

SOLIDS HANDLING

Solids handling, digestion, and disposal take almost as much expense and manpower to operate and maintain as the rest of the plant. The sludge thickening process attempts to decrease the amount of water that is handled by increasing the solids concentration in the sludge. If you can double the solids concentration, the amount of water needed to move a pound of solids is cut in half. Most anaerobic digesters have to be heated. Each gallon of water must be heated from 60-70 degrees F to 94-96 degrees F. If you have to pump twice as much water to the digester, the cost of heating the digester doubles and the detention time is cut in half. Less water to the digester also means less chance of an upset do to temperature fluctuations and less supernatant returning to the head of the plant.

GRAVITY THICKENERS

A gravity sludge thickener is a scaled down clarifier. The process is identical but the unit is designed for heavier sludges and lower flows. Surface loading rates are about 400-800 gpd/sqft. Detention times vary from 1-2 days. The solids loading on the unit is calculated in pounds per day/sqft. The efficiency of the process is dependent on three factors: the solids concentration, the settleability of the sludge, and the temperature. Secondary sludges and waste activated sludge in particular are more difficult to handle than primary sludges. Primary sludge will normally run 4-6% solids (94-96% water) while trickling filter sludges will be about 1-2% solids and waste activated sludge will run about 0.5-1.0% solids. Blending secondary sludges with primary sludge in a gravity thickener may improve the overall solids concentration, but activated sludge may require additional treatment like dissolved air floatation (DAF) prior to blending.

The sludge rakes and drive mechanism must be able to handle the heavier solids in a gravity thickener. There are vertical pickets attached to the rake assembly. These pickets help mix the blended sludges and aid in the release of gases to prevent rising sludge in the unit. If sludge is held in the thickener too long it will become septic. This can result in odor problems and floating solids. Septic sludges are the most difficult to de-water. This means higher dosages of chemicals, like polymer in DAF units or centrifuges and lime in vacuum filters and belt presses, will be required.

The operational control parameters for gravity thickeners include detention time, sludge blanket depth, and sludge withdrawal rate. The detention time should be shorter in warm weather. Sludges settle better in warm water and increased biological activity means that the sludge will go septic faster. Sludge blanket depth should be between 5-8 feet deep. Sludge blanket depth will affect detention time, creating short detention times as the blanket depth increases. The withdrawal rate should be adjusted to maintain a constant sludge blanket depth. The Sludge Volume Ratio (SVR) is used to control the sludge retention time in the thickener. It compares the sludge solids concentration to the sludge blanket depth much like SVI in activated sludge.

The removal efficiency of a gravity filter is determined by comparing the suspended solids concentration in the effluent to the concentration in the influent (expressed as mg/l instead of percent). As an example, if the effluent SS is 800 mg/l and the influent solids are 4% the removal efficiency is 98%.

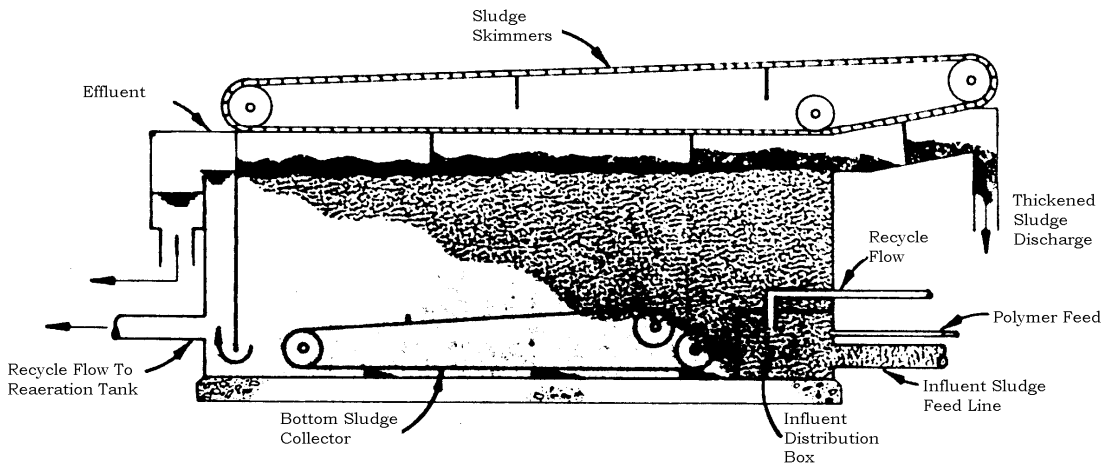
$$\frac{40,000-800}{40,000} \times 100 = 98\%$$

