

AD 101

Steve Dvorak, GHD

I want to thank you for inviting me to be here. It's nice to see this many people here. And I want to say that the previous two speakers have left me a lot less to talk about, but we'll do the best we can. I'm Steve Dvorak, a professional engineer, I'm from Wisconsin, and we have a few cows also. We have a system that we developed, we have a patent on it, we call it a two-staged mixed plug-flow anaerobic digester which is quite a handle. Basically anaerobic is without oxygen. We start out with a plug-flow. There are a lot of dangers to a plug-flow, as Mark mentioned.

What we really like about a plug-flow is the fact that you have almost a guaranteed retention time. When you go to a mixed digester, a pure mixed digester, literally you can put it in and 30 seconds later it might be coming back out again if you're that unlucky. But in a plug-flow you should have a guaranteed retention time. We design ours around a 22-day retention time. We do modify the plug-flow in that we mix it as it plug flows through the digester. If you look at flow being three-dimensional, and your flow is in the X axis, we actually create a vertical lift in the Y axis and we rotate tangentially in the Z axis, and so we corkscrew as we go through our digester. There are two stages in that we have a separate acid chamber in front of the methanogenic chamber.

As we mentioned, it's a biological system. We start out with a manure collection system that the farmer typically has already. We have them primarily at dairy plants, but we also have one at a beef packing plant. We're running 11 digesters now with about 16,000 cows going through the digesters. We just started one up in the State of Washington, at Lynden, at the Van der Haak Dairy. We did that project with Andgar, and Marlin Stadema is here from Andgar.

Our digester vessel is poured concrete. We have an acid chamber, then a methanogenic chamber, first in, first out, basic plug-flow concept. We mix with recycled biogas. The biogas, of course, goes to the top of the digester. We have a solid cover. We collect it underneath that cover. We take a portion of that and reinject it into the bottom. We create a mixing with recycled biogas. We have no moving parts inside our digester. We run a mesophilic temperature at 101°F.

Our basic system is that we take the total waste stream from the dairy, including parlor water, what you flush your holding area. If you have a flush system, we do have a system in Wisconsin where the dairy flushes its entire barn and we have an anaerobic digester for that. It's

been running for three years. We'll come out of the digester typically at about 5% solids, we'll take the solids, we'll go through a solid press and from there typically people are using it for bedding. You can compost it, you can dry it if you like. We have some people who are looking at doing that. The biogas goes to the engine generator where we produce electricity. We're looking at systems in areas where the utility is not willing to pay us much for electricity, so we're looking at LNG and compressed biogas and so forth instead of electricity. But typically we are producing the electricity. We're taking the heat from the engine generator and using that to heat the digester up to the 101° temperature and we're also using heat back to the dairy.

In Wisconsin we have surplus heat going to heat the parlor, the offices, the holding area. We have in-floor heating buried in the holding areas, and you can go there in Wisconsin to some of our digesters and see the holding areas where the cows are, and they'll have a little bit of steam coming off so we don't ice them up, which is a problem we have in Wisconsin. We also have them where we have maintenance buildings, in-floor heating in the maintenance shop and we'll heat the maintenance shop and so forth from the surplus heat. The engine generators will give you quite a bit of surplus heat. Basically we're producing the heat for the digester and heat for the dairy.

I don't believe you have this in Washington, but in Wisconsin, we have a program where if the dairy or anybody produces a heat source that will eliminate natural gas or propane purchasing, the State of Wisconsin gives them a tax credit or a grant and we have been able to get typically about \$50,000 just because we're able to do that function in Wisconsin.

The liquid, of course, comes off the solid press and typically we'll go out to lagoon storage for spreading, where it'll go for crop application. We also have one at a duck farm where we're doing complete secondary treatment and we're discharging that actually to a stream. They have a Wisconsin PDS permit and we're discharging to a stream; it has to meet our Wisconsin DNR requirements, we are getting that done. We're also looking at getting it clean enough so that we can give it to animals to drink. There are standards for that and that's probably our next project that we're getting pretty excited about.

This is a schematic of our digester with the cover off. We will have typically a reception pit and an acid chamber. Acid-forming bacteria multiply extremely fast and are very hardy. They will multiply at 100° in 2 to 3 hours and from the small chamber then we go into the larger chamber where we make the U and there is where we have the methanogenic or the gas-forming

bacteria, and they are a lot slower growers, 7- to 8-day population doubling growth rate, and then they'll go out to the end. We have what we call our skidsteer chamber where it will actually go through under a gas wall which maintains the gas inside the digester and we'll go into this chamber and overflow into a rear wall. From here we go to a collection pit where we will pump to a separator. This is sized so that we can drop in a skidsteer; if we ever would have to clean this chamber we can drop it in. Our floors are completely open. We can actually drive around our digester. If you pump that out, we can have a skidsteer in there in about 30 seconds, I guess.

