Weathering the Storm

The more you know about lightning, the better you can protect your staff and guests from its dangers

BY ALISON OSINSKI, PH.D.
Special to Aquatics International

Summer brings warm weather and large crowds to your pool. But summer also brings the thunderstorm season. And where there's thunder, there's lightning.

According to the National Severe Storms Laboratory, lightning is the second most frequent weather-related killer in the United States, with nearly 100 deaths and 500 injuries each year (floods and flash floods are No. 1). Lightning doesn't receive as much media attention as other severe weather hazards because deaths usually occur one at a time.

By becoming more informed about the facts of lightning and its harmful potential, you can establish a lightning safety policy that will protect your staff and patrons and protect your facility from damage.

Detection

The difference in reacting to a thunderstorm versus reacting to other emergencies is that with a thunderstorm, you have advanced warning. And the more advanced notice the better.

You can receive advanced warning of approaching storms by listening to an NOAA weather radio or by tuning a VHF radio to an NOAA weather station. Extensive static on the AM radio band also indicates an approaching storm.

Electromagnetic sensors and intracloud lightning detectors will help provide accurate predictions, and will let you know when it's safe to reopen the pool.

Photo illustration by Henry Olivas

John Caloggero, principle electrical specialist for the National Fire Protection Association, recommends that all pools purchase and install lightning detectors to measure electrical field intensity. Caloggero claims that if you wait until you hear thunder to determine the distance to a storm, the storm is already too close and poses a danger to patrons. Some state codes require lightning detectors at pool facilities.

Lightning detectors can detect intracloud lightning up to a half-hour before cloud-to-ground lightning is visible (see "Lightning Terminology" below). Detectors can help identify a severe weather situation before it arrives, and can help determine when the thunderstorms have left the area.

Most lightning detectors have an audible sound to alert you of an impending storm. Detectors work by sensing subtle, rapid changes in light intensity. The detectors come in directional and omni-directional models, costing between $200 and $900.

When you know a storm is in the area, you can employ the "flash-bang" method to estimate the distance to an electrical storm. When you see the lightning flash, count the seconds until you hear the thunder clap. Dividing the number of seconds by five will give you the approximate number of miles to the lightning. The flash and the thunderclap actually occur at the same time, but light travels at 186,000 miles per second and sound travels at about one-fifth of a mile per second.

Lightning Terminology

Thunder

Thunder is caused by the rapid heating and cooling of air near lightning. When air reaches 15,000 degrees F. to 60,000 degrees F., it expands and explodes. The resulting shock waves, then sound waves, are called thunder.

When a lightning strike is close, thunder sounds like a long crack, bang or snap. When the lightning strikes far away, thunder sounds like a long rumble because the sound arrives at different times due to the length of the bolt. We can usually hear thunder up to 10 miles away.

Thunderstorms

Thunderstorms form through a combination of moisture and rapidly rising warm air. Because they require warm air, thunderstorms usually occur in the summer months. The convergence of warm and cold fronts and the presence of mountains and sea breezes can all force warm air to rise.

Thunderstorms can form singly or as part of a squall line of an advancing cold front. They are characterized by dark, towering, threatening-looking clouds, and all contain lightning.

Thunderstorm watches and warnings

When meteorologists determine that weather conditions are conducive to the development of severe thunderstorms in an area, they broadcast a "thunderstorm watch." A severe thunderstorm has winds of 58 mph or more and hail 3/4 inch in diameter. Meteorologists broadcast a "severe thunderstorm warning" when severe thunderstorms have been observed and are imminent or are occurring in the immediate area.

Lightning

Lightning is the electrical discharge that results from a buildup of negative and positive charges in a thunderstorm. The different types of lightning include in-cloud, cloud-to-air and cloud-to-cloud lightning, which are cloud discharges with no channel to the ground. The more familiar cloud-to-ground lightning is caused when a negative charge at the base of a cloud is attracted to a positive charge at the surface of the earth. A surge of electrical current consisting of millions of electrons descends to the ground, and the return stroke appears as a bright flash of cloud-to-ground lightning.

Lightning formation

Positively charged ice crystals form at the top of clouds while negatively charged raindrops form at the bottom of clouds. The ground below the cloud becomes positively charged.