It is important to remember that all solids handling processes create sidestream flows that are returned to the head of the plant. These flows are high in BOD and suspended solids and have no dissolved oxygen. Tests for BOD and SS should be run on thickener effluent, or supernate, and other solids handling sidestreams every shift. The suspended solids are again settled in the primary clarifiers, but the organics that are present are mostly dissolved. The secondary processes must deal with the majority of the BOD. It should be included in any organic loading calculations like F:M ratios. Poor thickener performance can cause organic overloading in the biological process.

DISSOLVED AIR FLOTATION

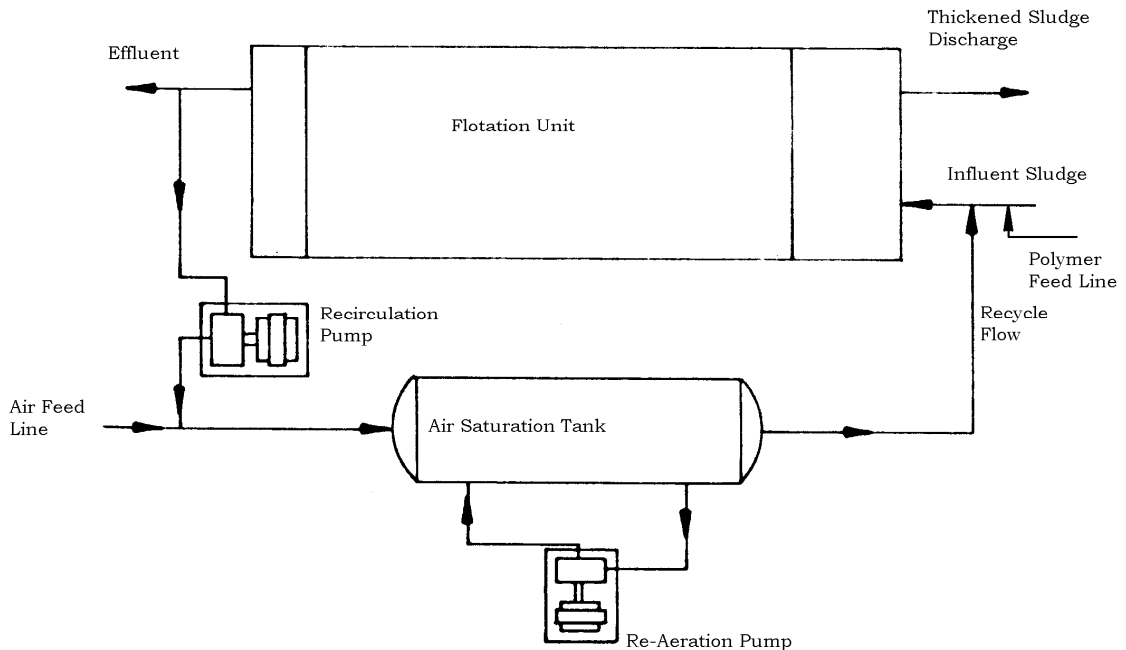
Dissolved air flotation is a sludge thickening process that is used in activated sludge systems. The solids concentration in waste activated sludge (WAS) is only about 1/10 that of primary sludge. That means it requires moving ten times as much water as primary sludge for every pound of solids. The DAF process uses air to float solids to the surface of the tank instead of settling the sludge to the bottom. In order to float a sludge particle, it must have a specific gravity that is less than 1.0. The air bubbles that are formed in the DAF unit are trapped in the sludge particles, with the aid of some polymer, and the particle becomes lighter than the water. The particles are concentrated in this sludge "scum" and skimmed off of the surface of the tank. Solids concentrations can be increased to 2-4% solids and it will take 1/4 the volume of water needed to move each pound of solids to the digester.

