

How do I . . .

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How do I measure ammonia in the clarifier?

If the clarifier effluent is low in suspended solids, a sample can be collected from the clarifier surface to perform an ammonia analysis. If the clarifier effluent is high in suspended solids, such that it would affect the ammonia analysis, use a centrifuge to separate the suspended solids and perform an analysis on the centrate of the centrifuge tube.

There are several methods for analyzing the sample. The degree of accuracy of the method is not as critical as the ability to measure the ammonia concentration, monitor the trending of the ammonia concentration, and make timely process control decisions on-site. Small, single parameter colorimeters are available for accurate ammonia analysis. This method provides a digital readout of the ammonia concentration of the sample. The initial cost for the meter is more than an aquarium kit, however, the colorimeter does provide a more accurate analysis, especially when ammonia concentrations are high. However, it will likely require you to dilute the sample so the results are within the range of the meter.



A less expensive method is to purchase a test kit for ammonia nitrogen, commonly sold at aquarium stores. While this type of test kit can be accurate enough for process control testing, you will need to verify its accuracy. When collecting a final effluent sample for submitting to a lab for reporting purposes, draw off some of the sample and perform an ammonia analysis with your field test kit. Record this data and compare it to the ammonia value that your contract laboratory reports. If the ammonia values determined by your field test kit is close to the ammonia value reported from your approved lab, you will have confidence in using the field test kit for operational decisions. Performing this “split-



sampling” procedure periodically can also indicate when the chemical reagents in the field test kit are becoming ineffective and the data is unreliable. Once you have determined which field kit provides accurate data, you can begin evaluating the treatment system for complete conversion.

There are two different methodologies for measuring ammonia nitrogen. The Nessler method offers a higher detection range than the Salicylate method, however, the Nessler method contains a mercury compound in the reagents. The waste products from the Nessler analysis are considered hazardous waste and need to be disposed of in an approved manner.

How do I measure ammonia in the aeration tank?

The difference between measuring ammonia in the aeration tank and in the clarifier is that the suspended solids concentration in the aeration tank will invalidate the results. Use the centrifuge to quickly separate the suspended solids and obtain a sufficient sample for ammonia analysis.

Collect a sample from the aeration tank effluent. Fill two centrifuge tubes to the 100% mark and spin the sample for two minutes. After centrifuging, the clear liquid on top will be of sufficient volume to analyze for ammonia.



Another method is to draw a sample for ammonia analysis from the supernatant of a settleometer analysis after it has had time to allow for bacteria separation from the clear water. Collect a fresh sample from the aeration tank but don't allow the settleometer to sit for more than a few minutes before a sample is collected for analysis.

Once a clear sample of the aeration tank effluent is collected, analyze with the same ammonia test methodology you use for process control.



How do I eliminate the biological foam on the aeration tank?

As the dissolved and suspended pollutants continue to flow into the aeration tank, more bacteria are generated. If excess bacteria are not removed or “wasted” from the Secondary Stage, the bacteria concentration increases to a point where competition for the incoming “food” becomes extreme.

There are certain bacteria which can naturally out-compete for the food source when the food becomes more scarce. These types of bacteria are also known to generate a brown foam on the aeration tank’s surface. This “starved growth” condition is commonly referred to as a low F/M ratio environment (low food to microorganism ratio). A low F/M ratio in the aeration tank can promote biological foam which may migrate to the clarifier surface. To prevent this low F/M ratio in the aeration tank, an operator must either increase the food (influent cBOD) coming into the aeration tank or decrease the oxidative pressure within the aeration tank.

Operators have little control of the organic load coming into the treatment system. However, operators have several methods to control the “oxidative pressure” which is applied to treat the influent organic loading. Oxidative pressure is defined as anything which allows the treatment system to move closer to complete conversion of the influent organic loading. An example of adding oxidative pressure would be to bring more aeration tanks into service and thereby increasing the available detention time for treatment. Other examples include increasing the run-time of the blowers to provide longer aeration cycles, or increasing the concentration of bacteria in the aeration tank. Oxidative pressures are operational modifications which apply more “pressure” to completely oxidize the waste and reach complete conversion.

If an aeration tank is experiencing a low F/M ratio, which in turn is generating a biological foam, the operator needs to reduce the oxidative pressure to prevent this foam generating environment. Operational controls which reduce oxidative pressure on the aeration tank are to reduce the blower run-time (reduce timer settings), reduce the concentration of the bacteria in the aeration tank (increase wasting rate) or, if necessary, reduce the aeration tank capacity (take aeration tanks off line).

If the aeration tank effluent ammonia concentrations are < 1 mg/L, you have sufficient aeration tank detention time, sufficient volume of mass in the aeration tank, and/or sufficient aeration being applied. Start reducing these sources of oxidative pressure until you detect an increase in aeration tank effluent ammonia concentrations. An increase in aeration tank effluent ammonia will indicate you have reduced the oxidative pressure too much.