Charges become separated in a cloud through updrafts — the stronger the updrafts, the greater the electrical potential. Lightning occurs when the attraction between opposite charges becomes strong enough to overcome the air's resistance to electrical flow. This entire process lasts less than a second.

A lightning stroke originates from negatively charged step leaders at the base of the cloud, which surge horizontally and vertically. When close to the ground, a step leader pulls up a positively charged streamer from a tall object in the area. The visible lightning bolt is the positively charged return stroke travelling upward at approximately 60,000 mph. Lightning may appear to flicker because the process repeats itself along the same path many times in a fraction of a second.

Types of contact

Most people imagine lightning striking as a direct hit, but other forms of contact are more common. A flashover can occur when the current flashes over the outside of the body. A side flash hits a primary conductor, then a portion of the current travels through the air and strikes another person or object. A ground current — when lightning strikes the ground close to a group of people — is the most common type of lightning contact, usually resulting in multiple victims.

– A.O.

Pool lightning policy

All pool facilities, both indoor and outdoor, should have a pool-closure policy for lightning and severe weather situations. You should plan and rehearse evacuation procedures as you would for other emergencies.

When the intensity increases on your lightning detector, it's time to act.

Electricity seeks the path of least resistance, and water is an excellent conductor. Pools are connected to a larger surface area via underground water pipes, gas lines, and electrical and telephone wiring. Lightning striking the ground anywhere on this metallic network may induce shocks in other areas.

Caloggero recommends clearing the water of all swimmers when a thunderstorm approaches; again, this applies to both indoor and outdoor pools. When evacuating the pool, avoid locations that are hazardous during a thunderstorm, such as picnic areas, playgrounds, golf courses, small boats and seashores.

If intensity on the detector decreases, the storm is moving out of the area and it may be safe to re-enter the pool. Remember though, that lightning can be unpredictable, and it's best to err on the side of caution.

Lightning safety rules

Lightning can be random and unpredictable — take a conservative approach. Preparedness and quick responses are the best defenses against a lightning hazard.

continued on page 37

Some quick facts

On average, 600 lightning bolts strike Earth every second, or 8.8 million times per day. Sparks can reach more than 5 miles in length and can attain temperatures in excess of 50,000 degrees F. A typical lightning bolt contains 1 billion volts and between 10,000 and 200,000 amps of current. A lightning flash could light a 100-watt light bulb burning continuously for three months.

