AEROBIC DIGESTION WORKSHOP

VOL II 1998

Panel Of Experts

TOPICS OF DISCUSSION

BETHANY WARR ACRES, OK

CHALLENGE

We have a project which we have been working on for a number of years with very limited success. For instance, the volatiles going in are 65%, volatiles coming out are 65%. We have plenty of air, plenty of detention time, but we just can't seem to make it work. Hopefully by the end of this evening we'll have a solution.

<u>Case study</u> – Bethany Warr Acres, OK

Main process	S.B.R. with nitrification
Sludge to aerated holding tank, then thickened in belt thickener to 3.3	
Solids in Digester	3.3%
pH	5.6
alkalinity	5.4 in, 4.8 out
ammonia	3 in, 6 out
V.S.S	65% in, 65% out
S.O.U.R.	7.7 in, 5.64 or less out
Air flow	80 scfm / 1000 ft^3
Temp.	80° F
Color	Light Brown – no foaming
Microbial Activity	Limited
Detention Time	Over 60 Days

Comments by Speakers:

DR. STOVER : If the system is designed for nitrification, is the SRT so high that the biomass is already digested/ stabilized prior to entering the digester? Another possibility is just the opposite; that the biomass is actively growing new biomass and maintaining the same VS% while actually achieving significant mass VS destruction/removal.

MR. SCISSON : Nothing is happening, so something is wrong.

At first glance, the thing that seems most wrong is the pH. Perhaps the pH is inhibiting microbial activity. Not knowing anything else about the plant, I would adjust the pH by turning off the air for at least a day. I would then check the pH, alkalinity, and ammonia.

I also want to know something about the sludge upstream such as the solids concentration, pH, and S.O.U.R. in the S.B.R. and the holding tank.

I also think the aeration rate is excessive. The air flow should be reduced by half.

If turning off the air doesn't work, I would try not thickening the sludge and pumping it directly to the digester. If more storage was required, I would then thicken the digested sludge. Without more information upstream of the digester it's hard to make an analysis on paper.

DR. DAIGGER : For this application, biological activity appears to be inhibited by the low pH. Is the pH of the feed 5.6? If so, the digester needs alkalinity. If feed pH is 6.5 – 7.5, but digested pH is 5.6, you can either add alkalinity or cycle the aeration on and off denitrify and recover alkalinity.

SECTION 1

MIXING AND AERATION

MR. PORTEOUS : So let's get started with the first section.

QUESTION 1 : WHAT IS THE THICKNESS (% TSS) OF SOLIDS THAT CAN BE DIGESTED FOR WASTE ACTIVATED SLUDGE OR WASTE-ACTIVATED PLUS PRIMARY?
Question by Thomas Wilson, Oak Brook, IL
And we're going to ask Dr. Novak to lead us off with that one.

DR. NOVAK : I think the issue that we've seen that really impacts digestion is can you get enough air in the sludge to keep things aerobic. I also think that the main concern if you're aerobically digesting sludge is how much oxygen can you supply, and I think that would limit what you can digest.

MR. PORTEOUS : Anybody else like to add to that?

DR. MALINA : Well, the thickness (% TSS) of the sludge that can be digested depends on the volatile solids concentration and the inert fraction. A high concentration of inert material, for example silt and clay during periods of high rainfall and infiltration, may cause mixing problems at relative low overall % TSS. If the % TSS approaches 8% at a volatile fraction of 75 to 80% the sludge is the consistency of "toothpaste". This material is difficult to mix and the rate of oxygen transfer will be low. Therefor, aerobic digestion depends on the composition of the sludge, not only the total suspended solids (%TSS).

DR. DAIGGER : In the work that Elena is going to present on Wednesday (Session 55, WEF, "Improving Aerobic Digestion to Meet Class B Requirements by Pre-thickening, staged Operation, And Aerobic/ Anoxic Operation: Four Full-scale Demonstrations"), and in the material reviewed last year (Aerobic Digestion Workshop Vol. 1, 1997: the Challenge of Meeting Class B While Digesting Thicker Sludges), we looked at several cases of digesting thickened solids. What we found was that if the solid content in the digester was about 3 to 3-1/2%, oxygen transfer was efficient. In some instances when the solids concentration of the digester exceeded 3-1/2%, a dramatic drop in oxygen transfer efficiency occurred. This would be real drop in the alpha value because of the kinds of effects that Joe (Malina) was talking about. So, 3 to 3-1/2% might be a reasonable, safe maximum concentration. In some instances you can go higher than that, but you probably shouldn't count on it.

MR. SCISSON : In the field we found that during the active digestion phase you can sometime digest in excess of 4% solids, but less than 4% is better. After it has been digested and in aerated storage, you can increase the solids to about 6%. When the sludge exceeds 6% solids it becomes thixotropic; that is, it acts like a solid until it's had enough energy imparted to it that it will fluidize. What happens in a digester, unless you have a really robust mixing system, is that around every diffuser, you'll have a little area of liquid that's fluidized and everything outside of there is this quaking Jello that just sits there and putrifies.

QUESTION 2a : WHAT ARE THE MIXING REQUIREMENTS FOR AEROBIC DIGESTION?
Question by Doreen Song, Scottsdale, AZ

QUESTION 2b : **WHAT TYPE OF MIXING, AND HOW MUCH IS NEEDED FOR THICK SLUDGES?**
Question by Thomas Wilson, Oak Brook, IL

QUESTION 2c : **DELINEATE BETWEEN MIXING AIR AND PROCESS AIR REQUIREMENT.**
Question by Doreen Song, Scottsdale, AZ
Dr. Daigger, would you like to begin?

DR. DAIGGER : Well, everybody knows it's 20 to 30 scfm per 1,000 cubic feet, right? That's what all the handbooks say. One of the interesting things is that, with thick sludge, sometimes you get the effects that Jim (Scisson) was talking about. It's not a matter of the solids setting; thicker sludges have little tendency to settle. So, it's not just the mixing energy, it's the solids concentration that you can actually mix and cause recirculation throughout the system. You do need to get a good amount of air in it, and I think 20 to 30 scfm per 1,000 cubic feet is not a bad number. But, it doesn't guarantee that it will mix if you have really thick sludges.

MS. BAILEY **:** In some projects we designed recently, especially if you have primary sludge that is extremely viscos, we ended up putting anywhere between 40 to 45 scfm per 1,000. And when we had lime stabilization, we ended up going as 60 scfm per 1,000. So the specific application can really make a difference. The other thing we found out, it depends on what is used to pre-thicken. 5% from a belt thickener is not the same as 5% from centrifuge.
Polymer usage also has an effect on the mixing energy required. Sludge thickened on a centrifuge is more difficult to mix and requires more energy than that from a belt thickener.

DR. MALINA : The degree of mixing depends on how the mixing energy is distributed and on the geometry of the tank. Designers have a tendency to install one aeration device in the middle of the digestion tank. The end result is that at a high concentration of solids in the excess activated sludge, aeration occurs around the aeration device only. The mixing horsepower (energy) should be distributed throughout the digestion tank to get good mixing and oxygen transfer. Dead zones, where no mixing occurs, will result when all the energy is installed at one place in the tank.

MR. PROTEOUS : Thank you, Joe. Anybody else? All right, let's go to the next one.

QUESTION 3 : **WHAT IS YOUR EXPERIENCE WITH FINE-BUBBLE DIFFUSER SYSTEM FOR MIXING AND OXYGEN TRANSFER IN AEROBIC DIGESTERS?**
Question by Steve Swanback, Walnut Creek, CA

MR. SCISSON : I have very little experience with that, and I hope someone can help me out. My firm recently designed an aerobic digestion facility for thickened sludge and when it came to selecting an aeration system there were no offers from fine-bubble diffuser manufacturers. I've talked with some of the fine-bubble diffuser manufactures and they'll say that they can go to 4% solids, but they sort of disappear when it comes time for action or to bid on jobs. I think that 2% solids is as thick as you could go with the fine-bubble diffusers.

