Presentation on Water Treatment Techniques and Tools

By Joe Wantulok

Introduction

Hello, my name is Joe Wantulok, and I am the president of WERECON Incorporated. We are a company based in Phoenix Arizona that manufactures water treatment equipment for Golf Courses and Agricultural applications. Before starting this company, I grew up in the northwestern United States, where I was involved in hardware and software development in the high tech industry. When I moved to Arizona, I needed a change of pace, so I went to work for a golf course in Scottsdale. I advanced through the ranks quickly and within two years, I was assistant superintendent in charge of irrigation for the 36 hole facility where I worked. I held this post for 5 years. During this time, I realized that the need for water treatment equipment was not being adequately met by the existing companies in that field. I felt that my experience in computers and advanced control systems could benefit this industry, so I went out on my own and started WERECON.

That was six years ago. Over that time, a lot has happened in the field of water treatment for turf and agriculture, and that's what I'm here to talk to you about today.

I'm going to start this presentation with an overview of water treatment as it presently applies to Golf courses to help bring up to speed those of you who are totally new to this technology. Then I'm going to discuss some of the tools available to you to achieve this objective and the strengths and weaknesses of the various approaches. After that, I'll move on to discuss some of the ways to apply these tools on your facility, at which time I will conclude, and allow some time for question and answer.

Water Treatment Overview

As more and more golf courses are being built all over the world, it has come to the attention of many superintendents and agronomists, that many of the problems with turf quality are related to the quality of the irrigation water. This problem is compounded by the fact, that as population grows, golf courses are required more and more often to make use of secondary sources of irrigation water such as surface water and treated waste water. To address some of these problems, people have begun using chemical amendment systems to increase

nutrients and mitigate alkalinity in their water sources. These systems fall into two major categories. Fertigation Systems, and pH Control systems.

Fertigation

Fertigation systems are machines that inject fertilizer into the irrigation system at the point where water enters the system. Usually at the pumping station, or vacuum breaker at the head end of the system. Because of the concentration of the fertilizers being used, and the small doses needed, these systems need to be highly accurate and offer repeatable performance.

Turf managers can benefit from the use of fertigation in many ways, including: Reduced labor, reduced waste, less interference with play, and more consistent turf quality. I will cover some of these in more detail later in this presentation when I discuss application methods.

pH Control

The second major water treatment technology is pH control. PH control is a variation on fertigation where an acidic product such as sulfuric acid, or a sulfuric/fertilizer blend is injected to lower the pH of the irrigation water. This has the effect of keeping dissolved solids and salts present in the irrigation water in solution so that they can leach through the soil rather than plate out in the top layers of the soil where they can do damage to the turf. PH control systems tend to be more sophisticated that standard fertigation systems, due to the reactive nature of the chemicals used. They also should employ more safety features due to the consequences that can be felt if there is a system failure.

If you have high pH, high salts or bicarbonate levels in your water, you can experience huge benefits from the use of pH control. Generally, in areas where this type of water problem exists, we have seen greater return on investment from the use of pH control than almost any other type of cultural improvement. The benefits can include improved soil consistency, better water penetration, and enhanced nutrient mobility in the soil. On the agricultural side, we have had several farmers that use state-of-the-art sub surface drip irrigation systems tell us that the use of pH control has made the difference between whether they have a viable crop or not.

Available Tools

During recent years, fertigation and pH control systems that were traditionally the domain of agricultural users have become much more sophisticated. This has allowed systems that were once only suited to low pressure fixed flow applications to evolve so that they can be used in to today's advanced high pressure, variable flow golf course irrigation systems.

Proportional vs Non-Proportional

Fertigation systems come in two major varieties: proportional, and non-proportional.

Non-proportional systems were the first widely used fertigation equipment. They consisted of an injection pump that was designed to come on when the irrigation cycle started, and shut off when the irrigation cycle stopped. This was achieved by either the use of a simple timer that was programmed to match the irrigation cycle, or by wiring the pump to the controls of the pump station. This type of fertigation system was well suited to an agricultural irrigation system where the pump station drove one block of irrigation. That block always created the same amount of water flow when it was running. Either the block was on, or the block was off. When it was running, the fertilizer was injected at a constant rate, and when it was off, no fertilizer was injected.

