Chapter 10: Activated Sludge

Process Description

Activated sludge is a suspended growth secondary treatment process that primarily removes dissolved organic solids as well as settleable and non-settleable suspended solids. The activated sludge itself consists of a concentration of microorganisms and sludge particles that are naturally found in raw or settled wastewater. These organisms are *cultivated* in aeration tanks, where they are provided with dissolved oxygen and food from the wastewater. The term "activated" comes from the fact that the particles are teeming with bacteria, fungi, and protozoa.

Like in most other wastewater treatment plants, when wastewater enters an activated sludge treatment facility the preliminary treatment processes remove the coarse or heavy inorganic solids (grit) and other debris, such as rags, and boards. Primary clarifiers (if they are provided) remove much of the floatable and settleable organic material. The activated sludge process can treat either primary clarified wastewater or raw wastewater directly from the preliminary treatment processes. As the wastewater enters the aeration basin, the activated sludge microbes consume the solids in the wastewater. After the aeration basin, the wastewater solids and microorganisms are separated from the water through gravity settling which occurs in a secondary clarifier. The settled solids and microorganisms are pumped back to the front of the aeration basin, while the clarified water flows on to the next component.

Operation of the Activated Sludge Process

Providing Controllable Influent Feeding

The feeding of wastewater to activated sludge systems must be controlled in a manner that ensures even loading to all of the aeration basins in operation. Well-designed flow splitter boxes should be incorporated into the front of the aeration basin and they should be checked periodically to ensure that the flow distribution is split as intended. In some situations, it is desirable to feed wastewater throughout various points in the aeration basin. This is known as step feeding. Step feeding is one method of