The biggest problem with fine bubble diffusers in aerobic digesters is that the aeration system becomes mixing-limited. That is, the volume of air needed to keep the sludge mixed and suspended in the tank exceeds the air volume needed to keep the sludge aerobic. This is especially true in a typical fill and draw operation. If the aeration system is sized for a tank full of unstabilized sludge, the system will be mixing-limited when the sludge is stabilized and you will not be able to turn down the air because you will lose mixing. The second biggest problem will be supernating. If you have to turn off the air to supernate the digester, the fine bubble diffusers are going to foul, especially the ceramic type. And with thicker sludges, you're going to have full floor coverage with hundreds or thousands of these diffusers. Each time they foul you're going to have to drain the tank and go down there with a brush and a hose and clean them all off before you can get started again.

MR. PORTEOUS : Anyone else? If anybody wants to ask questions from the floor, just raise your hand and I'll get to you.

AUDIENCE MEMBER : Can the panel delineate a little bit more on mixing air and process air requirements, please?

DR. DAIGGER : I guess that was the one I was assigned. Oftentimes theses systems are mixing limited so that, once you put enough air in to mix it, you're going to meet oxygen transfer requirements. Why use a more efficient device, a fine-bubble diffuser, when you already are going to be mixing limited? You need to put a certain amount of air into the digester to just get mixing in the system.

There are separate calculations: one is to look at the amount of mixing energy. How much energy is required 20, 30 or 50 scfm per 1,000 cubic feet? It's really a certain amount of energy per unit volume. That's because we tend to have 15 or 20 foot deep tanks, and a certain amount of air equates to a certain amount of energy that goes into it. The process air requirement, then, is how many pounds of oxygen must be transferred. You need to look at the amount of volatile solids that you're destroying in the system to do that calculation.

MS. BAILEY : I wanted to add something. Both Dr. Daigger and I will address this in the presentation on Wednesday, because now with the 503 regulations you have to put digester basin in series. In these basins, there is a certain detention time during which the biomass is active. For instance, volatile solids reductions will occur in the first 15 days. If you don't have enough oxygen within those 15 days, you will have problems. So converting a big digester of 60 days into two or three compartments doesn't mean you have to divide it equally in terms of air distribution. You have to shift most of the oxygen to the beginning, because that's when most of the oxygen uptake will occur. So that's actually a critically issue in designing digestion.

QUESTION 4 : WHAT ADVANTAGE DO YOUR DIFFUSERS HAVE OVER JETS WHEN AERATING WASTE SLUDGES OVER 1% SOLIDS CONCENTRATION?
Question by Robert M. Smith, Ambler, PA

MS. BAILEY : The only thing I want to address at this point is the fact that we do have an above-water orifice, so when you turn the air on and off, which is one of the procedures that we like to follow stabilize the sludge by creating an anoxic stage, it helps a lot that you have an above-water orifice, because if you leave the digester off for maybe four or five hours and you have a below-water orifice, it will clog. And the other thing I would say is we utilize shear tubes to significantly increase the mixing capability of the diffuser and this does seem to be effective in thick sludges.

SECTION 2

STAGED OPERATION / VSS AND PATHOGEN REDUCTION

MR. PORTEOUS : Our next section is Staged Operation / VSS and Pathogen Reduction

QUESTION 1 : HOW DO YOU GO ABOUT SIZING A MULTIPLE STAGE AEROBIC DIGESTER?
Question by Thomas Moran, Willits, CA

DR. DAIGGER : Good question. If you have information on the kinetics, meaning the decay rate, you can actually size the digester on a theoretical basis. If you look at going from a single completely mixed reactor to cells in series, you can calculate the reduction in volume that you could obtain, while still getting the same degree of treatment.

The regulations say that at low temperatures, we need 60 days of detention time. This is really for single, completely mixed digesters. It's fairly straightforward calculation to take a first order decay rate and determine the volume that would give the equivalent treatment with three tanks in series as compared to a single tank. And it's probable -- I didn't do the calculation -- that you could reduce your volume by at least half, if not a bit more, by using tanks in series.

So if you have a regulatory requirement, or a design that says for a single, completely mixed reactor, here's what you need, you can just simply use first order kinetics to determine the reduction in the volume and reduction in the size of the digester that would give the same performance with multiple tanks.

Going from a single tank to two tanks, there is a fairly significant reduction in volume. Going from two to three tanks there is a fairly significant reduction. When you start going beyond that, the benefits in terms of volume reduction starts to decrease. It's the old knee in the curve thing where going from one to two gives you a lot of benefit, going from two to three gives you some benefit but, if you had five basins the benefit from going from five to six would not be great.

From a practical perspective, three or four tanks in series is where you're going to have the most benefit in terms of begin able to reduce the volume.

AUDIENCE MEMBER : What kind of reduction in total volume are you seeking when you go from one to two tanks?

DR. DAIGGER : Just looking at a first order kinetics, going from one to two, you're going to see at least a 50% or more reduction in volume.

AUDIENCE MEMBER : Is that a reduction in total volume?

DR. DAIGGER: Total volume, yes. It's plug flow versus complete mix. It's a basic chemical engineering principle for volatile solids reductions. Also, what drives us to this thinking of 40 to 60 days is pathogens. Would anyone here in their right mind design a complete mix chlorine contact chamber? Why in the world do we design completely mixed digesters when we're really, today, using digesters for disinfection? We do plug flow chlorine contact chambers because they're more efficient. We couldn't use 20 or 30 minutes detention time in a chlorine contact chamber if it was a complete mix unit. So, with aerobic digesters, we're really designing and operating disinfection units more than digesters in terms of our performance requirements. We also have to achieve digestion, but it really is pathogen reduction, the disinfection, that controls the process.

We design plug flow disinfection units, chlorine contact chambers. So, if you think about that, we ought to be designing plug flow digesters.

MR. SCISSION : At the same time that you design digesters to be operated in series, they should have piping to allow them to be operated in parallel. I've had jobs where there were odor problems because the digesters were being operated in series with primary sludge plus RBC sloughings. The aeration systems for each cell were identical, and the first stage was totally overwhelmed. There were odors and there were expensive houses nearby, so they couldn't have that. So, as a fix, we lowered submersible pumps in to allow transfers from cell to cell, and we made it a complete mix system. By evenly distributing the load between the aerators we got rid of the odor problem because even through they had four cells and they were designed to go one, two, three, four, the aerators in each cell were the same size. So they were too small in the first ones and too big in the last ones. But if you have a staged system, you have to make sure that the air supply to each stage is proportional to the expected demand.

MS. BAILEY : Which goes back to the statement that I made earlier that if you do a rehab of a parallel system and now you want to meet the pathogen reductions it's a good idea to convert them into two digesters in series. As a result, you now have a higher oxygen demand in the first digester so the old aeration system will be inadequate to meet the oxygen demand in the first tank. You need to have the flexibility to shift more air into the first tank. If you don't, the oxygen uptake will exceed the supply of air and the first digester will have odor problems.

DR. DAIGGER : You also have to be careful on the size. You have to match the oxygen transfer with the size of the reactor, obviously. If you start sizing exclusively on kinetics, and you can't transfer enough oxygen in the first stage, then you have a problem. I've seen some systems, with a very small digester, where you just can't get enough oxygen into that tank. It you get up to 3 to 4 to 5 % solids, then you can't transfer enough oxygen into the sludge.

So if you want to go small size, with high solids content, you've got to be very careful on sizing. If you just size on kinetics, you could very well be oxygen transfer limited, and that can be a real problem.