The problem with using this type of injection on a golf course, is that a golf course pump station may be able to output from zero gallons per minute up to 3000 or more gallons per minute and anywhere in between, depending on irrigation demand at any given time. Needless to say, if your fertigation system is outputting the same amount of product when you are hand watering greens at 100 gallons per minute, as it is when you are irrigating at 2500 gallons per minute at night, you will not get the consistency you need. This problem brought about the advent of proportional fertigation.

A proportional fertigation system makes use of an injection system that can output a variable rate depending on water flow. These systems incorporate sophisticated controls that monitor a flow sensor in the irrigation main line. Using this flow data, the control system varies the output of fertilizer to match current water demand. In the previous scenario, this system would inject 25 times as much fertilizer at 2500GPM as it would when you were hand watering at 100GPM. The key to effective golf course fertigation is to keep the concentration of fertilizer in your main line constant at all times. Most proportional systems represent your ultimate application rate in parts per million or PPM. When I say this to a lot of turf managers, they roll their eyes and remember the fun they had in their chemistry classes. In chemistry, PPM is usually considered to be parts per million by weight. In fertigation, PPM is much simpler, it represents parts per million by volume. In fertigation, one PPM is simply one gallon of fertilizer per one million gallons of water used, or here in

Canada, one liter of fertilizer per million liters of water used. So, if you have a system that allows you to set your rate in PPM, and you know approximately how much water you will use in a given period of time, it becomes easy to predict how much fertilizer you will use.

In Arizona, in the summertime, it is common for a golf course to use one million gallons of water in a 24 hour period. If a superintendent has his system set to inject at 50 PPM, he knows that he will use approximately 50 gallons of fertilizer per 24 hour period.

Fertilizer Delivery

In fertigation, one of the first tasks that needs to be overcome is that of pressure differential. On one hand, you have a bulk storage tank full of fertilizer that is just sitting there. The fertilizer is under only atmospheric pressure, or what we would call zero PSI. On the other hand you have the irrigation main line that contains pressurized water that may be anywhere from 90 to 150 PSI on a typical golf course. In order to get the fertilizer out on the golf course, you need to take the zero PSI fertilizer and put it into the pressurized main line in an accurate fashion. This can be achieved in a number of ways, but is traditionally done using either a metering pump, of a venturi injector.

Traditional Metering pump systems

Metering pumps are available in several varieties. The main types used in golf course fertigation systems are either mechanically actuated or hydraulically actuated diaphragm pumps. A diaphragm metering pump incorporates a hollow chamber that is sealed with a movable diaphragm. On the suction stroke, the diaphragm is withdrawn from the chamber to pull product from the tank into the chamber. On the pressure stroke, the diaphragm is pushed back into the chamber, forcing the fluid to exit the chamber back through the injection line and into the mainline. In the mechanically actuated diaphragm pump, a motor or a magnetic solenoid moves a pushrod which is physically attached to the diaphragm. In an hydraulically actuated pump, the diaphragm is moved by oil pressure that is created behind the diaphragm. As a general rule, mechanically actuated pumps can not create as much pressure as hydraulic pumps, because the mechanical pushrod doesn't support the diaphragm as well as the hydraulic fluid. Hydraulic pumps, however, need the added maintenance of period oil changes to ensure proper operation.

Using metering pumps, the application rate is usually controlled in two different ways. The output of the pump can be varied either by adjusting how fast the diaphragm moves back and forth, or by adjusting the distance the diaphragm

travels on each stroke. Usually in a proportional fertigation system, the control system will vary the pump speed to adjust for varying water flows in the main line, and the turfgrass manager will adjust the length of the stroke to control the overall output of the pump.

