19. Sludge Thickening

Prior to the sludge stabilization process such as anaerobic digestion, the solids content of the sludge is increased by utilizing an appropriate thickening process.
Notes:
1) There is an upper limit of the solids concentration that can be effectively treated as increasing the solids concentration reduces its ability to be mixed and pumped easily. Digesters can effectively treat sludges with upto about maximum 7% - 9% solids.
2) If a 5000 mg/l (0.5%) sludge is thickened to 5% solids concentration - it will reduce the volume of sludge by 90%

19.1 Advantages of sludge thickening

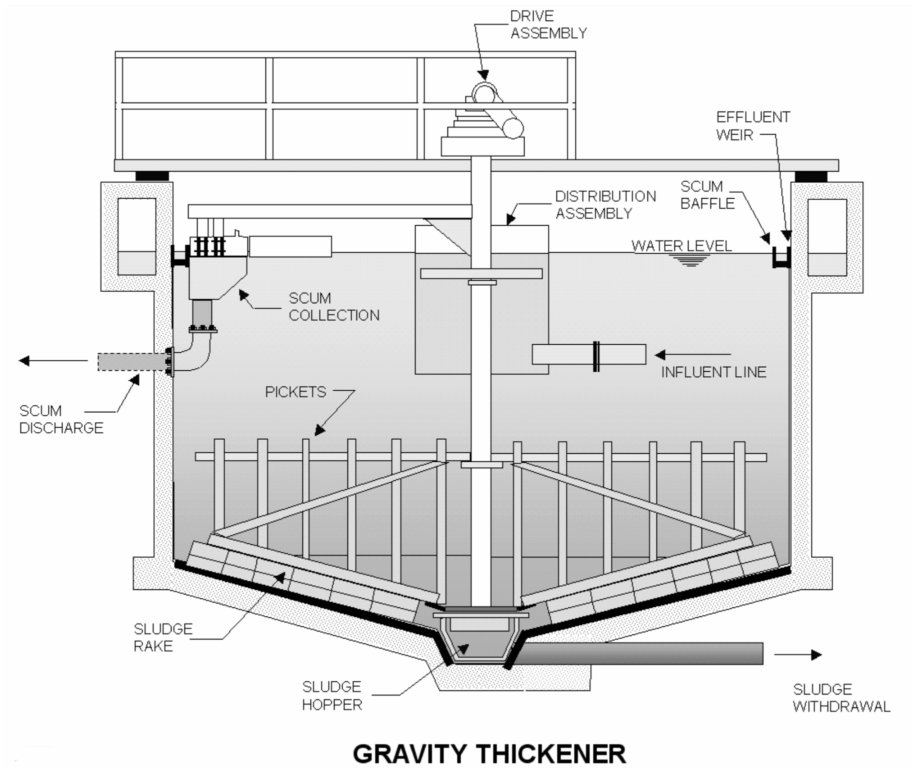
- Improved digester performance due to a lower volume of sludge
- Capital Cost savings associated with less digester volume requirements
- Operational costs savings - for sludge heating and mixing

19.2 Sludge thickening methods

1. Gravity thickener - more suitable for primary sludge
2. Dissolved air floatation thickener - more suitable for lighter, fluffier floc such as the secondary sludge.

19.3 Gravity thickener

The gravity thickener is designed and operated similar to a circular primary and secondary clarifier.



19.3.1 Principles of gravity thickener operations

- Upon entering the tank from the center, the sludge solids settle under the influence of gravity and these settled solids accumulate in the bottom of the gravity thickener as the sludge blanket. As the sludge becomes thicker it helps squeeze out more water from the sludge increasing the sludge solids content.
- Typical solids loading rates of a gravity thickener used for thickening primary sludge is 20-30 lbs TS/day-ft^2
- A picket fence-like mechanism which is attached to the bottom sludge rake arms is primarily to release entrapped gases. The sludge rake arms rotate at a very slow speed to ensure that it does

not cause turbulenece causing the sludge to rise. The sludge is gently raked towards a sump in the center, from where the solids are withdrawn. The sludge rake encounter much higher torques than the typical primary clarifier rake, and is therefore designed to be more stronger and heftier.