DR. MALINA : I think that Jim (Scisson) made a good point. Aerobic digesters usually are designed to handle excess activated sludge. The addition of primary sludge to excess activated sludge changes the characteristics of the sludge and the kinetics are altogether different than those observed for only excess activated sludge. In fact the solids in the primary sludge undergo aerobic bioconversion into simpler soluble organic material which is the substrate that is converted to new biological solids (biomass, biosolids); therefor, the net destruction of volatile solids is minimal. It is important to identified the characteristics of the feed sludge. You can't just pull number out without knowing what you're dealing with. Some of the operation problems are the result of designers using the same design criteria for aerobic digestion, regardless of the type of sludge, for example, will require more energy for mixing and for oxygen transfer to maintain an aerobic environment than only excess activated sludge with no primary sludge.

MR. PORTEOUS : Thank you. Yes sir?

AUDIENCE MEMBER : I think they've kind of glossed over the question, though, how do you meet the pathogen requirements by staging the digester if you can't do it because the oxygen transfer is poor, what do you do?

MS. BAILEY : No, you can do it if you design appropriately for it. What we keep going back to is that oxygen transfer efficiency is not very good in thicker sludges.

What we have done recently because we've been communicating with a lot of the researchers, especially Dr. Daigger, we've been shifting a lot of air to the first stage of the digester but we've also been using what we call viscosity factors. And that's like a correction factor, so to speak.

So in a lot of the systems, while we still design based on 2 pounds of oxygen per pound of VSS removed, as the process air requirement, it is essential to realize that the detention time in the first digester will define what percent of the total volatile solids we will reduce in that first digester. So if the detention time is, let's say, 15 days, and the temperature is 15° C, it will then be about 70% of that total oxygen would have to go into the first digester. The next thing we do is we add the viscosity factor on top of that. A viscosity factor of 1 in our terms means it's not pre-thickened.

If it's a belt thickener that thickens to 5 or 6%, then we may have a viscosity factor of 1.25. If it's a centrifuge or a DAF then it is higher. If it's primary, which we call undigested sludge, then it goes higher that that. We have seen viscosity factors as high as 1.85. So what that really means, it goes back to what Dr. Daigger said, in terms of scfm per 1,000 , that 30 scfm per 1,000 wouldn't even come close to meeting requirements. So your biological requirements are not the sole factor to consider, because of viscosity, the air requirements are a lot higher than that. But it can be done. We have a lot of cases where we feed at 6 to 8% solids, but we designed with sufficient air to meet both the high demand from staged operation and the high viscosity. Does that answer your question?

AUDIENCE MEMBER : No.

MS. BAILEY :	Okay, what's your question?
AUDIENCE MEMBER :	You've got a facility, you're not meeting requirements.
MR. PORTEOUS :	The pathogens, I think.
MS. BAILEY :	The pathogens, is your question?
AUDIENCE MEMBER :	Yes.
AUDIENCE MEMBER :	How do you achieve pathogen reduction?
MS. BAILEY :	This is where stages operation is essential-that each basin is isolated from the previous one.
AUDIENCE MEMBER :	Then you wouldn't be putting fresh sludge in when you're getting ready to send it out.
MS. BAILEY :	Correct. That's the benefit of staged operation.
AUDIENCE MEMBER :	So I guess one of the things you could do would be to avoid thickening so much in your first stage so that it's thinner and then should not have such a high oxygen uptake requirement and then go to further isolated tanks for disinfection. It could also be further thickened prior to these tanks.
DR. NOVAK :	You're going to have to look at what you've got. In terms of getting better disinfection, the answer is staging. This has to be plug flow. Then it becomes a matter of being able to transfer the oxygen in the first stage. If you have the opportunity to put the oxygen right in there, that's one way to do it. As you say, another way to do it is to actually put thinner sludge, because what we're really seeing is that if the sludge gets too thick, then transferring oxygen is a problem, and of course it's going to be thickest in the first stage where a lot of the digestion occurs, however, it's still the most undigested sludge that you have in the process. So you certainly could put thinner sludge in that first tank and then thicken from there into the subsequent stages of the reactor.
AUDIENCE MEMBER :	Would it also be appropriate in the previous example with RBC and primary sludge to feed primary sludge to the first two reactors, RBC sludge to the third, and then have the fourth one separate for disinfection?
DR. DAIGGER :	Yes. Or, you could also feed two-thirds to the first one, and the other third to the second one. The two-thirds that goes in the first one goes all the way through, the one-third goes through 3 basins. But you still get sufficient isolation for disinfection.
AUDIENCE MEMBER :	You've got to work with what you know your oxygen transfer capability is going to be.

DR. DAIGGER : That's right.

DR. MALINA : Yes, well the thicker the sludge, the more protection to the organism. The organic matrix in which the microbes are enmeshed protects the organisms. Destruction of volatile solids results in more exposure of the bacteria to agents that the result in disinfection and pasteurization. The die-off of pathogens in aerobic digestion is a function of time and temperature as well as pH. Therefore, these parameters control pathogen die-off to a greater extent than aeration and mixing.

AUDIENCE MEMBER : So the question asked is important, how much time do you need to come up with a high enough die-off of the pathogens?

MS. BAILEY : Well, Jim (Scisson), you had experience with Clyde where you put three digesters in series and you had an average of, what, 7-1/2 million going into the first one, and then barely made it to less than 2 million in the second one, but then on the third one it was down to 140,000 which is way below Class B requirements. So in that case you needed three digesters in the series to get below 2 million.

MR. SCISSON : What we did was to add another 20 days detention time. And the extra 20 days detention time reduced the pathogen count by 90%. But, initially on that project the two primary digesters operated in parallel. Later we operated them in series. Before the switch the S.O.U.R. out of the first-stage digesters was rarely near the EPA level for vector attraction reduction. After the change to series operation, the S.O.U.R. has been below 1-1/2 milligrams per hour per gram total solids.

Plug flow operation is more efficient than complete mix for at least three reasons. First, the plug flow tank reduces short-circuiting and gives you a higher actual detention time than a complete mix tank. Second, by pumping fresh waste to only one tank, you do not re-inoculate the downstream tanks with new pathogens. Third, the plug-flow system provides different environments to each tank that allows different kinds of bugs to work more efficiently.

QUESTION 2 : HOW SMALL A SYSTEM CAN BE MADE THAT IS STILL EFFICIENT? WHAT'S THE SMALLEST DETENTION TIME YOU CAN HAVE?

Question by M. Carpenter, Salem, OR.

MR. PORTEOUS : Now, I think that's good question. And, Dr. Daigger, would you like a shot at that one?

DR. DAIGGER : Okay. The smallest possible system is one limited by oxygen transfer. You've got a certain number of pounds of degradable solids that you're putting into the digester, and it's going to require a certain amount of oxygen, roughly two pounds of oxygen per pound of volatile solids. And, there is a maximum limit (depending on the aeration system) on the volumetric oxygen transfer capacity that you can achieve.

So, from a theoretical perspective, the very smallest digester is the one that is just big enough to transfer the oxygen that you need to stabilize the organic matter that you're destroying. But in a staged system, most of the demand occurs in the first stage. So you really have to think about that from the perspective of the first stage, and you may well have 70% of the oxygen demand occurring in the first stage. So the very smallest possible first stage is where your ability to transfer oxygen is just equal to the amount of oxygen demand that you're placing on the system.

AUDIENCE MEMBER : How does the more fibrous material affect digester performance?

DR. DAIGGER : It screws it up.

AUDIENCE MEMBER : So, in other words we need to remove it prior to digestion.