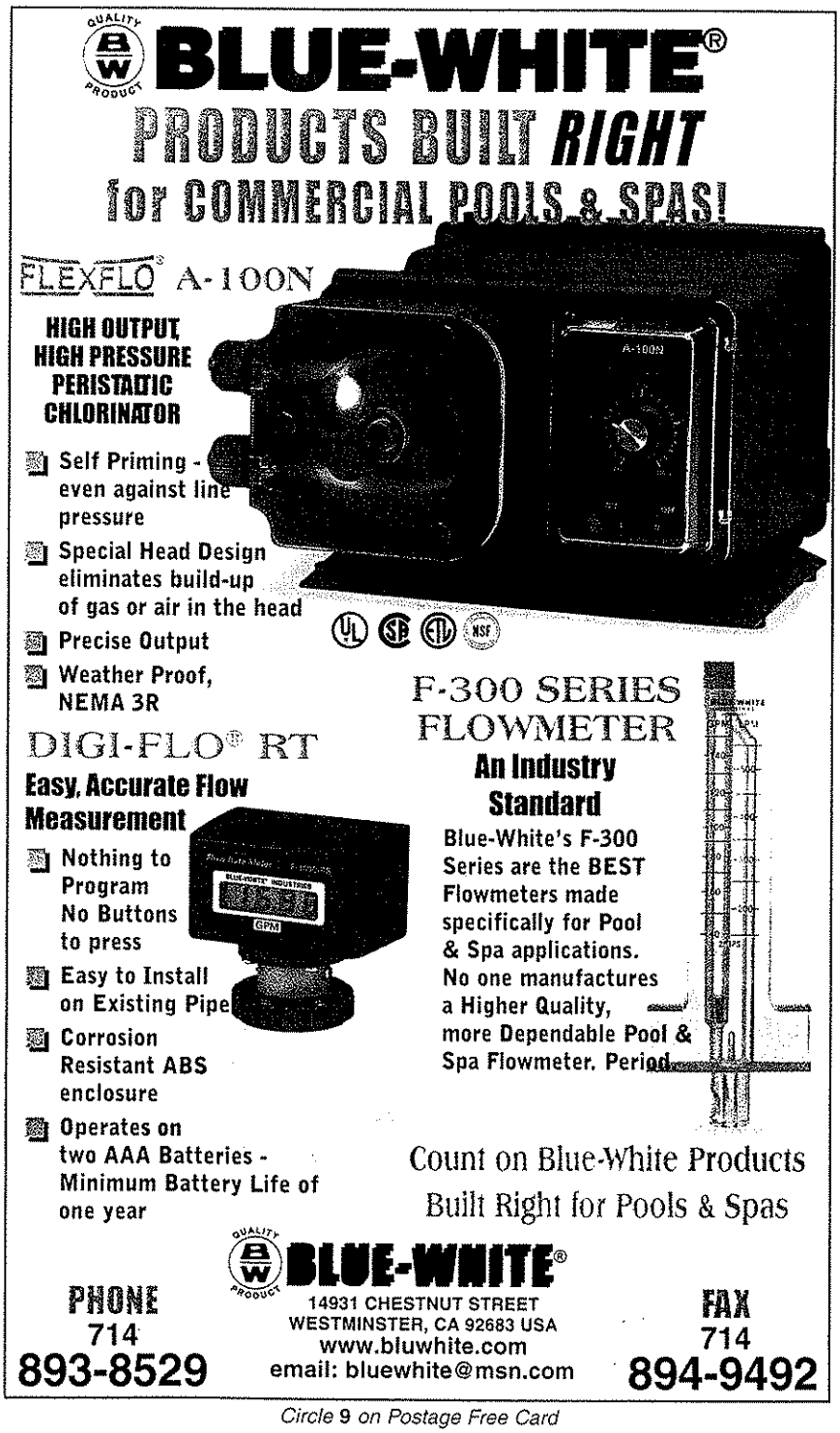
Lightning is most likely to occur in the Southern and Central states, and least likely on the West Coast. Florida has the highest number of lightning strikes; lightning kills more people in Florida than any other meteorological phenomena combined.

Of the approximately 100 people in the United States killed each year from lightning, perhaps five times as many are struck, but not killed. More likely effects are loss of consciousness, amnesia, paralysis, burns, and damage to the heart, lung and brain.

The chances of being struck by lightning are 1 in 600,000, and most lightning victims are on or near the water. Eighty percent of lightning victims are male, and 80 percent of fatalities occur between 10 a.m. and 7 p.m. Most victims die from respiratory failure.

Lightning also causes damage to the natural and built environment in the form of split trees, fires, electrical failures and damaged electrical equipment through power surges. Productivity is affected through forced work stoppages.

– A.O.



Circle 9 on Postage Free Card

Lightning detection companies

Thor Guard offers integrated lightning prediction and warning systems that use a sophisticated sensor and computer to measure and analyze the electrostatic field in the atmosphere. Contact Thor Guard, P.O. Box 451987, Sunrise, FL 33345-1987, (954) 835-0900, fax (954) 835-0808, *sales@thorguard.com, www.thorguard.com*