Metering pumps have their pros and cons. On the positive side, metering pumps are a long proven technology. They tend to be very robust and can go millions of strokes without any operator maintenance. They are also generally tolerant of a wide variety of fertilizer products depending upon their materials of construction. On the negative side, metering pumps cause the fertilizer product to be pressurized to at least the main line pressure. With pressurized chemicals, care should be taken in the observation and maintenance of the injection lines so that they don't rupture. For this reason, metering pumps are not the most desirable injection method for the aggressive products used in pH control. Additionally, a diaphragm failure can lead to fertilizer entering the inner workings of the pump which can be a costly repair.

Venturi Systems

The second major technique for getting product in to your irrigation lines is the use of a device called a venturi. The venturi is an almost magical device that looks like a tee fitting. This device has three ports. When water is forced into the inlet port, it generates a suction on the side port that draws in fertilizer product. The fertilizer then violently mixes with the water, and the fertilizer/water mixture comes out the outlet port. This effect happens because of the special shape of the venturi. However, the physics as to why this all happens is beyond the scope of this presentation. In a golf course venturi fertigation system, water is drawn from the irrigation main line into a side loop in the fertigation system. The pressure of the water is elevated by a small booster pump which then rams the water through the venturi. The fertilizer is then drawn into the venturi and a weak mixture of fertilizer and water is injected back into the main line. The application rate is controlled by several different methods by controlling how much product is allowed to flow into the suction port of the venturi. This type of system moves quite a bit of water through the system when it is running, usually between 15 to 20 gallons per minute of water per injector. Because of this large volume of water in relation to the amount of fertilizer being injected, the mixture being injected into the main line is usually only about 3 percent fertilizer. This helps to minimize localized corrosion at the injection site caused by aggressive fertilizer and pH control agents. Like the metering pump, the venturi has it's pros and cons. On the up side, in a venturi system, the concentrated product is never under pressure. This makes it ideal for use with aggressive pH control products. It also offers simplicity and superior mixing when compared to metering pumps. Additionally, it has less moving parts in contact with concentrated chemicals which makes repair less costly. On the down side, due to some of the small openings in the venturi, it is more susceptible to clogging than metering pumps

and high quality products should always be used. Also, because the venturi actually mixes the product with water within the system, if you use products that react badly with your water chemistry, you can cause internal buildups in the venturi that may make it stop working.

Chemical Compatibility of Materials

No matter what method of injection that you choose, it is important to pay close attention to chemical compatibility issues. Be sure to ask the manufacturer whether the materials that the system is made of are compatible with the chemicals you plan to use. This is especially important with pH control products. If a fitting in your system breaks that comes in contact with concentrated product, be sure to get a replacement fitting from the manufacturer, not your local hardware store. This is especially true with plastic fittings. Many plastic fittings are available in a wide range of materials from the same manufacturer. We have seen fittings that are made of chemically resistant PVDF and non resistant Nylon from same manufacturer that cannot be visually identified which is which.

pH Control

Now, lets talk a little about pH control systems. PH Control systems are really just a variation on fertigation systems. The main difference between the two is method of setting the rate. In a fertigation system, the rate will ultimately be set to provide you with a certain amount of fertilizer, or a certain amount of a particular nutrient per a certain amount of irrigated area. In a pH control system, what you are really doing is setting the rate to provide you with an amount of acid that will react with your water to give you a desired effect. The amount of work that the chemical does on your water can generally be represented by the pH of the water after the introduction of the chemical. For this reason, most pH control systems incorporate a fertigation system, that also has pH sensors and a control system that can use this data in some way to control the reaction. PH control systems come in three major varieties: pH Driven systems, flow driven proportional systems, and hybrid auto adjust systems.

pH Driven Systems

Some of the first pH control systems were pH driven systems. They used a pH sensor to continuously measure the pH of the water while you were irrigating. If the pH was too high, it would add more acid. If the pH was too low, it added less acid. These systems have two major weaknesses. The first is that the system totally ignores water flow in the mainline which is a major factor in acid requirements. As a result, the controls are always trying to second guess the irrigation system which results in highly unstable performance. The second problem is that the entire system operation depends on the reliability of the pH sensor. PH sensors are laboratory grade components which need to be

calibrated frequently, and replaced on a regular basis. If the sensor fails in this type of system, it can have catastrophic results on the golf course. Because of these problems, our company has not viewed this technique as a viable means of pH control.