DR. MALINA : Designing aerobic digesters to handle rags, other bulky fibrous materials and large objects that are removed from municipal wastewater during treatment is repeating the history of operating problems encountered with anaerobic digestion. In the early days, the digestion tank was not considered a process to be controlled, but the digesters were the receptacle for all the trash removed from the wastewater. Once we get the material out on screens we should keep it out. Grinding or shredding of the screenings results in strands of rags that can result in problems with centrifugal pumps and other equipment. Removal of all the large "chunks" during treatment allows for better opportunities for control of the digester, especially aeration and mixing. Separating the rags and other fibrous materials gives a digested sludge that is a more homogeneous and lends itself to beneficial use alternatives. If all residuals are put un the aerobic digestion tank, then forget about controlling the process.

Once again, I agree that a certain length of time in the aerobic digestion tank is required to kill-off indicator organisms. A hydraulic detention time of 15 to 20 days usually is needed for good die-off. Higher die-off will be accomplished at 20 days, than at 15 days, for the same feed sludge.

MR. PORTEOUS : Let's try another one.

QUESTION 3 : HOW CAN VOLATILE SOLIDS REDUCTION BE PREDICTED OR ESTIMATED?
Question by R. Dale Richwine, Beaverton, OR

DR. DAIGGER : The best way is to do actual pilot studies to determine the volatile reduction. The problem we get into, especially if you're doing staged digestion, is whether you'll be able to transfer more oxygen in the first stage then you can in full scale. So you've got to be careful so that you look at both your decay kinetics and oxygen transfer capabilities and match these. Otherwise you'll end up with the problem that we just talked about. The first stage is going to be sized based on oxygen transfer limitations.

So, the best way to get those kinetics is to do a pilot study, or even a bench scale study, as long as you don't let the decay kinetics override the oxygen transfer capability.

The quality of the sludge is also critical to the decay rate. Consider, for example, high volatile solids versus low volatile solids. You've got to look at your mass balances because you can get significant volatile solids reduction and not have significant change in your volatile solids fraction. So, you've got to look at your total pounds of volatile solids destroyed. Let me mention that we're talking about Mesophilic systems. I think we ought to talk about Thermophilic systems later on. With Thermophilic systems, the mixing and oxygen transfer dynamics change. When we start operating at 130, 140, degrees the viscosity issues change, the oxygen transfer dynamics change, and the decay kinetics change. I think we're going to talk some about that, but so far the comments have mostly addressed the Mesophilic process.

DR. NOVAK : I think a volatile solids reduction percentage, from what I know of sludges, is nonsense. I think you're going to find sludges where you can't meet the percent volatile solids reduction and it's no fault the process, nor does it imply that there's something wrong.

I'm different than the rest of these people in that I do research and I've been trying to figure out for 20 years or more what activated sludge flocs are all about. What I can tell you is when you aerobically digest waste activated sludge, you tend to biograde proteins more than anything else. So when we look at enzyme activity goes to almost zero. So you tend to accumulate polysaccharides in solution and degrade proteins and so you have a release of ammonia. And that has a lot of interesting implications.

But as far as this question is concerned, if your basic sludge is high in carbohydrates, high in polysaccharides and low in proteins, you're going to find it's very difficult to meet volatile solids reductions. If you want to look at the rates, however, I agree, you need to look at some kind of pilot study. That's the only way you'll be able to predict results accurately.

DR. MALINA : O.K., but I think to talk of the efficiency of aerobic digestion in terms of percent reduction of volatile solids is misleading. Excess activated sludge produced at a treatment plant that is operated at a long sludge age (solid retention time) may contain less biodegradable solids than activated sludge produced at a plant operating at a short sludge age. In the one case only a small fraction of the biosolids are biodegradable, while in the case of the short sludge age more biosolids are degradable. The use of fixed percentage of reduction in volatile solids could lead to discharge of treated biosolids that could cause odors and may be a potential hazard to human health. In my judgment, aerobically digested sludge that has a volatile solids content of 50% or less should be "stable", that is, the oxygen uptake rate is low and the sludge dewaters well.

DR. DAIGGER : Well, that's really why we have the S.O.U.R. test as an alternative, an equally valid, demonstration of stability. The 38% is a carryover from anaerobic digestion, and the regs clearly say "or". So if you get 38% reduction, fine, you don't have to worry about the S.O.U.R. but, for most aerobic digestion applications you're going to be looking at the S.O.U.R. as the parameter that's most indicative of stability.

SECTION 3

NITRIFICATION / DENITRIFICATION AND CONTROLS

QUESTION 1 : **REDUCING NITROGEN CONTENT IN SLUDGE IS OF INTEREST TO US. WHAT OPERATIONAL STRATEGIES HAVE BEEN SUCCESSFUL IN REDUCING NITROGEN, AND WHAT PERCENTAGE REDUCTION COULD WE EXPECT TO SEE?**
Question by Eric Hancock, Litonia, GA

MR. PORTEOUS : Dr. Novak, would you like to begin?

DR. NOVAK : Well, again, what you do in aerobic digestion is you tend to degrade proteins, so you'll see a lot of release of ammonia in there, and the amount you release depends on how much protein is in the sludge to start with. I think all of that protein, by the way, is natural material that the organisms produce as part of that flocculation matrix. Now, that occurs fairly rapidly. You release ammonia over just a couple of days of digestion and you don't see a lot of additional reduction after that.

MR. PORTEOUS : Dr. Stover?

DR. STOVER : Well, I think there's a couple issues here. One is the nitrogen itself you're looking at, whether you dewater or not, affects how much nitrogen you have remaining in the sludge versus in the bulk liquid. So whether you dewater or you end up applying liquid sludge is going to make a big difference on how much nitrogen you're going to be able to remove. But one of the option I think is on on/off aeration where you can do nitrification/denitrification . You've got to break down that bound organic nitrogen to ammonia nitrogen. Then you can nitrify and denitrify if you have the oxygen transfer capacity and then you can remove total nitrogen.

Basically, when you're breaking down the volatile solids, whether it's primary solids or an industrial type sludge or an activated sludge, those solids are degrading and their carbon is a food source for other bacteria and you're growing new bacteria. So then if there are mechanisms to grow that bacteria under nitrogen-limiting conditions, you can reduce your nitrogen.

One example again would be if we look at something like a Thermophyllic system you converted to carbon dioxide in the biomass, then you can end up with a lower biomass, but you also end up with lower nitrogen because you have less biomass. So the higher the solids reduction in total, the total pound of volatile solids destruction, the lower the total mass of nitrogen. But then if you raise the solids retention time and then try to get a lower nitrogen, I think you can get a lower nitrogen content in your solids also. And then if you digest it, you take out both liquid-free nitrogen and you carry out nitrification/denitrification if you're Mesophyllic, or if you're Thermophyllic you don't nitrify anyway, so then you take the ammonia nitrogen out, I think by some optimization and fine-tuning you can end up with a lower nitrogen content in your total solids, both a lower mass and a lower nitrogen content.

AUDIENCE MEMBER : Why reduce nitrogen in the sludge?

DR. STOVER : Pounds per acre per year.

MR. SCISSON : If you apply the sludge at the agronomic loading rate for nitrogen, the less nitrogen you have in the sludge, the more sludge you can put on each acre, which reduces the acreage needed for land application.

DR. STOVER : If you're got a high-quality sludge, your limitation is typically going to be nitrogen limitation. So your nitrogen loading is going to limit your sludge application rate, which is going to set the requirement for your land requirements. In some cases that's not going to be the principal consideration, but in a lot of cases it is the limited amount of land that you have available for sludge disposal.

QUESTION 2 : WHAT IS THE PANEL'S EXPERIENCE WITH ON/OFF DIGESTER AERATION?
Question by Ron Schuyler, Denver, CO

DR. DAIGGER : Of course we turn the aeration off to create an anoxic period to allow denitrification to occur. It's just like we've been operating liquid stream plants in recent years with aerobic and anoxic zones for nitrification/denitrification. Bugs are dumb! You can do the same thing within an aerobic digester as in the liquid process.
For thickened sludge, the experience has been that, when the aeration is off, you get very minimal settling because the sludge is already fairly thick. So, on/off operation works very well for nitrification and denitrification. If you have thin sludge, you can get some settling that's going to control the frequency with which you'll have to cycle the aerators to keep very much settling from occurring. Of course, if you get a lot of settling, the bugs are in the settled sludge, the nitrate's in the supernatant and you don't get denitrification. But I think the presumption is often that, "Well, I'm going to denitrify, so I have to have a mixer". In many cases that's not the case.