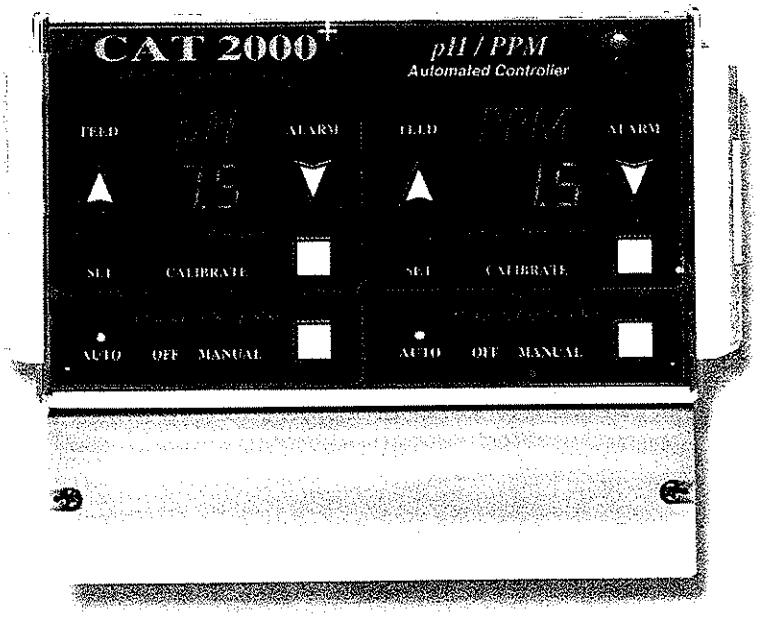
National Lightning Protection Corporation manufactures and supplies lightning protection, transient voltage surge suppression, and grounding equipment for commercial, industrial and military applications. Contact NLP, 4120 Brighton Blvd., Unit A-37, Denver, CO 80216-3729, (800) 628-2816, *feedback@safetypoint.com, www.safetypoint.com.*

To learn more

Here are some Web sites that provide information on lightning:

- The Federal Emergency Management Agency's Web site, *www.fema.gov/library/thunder*, provides lightning facts, statistics and advice on how to prepare your community in the event of an emergency.
- The National Lightning Safety Institute'sWebsite, *www.lightningsafety.com*, provides lightning statistics and safety information for individuals and facilities.
- NASA's Global Hydrology and Climate Center Lightning Team investigates the causes and effects of lightning and analyzes a variety of atmospheric measurements related to thunderstorms. The team's Web site is *http://thunder.msfc.nasa.gov.*
- The U.S. Dept of Commerce's National Severe Storms Laboratory develops educational resources to inform the public of lightning hazards and improved planning for lightning avoidance. The Laboratory's Web site can be found at *www.nssl.noaa.gov/researchitems/lightning.shtml.*
- The National Atmospheric and Oceanic Administration's Storm Prediction Center monitors and forecasts hazardous weather phenomena across the United States. The Center's Web site can be found at *www.spc.noaa.gov.*
- The Lightning Safety Web site, *www.pafb.af.mil/45OG/45ws/LightningSafety/index.htm*, offers a quick reference section, a downloadable lightning safety briefing, lightning trivia and a links page.
- The National Weather Service is the official voice of the United States for issuing warnings during life-threatening weather situations. Point your browser to *www.nws.noaa.gov.*

Water Quality Control



The All New CAT 2000 PLUS PROGRAMMABLE CONTROLLER

Let's face it. You used to have to pay a lot of money for a chemical controller that you could rely on. Affordable equipment meant sacrificing dependability or settling for a product that looks more like a science project than a serious piece of commercial pool equipment.

Chemical Automation Technologies changed all of that five years ago with the microprocessor-based power of the CAT 2000 automated water chemistry controller. Now the all new CAT 2000 PLUS offers a host of advanced programmable features while maintaining the reliability, performance and ease of operation that you can expect from a CAT Controller.

Chemical Automation Technologies, Inc.
18568 Office Park Drive Gaithersburg, MD 20879 USA
Toll Free: 800-657-CATS International: 301-990-8825
Internet: www.chemauto.com E-Mail: info@chemauto.com

Circle **13** *on Postage Free Card*

continued from page 35

Here are some common-sense lightning safety rules:

- Evacuate both indoor and outdoor pools.
- Seek shelter in a safe, enclosed building — avoid temporary structures or small huts — or an all-metal vehicle such as a car or truck. When evacuating to a vehicle, keep the windows rolled up tight.
- Keep a safe distance from open doors and windows (windows can shatter in a storm).
- Keep a safe distance from metal pipes, sinks, showers and tubs.
- Don't use plug-in electrical equipment.
- Don't handle open containers of flammable materials (pool chemicals).
- Don't hold metal objects such as vacuum poles, extension poles, shepherd's crooks, golf clubs or fishing rods, all of which can act as lightning rods.
- Avoid wet ground — wet soil conducts better than dry soil.
- Avoid elevated areas and open spaces.

Prevention and response

You can install lightning rods and lightning conductors to help prevent damage to equipment and facilities. On tall buildings, positive charges at the tip of lightning conductors create positive ions, which flow up to reduce the negative charge at the base of the thundercloud. Negative charges in the cloud are attracted downward, and the lightning will follow the ion path and hit the conductor. The electrical current would then flow down the conductor cable and enter the ground.

