Lightning Protection:
A Necessity—Not an Option

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Mankind cannot prevent lightning. But since the Chaldeans of Babylonia, who developed a system of weather prediction that involved counting thunder, we have tried to calculate when and where lightning would strike.

The National Weather Service records "thunderdays" based upon whether remote station weather observers actually hear thunder. However, in "The Measurement and Use of Lightning Ground Flash Density" by Leon G. Byerley III, et al, recent research indicates that, although of great historical and some meteorological significance, thunderday data is not a measure of the incidence of lightning in a given area and should not be used for lightning risk assessment.

To Everything There Is a Season

Thunderstorms, synonymous with lightning, are most prevalent during March/April through September/October for the northern part of the country. Though in the south — from Florida to Texas — the lightning season can be 12 months of the year.

The U.S. averages over 100,000 thunderstorms, producing 100 million lightning flashes each year. About 20 million flashes strike the ground.

According to the Lightning Protection Institute (LPI), most lightning strikes occur at the front edge of an approaching storm. Studies indicate that when lightning does strike, the next strike will likely occur within three miles. However, since a lightning strike can travel up to ten miles before actually hitting the ground, it is totally unpredictable. Therefore, it's extremely important to seek shelter and protect yourself from lightning as soon as you see a thunderstorm or hear thunder which can be heard at a distance of three to four miles. Remember too, it is also possible, during these storms, for lightning to strike from an overhanging cloud, even when the sky above you is still clear.

Early Warnings

Today, with advances in technology, we are able to predict the risk for lightning strikes with greater accuracy. According to Christoph Zimmermann, market manager for golf for Global Atmospherics, Inc. in Tucson, Arizona, early detection and warning sytems allow us to mitigate damage and address human safety concerns. They relay information regarding imminent thunderstorms, detect in-cloud lightning activity and cloud-to-ground discharge — where the lightning actually strikes earth. The computerized sensors are also programmable to automatically shut down the irrigation system to reduce the damage to equipment, as needed, and automatically operate audible and visual alarms, alerting people to clear the golf course. When the danger has passed, the sensors signal an all-clear.

Lightning and Links

Keeping golfers safe and greens green is no small undertaking. The latest irrigation systems are similar to a water distribution system of a small municipality. A typical golf course has a pumping station, reservoir (ponds) and miles of water mains connected to a dozen or so remote satellite controllers that direct the flow of water to hundreds of sprinkler heads throughout the course. These microprocessor remote controllers are programmed from a central computer located in the maintenance building. The entire system is interconnected to the central computer with miles of buried AC power and signal data lines. This phenomenon of modern engineering works just fine when the sun shines, but when the sky darkens the golf course superintendent breaks into a sweat with the first clap of thunder. He is well aware of the odds that the first bolt from the sky could strike the ground and travel along the underground wires and destroy a remote controller or wreck the central computer.

Liability, Litigation And the Bottom Line

In the United States, over 1,200 people are struck by lightning every year. Of those, five to ten percent are fatal. Out of these 120-150 lightning-related deaths, five to ten percent occur on golf courses.

Last year Global Atmospherics was asked by insurance companies to verify (out of 8,000 claims investigated) approximately 140 claims due to lightning on golf courses. "Forty-eight percent of the losses included the irrgiation systems: electrical controllers, satellites, valves and sprinklers. The average financial loss incurred was $4,230, ranging anywhere from a low of $1,500 to a high of $15,000. Forty-three percent of the losses were due to hits on well-pumps. Here, the average loss was $4,275. The final nine percent were due to strikes that disabled or destroyed golf carts, battery charger packs and big-screen televisions," says Zimmermann.

"The Tampa Bay area is the lightning capital of the world." says Peter Bass, CGCS, at the Tampa, Florida

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Palma Ceia Golf and CC. "And this past summer was no exception. We recorded over 50 lightning strikes within a five-mile radius, and had at least six direct hits on our property."

Chris Bower, Golf Course Superintendent, in Winter Haven, Florida, confirms Bass' "lightning capital" theory. "In the summer of 1994 we experienced many lightning strikes in our surrounding Baytree Golf Course in central Florida. On several occasions severe damage was done to our computerized irrigation system. This resulted in costly repairs and extended periods of downtime for both our computer and weather station."

In the event of a lightning strike involving the irrigation system, the down time (the time needed to resume full irrigation capabilities) usually was one to two weeks. This meant that in some areas, superintendents were unable to irrigate part or, sometimes, all of their courses during critically dry periods.

Considering the initial cost of an irrigation system is in excess of $250,000, the few thousand dollars spent for protection would be a better investment than liability insurance.

Grounding Guidelines

Even with forewarning, lightning stikes will occur on golf courses and when they do, the preferred target, according to insurers, is the irrigation system.

While no piece of equipment can survive or prevent a direct strike from lightning, the goal should be to provide as much protection as possible. Proper grounding is essential. The purpose of grounding is to break up the electrical energy of a lightning strike and provide a path to ground that is easier for the lightning to find than through the equipment.