QUESTION 3 : TYPES OF CONTROLS, HOW DO WE CONTROL THIS PROCESS?
Question by Pedro Mendoza, Miami , FL

MS. BAILEY : We've been designing a lot of digesters like Dr. Daigger described with anoxic zones, and in the last few years we've been recommending to operators to measure nitrates. When nitrates are reduced to 10 mg/l, you turn the air back on and so forth. However, it has not been very easy.
ORP is one way to control the process, but we have not found that to be very reliable in thicker sludges. We just now acquired a new product from Denmark, and actually Nicholas is here. The idea is to basically be able to control the nitrates. Do you want to add something on that, Nicholas? You probably know a lot more about it than I do.

MR. HEINEN : In effect what we have is a system based on N.A.D.H. measurement, and we have seen that the cases where we have complete nitrification and complete denitrification, we are able to see the end of nitrification and the end of denitrification with N.A.D.H. measurement.
I can add also that we have developed at the same time a process where we are able to nitrify and denitrify at the same time based on the fact that we are controlling the oxygen and the fact that we have an oxygen gradient in the sludge floc, and then we can create an aerobic and anoxic zone in the same sludge floc causing nitrification and denitrification simultaneously and this could be used also in aerobic digestion. That would solve any pH problems fully.

DR. STOVER : Out of the problems or concerns that I would have with that is I understand how that would work in an activated sludge system, but the biggest problem I've seen in reactor where you are limited by oxygen transfer is whether you will actually get the nitrification in the digester, and probably even the bigger problem I think is the possibility of odor. The biggest problem I run into, when you have your reactor size set such that oxygen transfer is the limiting factor, is an odor problems during digestion. That's also an issue when thickening up the solids.

And maybe you have some experience with that, but the concern I would have with using that approach in a digester where you're really thickening up the solids and you have viscosity and oxygen transfer problem is the ability to achieve nitrification, but then while you're trying to do that, if you try to operate at a low enough D.O. where that you get the denitrification within the sludge floc, you'll see that sludge floc start deteriorating.

If you have to take your D.O. down lower, I think you're going to get odor problems, which is really the biggest problem I've seen with trying to use the concepts you're talking about if you don't design and size it right up front and make the reactor size large enough with the oxygen transfer capacity to meet your oxygen demand.

MS. BAILEY : Maybe I should have explained that. We were not thinking about doing it in every digester. The first digester would still be designed based on oxygen requirement to achieve nitrification, and in most cases, in staged digestion, we don't see that we can even nitrify in the first digester anyway. This would have been for the second stage digester and the third where you see the pH problem.

So basically, when you start seeing the pH dropping, then this will be a good way to keep the optimum oxygen balance instead of sizing it based on excessive amounts of air, and hopefully avoid having to turn the air off, which is what most operators feel uncomfortable with. They don't like this idea turning the air off for five hours.

If you fully nitrify in the first stage, then you operate with a 0.1 to 0.5 D.O. in the remaining stages, then you can still do that nitrification/denitrification. And you're right, we have one case that we want to test where there is actually four different thickness of solids. It goes to the first digester at 8% solids. By the time you go to the fourth digester it's 3% solids. That's going to be one of the things we want to try to see what level of solids we can operate in that low D.O. zone.

DR. STOVER : Yes, on the staged concept, I think that would be possible. I think the problem occurs when you start looking at converting digesters or modifying digesters and if you try to do simultaneous nitrification/denitrification, I think you're got a serious problem.

But I agree, I think if you design and size for the process, and you go for second or third stage, that certainly makes sense.

MR. SCISSON : Three simple ways to monitor the digester are with alkalinity, pH, and ammonia.

Alkalinity is an indicator of stability, it the sludge is septic or oxidized. As the sludge nitrifies it creates acid and depletes alkalinity. When the sludge is septic, alkalinity increases.

Down here in Florida they've done that for years. They've watched the alkalinity and turned off the air when the alkalinity gets too low. The same thing is true with pH, especially if you're batch digesting waste-activated sludge, it can go from a neutral pH to 5.5 in the course of a day once you've got it all cooked out. And by watching the pH, you know that when your pH drops you have lots of nitrates and you can turn the air off.

A third indirect indicator of oxidation is ammonia. Increase in ammonia concentration indicates septic conditions. Any of these indicators can be used to vary the air supply.

I wish we had known about air cycling back when I started out as an operator. When the sludge was fully digested the pH would fall to 5.5 or less. To raise the pH for land application we would slurry up hydrated lime and pour it into the digester. It was hot and dusty, and we wore face shields, duct masks, gloves and raincoats to keep us from being dusted all over. It was a lot of work. If we had known all this then, we could have been lazy and just turned off the air for a day.

SECTION 4

PRODUCTS FOR PRE-THICKENING/POST THICKENING

QUESTION 1 : **WHAT IS USED FOR PRE-THICKENING OR WHAT CAN BE USED?**
Question by Gay L. Slaughter, SR., Accokeek, MD

DR. MALINA : After leaving what we talked about earlier, the question remains "How thick must the sludge be"? The focus of this discussion is aerobic digestion of excess activated sludge. The consensus in this room seems to be 3% TSS. A belt thickener with minimum chemical addition may produce a 3% sludge. Dissolved air flotation also may result in a 3% sludge when it is strictly activated sludge is the feed. Different sludge will require different types of handling and pre-treatment.

The details of a good sludge handling system have not been discussed to this point. The type of sludge and characteristics must be determined. For example : activated sludge only, primary sludge and excess activated sludge, or excess activated sludge generated at a municipal treatment plant that does not have primary sedimentation. It may be that if you separate primary and waste activated sludge you may produce a blended sludge that contains 3% solids. Other sludge combinations may require pre-thickening to 3% solids.

You could over-thicken. As discussed earlier 8% solids may be the maximum concentration of excess activated sludge that could be mixed and aerated in an aerobic digester. The various issues involved in aerobic digestion and pre-thickening must be considered as an integrated system. The treatment objectives or goals of aerobic digestion must be clearly defined. The overall system including all components should be optimized to bring about a cost-effective and efficient design. Optimizing each of the individual components separately, for example optimizing pre-thickening by itself followed by optimization of the aeration system in the aerobic digestion, could lead to unnecessary spending.

MS. SCISSON : But then after design you do need a thickener right now. Gravity belt thickeners are the most common sludge thickeners being installed. But there are many other thickeners that can be used, depending upon the application, for example, gravity thickeners and rotary drum thickeners.

QUESTION 2 : **IS THERE ANY EVIDENCE THAT POLYMER INHIBITS AEROBIC DIGESTION?**
Question by Jim Porteous, Austin, TX

DR. NOVAK : I've never seen a case where polymer would inhibit aerobic digestion. I can imagine if you'd load up an excess amount of polymer you'd cause problem, but I haven't seen that happen.

AUDIENCE MEMBER : There was some work on polymers inhibiting nitrifiers at one point. I believe there are certain polymers that could inhibit nitrifiers and therefore you could end up with a digester full of ammonia because you're not nitrifying.

DR. STOVER : I think that's certainly possible. I think the bigger concern I would have is if you're really trying to thicken up your sludge, I think one of the problems you encounter is that if you overdose on polymer you impact your viscosity, impact your oxygen transfer. You do have a problem I think with overdosing on polymer, but not so much from inhibition.

