What every operator should know about primary treatment

Ken Schnaars

Knowledge	Principle	Practical considerations
Primary treatment	Primary treatment via sedimentation is one of the first and earliest processes used at a water resource recovery facilities (WRRFs). The first primary treatment processes typically were constructed with anaerobic digesters where the primary sludge was sent to be stabilized.	Primary treatment is the first major process where solids and biochemical oxygen demand (BOD) are removed from the process using gravity. The influent wastewater velocity is reduced in primary sedimentation tanks so suspended solids, settleable solids, and BOD can settle to the bottom of the tank; lighter solids, such as grease and plastics, float to the surface to be removed.
Tank configuration	Primary sedimentation (settling) tanks are designed to enable solids to settle. They can be constructed in different configurations to achieve the primary treatment objectives.	Primary sedimentation tanks configurations include circular, rectangular, or square. The most common designs are circular or rectangular. Square primary tanks are not as common. Rectangular tanks are typically designed with length to width ratios of 3:1 to 5:1. The length of rectangular primary tanks range between 15 and 90 m (50 and 300 ft). The width of a primary tank can vary but the maximum width of each section of the tank typically does not exceed 6 m (20 ft). The maximum width of a primary tank section is determined by the maximum width of the flights, which typically is 6 m (20 ft). If additional tank width is required, then additional basin sections are constructed with flights divided by an open wall with columns. The diameter of circular primary sedimentation tanks is determined by the WRRF's flow rate, detention time, surface overflow rate, and other parameters. The liquid depth within a primary sedimentation tank should be a minimum of 2.5 m (8 ft); however, 3 m (10 ft) are mandated in recent standards. Current primary sedimentation tank designs often exceed this depth and have specified liquid depths of approximately 4.5 m (15 ft).

Knowledge	Principle	Practical considerations
Primary sedimentation tank collection mechanisms	Primary sedimentation tank collection mechanisms collect and remove settled and floatable solids.	In a circular tank, the collector mechanism contains a scraper mechanism on the tank bottom and scum skimmer on the tank surface. Primary sedimentation tanks need scraper type bottom collectors to move the settled sludge to the withdrawal hopper in the center of the tank. It is also important that the tank bottom have a substantial slope to help move the settled sludge toward the center of the tank. The typical slope for a circular tank bottom is a 1 unit of vertical drop for every 10 units of horizontal distance.
Primary treatment efficiencies	Removal efficiency increases with fresher wastewater. If influent wastewater is septic, removal efficiency through a primary sedimentation tank will suffer.	Knowing and understanding the typical standard removal efficiencies in the primary treatment process will help operators know when there is a process issue. The typical primary treatment process should remove the following amounts of these types of solids. ■ Total solids should be reduced 10% to 15%. ■ Settleable solids should be reduced 95% to 99%. ■ Suspended solids should be reduced 40% to 60%; and, sometimes, as much as 70%. ■ BOD should be reduced 25% to 35%. Removal efficiencies may increase with chemical addition.
Surface overflow (settling) rate	Surface overflow rate is one of the hydraulic controls used to determine the performance of primary sedimentation tanks.	The surface overflow rate in a primary sedimentation tank is related to the hydraulic loading in the primary sedimentation (settling) tank and whether the tank is receiving only influent wastewater or a combination of influent and waste activated sludge (WAS). Primary settling tanks and secondary clarifiers use surface overflow rates as a process control parameter. Primary settling tanks are designed with faster surface overflow rates. (Secondary clarifiers are designed for slower overflow rates to enable lighter secondary floc particles to settle.) Typical surface overflow rates for primary sedimentation tanks are as follows. **Influent alone** ■ At average flow, the surface overflow rate will be 32 to 49 $m^3/m^2•d$ (800 and 1200 gal/d•ft^2). ■ At peak flow, the surface overflow rate will be 122 $m^3/m^2•d$ (3000 gal/d•ft^2)maximum. **Influent mixed with WAS** ■ At average flow, the surface overflow rate will be 24 to 30 $m^3/m^2•d$ (600 to 800 gal/d•ft^2). ■ At peak flow, the surface overflow rate will be 49 to 61 $m^3/m^2•d$ (1200 to 1500 gal/d•ft^2).
Weir overflow rate	The weir overflow rate measures how much water flows over the weirs.	The weir overflow rate is the quantity of water that flows over each linear foot of weir per day. The maximum primary tank weir overflow rate varies with facility size. For WRRFs smaller than 3785 m^3/d (1 mgd), the weir overflow rate is 248 $m^3/m•d$ (20,000 gal/ft•d). For WRRFs larger than 3785 m^3/d (1 mgd), the weir overflow rate is 373 $m^3/m•d$ (30,000 gal/ft•d).