"The average lighning strike produces 25,000 volts at 20,000 amps and can destroy *any* controller — even if it is properly grounded. Electricity always takes the path of least resistance, meaning it travels down the wiring system. High voltage or high current can enter the controller through the supply or field wires. This can either cause minor damage, or it can result in the destruction of the controller," warns John Terry, technical services manager for Rain Bird Sales in Tucson, Arizona. There is no easy way to establish a grounding regimen that will apply to every location, since requirements and conditions will vary dramatically from one area to another. However, Doug Colson, field service manager for The Toro Co., Irrigation Division in Riverside, California, provides some general guidelines.:

- The goal for ground resistance should be ten ohms or less; however, a range of 11 to 30 ohms still means there is good grounding protection. When the resistance of the soil is above 30 ohms, this indicates poor grounding. You'll need to take improvement steps.
- If ten ohms cannot be reached with one copper clad rod, two rods should be welded together using Cadweld Products to rework better soil and more consistent moisture and temperature.
- If ledge rock or rocky conditions prevent driving rods, lay the rods or No. 8 wire in a straight trench.
- A copper plate may be buried in an irrigated area near the controller location. Install the copper plate in a trench three to four feet deep. Backfill with good top solid, bentonite clay, salt (magnesium sulfate or rock salt) or use Ground Enhancement Material (GEM).
- Where several clocks are grouped, use one ground rod per controller and separate the rods by at least eight feet. *Never connect two or more controllers to one rod. The surge will run down one ground wire and back up the other into the second clock.*
- Install a drip system over the plat to keep the area moist and keep resistance low.

Many experts recommend the use of GEM over bentonite or salt. Bentonite will lower the resistance of the soil, but can only do so when the bentonite is in solution. When the bentonite loses moisture, its effectiveness is decreased. The use of a drip system can improve the effectiveness of bentonite. Salt compounds like epsom salt and rock salt leach into the soil and reduce ground resistance. However, as the salts are depleted, the soil returns to its original state. To avoid this situation, a salt grounding system must be recharged with new salt. Installation of a drip system is not necessary when GEM is used.

Problems of Placement: "The problem of adequate grounds at remote satellites on commercial landscapes built on sand or rock can be a vexing one. In sandy soils the water table may be 50 to 100 feet deep. Or, there may be so much rock or shale that pounding a ground rod more than two feet is virtually impossible. If this is the case, the only solution is to ground with horizontal grounding sheets," recommends Joe Becker, owner of D&B Sales Associates, Inc.

"If you are unable to drive an eight or ten foot rod vertically, drive the rod at an angle, or at least lay in the ground horizontally. In sandy or rocky areas where the ground resistance is high, surround the rod with GEM to lower the resistance. To get the resistance down to 15 ohms or less, you'll need to use horizontal copper plates along with GEM," says Dwayne Wells, product manager at Legacy Golf Irrigation of Fresno, California. "It's fairly expensive, but worth the price. Unlike rock salt or epsom salt, you never have to add additional GEM."

For the bare copper wire that runs from the controller to the ground rod and copper plates, Wells suggests No. 4 bare copper wire, since it has a larger diameter than No. 6 bare copper wire. The larger diameter of No. 4 wire provides a larger surface area, which reduces the friction loss and ensures the ground wire will be the path of least resistance.

The Cadweld Connection: Just about every authority on grounding recommends the use of Cadweld connections. "A Cadweld connection is exothermic welding — widely used in connecting cables, ground rods, terminals and connectors into a complete grounding system. To make these con-

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nections, the only tool needed is a flint igniter. The resulting molecular bond produces a permanent connection that will not loosen or corrode over the lifetime of the installation," says Keith Switzer, applications engineer for ERICO Products, Inc.

Switzer outlines the Cadweld process:

- The ground rod is driven into the ground with a sledge, using a driving sleeve to prevent mushrooming.
- A disposable mold is placed on the rod and the ground wire is inserted through the sleeved hole as far as it will go. The mold is then pushed down until the rod contacts the wire.
- A disk is placed in the mold and a premeasured amount of weld metal from a container is poured into the mold.
- A cover is installed on the mold and starting material, which remains on the bottom of the weld metal container and is tapped into a hole in the cover.
- The welding process is started with a flint igniter.
- After 30 seconds to one minute, the mold can be broken off the connection, or it can be left in place.

Cadweld connectors continue to be recommended more frequently over clamps. "Because of temperature changes, within six months clamps become loose. It's true the Cadweld connections may cost about $6, compated with $2 for clamps, but who wants to retighten clamps every six months?" Colson asks.

Computer Protection: Every central computer should have an independent power supply to protect itself against power sags, surges, transients, noises and power outages. Becker explains, "Most pieces of conventional electrical equipment can tolerate short-term power variances without any noticeable effects. However, some solid-state or electrical equipment like computers are more sensitive."