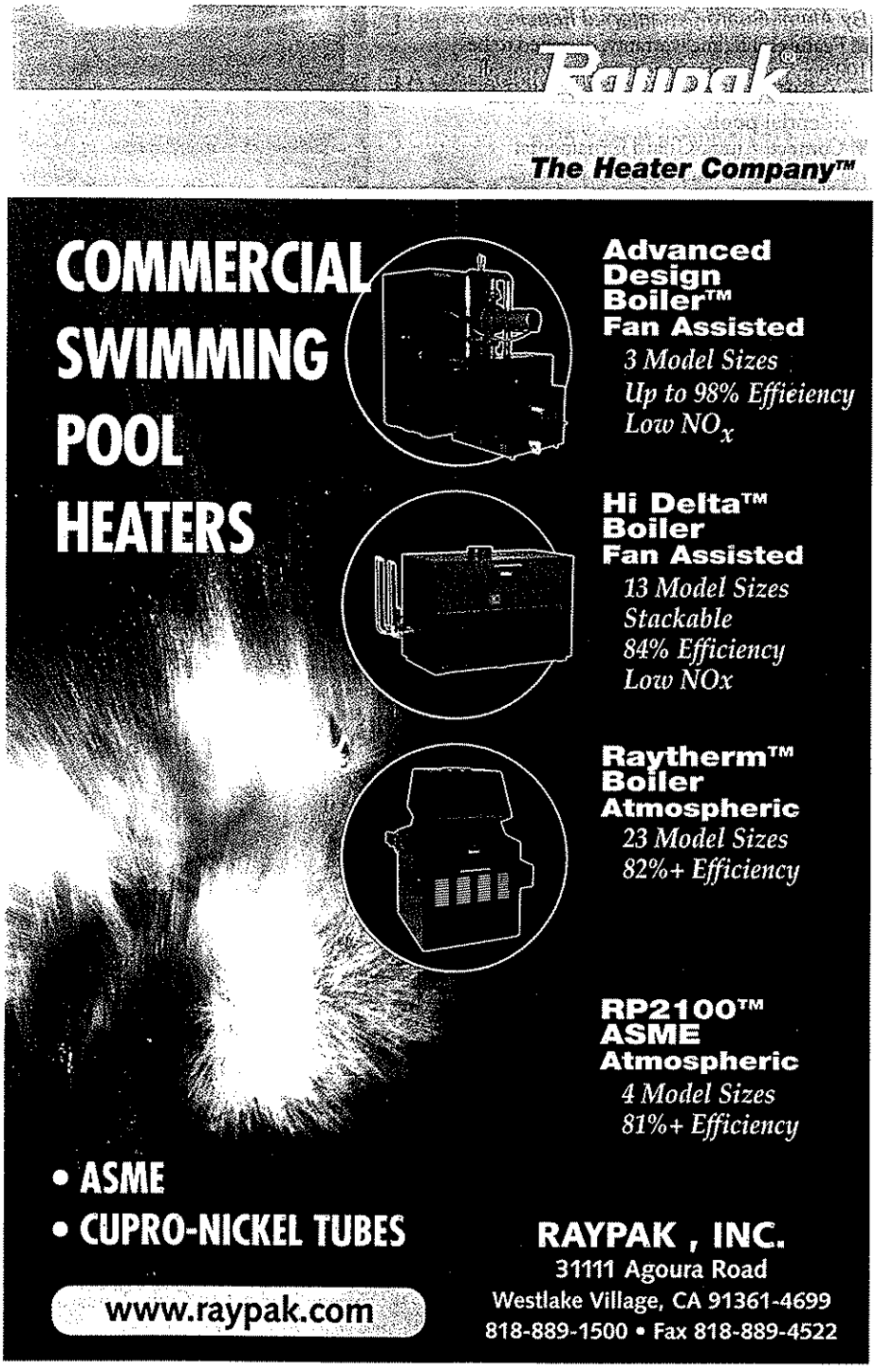
You would know when you're about to be struck because you'd feel the electrical charge. Your hair would stand on end and your skin would tingle as electrical charges travel up your body from the ground toward an electrically charged cloud.