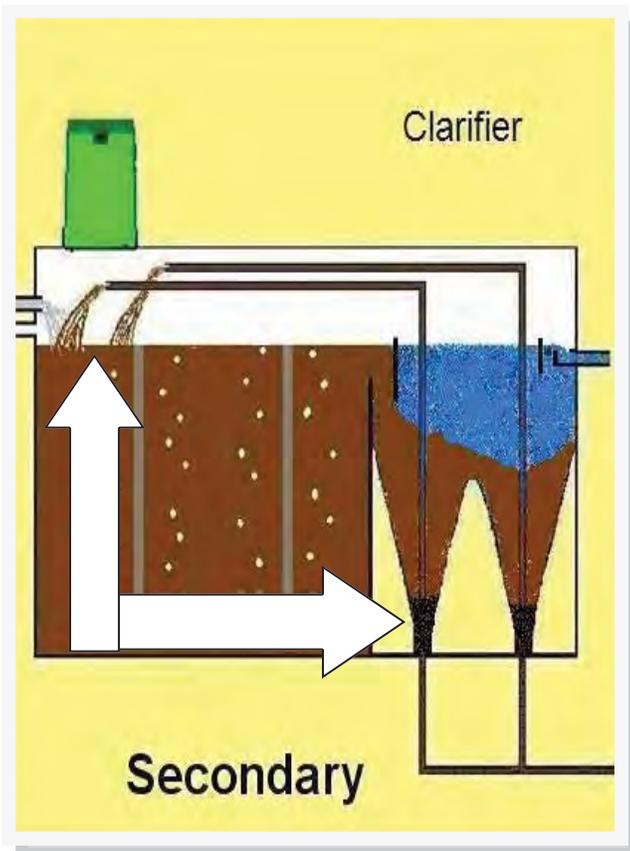
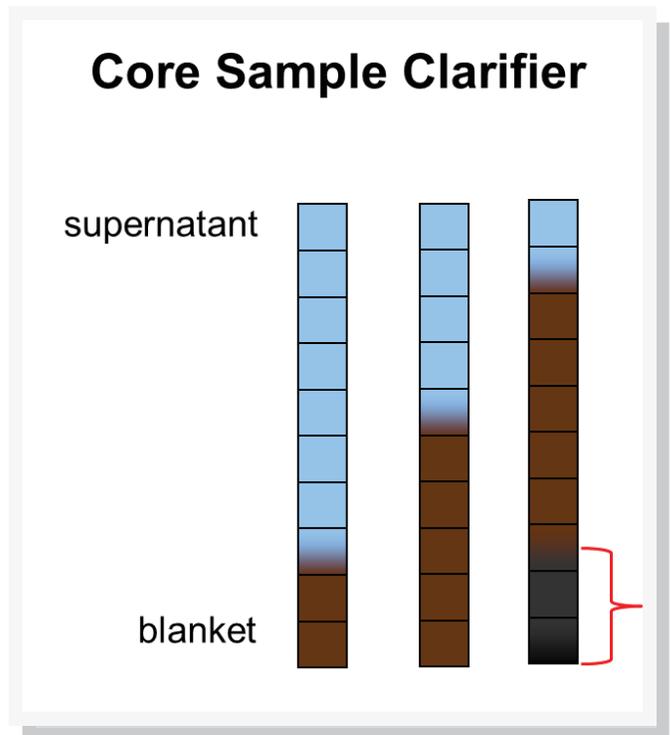
Instead of reducing oxidative pressure some operators will attempt to increase the influent organic loading to increase the aeration tank F/M ratio. Attempts include adding a waste load to the influent to change the aeration tank environment. Typically this is done by supplementing the influent with an inexpensive dog/rabbit food. This method is strongly discouraged because you are spending time and money to add waste to the treatment system, which costs you time and money to remove again. By reducing oxidative pressure you eliminate the generation of the biological foam, reduce your operational cost (reduced pumping, electrical costs) and avoid increasing cost by purchasing a supplemental organic loading. There are just too many starving dogs in the world to waste dog food! Focus on reducing oxidative pressures in the treatment system, which will save you money.

How do I determine if ammonia is being released in the clarifier blanket?

If clarifier effluent ammonia values are greater than the aeration tank effluent ammonia values, then aerobic bacteria are breaking down and releasing ammonia nitrogen in the clarifier. As the sludge blanket increases in depth it is more likely for the sludge blanket to release ammonia nitrogen. If the situation is severe you may notice a darker color to the sludge layer in the bottom of the clarifier when using the clarifier core sampler.

If the problem is just starting to become an issue, you might not notice a darker color to the sludge blanket. To stay ahead of this problem, you could monitor the ammonia concentration in the clarifier's Return Activated Sludge (RAS).

Collect a sample of the clarifier RAS and centrifuge it to obtain a clear liquid sample (centrate) at the top of the centrifuge tube. Use this sample to chemically measure the ammonia concentration. If the RAS is starting to release ammonia nitrogen, you should see an increase in ammonia nitrogen in the RAS when compared to the aeration tank effluent.



If ammonia nitrogen is being released from the sludge blanket, an operational adjustment is required. Ammonia is released in the clarifier sludge blanket because the aerobic bacteria are without dissolved oxygen for too long.

If the RAS ammonia nitrogen is greater than aeration tank effluent ammonia nitrogen then bacteria are breaking down in the clarifier and need to be brought back into an aerobic environment in the aeration tank to prevent ammonia release.

It could be that the RAS pumping rate is too slow, which causes bacteria to remain in the clarifier too long. If the RAS pumping rate has been measured and found to be acceptable, then typically the entire system contains too much bacteria and an increase in wasting would be indicated.

How do I measure total alkalinity in the aeration tank?

Collect a sample from the aeration tank effluent. Fill two centrifuge tubes to the 100% mark and spin the sample for two minutes. The clear liquid left on top after centrifuging is of sufficient volume to analyze using most field test kits.

It is recommended that you do not use “test strips” as a methodology to determine total alkalinity because it is too subjective. There are inexpensive titration test kits which use eye droppers to apply the acid reagent. Simply count the drops of acid that is added to the sample until you observe an obvious color change. Multiply the number of drops by the test kit multiplication factor to determine the total alkalinity in the aeration tank.

The test kits typically allow you to measure both phenolphthalein alkalinity and total alkalinity, depending on which indicator reagent is used in the analysis. It is the total alkalinity that is required to be greater than 100 mg/L in the aeration tank effluent to prevent lowering of the pH and inhibition of the nitrification or conversion process. The phenolphthalein alkalinity is not used in making process control decisions.