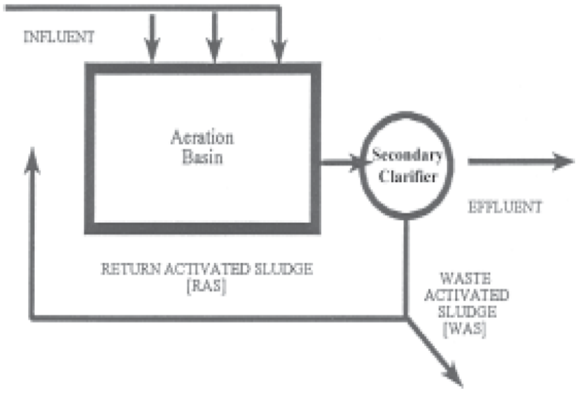

Figure 10.2 - ***Convention Step Feed Aeration***

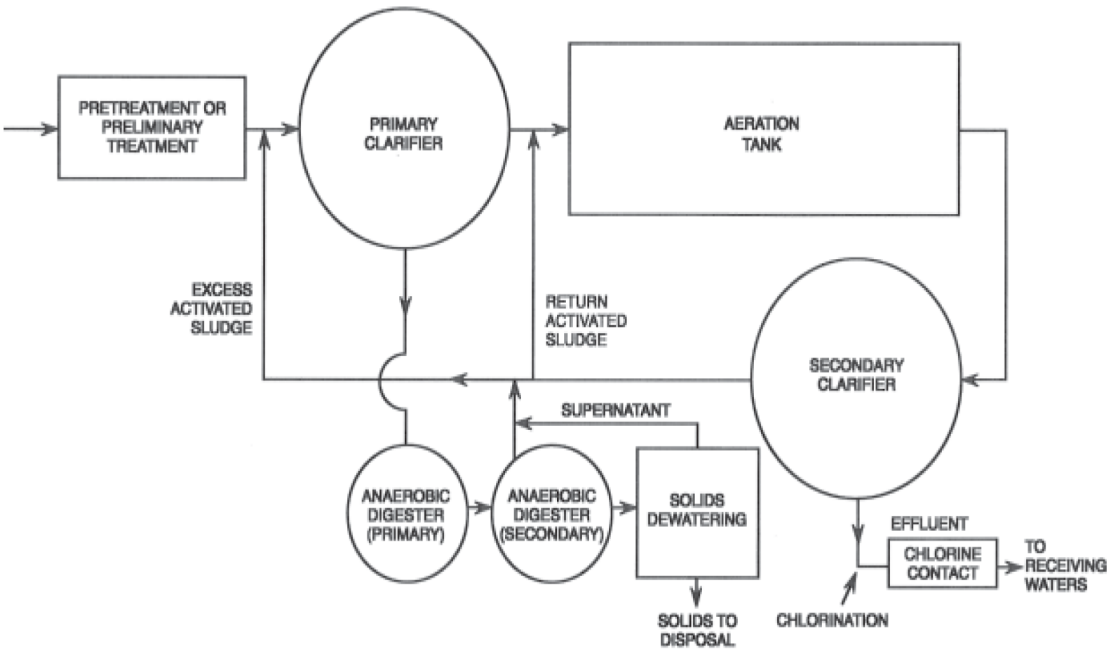

Figure 10.1 - ***Plant Layout***

relieving the high oxygen demand that can occur where the influent flow and RAS enter the aeration basin. However, a downside to step feeding is that some of the dissolved solids in the influent may pass through the aeration basin too rapidly, and show up in the effluent as BOD.

Maintaining Proper Dissolved Oxygen and Mixing Levels

Activated sludge microorganisms need oxygen as they oxidize wastes to obtain energy for growth. Insufficient oxygen will slow down or kill off aerobic organisms, make facultative organisms work less efficiently and ultimately lead to the production of the foul-smelling by-products of anaerobic decomposition. As the mass of organisms in an aeration tank increase in number, the amount of oxygen needed to support them also increases. High concentrations of BOD in the influent or a higher influent flow will increase the activity of the organisms and thus increase the demand for oxygen. Sufficient oxygen must always be maintained in the aeration tank to ensure complete waste stabilization.

This means that the level of oxygen in the aeration tank is also one of the critical controls available to the operator. A minimum dissolved oxygen (D.O.) level of 1.0 mg/L is recommended in the aeration tank for most basic types of activated sludge processes. Maintaining > 1.0 mg/L of D.O. contributes to establishing a favorable environment for the organisms, which produces the desired type of organism and the desired level of activity. If the D.O. in the aeration tank is allowed to drop too low for long periods, undesirable organisms, such as filamentous type bacteria may develop and overtake the process. Conversely, D.O. levels that are allowed to climb too high can cause problems such as floc particles being floated to the surface of the secondary clarifiers. This problem is particularly common during cold weather. For these reasons it is important that the proper dissolved oxygen levels be maintained in the aeration basin. This requires routine monitoring by the system operator using a D.O. meter.

Controlling the RAS Pumping Rate

The amount of time that solids spend on the bottom of the secondary clarifier is a function of the RAS pumping rate. The settled microorganisms and solids are in a deteriorating condition as long as they remain in the secondary clarifier. If sludge is allowed to remain in a secondary clarifier too long it will begin to float to the surface of the clarifier due to nitrogen gas released during the biological process of de-nitrification (rising sludge). Monitoring and controlling the depth of the sludge blanket in the secondary clarifier and the concentration of solids in the RAS are important for the proper operation and control of the activated sludge system. A sludge settleability test, known as a settleometer, can be used to show the rate of sludge settling and compaction. This information is used to determine proper RAS pumping rates. Typically, RAS pumping rates of between 25% and 150% of the influent flow are commonly used.

Maintaining the Proper Mixed Liquor Concentration

The activated sludge process is a physical/ biological wastewater treatment process that uses microorganisms to separate wastes from water and to facilitate their decomposition. When the microorganisms in activated sludge come into contact with wastewater, they feed and grow on the waste solids in the wastewater. This mixture of wastewater and microorganisms is known as mixed liquor. As the mixed liquor flows into a secondary clarifier, the organism's activity slows and they begin to clump together in a process known as bio-flocculation i.e. the ability of one floc particle to stick to another. Because the velocity of the water in the secondary clarifier is very low, the flocculated clumps of organism settle to the bottom of the clarifier (as sludge), while the clarified water flows over a weir. The settled organisms are constantly pumped back to the front of the aeration basin to treat more waste. This is called return activated sludge, or RAS, pumping.