- The thickened solids are drawn-off at regular intervals and the liquid fraction is decanted from the top and returned to the primary clarifier. The typical sludge concentration factor is about 2.
- The sludge blanket is kept about three feet.
- The sludge blanket depth is typically maintained so that the sludge does not turn septic and the effluent is relatively clear and free of solids.
- Sludge Volume ratio (SVR) provides a means of regulating the detention time of sludge within the blanket of the thickener
- SVR is defined as the volume of the sludge blanket divided by the daily volume Of sludge pumped from the thickener.
- SVR is a relative measure of the average detention time of solids in the thickener and is calculated in days.
- Typical SVRs for primary sludge range from 0.5 - 2 days.
- Scum is removed from the top using a separate scum removal mechanism.
- Chemical additives may be utilized to enhance settling and control odors.

19.3.2 Elements of a gravity thickener

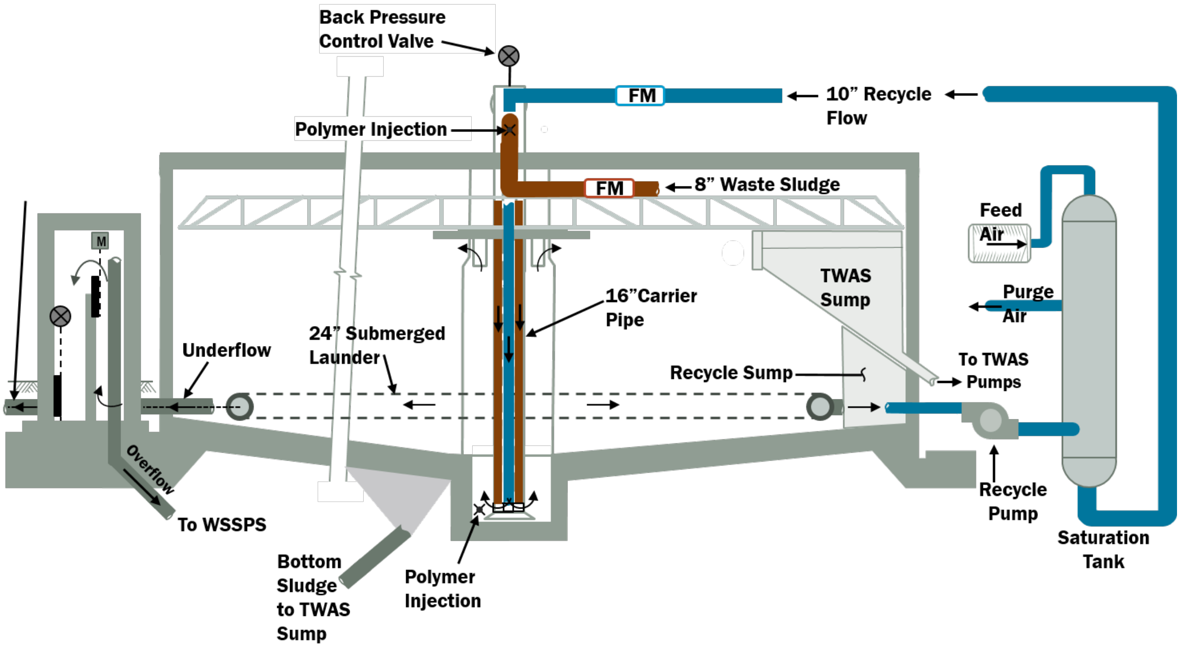
- center feed column and baffle
- drive assembly
- scum removal system
- thickened sludge pump
- sludge rake with pickets
- effluent weir
- sludge hopper and pump

19.3.3 Gravity thickener operational parameters

- type and quality of sludge
- hydraulic or surface loading rate (GPD/ft^2/day)
- solids loading rate (lbs/ft^2/day)
- sludge volume ratio - sludge detention time
- solids and hydraulic loading rates, and
- quantity and characteristics of the polymer used

19.4 Dissolved air floatation thickener (DAFT)

Opposite to the principle of the gravity thickener where the thickened sludge forms a blanket at the bottom, in the DAFT the thickened sludge forms a blanket on the top surface. Primary sludge is not generally suitable for thickening using DAFT as its solids are heavier and do not float easily. The WAS from the secondary clarifier which typically has a solids content of about 0.5% to 0.8% is thickened to about 4% to 6% concentration – thickened WAS (TWAS) using the DAFT.