Flow Driven Systems

The second type of pH control system is the flow driven proportional type. This system is simply a proportional fertigation system that incorporates a pH sensor to show the operator the current output pH. Additionally, the pH sensor acts as a safety so that if the pH drops below a certain preset value, the system will stop injecting acid. This system requires the operator to set the rate in PPM to achieve a certain output pH. This process is called “tuning” and should be done periodically to ensure optimum performance. These machines work well and tend to be very stable due to their proportional nature. The only weakness of this approach is that the outgoing pH is in direct proportion to incoming pH. If the incoming pH varies frequently, such as the case in golf courses with multiple co-mingled water sources, the system will have to be “re-tuned” fairly often to maintain the desired performance.

Auto Adjust Systems

The Adaptive Auto Adjust™ system was pioneered by our company. It is simply a flow driven proportional pH control system that has the capability to automatically tune itself. Acid is injected proportionally to flow, and every two minutes, the system makes some decisions based on statistical performance. It then adjusts the PPM rate using some special rules to achieve the optimum output pH. This technology is incorporated in most of our pH control systems and represents the best of all worlds.

Safety Issues

Whenever pH control is used, special attention should be given to product handling safety. Sulfuric acid should **never**, I repeat **never** be injected directly under pressure. The consequences of a ruptured line or fitting can be devastating to both personnel and equipment. Some sulfuric/fertilizer blends can be injected under pressure safely due to the fact that many of these products do not attack human flesh, however many of these products are still aggressive toward equipment. It is always preferable to inject acid based products in a non pressurized system such as a venturi based machine. Additionally, it is advisable to store acid based materials in a tank that incorporates a secondary containment vessel in case the primary tank springs a leak. You should also have adequate eye wash facilities and personal protective equipment nearby. Despite these safety requirements, please keep in

mind that any chemical can be made dangerous if it's not handled properly. There is a lot of fear that surrounds some of the acid based pH control products, yet with proper handling, pH control has been a tremendously beneficial tool for hundreds of facilities and has an excellent safety record.

Application

Now that we have discussed some of the various methods of fertigation and pH control, lets talk a little about the various techniques for using this type of equipment.

Microfertigation vs. Application oriented Fertigation

There are two major methods for the use of fertigation equipment. Application oriented fertigation, and microfertigation. Application based fertigation is the use of large fertigation systems to put out a product application through the irrigation system. This method is often used in agricultural sites to provide a specifically timed dose of product to a crop to get a specific result. They may put out one application to stimulate root development, than another to promote leaf growth, than another to help the plants set fruit. This technique works well in Ag due to the fact that their plants go through a very fixed life cycle from seed to growth, to harvest, to death.

Golf courses needs are somewhat different from this. Obviously, the turf has a cycle as well from summer to winter and overseeding where applicable. However, on a day to day basis, the nutrient requirements of the turf are fairly constant. This is where microfertigation comes in.

Microfertigation is the continuous application of a small amount of nutrients through the fertigation system at all times. This technique is much better suited to the needs of turfgrass and is the method we recommend to most golf course superintendents. Microfertigation has several major benefits. First, it levels out the peaks and valleys of fertility usually associated with granular applications. Secondly, it minimizes inconsistencies associated with irrigation malfunctions. For instance, if you have a stuck gear drive on two fairway, it will probably be repaired in a day or two. With application based fertigation, if that head was stuck on the night of your major fertigation application, you may have a burned out stripe where that head was stuck. With microfertigation, you may have gotten a little more fertilizer in that area, but it will even out after the head gets repaired. Additionally, if you are using the application oriented method, twice a month, the dosages will be 15 times higher than if you fertigate every day. Another benefit to microfertigation relates to the complexity of the piping of your irrigation system. In a typical golf course irrigation system, it takes a significant

amount of time to build up a consistent level of fertilizer everywhere in the system. If you are constantly turning on and turning off your fertigation system, you cannot achieve the consistency you can if your system runs at a low rate all the time.