The clarified effluent is typically disinfected and then discharged from the facility. As the organisms in the aeration basin capture and treat wastes they grow and reproduce and more and more organisms are created. To function efficiently, the mass of organisms (solids concentration) needs a steady balance of food (wastewater solids). If too many organisms are allowed to grow in the aeration basin, there will not be enough food for all of them. If not enough organisms are present in the basin, they will not be able to consume the available food and too much will be lost to the effluent in the form of BOD and TSS.

This balance between the available food (F) and the mass (M) of microorganisms is described as the F:M ratio of the system. The job of an activated sludge wastewater treatment plant operator is to maintain the correct mass of microorganisms for the given food supply. Because the food supply does not typically change very much (that is, the amount of wastewater solids usually stays the same from day to day), operators must adjust the mass of organisms that are allowed to accumulate in the aeration basin. This adjustment is made by removing or *wasting* organisms out of the system. Sludge that is intentionally removed from the activated sludge process is referred to as waste activated sludge, or simply as WAS.

Activated sludge provides treatment through the oxidation and separation of soluble organics and finely divided suspended materials that were not removed by previous treatment. Aerobic organisms accomplish the process in a matter of hours as wastewater flows through the aeration tank and secondary clarifier. The organisms stabilize soluble organic material through partial oxidation resulting in energy for the organisms and by-products, such as carbon dioxide, water, sulfate and nitrate compounds. Finely divided suspended solids such as colloids are trapped during bio-flocculation and thus removed during clarification.

Conversions of dissolved and suspended material into settleable solids as well as oxidation of organic substances (digestion) are the main objectives of the activated sludge process. High rate activated sludge systems tend to treat waste through conversion of the dissolved and settleable solids while low-rate processes rely more upon oxidation of these solids into gasses and other compounds. Oxidation is carried out by chemical processes, such as direct oxidation from the dissolved oxygen in the aeration basin, as well as through biological processes.

Microorganism capture much of the dissolved organic solids in the mixed liquor rapidly (minutes), however, most organisms will require a long time to metabolize the food (hours). The concentration of organisms increases with the waste load and the time spent in the aeration tank. To maintain favorable conditions, the operator will remove the excess organisms (waste sludge) to maintain the required number of workers for effective treatment of the waste. The mass of organisms that the operator maintains is a function of the mixed liquor suspended solids (MLSS) concentration in the aeration basin. By lowering the MLSS concentration (increased wasting), the operator can reduce the mass of organisms in the system. This effectively raises the F:M ratio of the system. By raising the MLSS concentration (reduced wasting), the operator can increase the number of organisms in the system available to provide treatment. This has the effect of lowering the F:M ratio. Again, controlling the rate of sludge wasting from the treatment process is one of the important control factors in the activated sludge system.

Review of Key Activated Sludge Operator Controls:

- Providing Controllable Influent Feeding
- Maintaining Proper Dissolved Oxygen and Mixing Levels
- Controlling the RAS Pumping Rate
- Maintaining the Proper Mixed Liquor Concentration (controlling the F:M ratio of the system)

The successful operation of an activated sludge process requires a skilled operator that is aware of the many process control factors influencing the treatment and constantly checking these factors. To keep the microorganisms working properly in the activated sludge process the operator must maintain a suitable environment. Toxic substance can kill the organisms in an activated sludge system if allowed to enter the system. Uneven flows can starve or overfeed the microorganism population and the failure to supply enough oxygen may create an unfavorable environment, decreasing the organism activity or even leading to death of the organisms.

Types of Activated Sludge Treatment Processes

The activated sludge treatment process can be operated in a variety of different modes. Each of the variations utilizes the basic process of suspended growth in an aeration tank, but new methods of operation are routinely being added to the industry. The three basin modes of operation for the activated sludge process are:

- Convention Activated Sludge
- Extended Aeration Activated Sludge, and
- Contact Stabilization Activated Sludge

The primary difference between these three modes of operation has to do with the length of time that the microorganisms reside in the treatment system. This concept is expressed as the system's solids retention time, or SRT. A system's SRT is calculated as the pounds of MLSS in the system divided by the pounds of suspended solids that enter the system everyday. For example; a system that maintains 1000 lbs. under aeration and receives 100 lbs./day of solids is operating at a SRT of 10 days.