Because we run basically different zones, we take samples, raw manure will come from a cow at 7 to 7.4, 7.5 pH. And so that's what will come into our reception bed. From here we'll put it into the acid chamber. Acid-forming bacteria, hence their name, break down complex structures, proteins, carbohydrates, starches, and so forth, and they create acids. By creating the acids, you would expect the pH to drop. And when we take samples from our chamber here, we'll get a pH down to about 6.0. So they are doing what we intended they do. We'll drop the pH. The methogenic bacteria basically consume the volatile fatty acids. They consume the acids that were made in this chamber and, as they consume those, those bacteria give off gas as their bodily function, and when we take samples over here we will have raised that pH from 6 up to 8 or 8.2. So if you're using lime in your soil because you're running acidic soil, we actually have increased the pH of the manure, which is because we reduce the volatile fatty acids.

This shows a digester, this is actually our first digester that we built on a dairy farm in 1999 at Gordondale and it's a concrete structure with a precast hollow-core panel roof structure. It's a U shape, goes back, here's where it goes into the effluent chamber. It's insulated. This is Wisconsin. We insulate it, it runs 12 months a year, he's running it today, and that's what it looks like when it's finished. We have an in-ground digester with a solid roof, we have a low profile, you can walk on that, we have people driving skids through there. I don't recommend that, but we have basically designed it for that. This is his building that he put up for it. You have the Genset in here, we have the solids separators in here, and in this area here where the wall is higher is where we have the storage for the separated solids.

Digesters in the dairy business typically produce biogas that is 55 to 60% methane, the rest of it is primarily CO₂. We typically like to see about 58% methane, 42% CO₂. You have some trace amounts of H₂S, nitrogen, and so forth. We like to believe that we're about the most efficient digester out there and on a straight-cow basis we'll take 5 to 5.5 cows to produce one

kilowatt per hour. So if you had a 1,000-cow dairy we'll tell you we'll produce about 200 kilowatts per hour, 24-7. We use Genset to provide the electricity and the heat, small amount of H_2S , as Mark said, you need to have an automatic flare so if you have surplus biogas or if the engine is down, you flare it. For a couple of reasons—first of all, the safety; second of all, the biogas smells. If you smell biogas from the digester going to the engine, we didn't really eliminate odor, we made it very strong and very concentrated. Biogas does smell. When you burn it in the engine, the engine basically purifies and changes it to CO_2 for you, but it does smell, so you want to flare it so that your neighbors don't know that your engine is down. If you don't flare it, you'll definitely know it.

Burning biogas, there are a lot of issues about burning biogas. We hear that all the time. Do you need to scrub biogas, do you need to do filtering, what do you have to do for preconditioning? The biogas that you get from a cow facility or an animal waste facility is much cleaner than we're getting off landfills. Landfills have more contaminants in them. If you think of what goes into a landfill, there are lot of things that go into landfills that we don't put into organic-type digesters. We're finding, and Mark touched on this as well, that if you monitor your engine temperature, keep your engine temperatures hotter so that your dew point is up there and you aren't condensing your gas or your moisture in your gas stream going into the engine, and you'll keep these hotter temperatures in your engine oil block, you'll keep the H_2S out of your oil, you'll keep it as a vapor. H_2S in vapor stage is not corrosive. H_2SO_4 in liquid stage is. So you need to keep your temperature up there. You have certain requirements of pressure to the engine, so we're just running a small centrifugal type rotron blower to keep the pressure up there, but we're not scrubbing the gas going to the engines. We're burning it as is.

Question—

From the -----? No, not seeing that, not at all.

Engines, we have a CAT engine at Gordondale, and it just had 24,000 hours on it. Fabco, the local CAT dealer in Wisconsin, came out to check the engine. They like to change that engine out when the valve wear gets to be about 90-thousandths and at 24,000 hours they had valve wear between 9 and 13-thousandths, so they were extremely happy with that. That just happened. Any other questions on that?

This shows that Wholesome Dairy in Wisconsin, he's running about 3800 cows, and we originally put in a Deutsch engine. He put on another barn addition, so we ended up with more

cows and now we have added a CAT engine. The Deutsch engine is a little bit larger than the CAT, so he's running about 750 kilowatts right now, and he's got about 3200 milking and about another 500 or 600 dry cows. In a typical operation, you'll see the heat recovery from the engine exhaust, we'll save the heat off the engine exhaust as well as the heat off the engine block so we'll have the two sources of hot water. He's about 20 miles south of Green Bay, Wisconsin.