Along the same lines, if that polymer inhibits nitrification, then you could in fact get into a situation where you're limiting oxygen transfer because of viscosity, which is going to limit your digestion rate, and then also you can inhibit the nitrification because of the polymer.

So I think that's certainly possible. More probable is that where you're trying to really thicken, and you're having a problem thickening. For example, maybe if you've got a filamentous sludge, a bulky sludge, and you're dosing it with a lot of polymer to get it to thicken up to achieve really high solids concentration, then I think you could get into a problem with some of the polymers.

DR. NOVAK : But that's more a case of misuse of polymer, I think, than it is proper use.

DR. STOVER : Right. And I would think it would tend to be more that type of situation when you have a problem.

DR. DAIGGER : An experience that I've had is treating some of the wastewater from a polymer formulating plant. Some of the components in polymer are inhibitory to nitrification. However, it is a polymer overdose that gives you that circumstance because an overdose is required to increase the dissolved polymer concentration rather than the polymer attaching to the solids. The polymer must be dissolved before it's inhibitory. So it's an overdose to the point where some of the polymer stays in solution that causes that problem. We also found that the inhibitory material was not the polymer itself. It was the emulsifier, which is going to be carried away if you're in a gravity-belt thickening operation or something like that. It's going to be carried away with the wash water.

DR. MALINA : Well, the sludge at each plant is different. The chemical constituents in the water are different. You've got to pick the polymer to match the particular situation. If a polymer appears to inhibit nitrification, this polymer should not be used. Make sure the polymer is on the list of polymers approved by AWWA for drinking water treatment. In this way, no problems with discharging the overflow from the thickener will be encountered. The effectiveness of a polymer should be determined at the site where the sludge is generated. Talking the sludge from Houston to New England for evaluation is not representative. Collecting a sludge sample at the treatment plant for evaluation elsewhere involves truck transportation, followed by holding on the tarmac at an airport, and transportation in an airplane at 30,000 feet, followed by storage on the tarmac and finally transportation by pickup truck to the laboratory where the sludge may or may not be refrigerated prior to the evaluation. There is no way that the conditions described about could be simulated at the plant at which the sludge is generated. Evaluation must take place at the site of sludge production and polymer must be matched with the sludge as generated.

QUESTION 3 : **WHAT TYPE OF PUMPS AND ENERGY IN HORSEPOWER IS NEEDED AS A FUNCTION OF TSS TO PUMP RAW THICKENED SLUDGES TO THE DIGESTER?**
Question by Thomas Wilson, Oak Brook, IL

MS. SCISSON : At different times and different places, almost any type of pump could be used to pump the thickened sludge. Most common now is a gravity belt thickener with a little hopper at the end of the belt with a progressive cavity pump, because it's small, and works well. It's designed with an open throat so the sludge just falls down and then you can pump it. It's nice and compact and reliable.

If you drop it into a proper wet well, you can use other different pumps besides the progressive cavity pump. You could use a centrifugal pump. You could use a screw centrifugal pump like a Wemco pump. You could use a diaphragm pump. You could even use a plunger pump, or a rotary lobe pump.

The pump selection will depend upon the sludge solids, and how it is to be used. For sludges of 4% solids or less, either centrifugal or positive displacement pump will work if properly applied. Above 4% solids it's safer to use positive displacement pump, like the progressive cavity. Centrifugal pumps do not deliver consistent performance at higher solids contents, especially with freshly-polymerized sludge. In these cases the sludge is thixotropic and the pump will liquify the sludge in the volute and not be able to move it against the jelled sludge.

The power required to pump the sludge is still a function of the flow and head. We generally oversize the pumps to run at lower rpm's.

It is important to remember when you're pumping thickened sludges that you want to have as short a suction run as possible to your pump. Some of these pumps, like the progressive cavity pump, will not pull a suction, at least not very much of a suction. So you want to have flooded suction and a short suction run, because the sludge tends to set up in the these long pipe runs and no matter how much suction you put on that line, the sludge won't move. So you want to have a short suction run and flooded suction in all cases. It's also important to use variable frequency drive and a wet well level controller, especially with the GBT and those little hoppers. I've been in plants where the operated has to continually adjust the pump speed to prevent it from overflowing or running dry.

SECTION 5

ATAD

QUESTION 1 : **WHAT ARE THE DESIGN OXYGEN REQUIREMENTS OF ATAD AND CAN ATAD PROCESSES ACCEPT PRIMARY SLUDGE WITHOUT CAUSING ODORS?**
Question by Michael Convertino, Evergreen, CO

DR. STOVER : I think, well first there's two separate issues there, both related to oxygen requirements, and that is the oxygen requirement for volatile solids destruction is 1.42 pounds of oxygen per pound of volatile solids destroyed. At the high temperatures of the ATAD system, you don't nitrify. Nitrifiers die off around 115 degrees (F) or maybe 120 degrees (F). So there is no oxygen requirement for nitrification. So you can design for the volatile solids destruction if you have biological solids. But then you have to look at whether you have primary solids or if it's municipal or industrial. The oxygen demand for those solids can be significantly different. The way I look at those solids is by doing a COD balance and getting the oxygen requirements for those solids through a COD balance. You can also do a COD balance on your biological fraction, or you can take the theoretical of 1.42 pounds of oxygen per pound of volatile solids destroyed. You go back and you estimate your volatile solids destruction as we talked about in a pilot study or bench scale study. If you're mixing sludges it's different ball game. You have different quality sludges and you have to understand the dynamics of your decay rate and the dynamics of your oxygen requirements. In the ATAD system you're opening at 130, 140 degrees (F), there's viscosity differences, there's oxygen transfer differences, and so all of that's got to be taken into account.

Can you design a system to deal with odor problems? Well, if you match the oxygen transfer with the oxygen demand and you get the transfer, you won't have an odor problem, you get the musty odor effect. But if you have a high volatile solids content with high proteinaceous matter, if you break down those solids you get a high destruction rate, and typically if you get a very high destruction rate, then you end up with a high bulk liquid ammonia nitrogen concentration. That ammonia nitrogen reacts with the carbon dioxide, which is also biologically produced, then you produce ammonium bicarbonate alkalinity and your pH goes up. Now your temperature's high, your pH is high, and so you tend to volatilize ammonia nitrogen. So the issue, if it's designed right, is not the typical odorous type problems that you're talking about, I think it's more that the process should be balanced. For any kind of biodegradable material you can design a system, whether it is separate or combined, as long as you do the dynamics and you look at the breakdown of those materials and do your balances, and I think you can design for it. Your real problem is with is the high pH and high temperature. You can get very high ammonia nitrogen concentrations and get the volatilization of the ammonia. So that becomes to me more of an issue as far as odor control looking at the ammonia volatilization

DR. NOVAK : We've been looking at ATAD's in the field, five or six of these, and what we've seen from the one company whose product we've been looking at is because you need the solids up the high enough to generate heat, none of the first stages in ATADs are what I would call aerobic processes.

Typically what we've seen is the sludge gets just horrible. We've seen conditions over the raw sludge increase easily by an order of magnitude, quite often levels that would boggle people's mind that are huge. The sludges seem to come apart. We've seen biopolymer in solution running 6,000 and 8,000 milligrams per liter. Most of that material constitutes a polymer demand. So when you start looking at ATADs, I think you have to start thinking about what else can you do, what's going on here, and we've just been doing studies of that kind. As they said, it's something that you need to go into in some detail. What we've seen is if you have a second and a third stage, you might get a little bit of improvement. If you then go to a separate Mesophilic digester you'll also find that you get a certain amount of improvement, quite a bit of improvement, in fact.