Not surprisingly, there is a relationship between the SRT and the F:M ratio, although they are not exactly the same thing because the F:M ratio actually enumerates the *mass of living microorganisms* divided by the *edible solids* (BOD) that enter the system everyday. Systems that operate at a SRT of around 3.5 to 10.0 days are considered conventional activated sludge. Extended aeration systems generally operate at SRTs of greater than 10 days. Contact Stabilization systems separate the aeration basin into two parts. In the first part, known as the contact basin, microorganisms capture the dissolved and suspended waste solids. In the second zone, which is called the stabilization basin, the microorganisms complete the job of metabolizing the captured food. Contact Stabilization systems typically operated at SRTs below 3.5 days. Because of this, this process is typically used in industrial applications or severely overloaded municipal treatment plants that do not have enough available aeration basin volume.

Conventional Activated Sludge

Conventional activated sludge plants are the most common type in use today. These systems are usually equipped with primary clarification prior to the aeration basin. This method of operation produces a high quality effluent and is able to absorb small shock loads without lowering the effluent quality.

The following ranges describe the typical operating parameters for conventional activated sludge systems:

- Detention time in aeration basin = 4-8 hrs.
- MLSS in aeration basin = 1000-4000 mg/L
- System SRT = 3.5 – 10.0 days
- System F:M Ratio = 0.25 – 0.5 : 1
- RAS pumping rate = 15-75% (of plant influent flow)

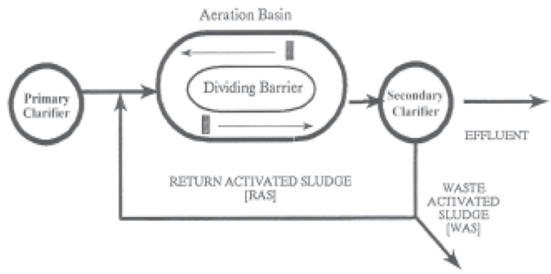

Figure 10.3 - ***Conventional Aeration***

Extended Aeration Activated Sludge

The extended aeration mode of operation is often used in smaller package-type plants and complete oxidation systems. Extended aeration is typically a very stable activated sludge processes, due to the light loading (low F:M) that these system's operate under. In extended aeration, the low F:M ratios are made possible by the use of larger aeration basins and sludge ages that are commonly greater than 10 days. Although the process is stable and easy to operate, it is common for extended aeration systems to discharge higher effluent suspended solids than found under conventional loadings.

Extended aeration processes generally operate within the following ranges:

- Detention time in aeration basin = 12-24 hrs.
- MLSS in aeration basin = 2000-5000 mg/L
- System SRT = > 10 days
- System F:M Ratio = 0.05 – 0.15 : 1
- RAS pumping rate = 50-150% (of plant influent flow)

Contact Stabilization

Contact Stabilization is a variation of the conventional activated sludge process that attempts to speed up the capture of the wastewater solids and then rapidly separate the solids from the liquid in a secondary clarifier. The solids stabilization then occurs in a separate tank. The process is best applied where other activated sludge modes would fail due to the short SRTs and detention times.

Contact Stabilization requires a different configuration than the other modes of operation. A small initial aeration basin, known as the contact basin, is where the influent and the microorganisms first come into contact. In this basin, the microbes rapidly capture as much dissolved organic matter and suspended particles as possible. They are then sent to a secondary clarifier to be separated from the liquid. RAS is pumped from the secondary clarifier to a separate stabilization basin, where the microbes are given enough time and oxygen to metabolize much of the waste solids. The flow from the stabilization tank enters the contact tank, thus supplying hungry microbes right at the point where the influent enters the system.