He is running at 750 kilowatts constantly and he also takes the heat from this engine and he heats his parlor, offices, holding area, and a very large maintenance shop.

The digester effluent—we take everything from the dairy, including parlor water, and run it through the digester. After it's digested, we separate it so that all the solids have been digested. I think that is important. Some of the fixed film digesters that are out there are separating solids first and then doing digestion, but I guess I haven't quite figured out why you would want to do that and then you have smelly solids left over, I guess. But this is what we're doing. We're digesting everything and then separating solids afterwards. Primarily I think every dairy that we have is using the solids for bedding. The issue that also comes up is, what about sand because sand is obviously the best bedding you can have. I respectfully tell you that we are disproving that. That's a big statement. I grew up on a dairy farm in Wisconsin and sand is pretty big in Wisconsin as well. We are disproving that. We are dropping the somatic cell count on dairies that use this, we're dropping significantly the number of mastitis cases on dairies that are using digested solids instead of sand.

Our largest setup for digesters right now is at Fair Oaks, Indiana. We have four digesters there on a farm that Tony Boss runs. He's currently running about 7,000 cows through those four digesters and he has another two dairies that he built previously that are bedded with sand and the surplus bedding that we are separating here—he has now converted one of those two previous dairies over to this and we started to build two very large digesters to run another 8,000 cows at those dairies. At the end of this year, we will have about 15,000 cows at Tony Boss's place that we switched over from sand bedding to recycled manure. Somatic cell counts at the dairies this year in the summertime—he had two dairies that were below 100. They averaged about 120 for the entire year. I think he would tell you that his mastitis reduction and his sick cows from mastitis on a typical 3500 cow dairy, the size he is running, he is averaging about maybe 3 to 4 per month with mastitis.

Why is that? Marlin has some data here from digested solids at the Van der Haak Dairy that was analyzed at Udder Health Systems in Bellingham. We had zero detection of lactose fermenters in the bedding, we had zero detection of klebsiella mastitis bacteria. That's why this is working. If you also physically look at the solids, I know some of you in this room have been up to Van der Haak's or Wisconsin, you can take it in your hand and squeeze it and you can wipe it off and it leaves your hand. It doesn't stick to your hand. It also means that it doesn't stick to the udder and it doesn't stick to the end of the teat.

Typically a farmer will use about 40% of the bedding that we separate. Every dairy right now is selling the surplus to neighboring dairies for bedding. Wholesome Dairy south of Green Bay is selling it to eight other dairies, and they all switched over from something else. They were using sand or using sawdust or something else and they have all switched to that, so he is actually selling his solids out for bedding to other dairy farmers.

The liquid that comes through a separator, of course, is digested as well. As Mark mentioned, there is great odor control. We'll have 1 to 2% solids coming through the separators. Now we're in the stage here where before we had people trucking it with semi-tankers and running it on their fields, we're now irrigating it. We see a corresponding reduction in NPK. We will see off the separator that we are finding about 50% of the phosphorus going with the solids and about 50% with the liquid. So if we do that, you can see that you can double your application rate per acre. If you put in a primary lagoon for settling and then the secondary lagoon where you irrigate out, which is what we're also doing on most of our dairies, we'll get this reduction NPK down to about 80%.

Here is a typical separator at Gordondale Farm. Effluent pit is here, it gets pumped up into a hopper, the overflow goes back to the pit so it makes a cycle there. The material comes through here, this is the line that goes out to the storage lagoon and the solids go into the auger. That auger dumps it into this building here, it will stack like that, of course. This will run about 65 to 70% moisture. The surface dries extremely well. What the cows lie on is much drier than that. That's what he beds with.

That manure at the Gordondale Farms, we've had it tested by the EPA. The coliform reduction which is *E. coli*, would be 99.3 to 99.4% reduction. The environmental strep-type bacteria, a little bit tougher, we'll do about 96 to 97%; the staph series of bacteria we'll begin at 99%, so we'll do about a 98 to 99% total bacteria reduction but we're also seeing that lactose

fermenters, klebsiella is 100% reduction. There are all kinds of data on that, we actually did bring some along, if you would like to look at it. At the Gordondale Dairy, the EPA AgStar program has done a one-year study on pathogens. They took 24 different samples. That'll be published pretty soon, but we actually brought one example along.