Measure the total alkalinity in the aeration tank effluent. Since the nitrification process (conversion of ammonia to nitrate) occurs in the aeration tank, it is critical to the treatment process to monitor total alkalinity in the aeration tank. Total alkalinity values can change as the water passes through downstream treatment stages. Values measured at locations downstream of the aeration tank (i.e., final effluent) might not accurately reflect the total alkalinity situation in the aeration tank.

When total alkalinity concentrations decrease below 100 mg/L, the system could quickly consume the remaining alkalinity depending on the remaining ammonia nitrogen to be converted. Ammonia nitrogen requires 7.14 mg/L of alkalinity for every 1.0 mg/L of ammonia present in the aeration tank that is converted to nitrate nitrogen. For example, having 100 mg/L of total alkalinity while still needing to convert 10 mg/L of ammonia is not sufficient. Although the system is nitrifying well, the alkalinity demand will require an additional 71.4 mg/L of the available alkalinity leaving less than the desired target of 100 mg/L of alkalinity.

Monitoring with pH is ineffective if your desire is to prevent a process upset. When alkalinity is depleted the pH will drop rapidly after it is too late to make an adjustment. Monitoring total alkalinity will provide an early warning to prevent an upset.

How do I determine how much aeration capacity is required?

The treatment system is designed for an influent cBOD concentration and average daily flow rate. The total organic loading to the system is a function of both of these values. If influent cBOD concentrations remain the same but the influent flows decrease, then less aeration or “oxidative pressure” is required because the total organic loading will be less at lower flow rates.

As the bacteria convert influent pollutants into more bacteria, they generate heat that will assist in keeping the aeration tank water temperature above 10 C. However, when the influent organic loading is low, less heat is generated. When this situation is compounded with cold ambient air and excessive aeration, the water temperature can drop well below 10 C.

A simple calculation can be used to estimate how much aeration capacity is required. One parameter used to design treatment systems is the organic loading rate. Compare the actual organic loading rate that is received at the treatment system to the design organic loading capacity to determine the percent of capacity in use. If the system is not using all of its design organic loading capacity, it may be possible to reduce the oxidative pressure being applied (i.e., take aeration tanks out of service, reduce aeration blower run-time).

For example:

A treatment system is designed for a flow of 10,000 gallon per day and an influent cBOD concentration of 200 mg/L. This system actually receives only 4,000 gpd with an influent cBOD concentration of 175 mg/L. What is the percent oxidative capacity being used?

Design Organic Loading =

$$(10,000 \text{ gpd} \times 200 \text{ mg/L cBOD} \times 8.34 \text{ lbs/gallon}) / 1,000,000 = 16.7 \text{ lbs cBOD/day}$$

Actual Organic Loading =

$$(4,000 \text{ gpd} \times 175 \text{ mg/L cBOD} \times 8.34 \text{ lbs/gallon}) / 1,000,000 = 5.8 \text{ lbs cBOD/day}$$

Percent Oxidative Pressure =

$$(5.8 \text{ lbs cBOD/d actual loading} / 16.7 \text{ lbs cBOD/d design loading}) \times 100 = 35\%$$

Since the treatment system is receiving only 35% of its design organic loading, in theory, you should be able to reduce the aeration to match this lower loading. Begin by reducing blower run-time and monitor the aeration tank water temperature and effluent ammonia. Reduction in the aeration should increase water temperature, which will eventually lead to a reduction in effluent ammonia. If less than half of the design organic loading is being used then taking half of the aeration tanks out of service would move the system closer to its design aeration requirement.

Taking half the aeration capacity out of service could prove to be too much of a reduction of oxidative pressure and periodic ammonia spikes may occur. If so, increase the biomass concentration in the aeration tank in service until you reach a centrifuge spin which will consistently produce an ammonia concentration less than 1 mg/L but does not impact the settling characteristics (such as an aeration tank centrifuge spin of 4% or greater that would typically impact settling).

How do I measure solids in the clarifier?

A simple method to identify if bacteria are “hiding” in the clarifier is to use the core sampler and measure the compacted sludge blanket in the clarifier. If the sludge blankets are less than 30% of the clarifier water depth, then the majority of solids are in the aeration tank. If the sludge blanket in the clarifier is greater than 30%, the bacteria are “hanging out” in the clarifier too long. For clarifiers designed with multiple hoppers, measure the blanket depth of each hopper and average the values. It is common to see the first hopper in a multiple hopper clarifier maintain a higher blanket level than downstream hoppers.



Lower the core sampler slowly into the middle of the hopper clarifier, carefully avoiding submerged piping. “Dropping” the core sampler into the clarifier will provide inaccurate sludge blanket depths. Also lower the core sampler vertically and do not collect a sample as if you were “spear fishing”.

If the sludge blanket is less than 20% to 30% of the clarifier water depth, then the majority of the bacteria are in the aeration tank.

One way to quantify, or measure, the amount of bacteria in the clarifier is to discharge the clarifier core sample into a bucket and use the centrifuge to determine the amount of bacteria in this clarifier “profile” sample.

If there is a two-hopper clarifier, core each hopper and mix both core samples in a bucket before centrifuging. Neither hopper should have a sludge blanket greater than 30% of the clarifier water depth, however, the first hopper sludge blanket depth is typically higher than the second hopper.

The centrifuge values of clarifier core samples should be less than the aeration tank centrifuge values. If the clarifier core samples are similar in value to aeration tank values, then there is too much mass in the clarifier.



How do I determine how much sludge to waste?