The operating parameters for Contact Stabilization process are as follows:

- Detention time in the contact tank = 0.3-3 hrs.
- Detention time in the stabilization tank = 4-8 hrs.
- MLSS in the contact tank = 1000-3000 mg/L
- MLSS in the stabilization tank = 2-6 times the concentration in the contact tank
- System SRT = < 3.5 days
- System F:M = 0.5 - > 1.0 : 1

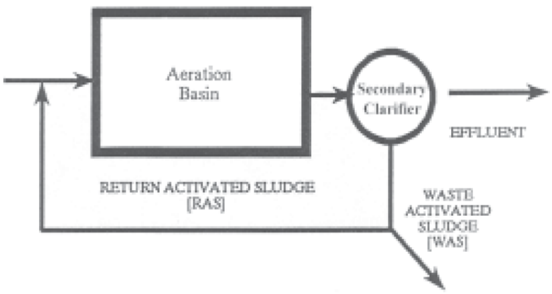

Figure 10.4 - ***Extended Aeration***

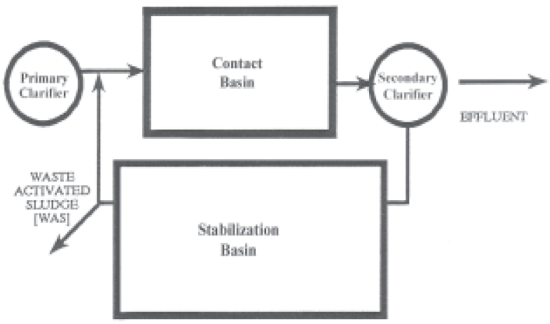

Figure 10.5 - ***Contact Stabilization***

- RAS pumping rate = 25 – 100% (of the influent flow)

The activated sludge wastewater treatment process is capable of producing an excellent effluent quality when properly designed, constructed and operated. BOD and TSS removal rates in excess of 99% are not unusual. There are three areas of major concern for the operator of an activated sludge plant.

1. The characteristics of the influent that is going to the aeration basin.
2. The environment in the aeration basin that must be maintained to ensure good treatment.
3. The operating conditions within the secondary clarifier, which affects how well solids separation will occur.

As you may suspect, all three of these areas are closely related and influence each other.

Influent Characteristics

Organic and Hydraulic Loading

In most municipal activated sludge wastewater treatment facilities, the influent flow and BOD/TSS concentration does not vary by more than 10% from day to day. This results in a relatively stable (and predictable) loading being applied to the aeration basin. However, for some facilities, the flow or the BOD/TSS concentration (or both) varies greatly. One example of where this might occur is a small package treatment plant that treats the discharge from a school. In this situation, the influent flow only occurs from 8:00 AM until 4:00 PM and stops entirely on weekends (and for three months during the summer). In another example, a municipality may have a tremendous loading increase (both flow and BOD/TSS) for several days a week while a local industry, such as a food processing plant, is in operation. Because a large part of the operator's job is to maintain the correct mass of microorganisms to meet the incoming food, operating in a situation where the influent loading is constantly changing greatly complicates matters. Therefore, all changes to the influent loading must be understood and considered by the operator of an activated sludge system. This requires accurate influent flow measurements and at least periodic influent BOD and TSS sampling and analysis.

The Effect of Toxic Substances

Toxins pose another consideration for the operator of an activated sludge plant. If the influent that is being fed to the organisms in the aeration basin cannot be metabolized or if it is toxic, the organisms will die off and the process will fail. An example of this situation is when recreational vehicles (RVs) are allowed to discharge large amounts of holding tank waste to a treatment plant. Chemicals, such as formaldehyde, are often used to stabilize RV holding tanks. Formaldehyde is highly toxic to activated sludge microbes, so even a single RV's discharge can kill-off a small package plant. Please be aware that microbe friendly, biodegradable alternatives are available as a replacement for formaldehyde based products.

Aeration Basin Environment

Food and Dissolved Oxygen

The aeration basin environment itself can best be described as a zoo of microorganism, each competing for oxygen, food and the ability to reproduce. It is the job of the activated sludge system operator to provide this zoo of organisms with the correct amount of oxygen, mixing and food. The food is of course supplied in the form of dissolved and suspended solids in the wastewater itself.

The level of oxygen in the aeration basin can be controlled (to an extent), although many older systems are simply run all-out to provided as much aeration as possible, even though it may not be enough. A dissolved oxygen level of >1.0 mg/L is desirable, but it is important to understand that the required level of dissolved oxygen is actually related to the F:M ratio that the system is operating under. This is because the microorganisms in the basin primarily consume the oxygen as they capture and metabolize the dissolved and particulate waste solids.