This is what Gordondale's cows look like, bedded on the solids. Deep free stalls—you have about 8 inches of separated solids here. He's been using this for about 3.5 years now and has never cleaned them out. He just keeps adding like you would with sand. He gets virtually 100% of the cows lying in the free stalls and everybody that I take to this dairy, you'll not find cleaner cows. And you'll see that you have no open sores. It doesn't keep the sores open like sand does. Clean cows that are easy to prep before they go into a milking parlor.

This is actual data that we had from two dairies where we had the phosphorus and we took it on a pounds-per-ton basis going into the digester. The phosphorus that was removed with the solids and the phosphorus that stayed as a liquid. And that's straight off the separator. If you go to a settling lagoon, you get more settling than that.

This happens to be Ken Buehl who has a master's degree in veterinary science. He's one of the owners, the manager of the Wholesome Dairy near Green Bay. I took this picture of irrigating with the liquid effluent. I was getting brown spots on my glasses but couldn't smell it. That's the first very impressive thing about it. You can be here, pumping straight out of a second lagoon, and you don't smell it. I once gave a tour with liquid being irrigated and the head of the Minnesota Pollution Control Agency was there. We were out in the field with plastic boots on, and we had about this much manure effluent on an alfalfa field. I asked him, "What do you think?" He said, "I have a serious problem."

I looked at him, was a little shocked because I was pretty impressed, and I said, "What's your problem?" He said, "I'm going to go back to the office and nobody's going to believe me." That was his problem.

Last year, Ken Buehl spread 25,000 gallons per acre of digested effluent after his first hay cutting. He put another 25,000 gallons per acre after the second cutting. We had a very dry year in Wisconsin, so third crop cutting got 30,000 gallons per acre. Out of the second lagoon, the nitrogen and phosphorus contents probably were about 20% of what he started with because it settled out. You can see he's putting it right on his growing crop, alfalfa, corn, soybeans. The digester process which is a bacterial process—one of the things that it does is mimic what soil

bacteria do for you naturally. Cow manure basically is 80 to 85% organics. Soil bacteria mineralize it and change it to inorganics. Plants use inorganic material for growth. A digester changes it from organic to inorganic, so it does the same thing the soil bacteria do for you. When you spread manure on your crops, you get burned crops, burned leaves, we all know that. That's organics burning organics. When you thin the manure so your viscosity is such that it doesn't stick on your leaves and you convert it to inorganics, you don't have the burning effect, so we're able to put 25,000 to 30,000 gallons per acre on top of green crops. We're not putting it on in March and not in November, which is traditionally what we do in Wisconsin and in the Midwest. We're putting it on crops where we can utilize it, it's now in an inorganic form so the crop uptake is much, much faster, hence you have less leaching, less runoff, and the crop can utilize it.

Last year, Ken Buehl sold about 40 million gallons of digester effluent. He sold his liquid to other farmers, for \$35 per acre. Not too many people in Wisconsin or the Midwest sell liquid manure, and he was selling it at \$35 per acre. Selling his separated solids they did not use for bedding. The neighbors who bought the liquid were averaging about 3.5 tons of dry matter per acre for alfalfa, in a dry year. Where he irrigated at \$35 per acre to these farmers, they went 3.5 tons per acre to 7 tons. The cheapest \$35 they probably spent. He actually sold his manure and it was all done in June, July, August, and September. That's a huge advantage.

Tony Boss in Indiana is doing the same thing. He has center pivots, spreads all of his effluent now in the summertime on his crops. When you take the solids out and you biodegrade it, you can get it through a nozzle with no problem, and there is no more trucking. He was spending about 1.5 cents per gallon to tanker this out with sand. He's now spending 0.2 cents to irrigate it, 42 million gallons per year. You can all do the math.

We're putting in the last digester for him. The rural cooperative that he's in says they don't want any more green power and they aren't going to buy electricity from him. He's still putting in the digester and not selling any electricity. He might be trying to do something else with liquefied natural gas or something but there will be no electricity.

Question—

On the last two dairies he has flush and on the first two dairies that we're converting over now he has vacuum trucks. We have a flush dairy. His are flushed flumes and we also have a complete flush in Wisconsin. You can do that. It takes a little bit different engineering but we have been successfully doing it.

GHD started off putting in digesters for dairies with the idea of producing electricity. I would have to tell you right now that this (nutrients) gets to be more exciting than electricity does and I think it's getting customers more excited.

Any questions?

You're welcome to come to see any of our digesters. We give a lot of tours. You need to go and kick the tires. You need to see what the people are doing. It's not just strictly odor control, not just strictly electrical. You need to see it as a total management system and how it fits into the manure system.