Knowing how much mass is enough for complete conversion and when too much mass affects the separation process are the keys to maintaining the biological process of the treatment system. We can easily determine when sufficient mass is available by maintaining aeration tank ammonia nitrogen concentrations at less than 1 mg/L. By using the centrifuge you can measure or quantify how much mass is needed to convert all the waste into bacteria. Typically, small activated sludge package plant will achieve complete conversion with aeration tank concentrations between 2% and 4% when measured with the centrifuge. The minimum aeration tank centrifuge spin concentration which provides ammonia nitrogen concentrations less than 1 mg/L is the minimum target concentration. Simply maintain an aeration tank concentration which achieves ammonia nitrogen concentrations less than 1 mg/L. As the aeration tank centrifuge concentration increases, bacteria settling rates slow down. Typically the settling rate is not significantly impacted until the aeration tank concentrations begin to exceed 4% or unless the filamentous bacteria are dominating the treatment system.

Build up sufficient biomass to reduce effluent ammonia below 1 mg/L. When the settling rate is greater than 80% in the settleometer after 5 minutes, reduce the aeration tank centrifuge spin by increasing the wasting rate. This is the target aeration tank centrifuge spin you should maintain.

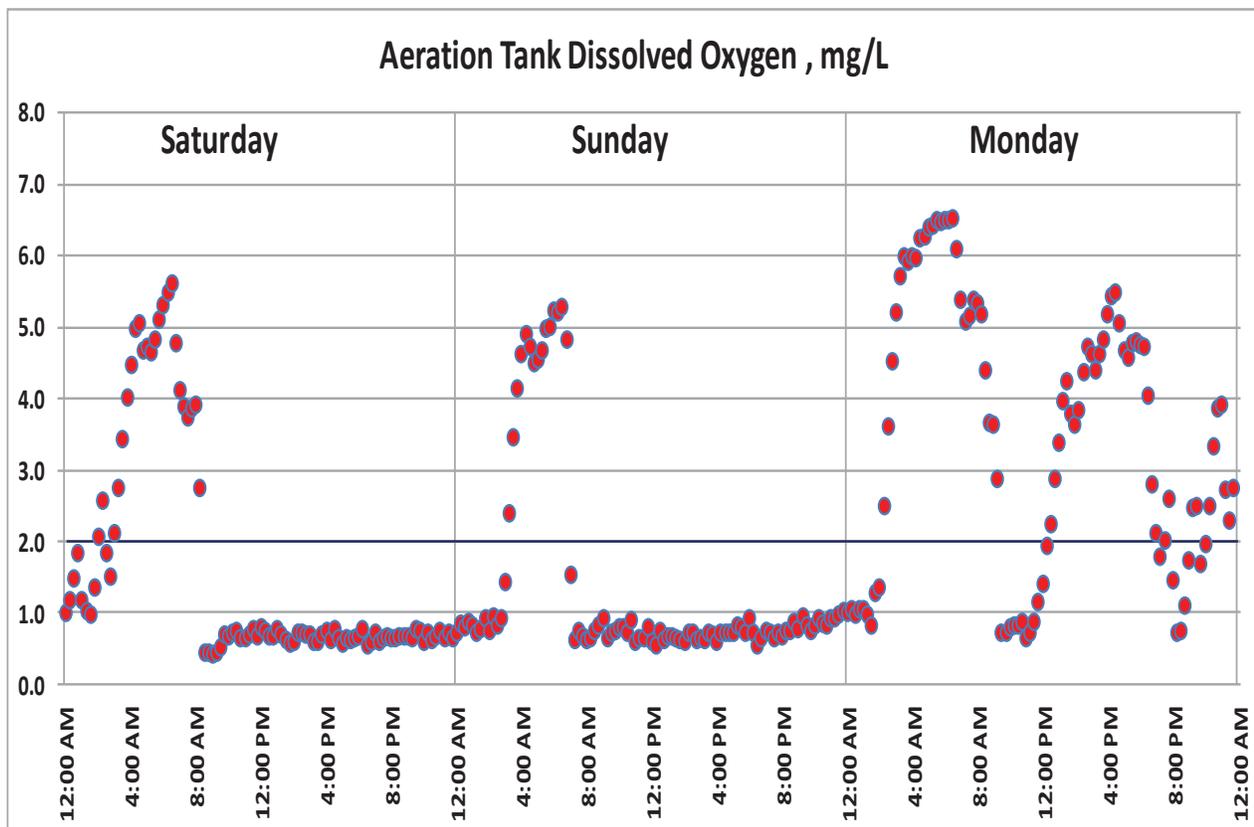
There are many ways operators “calculate” how much mass to waste. This method does work to provide a bacteria concentration which achieves complete conversion but does not inhibit separation. However, there is a simpler way. If you measure ammonia concentrations of less than 1 mg/L, you have sufficient bacteria mass. As long as it is settling well (less than 80% in 5 minutes), there is not an excessive amount of biomass. By simply measuring the concentration of mass in the aeration tank by centrifuge, you can maintain this target centrifuge spin, which provides complete conversion and adequate separation. A 15 minute centrifuge spins will indicate if you need to increase or decrease the wasting rate to bring balance back to the process. (No math involved!)

How do I measure DO in the aeration tank?

Begin by monitoring the DO concentration near the discharge of the aeration tank into the clarifier. Place the DO probe within 1-2 feet of the surface of the water and record the data. Use this same location as a reference point so all the dissolved oxygen data collected will be related to this same location. The data loses significance if you measure the aeration tank effluent one day and then measure a different location the next time in the aeration tank.

In a small treatment system, which has only one aeration tank, this should be sufficient since these smaller aeration tanks exhibit a complete mix environment. In a larger treatment system, which has multiple aeration tanks, monitoring the DO at the effluent of each aeration tank will provide valuable insight of the oxygen demand as it travels through the treatment process.

The DO concentrations which provide sufficient conversion of ammonia nitrogen will be your targeted DO values. DO residuals of 2 mg/L typically are sufficient for complete conversion.