We've looked at conditioning. We found that using iron or even alum is very, very beneficial compared to polymer, you can cut your polymer requirements way down if you use iron or alum. I can't get into all the details, but I think that ATADs are much more complicated than simple oxygen transfer because you can't generate the heat without high solids concentration and with the high solids you can't get enough oxygen in there to make the contents aerobic so they undergo these same things that anaerobic digester do, and that means the sludge gets really poor. And then you're wrestling with trying to recover from this through subsequent stages and in conditioning.

DR. STOVER : If you're using polymer, the pH can be like 8 to 9 because of the ammonium bicarbonate alkalinity. So if you're using polymer at that pH versus then it you lower the pH with alum or iron to pH-7, I think what you'll see is that it requires a lot lower polymer does, probably both because of the conditioning but also because the polymer reaction to neutral pH is going to be better, or is that what you see?

DR. NOVAK : No, absolutely not. We've looked at adjustments of pH and haven't seen big pH problems. Basically the specific thing that we looked at is what controls the chemical conditioning or polymer requirements. All of this soup that you generate, this stuff in solution, requires polymer for conditioning, the proteins are always the worst of those, and they are pretty much selectively removed when you use iron or alum. So it's the reaction with some kind of aluminum or iron hydroxide that seems to remove proteins. And when you get those out, then your conditioning requirements fall way off. Certainly adjusting pH will do a little bit, but it's not what seems to be causing the changes. We've looked at probably six plants like and struggled with how to improve 8-10 sludges because they really do get very bad after the first stage.

(Addition questions relevant to ATAD are on pages 27, (NITRIFICATION/DENITRIFICATION AND CONTROLS), and 49 (FOAMING / TEMPERATURE).

SECTION 6

FOAMING / TEMPERATURE

Question 1 : **HOW CAN TEMPERATURE BE CONTOLLED WITH THICKENED WASTE-ACTIVATED SLUDGE (5-6%) WHEN IT'S BEING FED TO A DIGESTER?**
Question by Steve Black, North Yoke, Ontario

DR. DAIGGER : When you're feeding thickened sludge into a digester and destroying those volatile solids, you're combusting them and releasing heat. The higher the concentration of solids, the more heat that's available to increase the temperature of the water you're putting into the digester.

If you accept that you're going to feed at a given concentration and, if you're getting digestion, you're getting a certain amount of heat release and you're going to have temperature elevation unless you cool the system. The alternative is to put more water into the digester. Rather than thicken all the sludge going into the digester you could feed thinner sludge and then pull sludge out of the digester, run it through the thickener, dispose of the liquid and put the solids back in.

We obviously want to achieve a certain solids concentration in the digester so that we can achieve our intended SRT in a given volume. We can do that by thickening the digester feed. We can also put more water into the digester to absorb the heat and avoid the temperature increase and then take the water back out by thickening the digester contents.

You're running it through the thickener one time in either case. It's just a matter of whether you run it through the thickener before it goes into the digester, or take the sludge out of the digester and pull the water out by thickening the digesting sludge and putting the solids back in so that we can achieve our required SRT.

DR. STOVER : One of the things you can do is to waste, both thickened sludge and waste-activated into the digester. By balancing that, you balance your waste-activated and your thickened sludge so that you don't get the problems with the oxygen transfer. If you thin your sludge, you may reduce your retention time but you can still get as good a solids reduction and as good a solids dewatering. So one of the option in the plants that I've seen where you're got this problem especially in the summertime, is to direct feed from your thickener to the digester, feed your waste-activated sludge, balance the two with your oxygen transfer, if you have the capability to play with your volume. If you can't and you thicken up and don't get the oxygen transfer, then you're not getting the volatile solids destruction and the solids don't get dewatered well coming out of the digester. You may be better off blending waste-activated thickened sludge, try to get the oxygen transfer, try to balance that between the cell decay, and you may end up actually in a better situation by running for a certain time of the year, especially in the summertime with more dilute solids and still end up with a fairly reasonable operating situation.

MS. BAILEY : I agree with Dr. Stover. We've done that in Paris, Illinois, actually. What they do in the wintertime, because of the detention time required, they pre-thicken primary sludge three times a week, and then they go straight to the digester with dilute sludge the other two days a week. Monday, Wednesday and Friday they pre-thicken and then Tuesday and Thursday they bypass the thickener. This seems to work better with their schedule than pre-thickening for half of each day. Then in the summer, when it's very hot, they reverse that. So they would pre-thicken only twice a week, and that seems to work.

DR. STOVER : And you'd be surprised, lots of times you can actually accomplish your digestion and get better dewatering by doing that and you actually meet your volatile solids whereas if you keep it thick and you let it deteriorate, you start having odor problems, you don't get the digestion, you don't get the dewatering.

QUESTION 2 : IF FOAMING COMMON IN DIGESTERS AND HOW DO YOU PREVENT IT?
Question by Robert Munro, Orlando, FL

MS. BAILEY : I think pretty much the things we just talked about, keeping it below 35° C. The only installation we have that is covered can be borderline Mesophilic, reaching about 30° to 35° C. We have not seen foam and it's pre-thickened to over 8% solids. We believe the only reason that we're successful is because it has shear tubes that basically create a lot of shearing in the reactor. We did a side-by-side test with a device that had a mixer combined with air against our draft tube design and we saw excessive foaming from their system but not with ours when the temperature were at 100° F. So the only thing I can say is probably if you can have enough energy in the basin, but you also have enough shearing to prevent foam build up on the surface, maybe that helps. And I'm afraid we only have one installation that is high in temperature so far. It's completely covered, insulated covers, insulated air line, the whole thing.

DR. STOVER : One of the things I've seen in that regard, as you start approaching Thermophilic temperatures, I think what happens is you're still at your Mesophilic decay rate and you don't see that much foam. If you kick over into the Thermophilic temperature range and you bring in new solids and those solids hit that higher temperature, those cells start lysing and you get a lot of proteinaceous release, all of a sudden you get a lot of cell release, you get a lot of activity, all of a sudden you get a high increase in decay, and that's when you really see the excessive foam. I think it's when it's in that transition when you're going into the Thermophilic, because your cell lyses increases significantly. I think what happens is when you go into that Thermophilic condition you see excessive foam because you've got all this proteinaceous material from the cell breakdown, which creates an extensive amount of foaming. Then you get on up into the Thermophilic condition and when you get up there, you get through that zone into the Thermophilic and stabilize, you're breaking down that material at a faster rate as it's being released, then I think your foaming backs off again. I don't think you see as much foaming in the Mesophilic system. When you go over into Thermophilic, then I think you're really going to see the foam.

DR. NOVAK : Yes, we've seen it in ATADs. In fact we've been recirculation some of the centrate and the whole activated sludge plant starts to foam, a big problem. You really create that mess, that soupy stuff that causes problems.

MR. SCISSON : Two other common causes of foaming are Nocardia and septic conditions in the digester. So if you have Nocardia in the aeration tank, sooner or later you're going to have it in the digesters as well. And then you're going to reseed it from the digesters into the aeration tanks every time that you supernate. So prevention of Nocardia can keep a lot of the foaming away. Septic conditions also can cause foaming in the aerobic digester since they're supposed to be aerobic; they're not supposed to be anaerobic. And when they're septic long enough, high turn into anaerobic digesters and the first thing they do is foam up.

Aerobic digesters that are fed septic sludge in a batch or semi-batch operation and digesters processing primary sludge are prone to septic foaming. Sooner or later the oxygen demand totally overwhelms the aeration capacity and foaming starts. The foaming continues until the waste is stabilized.

SECTION 7

SOLIDS HAULING AND DISPOSAL

QUESTION 1 : **FOR IN-TANK GRAVITY THICKENING IN EXTENDED AIR OR CONVENTIONAL ACTIVATED SLUDGE PLANTS WITHOUT PRIMARY CLARIFIERS, WHAT IS THE MAXIMUM AND AVERAGE PERCENT SOLIDS IN THE DIGESTER ONE COULD EXPECT?**
Question by Tracy Cork, Albany, OR

DR. DAIGGER : If you're thickening by gravity, 2 to 3% is about as good as you're ever going to get and with a lot of sludges. 3% might be wishful thinking. So you shouldn't really count on too much more than a couple of percent, and to get 3%.