If the BOD loading increases, the amount of dissolved oxygen that is needed in order for the microbes to capture and stabilize the waste will increase. If the BOD loading decreases, the oxygen demand for the system will go down. This phenomenon can be observed every day in an aeration basin during peak loading (usually around 9:00 – 10:00 AM). At this time, the oxygen demand in the aeration basin will be at its highest, because a large amount of food is entering the basin and the microbes are utilizing lots of dissolved oxygen as they capture and begin to digest the food. In the middle of the night, when the loading is low, the demand for dissolved oxygen will go down. You can actually see this effect when using a dissolved oxygen meter to measure the D.O. levels in the aeration basin. Some system run at less than 1.0 mg/L of D.O. and yet operate well because they are still operating within an acceptable F:M range. Some highly loaded systems need much more than 1.0 mg/L of D.O. just to get by. Remember that it is easier to dissolve oxygen into cold water that into warm water. Therefore cold weather increases aeration system performance, although the microorganism activity is reduced.

Adequate Mixing

Thorough mixing of the contents of the aeration basin is also very important. No settling should occur in the basin itself. Solids settling can be evaluated using a stick or a sludge blanket indicator by probing around the bottom of the aeration basin. Solids that settle to the bottom of the basin will rapidly become septic and cause a variety of problems, such as increased oxygen demand, lower aeration basin detention times and excess growth of the types of filamentous bacteria that are associated with septic conditions.

However, excessive mixing also has a down side. If the turbulence in the aeration basin is too high, a phenomenon known as floc shear will occur. Floc shear is characterized by floc particles that are broken up. In the secondary clarifier, this leads to increased effluent TSS concentrations. Floc shear can be diagnosed using a microscope. Under magnification, the broken floc particles are evident. If a microscope is not available, look for signs of excessive turbulence in the aeration basin whenever the effluent TSS seems unusually high without another obvious cause.

Maintaining the Correct F:M

In order to achieve good treatment and a stable system, the mass of microorganisms must be maintained at the correct level needed to consume virtually all of the food that enters the system each day. One way to think about this situation is to consider how you might go about feeding your pet dog everyday. If you have a dog that weighs 100 lbs., it probably eats around 2 – 4 lbs. of dog food each day. If we describe your dog's diet in terms of a Food to Mass ratio, we would say that the F:M of your dog ranges from 0.02 – 0.04 to 1.00. Activated sludge wastewater treatment plants can be considered in the same fashion, except that they can be operated at a much higher F:M than your dog. Extended aeration activated sludge plants are operated at an F:M ratio of 0.05 – 0.15 to 1.00. In other words, if the mass of microorganisms in the aeration basin weighs 100 lbs., it can eat between 5 and 15 lbs. per day. Conventional activated sludge treatment plants operate at even higher F:M ratios. Conventional systems run at an F:M of between 0.25 and 0.5 to 1.00. This would be like a 100 lb. dog eating between 25 and 50 lbs. of food each day. Some Contact Stabilization processes operate even higher, with 1.00 to 1.00 ratios and beyond. This would be like a 100 lb. dog eating 100 lbs. of dog food everyday!

What is a strange concept to many people when considering this analogy is that, it is not the amount of food that an activated sludge wastewater operator is in control of, it is the size of the dog. By increasing or decreasing the overall mass of MLSS, operators actually change the number of microorganisms available to consume the daily load of waste solids. Although the amount of loading (food) varies a little each day, overall, it stays close to the same. However, operators effectively control the size of the dog by increasing or decreasing the mass of microorganisms (increasing or decreasing the daily WAS flow) in order to meet the loading.

The key to stabilizing the activated sludge process lies in doing a good job of maintaining the right mass of microorganisms to fully consume the daily loading, all of the time. To accomplish this, the amount wasted from the system each day needs to be close to the amount that enters the system each day, with some allowance for solids that are destroyed through digestion while in the aeration basin or lost to the effluent. Typically, this means that the number of pounds of solids wasted from a system each day must be around 50 – 70% of the total number of pounds of solids that enter the system each day. (Remember that the difference between the influent loading and the required WAS lbs./day is made up through digestion in the aeration basin and solids lost to the effluent).

