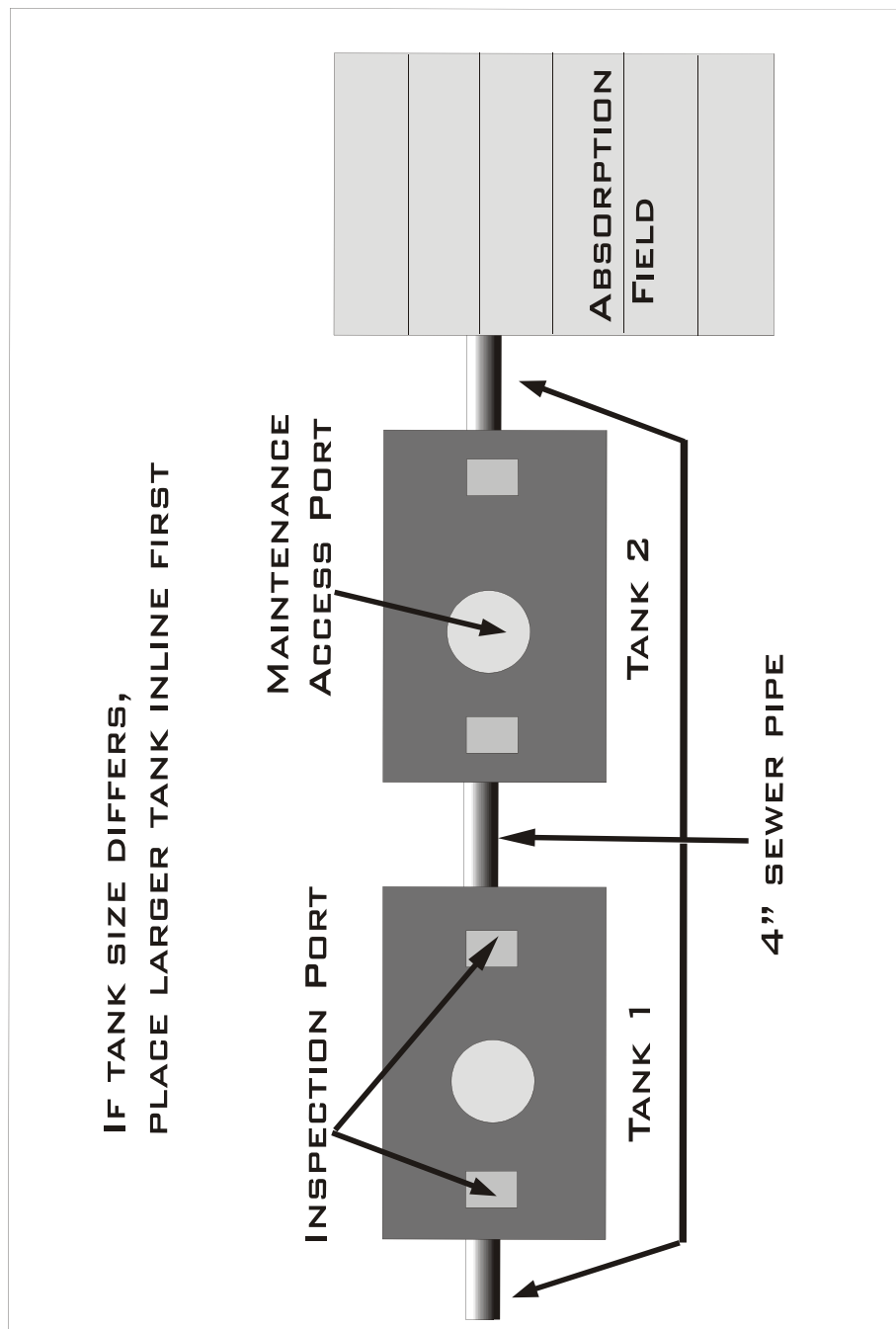
COMPARTMENTED TANKS

Although a single compartment tank can give acceptable performance, research data indicates that multiple compartment tanks perform better because they provide greater protection against solids carryover into the discharge pipe. Multiple compartment tanks have been recommended because of improved effluent quality. Adding a high quality effluent filter to a single compartment tank may provide equal or higher quality effluent than a 2 compartment tank with no effluent filter.