Dissolved Air Flotation Unit



The DAF unit consists of a rectangular tank with skimmers that move like a rectangular clarifier sludge rake on the surface and a sludge collector on the bottom. Skimmed sludge is removed from the front end of the unit and the sludge collector drags sludge to front of unit where it can be floated to the top. The effluent passes under baffles at the end of the tank and part of the flow is recycled back to the influent. The recycle flow is controlled by bleeder valve in the influent distribution box (bubble box). Before the recycle water is returned to the influent distribution box, it passes through a hydropneumatic tank that is charged with air.

DAF Unit Process Schematic



The bleeder or backpressure valve creates a line pressure of about 90 psi in the air tank. The recycle water picks up dissolved oxygen in the air saturation tank and, as it passes out of the bleeder valve into the DAF unit, the drop in pressure releases tiny air bubbles into the influent sludge flow. The same result happens if you shake up a can of soda and suddenly pop the top. Anionic polymers are used also introduced into the influent sludge flow to aid in the formation of a large floatable sludge particle. Polymer dosing is determined by running a jar test to establish the minimum dosage needed to create a sludge floc particle. The loss of recirculation flow or backpressure can result in a reduction of air bubbles and poor removal efficiency.

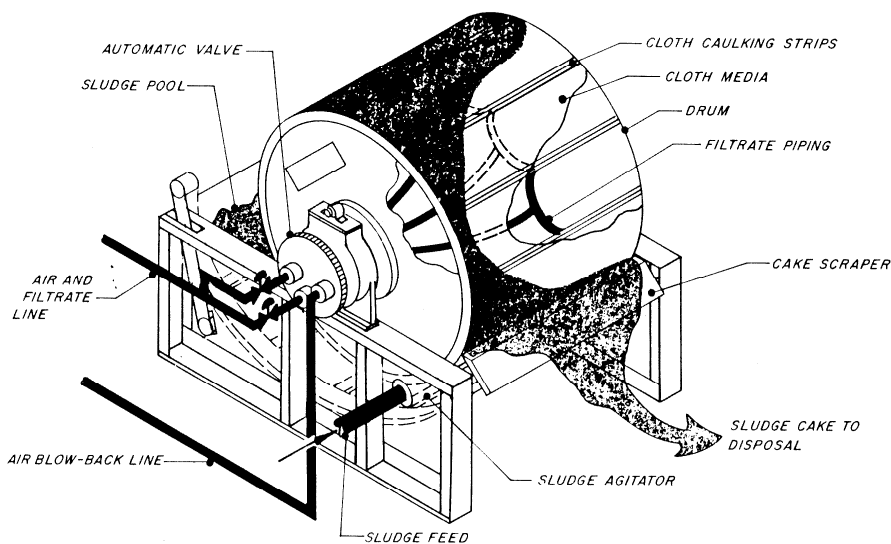
Process Control Variables for DAF Units

- Sludge Flow
- Air Flow
- Recirculation flow
- Recirculation Backpressure
- Skimmer speed
- Polymer dosage