Determining a Treatment Plant's F:M

To actually calculate the F:M ratio of a activated sludge wastewater treatment plant, we need to know how much food is entering the aeration basin each day and how many pounds of microorganisms are in the aeration basin available to eat the food. The amount of food is determined by calculating the BOD loading in terms of pounds per day of influent entering the aeration basin. The mass of microorganisms is calculated based on the mass, in pounds, of mixed liquor volatile suspended solids (MLVSS) in the aeration basin. The volatile suspended solids are used in this calculation because it is assumed the all of the volatile solids are comprised of living microorganisms and the non-volatile solids are inert matter that does not contribute to metabolizing the waste solids.

This is an example of the F:M calculation for an extended aeration activated sludge wastewater treatment plant:

(FOOD) 160 lbs./day BOD into Aeration Basin	=	**0.08 F:M**
(MASS) 2000 lbs. MLVSS in Aeration Basin		

Figure 10.13 - *Calculating F:M*

Whenever the conditions within an activated sludge treatment plant must be assessed, IT IS THE F:M RATIO THAT MUST FIRST BE DETERMINED in order to understand what mode of operation the system is in and determine how well it is functioning. Only after the F:M is understood can the other operating factors be assessed.

In the absence of the laboratory data that is necessary to calculate the F:M, some keen observation can be used to understand whether a system is running at a high F:M, low F:M or just right. For instance, if a clear, high quality effluent is being produced and the aeration basin has a small amount of crisp white foam on the surface and the mixed liquor is a chocolate brown color, the F:M is close to ideal and the system is running very well. Operations should continue in the same manner.

If the effluent quality is cloudy, large floc particles are exiting over the secondary clarifier weirs (straggler floc), the aeration basin has a lot of frothy white or gray foam on it, the mixed liquor has a light brown or tan color and the effluent BOD and TSS are elevated, the system is most likely running at a high F:M, such as an overloaded plant or a plant in start-up conditions. In this case, the operator should allow the system to build up a larger mass of MLSS by reducing wasting.

If there is a thick, dark foam on the aeration basin surface, the mixed liquor is dark brown or even a dark reddish color, sludge is floating to the surface of the secondary clarifier and very small floc particles that are about the size of the head of a pin (pin floc) are observed in the effluent, the system is operating at too low of a F:M. In this case, the operator should increase wasting.

Secondary Clarifier Conditions

Clarifier Design Features

The design of the secondary clarifier(s) of an activated sludge wastewater treatment plant can have a strong effect on how the system will perform as a whole. Desirable features that should be included in activated sludge secondary clarifiers include:

- Good inlet flow control structures that allow the operator to carefully regulate the hydraulic loading to the clarifier.
- Energy dissipating baffles at the mixed liquor inlet area that quickly slow the mixed liquor and direct it downward. Some provision for gentle mixing during entry into the clarifier is helpful at starting bio-flocculation. Some old and most new clarifier designs incorporate these features.
- Short-circuiting should be eliminated. Short-circuiting occurs when a portion of the mixed liquor that enters the clarifier is allowed to move rapidly toward the weirs and out of the clarifier. There are many causes of short-circuiting, such as thermal density-currents and poor baffle design, however, the most common cause is uneven weirs that draw the clarifier supernatant over one area at a much higher rate than other areas of the weir.
- Secondary clarifiers should be deep enough to allow some process upsets without the loss of the sludge blanket. For most treatment plants, this means a clarifier depth of greater than 12 feet.
- A detention time of between 2 and 4 hours should be provided for the highest flow (peak flow) that the clarifier will be subjected to. This is a function of the clarifier's volume.
- A surface-loading rate of between 300 to 1,200 gallons per day per square foot. This is a function of the clarifier's hydraulic loading and surface area.
- Effective sludge removal for the entire bottom of the secondary clarifier. This typically includes a sludge scraper mechanism that sweeps the bottom of the clarifier and moves settled sludge toward the RAS pump inlet box.
- Accurate control of the RAS pumping rate. This is critical for ensuring that the sludge is removed at the proper rate. Some form of RAS pump control and flow measurement should be provided.
- Drains should be provided for each clarifier so that they can be taken down for service and inspection.