19.4.1 Principles of DAFT operations

- WAS is conditioned with cationic polymer and introduced into the DAFT. DAFTs typically operate at a solids loading rate of 1-2 lbs TSS/hr-ft^2. Polymer feed ranges from 5-15 lbs of polymer/ton of the WAS (feed) solids.
- Recycled water from the DAFT is pressurized with air in the saturation tank and mixed with polymer treated WAS as it is released at the bottom of the DAFT using the Back Pressure Control Valve.
- The dissolved air from the pressurized water is released as minute air bubbles rises upwards carrying with it the polymer flocculated sludge to the surface. Adequate quantity of air is required to float the WAS solids. Air:Solids ratio is one of the key operating and control parameter. Typical air:solids ratios in a DAFT are between 0.03 - 0.05 lb air per lb TS. PS: Density of air used for air:solids ratio calculations - 0.075 lb air/ft^3 air - this value is given as part of the problem.
- The thickened solids floating on the top are scrapped off the surface of the DAFT by flights into the TWAS sump from where it is pumped to the digesters. The subnatant - water below the solids, part of it is used for the air pressurization in the saturation tank and the remaining is the underflow, which is returned back to the influent flow.
- The flight speed is critical to the DAFT performance. Fast flight speed would limit the thickness and density of the sludge blanket while slower flight speed would result in the thickened solids layer getting more dense and thick. Excessively thick solids layer could result in the solids escaping through the underflow.

19.4.2 Elements of a DAFT

- pressurization or saturation tank
- thickened sludge skimmer with drive assembly
- polymer dosing and injection system
- thickened sludge pump
- back pressure control valve
- underflow removal
- recycled flow system

19.4.3 DAFT operational parameters

- saturation pressure
- solids loading rate (lbs TSS/hr-ft^2)

- hydraulic loading rate (GPD/ft^2/day)
- feed solids concentration
- detention period
- air-to-solids ratio (lb air: lb solids)
- type and quality of sludge
- flight speed
- solids and hydraulic loading rates, and
- quantity and characteristics of the polymer used (lbs polymer/dry ton solids)

19.5 Solids thickening math problems

1. Calculate the air required (SCFM) to meet a 0.04 lb air:lb feed solids ratio for a 100 GPM WAS flow with a solids content of 6500mg/l? Assume 0.08 lbs air/SCF air. Solution:

$$\frac{lb\ \ air}{lb\ \ solids} = 0.04 = \frac{0.08\ \ lbs\ \ air\ \ SCF * X\ \ SCF\ \ per\ \ minute}{\frac{100}{1,000,000}\frac{MG}{min} * 6,500\frac{mg}{l} * 8.34\ \ lbs\ \ solids}$$

$$\Longrightarrow x\ \ SCF\ \ per\ \ minute = \frac{0.04 * 5.421}{0.08} = \boxed{2.7\ \ SCFM}$$

2. A treatment plant receives an influent flow of 30 MGD with a TSS concentration of 280 mg/l. The primary treatment removes 55% TS and the primary sludge is pumped to a 40 ft diameter gravity thickener. Calculate the average solids loading to the thickener in lbs TSS/day-ft^2
   Solution:
   Solids loading to gravity thickener=$\frac{(30\ \ MGD\ \ *\ \ 280 * 0.55\ \ mg/l\ \ * 8.34) lbs\ \ TSS\ \ per\ \ day}{0.785 * 40^2\ \ ft^2} =$
   $\boxed{30.7\ \ lbs\ \ TSS/day - ft^2}$