MR. SCISSON : With only waste-activated sludge and not having a separate decanter or a gravity thickener, generally what I've seen is 1-1/2 to 2%, and at the very best 2-1/2%. To do better than that you would have to have a separate decanter. Aeration tanks are not very good clarifiers, so if you want to do better you need separate clarification.

MS. BAILEY : Yes. The other thing, we have found is that we can actually thicken the digesters up to 3 to 3-1/2% with recycle of thickened sludge from the thickener.
It's a little bit complicated, but let's say you can waste at 0.7% to a gravity thickener, and then you take the thickened sludge and you feed that to the digester, and then the thickened material in the digesters keeps overflowing back into the thickener and then you remove the liquid in the form of a supernate, you can actually get a supernate out of a gravity thickener. So we recycle the thickened material from the bottom of the thickener to the digester and keep on recycling it back, and then you get rid of your liquid in the form of a supernate. And we can achieve about 3, 3-1/2% solids. I have listened to a paper at the Biosolids Conference in Seattle, and they said they can actually thicken up to 6% solids by gravity when adding polymer. But I have never actually seen that. It was a paper that was presented there. So I really don't know how effective that would be.

MR. SCISSON : That's an entirely different thing to add polymer. Then you can thicken to 4-6% solids.

MS. BAILEY : They are adding the polymer in the thickener.

DR. DAIGGER : I think we all agree that solids disposal is good. (laughter)

SECTION 8

RULES AND REGULATIONS

QUESTION 1 : **CLASS B SLUDGE NEEDS TO MEET THE PATHOGEN DESTRUCTION CRITERIA IN VALUES BETWEEN 1,000,000 AND 2,000,000 COLONY FORMING UNITS AT A VOLATILE REDUCTION OF GREATER THAN 38% AND A S.O.U.R. OF LESS THAN 1.5. DOES THIS 38% NEED TO BE MEASURED FROM THE INCOMING SLUDGE TO THE DIGESTER? IN ANY CASE, 38% IS A RELATIVE NUMBER. DO YOU BELIEVE THE EPA SHOULD SET A FIXED NUMBERICAL VALUE FOR VSS IN THE TREATED SLUDGE? IN SOME SOURCES, S.O.U.R. IS DEFINED AS MILLIGRAMS PER HOUR PER GRAM OF TSS, OTHERS AS MILLIGRAMS PER HOUR PER GRAM OF TS AND SOME AS MILLIGRAMS PER HOUR PER GRAM OF VSS. HOWEVER, THE SECTION 40 OF CFR PART 503 DESCRIBES TS. ARE YOU IN FAVOR OF SOME STANDARDIZATION OF THE CRITERIA IN THIS MATTER? WOULD YOU LIKE TO TALK TO THAT ONE?**
Question by Miguel Galvan, Corpus Christi, TX

DR. DAIGGER : Well, yes, is the person that submitted this, is he in the audience?

MR. PORTEOUS : No, he's not.

DR. DAIGGER : I guess I see some confusion in the question where it says a volatile solids reduction of greater than 38% and "and" a S.O.U.R. of 1.5. I think it's "or". You do not have to achieve both of them; only one or the other is required. I can understand the confusion that exists. But, it's "or", not "and". As Professor Malina said, for aerobic digesters the percent volatile solids reduction is really nonsense.

DR. MALINA : You can get 38% reduction in many ways. You can add inert solids like silt, clay, etc., into the sludge before or after aerobic digestion and they will result in a significant reduction in volatile solids without changing the mass of volatile solids in the sludge and without reducing the oxygen uptake rate. Total solids are used instead of suspended solids, because at the concentrations of sludge, filtration would almost impossible without adding chemicals.
The focus of the Regulations is on reducing the oxygen requirement, i.e. the oxygen uptake rate, so that you don't get odor production, vermin attraction, or other nuisance conditions.
Odor is a relative parameter or quality of sludge. What is an acceptable level of odor? Individuals who operate wastewater treatment facilities are well aware of the quality of the digested sludge by the odor given off by the sludge. No odor is acceptable to the golfer on the links, after biosolids have been applied to the course. Therefore, many efforts attempt to address and define the elusive stable sludge.

DR. NOVAK : But we've closer on aerobic than we are on anaerobic. I think S.O.U.R. is a surrogate for odor reduction, and I think it works pretty well.

DR. MALINA : Yes. Well-digested sludge from an aerobic digester has no odor, at least no offensive odor to a person who works with sludge.

DR. DAIGGER : From a regulatory perspective, it's something that's not part of the test. I think, logically, you have two circumstances. One is if the sludge is well digested and fairly neutral pH, then the ammonia is going to be gone anyway. If you're not controlling pH and it nitrifies so your pH is going to be 5 or 5.5, then it's not going to demand much oxygen in the test anyway.

AUDIENCE MEMBER : I guess the thing that's likely to happen is the sample will denitrify in a couple hours of travel time from the plant to the laboratory, and you're likely to generate some ammonia that may show up in nitrification, and perhaps you need to aerate again for an hour before you do your test.

AUDIENCE MEMBER : S.O.U.R. tests need to be run out under standardized conditions.

MR. PORTEOUS : Thank you. Let's go to our last question.

QUESTION 2 : HOW DO YOU COMMUNICATE SLUDGE SYSTEMS TO THE PUBLIC?
Question by Louise Harris, Silver Spring, MD

MR. SCISSON : She's working for a public relations firm and she's asking us?

MR. PORTEOUS : She's here in front. You can ask her yourself.

LOUISE HARRIS : I'm doing a newsletter and what I keep getting from wastewater treatment plants is that they're doing really good work and they're trying to figure out a way to tell the public that. So I just wanted to know what the experts thought.

DR. MALINA : In Austin, Texas the sludge undergoes anaerobic digestion, air drying in basins, and is composted. The finished product is marketed as "Dillo Dirt". The public uses the product. The people understand that the Dillo Dirt is composted sludge and a usable product that is available at nurseries and specialty shops. There are still many questions that are unanswered. What is the composition of the residual materials after the degradable organic material is decomposed? How long will it take for the residual solids to degrade in the soil to minerals? Will this residual material affect the soil structure in a negative way? These issues are not the kind of subject matter that one would like to include in a public relation newsletter.

AUDIENCE MEMBER : I just wanted to make a comment on that. I'm from the IOWA Water Control Association. The association is very active in this area. One of the things that they're done is they're put together a video to explain sludge and the beneficial use of biosolids to a lot of different public bodies. That's a lot of just meeting the talking to them. That's a big part of public relations.

DR. NOVAK : I agree. I think you have to do public relations. What I've noticed, and I serve on a planning commission for my little town, when people approach councils or board and they're planning to dispose of sludge on the land, everybody's suspicious. So that's a bad time to start your public relations. That's when you run into difficulty. So it really needs to be done much earlier. I think of the sophisticated utilities that want to get a rate increase and they start with little things two years ahead of time, so they build this into people's minds. I think that's the only way it can be done. In our area sludge is a bad word, and it shouldn't be.

MR. PORTEOUS : Thank you. I think we're just about out of time. I was hoping we could solve Bethany Warr Acres' problem, but it's going to have to wait till another time.

Thank you very much for coming, and I'd like to thank our panel for the great job they've done tonight. I'd like to thank the audience for giving up their Sunday evening to listen to discussions on sludge. I'm impressed with the number of people that are here, and let's hope you found the time spent rewarding.

(END OF PROCEEDINGS.)

(See page 3 for Panel Members' responses to Bethany Warr Acres.)