Knowledge	Principle	Practical considerations
Detention time	Detention time is how long a drop of water (or solid) stays within the tank before it leaves the tank.	The detention time for wastewater travelling through a primary sedimentation tank is typically short. The type of solids that settle in a primary sedimentation tank can turn septic quickly. The detention time in a primary sedimentation tank normally is designed to be between 1 and 3 hours; the average detention time is 2 hours. Wastewater temperature affects settling and detention time. During summer months, tank contents will become septic faster, so the detention time through the primary tank needs to be reduced and the removal of settled solids needs to be increased. During the winter months, liquid and solids detention times can be increased.
Primary sludge pumping	The purpose of primary sludge pumping is to remove the settled solids. The solids are sent to solids handling facilities.	WRRFs use different types of primary sludge pumps depending on the solids concentration and/or piping configuration. When the primary sludge total solids concentration is below 4%, a centrifugal-type pump, such as a recessed impeller (torque flow) pump can be used. Some facilities that have primary sludge concentrations 2% or less have used dry-pit submersible pumps. WRRFs that have higher primary sludge total solids concentrations of 4% or higher use positive displacement-type pumps, such as a progressive cavity pump. Long suction lines to the pumps also factor into pump choice. These lines can contain numerous gas bubbles, which could gas-lock a pump. Therefore, the correct type of pump must be selected to handle the primary sludge total solids concentrations and piping configurations. Typically, primary sludge pumps and sludge withdrawal systems are started based on cycle times and then operate for preset run times when the withdrawal systems are in the automatic mode of operation.
Volatile fatty acids (VFAs)	If a primary sedimentation tank is used as a fermenter, then the solids remain in the primary tank longer than normal primary tank parameters so VFAs are formed to assist with biological phosphorus removal in the activated sludge process.	Operators must carefully balance these tanks to operate as a fermenter while maintaining proper sedimentation. They must prevent the tank from becoming septic.
Enhanced primary clarification	Primary sedimentation tank settling efficiencies can be improved by chemical addition. There are newer advances being developed for the primary treatment process that could improve removal efficiencies without chemical addition.	Chemicals, such as polymers and alum or iron salts, are used to flocculate small solids so they form larger solids that can be settled more efficiently in the primary sedimentation tanks. Chemical addition, prior to the primary sedimentation tank also is effective in reducing phosphorus. The addition of chemicals prior to the primary sedimentation tank increases suspended solids removal efficiencies to between 60% and 70% (or higher) and BOD removal efficiencies to between 40% and 60%.

Knowledge	Principle	Practical considerations
Odor control	Because primary sedimentation tanks receive untreated influent, the chance for potential odors exists.	If septic wastewater enters a primary sedimentation tank or settled sludge remains too long, the tank could become septic and/or odorous. The highest release of hydrogen sulfide and volatile organic compounds occurs when the primary effluent flows over the weirs and splashes in the weir troughs. Some primary sedimentation tanks use submerged pipes with orifices, which eliminate the splashing and release of hydrogen sulfide. If this type of effluent device is used in a primary tank, a method must be designed to keep the liquid level in the primary tank above the submerged effluent pipe and the liquid level in the tank constant. Odors also can be released at other turbulent areas within primary tanks, such as the inlets. To prevent odors, operators can optimize the process, reduce turbulent areas in the tank, and/or add chemicals to inhibit odor constituents.
Floatable solids	Lighter-than-water material will float to the surface or primary sedimentation tanks.	Floating material contains grease, oil, plastic, and other lighter material. Floatables that rise to the surface are gathered and removed by scum collection equipment. In rectangular primary tanks, longitudinal collector mechanisms push the floatables to scum troughs. In circular tanks, a surface skimmer gathers and pushes the floatable solids to scum troughs where the solids are removed.
Troubleshooting	Making rounds to check on equipment enables operators to identify process or mechanical issues that need to be resolved.	The partial list below provides common observations and solutions for primary sedimentation tanks. **The solids collector mechanism has stopped moving.** The collector mechanism may have stopped because of high torque, a broken shear pin, a too-thick solids blanket, or debris in the tank. **The solids collector chain has jumped sprocket.** The chains could be too slack. The sprocket could be worn or loose on shaft. The sprocket shafts may not be parallel. Debris on sprocket caused the chain to jump off. **The primary sludge is too thin.** The primary sludge pump could be set to operate too often and/or too fast. If the sludge on the discharge side of the pump is thin, but the sludge blanket is thick, there may be a partial plug in the pump suction pipe, hydraulic overload, or short-circuiting. **Numerous bubbles appear on the tank surface.** The sludge blanket is too thick. The remedy is to remove more sludge. Check the sludge pump suction pipe for clogs and/or that solids are not overloading of the tank.

Ken Schnaars *is a certified operator and professional engineer in the Nashville, Tenn., office of Brown and Caldwell (Walnut Creek, Calif.).*