"For this reason, the central computer should have a dedicated power source direct from the service panel, with an uninterruptible power supply (UPS) to supply the battery backup in the event of a power failure," advises Doug Colson, field manager for The Toro co. "Some companies that sell UPS systems offer a low-cost UPS power supply, with a ten-year prorated warranty, plus $25,000 equipment damage insurance for the equipment connected to it."

A UPS unit will:

- Provide a stable, constant power supply to the computer at all times;
- Provide continuous power for 15 minutes in the event of a power loss. This would allow the operator time to close files and shut off the computer; and
- Protect the computer from power surges that may by induced on the incoming power source.

Controller Protection: Vince Nolletti, national sales manager for Paige Electric in Union, New Jersey states that, "Controller manufacturers incorporate lightning protection devices that divert the energy needs to be diverted to ground — ideally to the underground water table — in order for these protection devices to do their job."

"Irrigation manufacturers have greatly improved controller lightning and surge protection over the last few years. However, lightning protection cannot work unless the controller has been grounded, according to the manufacturer's specifications. If a high-voltage surge were to enter the controller, the surge is directed to the ground lug. As long as the ground is properly connected, the surge dissipates into the earth, causing little or no damage to the controller," says Terry.

"Lightning-simulation tests performed in the laboratory show that given a very specific strike on the same controller, repeatedly, and a various resistances-to-ground, the damage is predictable," says Nolletti. "The lower the resistance to ground, the lower the damage to equipment."

Preventative Maintenance

"One of the biggest problems is the lack of inspection of ground connections," says Colson. "Since copper is a very soft material, it is subject to coldflow, which makes for loose connections. And when connections are loose, corrosion set in." A resistance of ten ohms or less does not last forever. Soil moisture, corrosion and loose clamps are just a few things that can drastically change ground resistance.

Ground testing should be done frequently. "Many make the mistake of testing ground resistance during their slack time — when they get around to it," Colson cautions. "In many areas of the country, slack time is usually winter or fall. But spring is not usually a good time for testing either because the ground is wet. And even in summer you may get a good ground resistance reading on the fairway or in areas hit by sprinklers."

So when and where should the soil be tested? Colson advises that, though the dry time of year is the most accurate time for measuring resistance, superintendents should inspect various areas of the course and check basic continuity. "Check now, check again when it's wet, and again in late summer.

"When the contractor makes the installation of the controller and satellites, he meets the ground resistance specification. But after installation, it is the responsibility of the (property owner/superintendent) to have a maintenance program of the grounding system," says Colson. "If you have a good ground, it will contain the lightning to one location."

The Toro Co. recommends the following annual preventive maintenance program for all grounding systems prior to the lightning season:

- The connection to the controller must be tight and free of corrosion.
- The ground wire should have no sharp bends.
- The clamp connection on the rod must be tight and free of corrosion.
- Have the resistance checked annually. The most effective time to test resistance is during a dry spell prior to the lightning season. The lightning season is when we need the best possible surge protection and grounding system.
- Check with your local distributor regarding resistance testing service.

There are several ground-resistance testers on the market. One product

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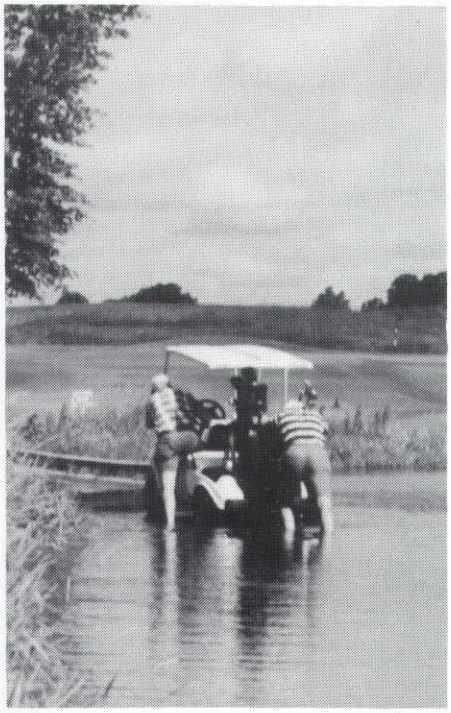
that comes highly recommended is manufactured by AEMC Instruments. AEMC manufactures a clamp-on ground resistance tester that is quick and easy to use without the need for auxiliary ground rods. Its list price is $1,895. However, unless you do much ground testing, it may be more cost-effective to hire a testing service.

Lightning is a threat to man and machine. It can cause inordinate damage and create chaos, but its destructive capabilities can be minimized. The key to managing the risks lies in an awareness of danger, protection through early warning, proper installation of equipment, assurance that strict grounding practices are adhered to and preventive maintenance.



HEAVY RAINS in the days preceding the Scholarship Scramble at Hidden Creek Golf Club made a normally small creek overflow onto the golf course. Electric carts could make it through the water but gas carts needed some help.