A data logging DO meter can provide the detail necessary to determine if the DO being applied is sufficient. If you are measuring dissolved oxygen one time during the day it would be like picking just one data point on the chart and basing your operational decision on that one event.

If a data logging DO meter is not available, a more complete DO profile can be obtained by measuring aeration tank DO at different times during the day and different days of the week. Once a more complete DO profile has been determined, adjustments to the aeration blower cycles can be made to maintain adequate dissolved oxygen in the treatment system.

How do I determine how much aeration time is required?

Matching the aeration being applied to the waste load being received provides for optimal treatment conditions and saves operational costs by reducing blower/motor runtimes. However, not meeting the aeration requirements will lead to upsets and permit violations. A simple way to “estimate” blower runtime is to calculate the actual organic loading being received and compare it to the design organic loading of the system.

For example: A treatment system is designed for a flow of 10,000 gallon per day and an influent cBOD concentration of 200 mg/L. This system actually receives only 4,000 gpd with an influent cBOD concentration of 175 mg/L. What is the percent oxidative capacity being used?

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Percent Oxidative Pressure =

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If the treatment system is operating at one-half or less of its design loading rate, then you might be able to operate the aeration at one-half its design (12 hours in a 24 hour period).

Begin by spreading the blower run time to a total of 12 hours of on-time, but avoid excessive periods of off-times. More aeration on-time should be programmed into the timer when the organic loading is being received and more blower off-time during periods of low flows and/or loadings (i.e., typically midnight to 5 am). Since the RAS is also controlled by the blower run times, extended blower off-times could allow settled solids to remain too long in the clarifier and denitrify. If the system does not receive sufficient aeration, the aeration tank effluent ammonia concentrations will increase.

If you are not sure of the actual influent loading or the intended design loading you can start by aerating continuously and measuring the aeration tank effluent ammonia nitrogen concentration. If the aeration tank effluent ammonia concentration is less than 1 mg/L you can begin decreasing blower runtime.

Important issues to consider:

The air-lift return activated sludge (RAS) pumps operate using the same aeration source as the aeration tank. Reducing blower runtime affects both the aeration tank and the RAS. A decrease in the air being supplied to the RAS pump will allow bacteria to remain in the clarifier too long. Solids which remain in the clarifier too long can denitrify and float to the clarifier's surface, which leads to solids loss or solids break down resulting in ammonia nitrogen release in the clarifier effluent. To prevent either of these situations in the clarifier, limit the duration of the blower off-time.

If the treatment system receives the majority of the organic loading during a specific time of the day (i.e. morning) the blowers should be operate more frequently during this period. If influent organic loadings decrease (i.e. school on summer break) longer aeration off-time can be used.

How do I measure biomass in the aeration tank?

Collect a sample of the aeration tank effluent and perform a centrifuge analysis to determine the concentration of bacteria by percent volume (v/v%). It is best to begin the analysis within 15 minutes of sample collection. Collect sufficient aeration tank effluent volume to fill 2 centrifuge tubes. This allows the centrifuge to be balanced and sample results should not differ significantly. If values are too varied, resample and perform another centrifuge analysis.

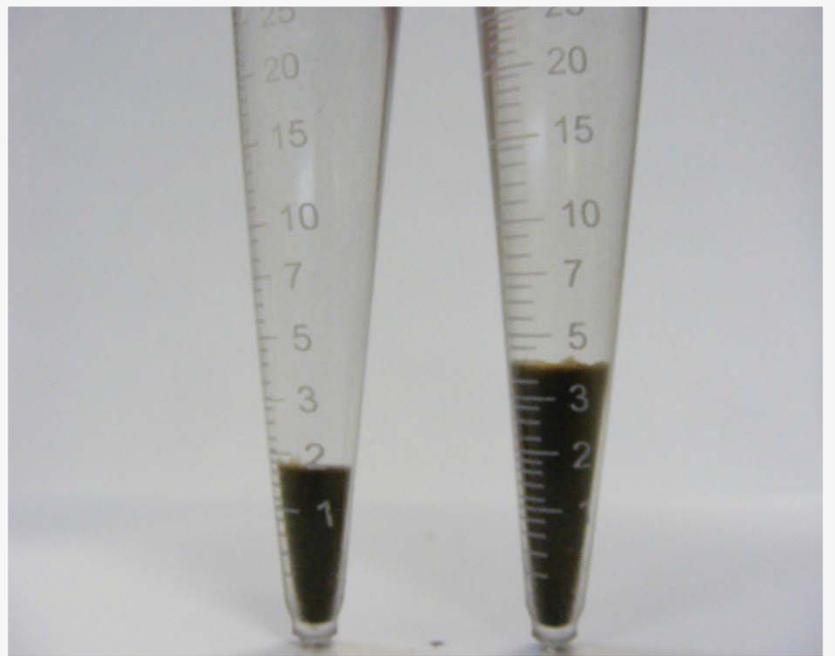
Fill each centrifuge tube to the 100% mark on the tube. Load the centrifuge tubes opposite each other in the centrifuge to prevent an unbalanced load. Typical sampling locations are the aeration tank effluent (to determine the amount of biomass in the aeration system); the return activated sludge (RAS) (to determine the compaction of the biomass in the clarifier and also to evaluate RAS pumping rates); and the core sample of the volume of solids in the clarifier (which is used in evaluating improper RAS rates or excessive biomass in the treatment system).

Aeration tanks usually operate well when spins range from 2 to 4%. Aeration tanks with spins less than 2% sometimes flocculate insufficiently to filter out suspended solids as it settles in the clarifier. If the system can achieve ammonia nitrogen values below 1 mg/L with aeration tank centrifuge concentrations less than 2%, then less oxidative pressure needs to be applied to prevent over oxidation of the biomass. This is best achieved by taking aeration tanks out of service, if possible, or by reducing the aeration runtime in order to limit the oxidative pressure.