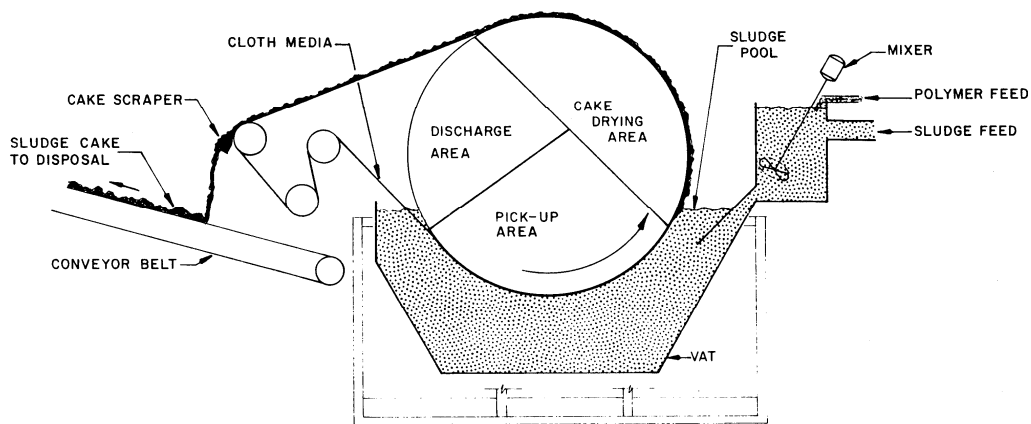
A DAF unit may not run all of the time in smaller systems. During startup a DAF unit must be conditioned before sludge is added to the process. This is referred to as “charging” the unit. Water must be air saturated and recirculated while polymer is added for at least 30 minutes prior to sludge addition. Floc carryover in the effluent should only last for 20-30 minutes after the sludge is introduced. If floc carryover continues, jar tests should be run to check the polymer dosage. The air to solids ratio may also need to be adjusted to improve particle floatation.

OTHER SLUDGE THICKENING PROCESSES

Vacuum filters, belt presses and centrifuges are also used to thicken sludge prior to final disposal or incineration. All of these processes utilize polymers to condition the sludge and aid in the separation process. Vacuum filters dewater the sludge by drawing a cake of sludge onto a belt drum and then sucking the water out of it.



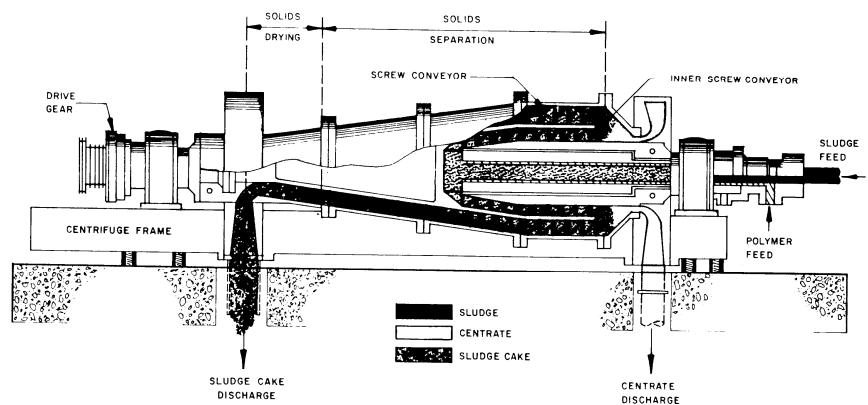
Vacuum Belt Filter



Vacuum Belt Filter Process Diagram

The filter belt rotates through a vat of conditioned sludge and the vacuum draws the sludge onto the belt. The sludge cake that is picked up on the belt moves out of the sludge vat and into the drying zone. The vacuum continues to draw air through the sludge cake to dewater it until the belt leaves the drum. The dewatered sludge cake is finally scraped off of the filter belt and carried by a conveyor to a disposal vehicle. A set of spray nozzles wash the belt as it returns to the drum. This process can produce solids in the 15-20% range, but the vacuum system uses a lot of energy.