The term “compartmented” as used here, refers to chambers within a tank or tanks placed in series. A number of arrangements are possible. Figure V-1 illustrates a single tank with a

watertight partition separating the individual compartments. The first compartment should have a volume of one half to two thirds of the total tank capacity. The total tank capacity must meet the minimum capacities shown in Table V-1 and should be 2-3 times the expected daily flow. Separate units can be linked together, one flowing into another as in Figure V-3.

Figure V-3. Two Septic Tanks In Series (plan view, not to scale)



SEPTIC TANK SAFETY

Excavations for septic tanks can create a safety hazard. Experience shows that depths as shallow as five feet below ground level have resulted in injury and loss of life. The installer is responsible for assuring that working conditions on the site are not hazardous to workers or the public. An excavation deeper than 5 feet cannot be entered unless OSHA standards for the entry are met. Children, animals, and non-authorized personnel should be excluded from the work site. One should never use electrical lights, appliances, or tools in or close to the water or wet ground near the septic tank or drainfield because this can result in explosion or electrical shock.

Because the liquid and solid contents of the septic system are capable of causing infectious diseases, it is important to always wash hands thoroughly after working on any part of the septic system, and before eating, drinking, or smoking. Work clothes should be changed before entering a house, food store, or restaurant, etc. Smoking should be avoided near septic tank openings because combustible gases may be present.

SEPTIC TANK DESIGN STANDARDS

General Requirements

Required of all septic tanks, regardless of the construction material:

- a. A recommended minimum liquid depth of three feet (distance from outlet invert to bottom of tank), but shall not exceed six feet. The effective inside length of rectangular tanks must not be less than 1.5 or greater than 4 times the effective inside width.
- b. The tank, including all extensions to the surface, must be water tight and constructed of durable material that is not subject to excessive corrosion, decay, frost damage, or cracking. Steel septic tanks have a short life because of corrosion and are not acceptable. The top of all tanks shall be designed and constructed to support a minimum of 400 pounds per square foot (lbs/sq ft). When buried more than 2 feet deep, the top shall support an additional 100 lbs/sq ft. for each foot of soil or portion thereof in excess of 2 feet.
- c. The openings of the tank (or top of the riser) should be at the surface and shall be no more than 12 inches below the finished grade. It shall be large enough for inspection, maintenance, and clean-out purposes. The opening or manhole shall be a minimum of 20 inches on the shortest dimension. Where the top of the tank must be more than 12 inches below finished grade, an extension collar shall be attached to bring the top within 12 inches of the surface. All below grade attachments to the tank, connections, riser, extensions and lid shall be water tight. When any opening larger than 8 inches extends to the surface, that opening shall be child and tamper resistant. Some examples include lids that weigh at least 65 pounds, or locks and anchors that are not removable without special tools.

- d. There shall be a one inch clearance between the underside of the top of the tank and the top of all baffles and partitions or other adequate openings, to permit venting of gas from the tank through the house stack vent.
- e. Space above the liquid line is required for that portion of the scum floating on the liquid. For tanks having straight, vertical sides, the distance between the top of the tank and the outlet invert should be at least 15 percent of the liquid depth, with a minimum of 7 inches. In horizontal cylindrical tanks, an area equal to approximately 12.5 percent of the total volume should be provided above the liquid level. This condition is met if the liquid depth (distance from outlet invert to bottom of tank) is equal to 85 percent of the diameter of the tank.
- f. Sewage lines carrying solids from the source to the tank should have sufficient slope to maintain velocities that carry solids. For household lines, a slope of between 1 percent (1/8 inch per foot) and 2 percent (1/4 inch per foot) is generally considered essential. The last 15 feet of sewer line preceding the tank shall not slope more than 2 percent (1/4 inch per foot).
- g. The invert of the inlet pipe shall be located at least three inches above the invert of the outlet when the tank is level. This space allows for momentary rise in liquid level during discharges to the tank. Liquid standing in the sewer line between the house and the septic tank causes solids accumulation and may cause stoppage or backup, and should be avoided.
- h. The septic tank inlet shall be a sanitary tee, elbow, or long sweep elbow with a low head inlet or baffle to direct incoming sewage downward and prevent flow from disturbing the floating scum layer. It should extend at least 8 inches below the liquid level, but should not penetrate deeper than 20 percent of the liquid depth.
- i. The length of the outlet device is important in that it must allow only clear effluent to leave the tank. It extends below the floating scum in the tank and ends above the sludge accumulation. If the length of the outlet "T" is improperly sized, the tank will require more frequent pumping to prevent scum from being carried out or sludge solids from being washed out with the effluent. The outlet device should generally extend below the liquid surface to a distance equal to 35 percent of the liquid depth. For horizontal or cylindrical tanks this distance should be reduced to 30 percent of liquid depth.
- j. The dividing baffle in two-compartment tanks shall extend from the bottom of the tank to at least six inches above the liquid line. The openings in the dividing baffle may be any shape but must have a minimum dimension of two inches and a total area of at least 12 square inches. The opening is to be centered in the baffle and at a point equal to 35 percent of the total liquid depth (30 percent liquid depth for cylindrical tanks) from the water level.
- k. Septic tanks shall have an access manhole (a minimum 20 inch dimension) for each compartment. If the manhole does not extend to surface grade, a small diameter (at least