Treatment systems which are consistently over-oxidized could experience an extremely fast settling biomass which does not filter out suspended solids. This may result in more frequent binding of slow sand filters due to solids

loss. If tertiary treatment is not available, there may even be a possibility of exceeding effluent total suspended solids limits.

Another possibility with an over-oxidized treatment system is that the aeration tank will experience a low food to microorganism ratio (low F:M) environment. Low F:M aeration tank environments can produce excessive filamentous bacteria which settle slow and are susceptible to hydraulic washout, even under design flow conditions. An increase in the wasting rate will address both of these situations. By increasing wasting, the aeration tank centrifuge concentration will decrease from its previous concentration.



How do I identify internal side streams as additional pollution sources?

Aerobic digesters are designed to store excess bacteria from the Secondary Stage. As the digester becomes full, the air can be turned off to allow the settling of solids. The clear water on top, the supernatant, can then be decanted off the top to recover additional digester capacity.

The decanted water should not cause a problem with the treatment system unless the aerobic digester has turned into an anaerobic digester by having the air off too long during solids separation. This becomes an even more important issue when the ambient air temperature is warmer. Digester supernatant can be a major source of additional ammonia to the treatment system.

A simple method to determine if the aerobic digester contains a high concentration of ammonia nitrogen is to sample the decant for ammonia nitrogen with the field test kit prior to decanting back to the aeration tank or to the head works of the treatment system.

If the decant is high in ammonia nitrogen, a "slug" load of high ammonia supernatant could pass through the secondary system not completely converted. The ammonia nitrogen is not necessarily toxic, but rather it may provide a load that exceeds the design capacity. A high ammonia slug load could cause a "toxic" effect if the total alkalinity is depleted and the aeration tank pH drops too low impacting the conversion process.

If the decant is high in suspended solids use the centrifuge to separate solids from the water and perform an ammonia analysis on the centrate of the centrifuge tube.



How do I evaluate settling with the two-minute diluted settleometer analysis?

Slow settling of the biomass (> 80% in 5 minutes) is usually caused by one of two situations: either the density of the biomass is low (bacteria wearing floatation devices) or the concentration of the biomass is too high (too crowded in the settleometer). The correct operational response depends on the situation, a density problem or a concentration problem.

To determine which situation is inhibiting settling, a two-minute diluted settleometer analysis is performed. Collect a sample of aeration tank effluent. Fill one settleometer to the 100% mark and a second settleometer to the 50% mark. To the second settleometer, which is one-half full, add clarifier effluent to bring the total volume to the 100% mark.

The two settleometers will have the exact same biomass but one is only 50% of the concentration of the other settleometer. Since there are no internal or external hydraulic pressures (density currents, RAS pumping rates), these settleometers reflect the “true” settling characteristics of the biomass.

Gently stir both settleometers and then hold the paddle still a few seconds to eliminate and water movement in the settleometers. Pull the paddles out and begin timing the settleometers.

Record the values after 2 minutes to determine the cause for the slow settling.



Diluted and Undiluted Settleometers of Dense Biomass

If the diluted settleometer settles significantly faster (photo above) than the undiluted, then the cause of the slow settling is that the concentration of the biomass is too high. If wasting is increased, reducing the concentration, the biomass should settle faster.



Diluted Settleometer of Dense Biomass

Another indicator of a dense biomass is if the bacteria settle so fast they do not provide any “filtering” of suspended solids as it settles (photo to the left). This is indicated initially by a cloudy, turbid supernatant which will clear up as time goes on.

If after 2 minutes the diluted settleometer is not significantly different than the undiluted settleometer (photo to the right), this indicates a density issue.

Density issues point to excessive growth of filamentous bacteria. The photo below illustrates “coning” which is another indicator of excessive fil-



Diluted and Undiluted of Filamentous Biomass



Coning Effect of Filamentous Biomass

How do I interpret the clarifier core sampler results?

The Core Sampler provides a window into clarifier operation. While the settleometer test reveals the settling characteristics of mixed liquor, the core sampler will show the actual settling characteristics of the mixed liquor in the clarifier.

In a clarifier core sample, look for three distinct zones: the Supernatant Zone, the Interface Zone, and the Blanket Zone. The Supernatant Zone will be at the top of the core sample and should be clear with little or no solids present. The Interface Zone will be in the middle of the core sample. These are uncompacted solids and usually indicate that the solids are still settling. The Interface Zone can also be due to the presence of an over abundance of filamentous bacteria. The Blanket Zone is at the bottom of the core sample and represents the amount of fully compacted solids.

One, two or all three zones may be present in a core sample. Ideally, a large fraction of the core sample would be clear supernatant with a small amount of interface and a blanket of less than 30% of the clarifier depth. This would represent a good settling sludge that separates well and compacts adequately. If the core sample is mostly blanket with little supernatant or interface, then it is likely that the RAS rate is too slow or that there are too many solids in the entire system (i.e., aeration tank spin is greater than a 4.0% centrifuge spin). If the core sample is mostly interface with little supernatant or blanket, then it is likely that excessive amounts of filamentous bacteria are present in the mixed liquor or the RAS rate is too fast. If the supernatant is cloudy or turbid, then the RAS rate is probably too fast.

By tracking the day to day variations in core sampler results, an operator can gain insights into the onset of settling problems. If the interface begins to increase over time, then an operator would expect that filamentous bacteria are beginning to dominate the mixed liquor in the aeration tank. Another filament indicator is that the supernatant will be very clear, a result of the filtering effect that filamentous bacteria provide by capturing small flocs and debris incorporating them into the flocs.