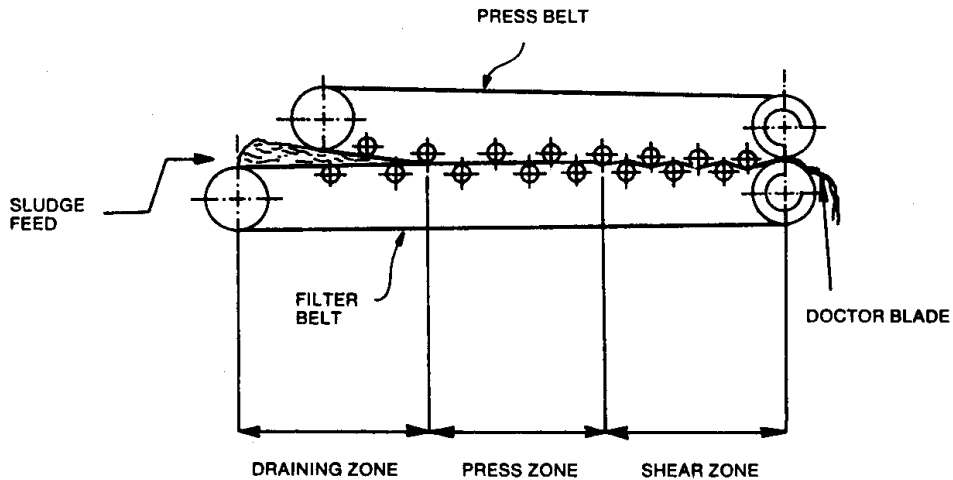
Centrifuges spin the conditioned sludge and separate the solids from the water by centrifugal force. The spin cycle of a washing machine will use centrifugal force to dewater laundry. There are two types of centrifuges. A batching centrifuge can only process a single load of sludge at a time. A scrolling centrifuge is designed to run with a continuous sludge feed rate.



Scroll-type Horizontal Centrifuge

Conditioned sludge is fed into one end of the centrifuge drum. The solids are forced to the outside and a scrolling conveyor pushes them out one end of the unit. The water that is left behind, called centrate, collects in the center and overflows to drain.

A belt filter press is the most simple and least expensive means of mechanically dewatering sludge. Digester sludge is first sent to a conditioning tank that rotates like a clothes dryer. A polymer is added and some of the water begins to drain from the sludge. The conditioned sludge is poured between two vinyl belts that travel through a series of roller drums that squeeze the water out of the sludge. After the sludge cake is scraped from the belts, a set of spray nozzles are used to clean remaining sludge from the belt. This creates another sidestream that returns to the head of the plant.



Belt Filter Press



Belt Filter Press
Conditioning drum on left
Scraper blades on right

BASIC STUDY QUESTIONS

1. Gravity thickeners resemble which other treatment process?
2. Why is thickening sludge important to digester operations?
3. What are other processes are used to thicken sludges?

BASIC SAMPLE TEST QUESTIONS

1. The vertical pickets on a gravity thickener:
 - A. Reduce the surface loading rate
 - B. Aid in mixing and gas release
 - C. Increase supernatant BOD
 - D. None of the above
2. The sludge blanket in a gravity thickener should be:
 - A. 1-2 feet deep
 - B. 3-4 feet deep
 - C. 5-8 feet deep
 - D. 10-12 feet deep
3. As the sludge blanket depth increases:
 - A. Detention time increase
 - B. Detention time decreases
 - C. Weir overflow rate decreases

ADVANCED STUDY QUESTIONS

1. Why is the removal efficiency of a gravity thickener important?
2. What are operational parameters for a gravity thickener?

3. How is a polymer dosage determined for a DAF unit?
4. How do you "charge " a DAF unit?

ADVANCED SAMPLE TEST QUESTIONS

1. Which of the following is not an operational control for a DAF unit?
 - A. Sludge Flow
 - B. Recycle Rate
 - C. pH
 - D. Skimmer speed
2. The detention time in a gravity thickener should be:
 - A. 1-3 hours
 - B. 4-6 hours
 - C. 10-12 hours
 - D. 1-2 days
3. Poor removal efficiencies in a gravity thickener will result in possible overloads in:
 - A. Pretreatment processes
 - B. Primary treatment processes
 - C. Secondary treatment processes
 - D. Tertiary treatment processes
4. The most difficult sludge to dewater is:
 - A. Primary sludge
 - B. Trickling filter sludge
 - C. Waste activated sludge
 - D. Septic sludge