2 inch diameter) pipe shall extend to surface from the cover to mark the location of the manhole. This pipe shall not penetrate the lid of the tank. Inspection risers at least 6 inches in diameter (large enough to easily remove and replace the effluent filter) shall extend to surface grade, centered over the inlet and outlet tees. All below grade attachments to the tank, connections, riser extensions, and lid shall be water tight. When any opening larger than 8 inches extends to the surface, that opening shall be child and tamper resistant. Examples include lids weighing at least 65 pounds and locks, or anchors that are not removable without special tools.

- l. The sewer line from the house to the tank, all fittings and pipe in the tank, all extensions to the surface from the top of the tank and the first 10 feet exiting the tank shall be schedule 40 pipe or heavier. Septic tanks shall be designed for at least a 20-year life. They shall be designed and constructed to withstand extremes in loads resulting from adverse conditions without excessive deflection, deforming, creep, cracking, or breaking. Change in shape shall be limited to 5 percent. Loads shall be based on 62.4 pounds per cubic foot for water and water-saturated soil. Top loads for design shall be 400 pounds per square foot plus 2,500 pound axle point load. Design shall be based on a 2 foot placement depth to top of the tank. If the tank will be placed deeper than 2 feet or subject to vehicular traffic over the tank, a design by a Kansas licensed structural engineer shall be done for the specific conditions.
- m. Refer to Table V-1 for minimum septic tank capacities

Special Considerations for Concrete Tanks

The anaerobic environment of a septic tank produces gases that combine with moisture to produce acids. Concrete above the liquid level is subject to corrosion and deterioration from these acids. This corrosion is best resisted by high quality concrete mix. Concrete septic tanks shall meet the following requirements, in addition to those above:

- a. The concrete design mix shall have a compressive strength of at least 4,000 pounds per square inch at a 28 day cure. The water-cement ratio shall not exceed 0.45.
- b. Baffles or other interior concrete units must be cast or built into the tank wall at the time the tank is constructed.
- c. Air entrainment additives shall be added to 5 percent volume. Other chemical mixtures are encouraged to reduce water content, improve cement placement in forms, and for wet handling of incompletely cured concrete.
- d. Concrete tanks and lids shall receive proper care during the hydration (hardening) period by: 1) monitoring and controlling temperature of the concrete and gradients (i.e. maintain 50-90 degrees Fahrenheit for conventional cure and up to 140 degrees Fahrenheit under low pressure steam cure.) and 2) monitoring and controlling humidity to prevent adverse moisture loss from fresh concrete (i.e. prevent or replenish loss of essential moisture during the early, relatively rapid stage of hydration.)