If the blanket begins to increase over time, the RAS rate should be checked and readjusted if necessary. Also, if the sludge at the bottom of the blanket is black or much darker than the rest of the blanket, the clarifier hopper walls may need to be scraped or possibly the RAS riser pipe is too far from the bottom of the sludge hopper and may need to be extended.



How do I determine the correct RAS pumping rate?

The target RAS pumping rate can be determined with the results of the settleometer test and the centrifuge test. To find the target RAS rate, first prepare a settleometer test with aeration tank effluent and record the settled sludge volume every 5 minutes for 30 minutes if the mixed liquor settles well, or every 5 minutes for 45 to 60 minutes if the settleometer settles slowly. While the settleometer test continues, prepare the centrifuge test with multiple samples from the aeration tank effluent and the RAS being returned to the aeration tank. Average the results from each sample location.

Once the test data is completed, set up a table to analyze the data. In the first line (Time =0) the settleometer test just begins and the Settled Sludge Spin is the aeration tank spin. The calculation column divides the aeration tank spin by the Settled sludge volume percentage (as a decimal). Once the table is complete, compare the theoretical settled sludge spin to the actual RAS centrifuge spin.

For instance, if the actual RAS spin is 5.2, then the solids retention time in the clarifier is just over 10 minutes. But the sludge does not stop settling until about 25 minutes indicated by very little settling in the time interval.

Determine the target RAS rate with settleometer and centrifuge by finding where the settleometer begins to “flatten out.” In the example that would be between 20 and 25 minutes with a theoretical settled sludge spin between 7.6 and 8.2. Choosing 7.8 for the target RAS spin, adjust the telescoping valve upward until the RAS spin reaches the desired concentration. If the actual RAS spin would have been 8.8, then the telescoping valve would have to be lowered to increase the RAS rate to the desired spin.

Settled Sludge Time	Settle Sludge Volume Percentage	Theoretical Settled Sludge Spin	Calculation
0	100	3.2	$3.2 / 1.00 = 3.2$
5	78	4.1	$3.2 / 0.78 = 4.1$
10	64	5.0	$3.2 / 0.64 = 5.0$
15	51	6.3	$3.2 / 0.51 = 6.3$
20	42	7.6	$3.2 / 0.42 = 7.6$
25	39	8.2	$3.2 / 0.39 = 8.3$
30	38	8.4	$3.2 / 0.38 = 8.4$
35	37	8.6	$3.2 / 0.37 = 8.6$
40	37	8.6	$3.2 / 0.37 = 8.6$
45	36	8.9	$3.2 / 0.36 = 8.9$

How do I correct a flow splitting issue into a clarifier?

Splitting flow equally between two parallel clarifiers is essential to optimizing treatment. If one unit receives more flow than another parallel unit, then that unit could likely fail under peak flow conditions, unable to perform beyond its design capabilities. Meanwhile the unit receiving less flow will be under utilized, performing well below its design capacity. The net result will be a less efficient treatment system and potential permit violations for suspended solids.

The best way to split any flow is to utilize a flow splitter box. In a properly designed flow splitter box, the flow is directed upward to neutralize any horizontal momentum of the flow and then allow the flow to proceed over equal length weirs that are at equal elevations. If the flow is not directed upward, the forward horizontal momentum of the water could cause a turbulent environment in the flow splitter box that may direct more flow over an individual weir. If the weirs are not level, or are at different elevations, then flows will definitely be unequal. If there are no overflow weirs, then the flow splitting would be random.

Poor flow splitting between clarifiers can be difficult to retrofit due to buried pipes and insufficient available head between the aeration tank and the clarifier to build a splitter box. However, if the flow can be equally split upstream of the clarifier, then the flows should be equal all the way through the parallel treatment trains.



Random Flow Splitter: No weirs, no flow control.



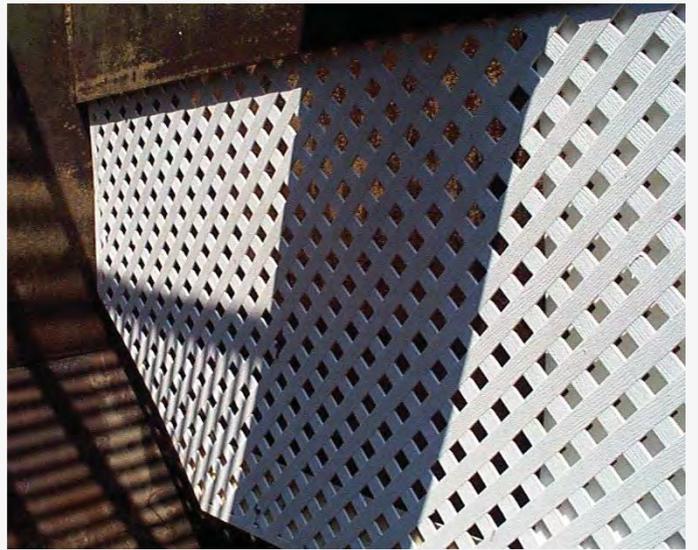
Proper Flow Splitter: Overflow weirs of equal length.

How do I eliminate a density current within a clarifier?

A clarifier density current occurs when mixed liquor enters a clarifier and flows between the higher density sludge blanket and the lower density clarifier supernatant. The mixed liquor has momentum and will continue in the direction of flow until it encounters the clarifier wall. Upon hitting the end wall of the clarifier, the momentum is disrupted and some of the mixed liquor can surface and flow over the weirs into the clarifier effluent. This loss of solids can impact sand filters by clogging them or be discharged into the receiving stream resulting in a permit violation. The installation of properly located baffles can break up a density current thus preventing solids loss and can also improve flocculation of the mixed liquor.