Although these features are all desirable, they are not always included in every secondary clarifier. This is in part because the cost of construction must be considered when clarifiers are designed and built.

RAS Flow Control

The sludge blanket depth in an activated sludge secondary clarifier should be determined at least twice a day by actually measuring the blanket at about the middle of the clarifier bridge. Several methods for measuring sludge blanket levels are available, such as the core sampler and the infrared detector. The method used is less important that ensuring that the measurements are performed in a consistent manner.

Table 10.2
Causes, Observed Effects and Remedies of Activated Sludge Separation Problems

PROBLEM	CAUSE	OBSERVED EFFECT(S)	POSSIBLE REMEDY
Dispersed growth	Microorganisms do not form floc and so are dispersed, forming only small clumps or single cells.	Turbid effluent. No zone settling of sludge.	(1) Check for excessive turbulence or over-oxygenation in the aeration basin (floc shear). Reduce turbulence if excessive. (2) Look for evidence of a toxic influent and control if possible. (3) Re-seed the aeration basin with live microorganisms if necessary.
Non-filamentous bulking or "Viscous Bulking"	Large amounts of exocellular slime are present in the floc. In severe cases, the slime imparts a jelly-like consistency to the activated sludge.	Reduced settling and compaction rates. Virtually no solids separation in severe cases resulting in overflow of sludge blanket from secondary clarifier. In less severe cases, viscous foam is present.	Investigate nutrient imbalance, especially nitrogen and phosphorus. The ratio of influent nutrients should be around: 1% phosphorus 5% nitrogen 94% carbon Supplement nutrients if needed.
Pin floc or Pinpoint floc in supernatant	Small, compact, weak, roughly spherical floc are formed, the larger of which settle rapidly. Smaller aggregates settle slowly.	Low SVI (< 100) and a cloudy, turbid effluent.	Raise F:M by lowering MLSS concentration in a controlled manner.
Large, jagged "straggler floc" in supernatant	Incomplete bio-flocculation, which leaves some large particles in the supernatant.	Slow settling and compaction during first 30 minutes of the settleometer test, although the SVI is only slightly elevated. This is common during plant start-up, when the mixed liquor is building or in plants that are organically overloaded.	(1) Lower F:M by building up mixed liquor. (2) Increase aeration basin volume.
Bulking	Filamentous organisms cause an open floc structure or inter-floc bridging and interfere with compaction and settling of activated sludge.	High SVI (Typically > 150) - very clear supernatant. Decreasing RAS and WAS solids concentrations. In severe cases, solids washout occurs where the sludge blanket is lost from the secondary clarifier. Solids handling processes become hydraulically overloaded.	(1) Lower RAS pumping rate to prevent solids washout. (2) Reduce MLSS concentration by ¼ - 1/3. (Lean the system out). (3) Identify the causative filament(s) and correct conditions that allowed growth. (4) Chlorinate the RAS (last resort).
Rising Sludge	Denitrification in the sludge blanket releases N2 gas, which floats chunks of activated sludge to the surface of the secondary clarifier.	Large chunks of activated sludge found on the surface of a secondary clarifier. If allowed to accumulate, a thick layer of sludge will form on the clarifier surface.	(1) Increase RAS pumping rate. (2) Lower MLSS concentration in a controlled manner.
Foaming/ Scum formation	Caused by the presence of grease and non-degradable surfactants. <u>Microthrix parvicella</u> and <u>Nocardia</u> sp. are the primary filamentous bacteria that cause the problem.	Foams float large amounts of activated sludge solids to surface of treatment units. <u>Nocardia</u> and <u>Microthrix</u> foams are persistent and difficult to breakup mechanically. Foams accumulate and can putrefy. Solids can overflow into secondary effluent or overflow tank walls onto walkways. Foam exiting in the effluent can be cited as a permit violation.	(1) Stop grease from entering the sanitary sewer. (2) Improve plant pretreatment (tighter mesh barscreen). (3) Increase wasting to remove grease from the system, after the supply has been stopped. (4) Stop decanting from digester (this recycles grease in the system). (5) Install primary clarifier to remove grease before it enters the aeration basin.