- e. Reinforcing steel shall be placed as designed by a Kansas licensed structural engineer to ensure floor, wall, and top do not crack from moisture, frost, soil load, water loads, axle loads, or other stresses. Loads as specified above shall be used for the design condition. Reinforcing steel shall be covered by a minimum of 1 inch of concrete and shall be placed within $\pm 1/4$ inch.
- f. Pouring the floor and walls of the septic tank at the same time (monolithic pour) is the preferred construction procedure. Very large tanks are often cast in 2 pieces and assembled in the field. All tanks shall meet the same structural strength standard as specified earlier. Two-piece tanks shall have permanently sealed, structurally sound joints and shall be water tested after assembly. A Kansas licensed structural engineer shall determine if the tank meets the strength specification.
- g. In areas of high sulfate water (greater than 250 mg/L) more acid producing gases are likely and additional corrosion resistance is appropriate. Recommended measures include ASTM C150 Type II cement (moderate sulfate resisting), ASTM C150 Type V cement (highly sulfate resisting), or coating interior concrete surfaces above the water line. Coatings that provide additional protection of the concrete include asphalt, coal tar, or epoxy. The product used should be acid resistant and provide a moisture barrier coating for the concrete. The product must not bleed into the water, risking groundwater contamination.
- h. Manufacturers are strongly urged to follow guidelines and meet the standards of the American Concrete Institute, National Precast Concrete Association, and American Society for Testing and Materials. Manufacturers should identify and advertise their products which meet these applicable standards.

Special Considerations for Fiberglass and Plastic Tanks

- a. All tanks shall be sold and delivered by the manufacturer, completely assembled.
- b. Tanks shall be structurally sound and support external forces as specified above when empty and internal forces when full. Tanks shall not deform or creep, resulting in deflection more than 5 percent in shape due to the loads imposed.
- c. Tanks, all below grade fittings, and connections including inlet and outlet pipe and risers shall be watertight.

SEPTIC TANK PLACEMENT SPECIFICATIONS

- a. The vehicle setting the tank must not enter the absorption field area during the process of placing the tank, as heavy traffic compacts the soil.
- b. Where natural soil is not suitable, tanks shall be placed on a bed of at least 4 inches of sand, pea gravel, or crushed granular noncorrosive material for proper leveling and bearing. Material shall be no larger than 2 inches in diameter and bed depth shall be at least four times the diameter of the largest material.

- c. Access manholes should be at surface grade, but shall not be more than 12 inches below surface grade. Where the top of the tank must be more than 12 inches below surface grade, a watertight collar and extension riser shall be added as necessary to raise the cover. Inspection openings placed over inlet and outlet tees or baffles shall be at least 6 inches in diameter and extend to the surface. This simplifies locating the tank and makes it easy to inspect and clean the effluent filter, check the condition of tees or baffles, and measure sludge accumulation.
- d. Septic tanks should not be placed into the water table (including perched or seasonal water table) because of the tendency of the tank to float. This is especially of concern when the tank is empty after being pumped; the displaced volume of the tank has a buoyant effect. Septic tanks should not be completely emptied if groundwater levels are significantly higher than the bottom of the tank. For existing tanks in any area subject to high water table or seasonally high water table, replacement tanks of plastic and fiberglass shall not be used unless precautions are taken to drain groundwater.
- e. Septic tanks shall be watertight. An adequate test for this is to fill the tank with water and let it stand for 8 hours to allow concrete to absorb water and for plastic tanks to adjust. The tank is then topped off and an initial measurement is made with a hook gauge with vernier scale, followed by another measurement an hour later. Any water loss shows water leakage and the tank should be rejected. Observations of the outside of the tank can also give clues about leakage losses. Any trickle, ooze, or exterior wet spot is reason to reject the tank. Precast, one-piece tanks are best tested at the plant before delivery. Two-piece tanks that are assembled on-site must be tested following placement but before back filling.
- f. The hole for the tank shall provide ample space around the tank that allows access for proper compaction. Backfill should surround the tank in uniform, compacted layers not exceeding 2 feet thick. Care must be taken during the installation and backfilling of fiberglass and plastic units to prevent damage to the tanks. The manufacturer's installation instructions must be followed, and usually includes filling the tank with water as it is backfilled. If the natural soil does not crumble easily, these tanks should be backfilled with sand. Medium to small-grained granular materials are the best fill around the tank's ribbing to provide consistent support. Because of potential soil collapse, it is unsafe and can be illegal for a person to enter a trench deeper than 5 feet without adequate shoring. Compaction should be done from the surface without entering trenches deeper than 5 feet.
- g. Special care must be taken in bedding the house sewer, septic tank, and outlet line to prevent uneven settlement, resulting in cracked or ruptured pipe at the point where the inlet and outlet lines connect with the septic tank. Shorter pipe lengths at the inlet and outlet also help to minimize this problem.

REFERENCES AND ADDITIONAL READING

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