Greens vs. Fairways

Another topic associated with fertigation usage relates to the varying requirements of different areas of the golf course. A lot of superintendents ask me if there is a way to only fertigate their greens. This question is understandable. Most turf managers have been programmed since they first started in this profession that the greens are the most important part of the golf course. Our company agrees wholeheartedly with this concept. Despite this fact, the question here is not what is the most important part of the golf course, but rather what part of the golf course is harder to fertilize. The average golf course consists of approximately 100 acres of turf, of this area, the greens comprise about 3 acres. The greens can usually be fertilized manually with walking spreaders or a spray rig in front of play with little or no interference. The fairways and roughs, however are another story. If you have a packed tee sheet, these areas can take days to put out a granular application. And woe to the irrigation man who has to water this fertilizer in amongst play.

If you have a problem with finding a fertilizer that will work on both your greens and fairways, tees, and roughs, you should always consider using your fertigation system to apply to the larger areas, and use conventional methods to apply to the smaller areas. You can isolate one area from another with fertigation by irrigating different areas at different times and turning off your fertigation system when it is not desired, but you need to allow enough time for the fertilizer levels to build up in your lines, and enough flush out time for levels to drop once the system is shut off. It should be your goal to minimize this isolation technique if not absolutely necessary, because it is a detriment to overall consistency.

Fertilizer Products

Today's fertigation and pH control systems consist of highly accurate machinery and intricate control systems. In order to get the best reliability from your system, you should follow some guidelines on the types of products you use in your system. The fertilizer products fall into two major groups: baseline products, and specialty products.

Baseline products

The first group is baseline products. These products generally provide one major nutrient per product. These include products such as UAN-32, CAN-17, phosphoric acid, Potassium Thiosulfate, and chelated iron products, as well as many others. These products can be used effectively with fertigation to help provide your base nutrient levels. As with all fertigation products, it is important to purchase good quality homogenous liquids from a reputable vendor. Additionally, steps should be taken to ensure that the fertilizer you are using is thoroughly compatible with your water. This can be a factor in certain parts of the world where water has high calcium contents. In these areas, some phosphorus products tend to precipitate when introduced into the water. This can cause problems with a fertigation system, especially venturi based systems.

Specialty products

The second group is specialty blended products. These are products that are either a blend of some of the above products, and also include other products such as soil amendments and wetting agents. There are a multitude of these types of products currently on the market today, and as long as they are made by a knowledgeable reputable vendor they can be very beneficial in fertigation. Be careful to make sure when using these products that they are chemically stable over time and varying temperatures. Sometimes it may take months to pump out a large bulk storage tank. If your product settles, or coagulates before you can use it, you may have a 500 gallon mess on your hands. Caution should also be used against using suspensions and fertilizers made from wettable powders due to the fact that these products often lack the long term stability to be used in fertigation.

Mixing Systems

Some fertigation manufacturers sell on site mixing systems for solubilizing dry fertilizers and mixing liquids. It is our opinion few people posses the specialized knowledge necessary to produce high quality stable fertilizers using this type of system, and its use should be avoided unless you are absolutely sure of what you are doing. Cleaning up the mess you create could be far more costly than the money saved by blending your own products.

Rinsing out your system

The single biggest problem we encounter with fertilizer systems is caused by people not rinsing out their tanks properly between the use of dissimilar products. Many fertilizer products are very incompatible with one another, and can form all kinds of interesting compounds when mixed together. Most liquids used in fertigation are many times stronger than those used in spray rigs for foliar applications. 20 gallons of product left in a 1000 gallon tank can easily

ruin 980 gallons of an incompatible product if the tank is not properly rinsed out. Tanks should be triple rinsed just like spray rigs, and if the only method of getting rid of the rinsate is to inject it, than you should expect to allow some time between the use of one product and another. Keep in mind, that in addition to ruining a tank full of product, a mixture that solidifies in your fertigation system can cause damage that costs thousands of dollars to fix.

Conclusion

This concludes my presentation. Hopefully, this has been a good starting point for all of you as you explore water treatment technology and its application as a tool in your agronomic practices. I appreciate you giving me some of your valuable time and hope this was worthwhile.

At this time, if any of you have any questions, I'll be happy to answer them.