There are two locations in a hopper type clarifier where baffles can improve performance. A flocculation baffle can be installed at the influent end of a clarifier where the scum baffle is located. A mid-tank baffle can be constructed at the peak of a two-hopper clarifier where the side walls of the hoppers come together.

To install a flocculation baffle, the scum baffle can be extended downward to within 1-2 feet of the hopper slant. Rigid plastic sheeting or landscape lattice can be fixed to the existing scum baffle to make the baffle. When mixed liquor enters this baffled region, the flow is gently mixed. This mixing increases collisions between bacterial flocs which promotes bigger, heavier flocs that will settle well. In addition, influent flows will “hit” the baffle and are redirected back into the influent flow. This rebound effect will help to disrupt currents which can persist through the length of the clarifier and carry solids to the effluent weir.



Installing a mid tank baffles is a little trickier. There is usually nothing for a mid-tank baffle to be anchored upon, the baffle will need to be fixed to the side walls of the clarifier. Typically, metal angle is attached to the clarifier side walls and wood boards or plastic sheets are then bolted to the angle. Care must be given to keep the top of the baffle below the water surface so that scum and other floatables are not trapped on the “wrong side of the skimmer.

How do I correct effluent weirs which are causing solids loss?

Clarifier effluent weirs can contribute to solids loss in two ways. Weirs that are not level can establish a current in the clarifier that leads directly to the lower end of the weir. Also weirs that are not optimally located in the clarifier can collect solids that are influenced by clarifier end wall current effects and flow over the weirs.

Clarifier weirs usually have some adjustments so that a weir can be re-leveled should the clarifier settle unevenly or shift slightly. To level a weir, fill the clarifier, block off the influent flow to the clarifier, and shut off the RAS. Since water will seek its own level, just loosen the adjustments and reposition the weir until the water level is even all around the weir. Then retighten the adjustments.

An example of a poorly located weir would be one that is perpendicular to the clarifier end wall or even too close to the end wall. If there is a density current of mixed liquor flowing across the clarifier (see How Do I Eliminate a Density Current Inside a Clarifier), it will continue uninterrupted until it encounters an obstacle, the end wall. Because there is a current flowing over the weir, solids will be carried along with that current over the weir. A simple method to reduce this effect is to block off the portions of the weirs that are close to the end wall. For a weir that is perpendicular to the end wall, taking the 2-3 feet of weir out of service by clamping wood or plastic to the weir. This will allow solids to resettle to the bottom of the clarifier rather than escape over the weirs. For a weir parallel to the end wall, taking the back side weir (the one closest to the end wall on a double sided weir) out of service can also reduce solids loss.



How do I calculate the SOR in the clarifier?

The Surface Overflow Rate (SOR) is a design criteria for clarifiers. The number is calculated by determining the peak flow rate into the clarifier (gallons per day) and then dividing that number by the clarifier surface area (square feet).

The significance of the surface overflow rate is that it provides a numeric value for the hydraulic capacity of a clarifier. In a clarifier, suspended solids settle with a downward velocity. But clear water is flowing upward toward the effluent weir at the same velocity that the mixed liquor enters the clarifier. This results in opposing flows. If the upward flow rate of the clear water is greater than the settling sludge flow rate of the mixed liquor, then solids can be carried over the weir into the effluent trough. If the settling sludge velocity is greater than the upward velocity of the effluent, then there should be no solids loss.

For example, a package plant clarifier may have surface dimension of 6 feet wide by 15 feet long. The clarifier surface area would be:

$$6 \text{ ft} \times 15 \text{ ft} = 90 \text{ ft}^2$$

If the design peak flow to the clarifier is **40,000 gallons per day**, then:

$$\text{SOR} = \frac{40,000 \text{ gpd}}{90 \text{ ft}^2} = 444 \text{ gpd/ft}^2$$

For small package plant clarifiers the maximum design surface overflow rate is typically 600 — 800 gpd/ft². For larger clarifiers with active sludge scrapers, the design surface overflow rate is usually 1000 gpd/ft².

How do I calculate the solids loading rate in the clarifier?

The Solids Loading Rate (SLR) is a design criteria for clarifiers. The number is calculated by determining the mass of mixed liquor (in pounds) into the clarifier and then dividing that number by the surface area of the clarifier.

The significance of the solids loading rate is that it provides a numeric value, not to be exceeded, for the amount of the solids entering a clarifier. In a clarifier, suspended solids settle, compact and only then will be pumped back to the aeration tank. A high solids loading rate to a clarifier can lead to a slower sludge settling condition, due to the high concentration and/or a sludge blanket that is greater than desired. Either condition can lead to solids loss.

For example, a package plant clarifier may have surface dimension of 6 feet wide by 15 feet long. The clarifier surface area would be:

$$6 \text{ ft} \times 15 \text{ ft} = 90 \text{ ft}^2$$

The design mass into the clarifier can be calculated by multiplying the mixed liquor suspended solids concentration by design peak influent flow rate plus the peak design return sludge flow rate and then multiplying by the conversion factor of 8.34.

For example:

$$\text{MLSS} = 3000 \text{ mg/L}$$

$$\text{Clarifier Influent Flow} = 0.040 \text{ MGD}$$

$$\text{RAS Flow} = 0.040 \text{ MGD}$$

$$\text{lb/d of solids} = 3000 \text{ mg/L MLSS} \times 0.080 \text{ MGD} \times 8.34 = 2002 \text{ lb/d}$$

$$\text{SLR} = \frac{2002 \text{ lb}}{90 \text{ ft}^2} = 22.2 \text{ lbs/d/ft}^2$$

For small package plant clarifiers the limiting design solids loading rate is 25 lbs/day/ft². For larger clarifiers with active sludge scrapers, the design solids loading rate is usually 35 lbs/day/ft².