If a strike is imminent, you should immediately drop to the ground. Don't lay flat on the ground, however; instead, squat down low, place your hands on your knees, tuck your head and balance on the balls of your feet.

A person or object struck by lightning does not carry a charge: There is no danger of shock to a person who provides first aid. Call 911 for medical assistance, then check for and establish an airway. Check breathing and pulse, and provide rescue breathing or CPR if necessary. Check for and treat severe burns. Burns are likely to be found in two places on a body — where the lightning entered the body and where it exited.

Alison Osinski, Ph.D., is principal-owner of Aquatic Consulting Services of San Diego. Osinski can be reached at alisonh2o@aol.com.

This article was adapted from a seminar Osinski presented at the 1997 U.S. Water Fitness Association's National Aquatic Conference. She obtained much of the information for the seminar from FEMA, NASA, the National Lightning Safety Institute, the University of Nebraska at Lincoln and the Weather Channel.



Circle 47 on Postage Free Card

POINT: Clear the Pool — Now

by Richard Kithil and Kevin Johnston
Special to Aquatics International

Lightning behavior is arbitrary, capricious and random. A first flash to earth can travel tens of miles from a distant cloud to a grounded object. Statistically, more lightning originates from the back edge of a thundercloud than from the front side, making decisions regarding the resumption of recreation activity difficult.

Risk management of the lightning hazard necessarily calls for a cautious and conservative approach. Safety at indoor structures is paramount, as recent national codes and standards illustrate. They recommend guidelines for decision-making to maximize lightning safety for indoor pools. And they recommend getting out of the water immediately.

Approximately 22 million cloud-to-ground lightning flashes occur annually nationwide. Lightning travels at about 1,000 feet in a millionth of a second. A typical flash is as thick as one's thumb. Lightning's currents average about 25,000 amps, with voltages in the hundreds of millions. Lightning follows Benjamin Franklin's maxim of *Path of Least Resistance* through the air and along, or through, the ground.

According to insurance information, the ratio of damage due to indirect effects vs. direct effects is some 2,000:1. This means that if lightning strikes the ground near an indoor pool, depending upon localized circumstances, it may be conducted into the building via low resistance conductors. These can be:

- Buried or pole-mounted telephone and electric wires
- Buried metal water lines or gas lines
- Metal light masts in parking lots with AC power fed from the building
- Fences that are contiguous to the building
- Cable TV lines, both aerial and buried
- Root systems of nearby trees
- Wet ground and wet paved parking lots (from rain) adjacent to buildings

Observable lightning effects inside pool buildings have included a main circulation pump destroyed, injuries to employees touching electrical panels, concrete footing of a poolside slide being blown apart and visible lightning inside a natatorium.

We know of no databases recording deaths to persons in indoor pools. Lightning studies from the National Oceanic & Atmospheric Administration (NOAA) over a 35-year period are not detailed and show only generalized activities or locations of lightning victims, as follows:

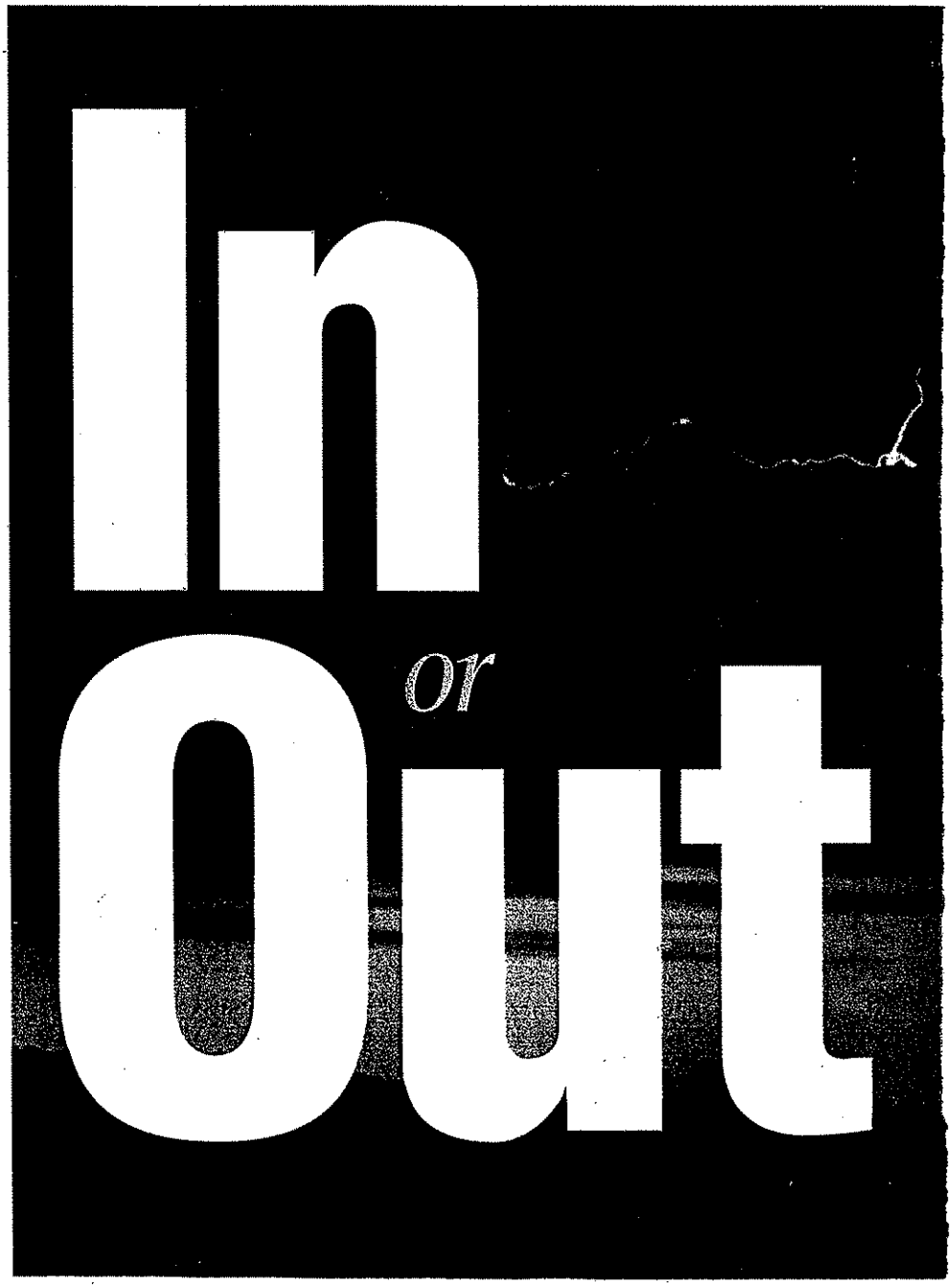
- Open fields/ballparks = 26.8%
- Under trees = 13.7%
- Water-related (fishing/boating/swimming) = 8.1%
- Golfing = 3.9%
- Driving machinery = 3.0%
- Telephone-related = 2.4%
- Radios/antennas = 0.7%
- All others/unknown categories = 40.4%

However, lightning incidents involving persons in non-pool buildings, such as houses, apartments, offices, small shelters and the like, are well-characterized with examples in the thousands. Such incidents describe lightning injury to people indoors on telephones, in contact with domestic water (sinks, tubs, showers, etc.) and touching metal doors, windows and other outside-to-inside conductors.

An Internet search of "indoor pools and lightning" will display more than 2,700 citations. Many of them describe pool safety procedures when under lightning threat. Six states have recommendations or regulations for suspending indoor pool activities when under lightning threat: Delaware, Maryland, Michigan, North Dakota, Rhode Island and South Dakota.

Delaware's state code reads that "during electrical storms, the use of a pool (indoor or outdoor) shall be prohibited." Several large national groups describe building interior pool

Continued on page 34 ▶



POINT continued from page 32

hazards (among them the National Collegiate Athletic Association) or have recommended indoor pool activity suspension (including the National Athletic Trainers Association, USA Swimming, the YMCA and the American College of Emergency Physicians) when thunderstorms threaten nearby.

All pool buildings should be equipped with lightning protection, as specified in the most recent version of the National Fire Protection Association's *NFPA-780 Standard for the Installation of Lightning Protection Systems.* Special attention should be paid to surge protection and bonding issues. A comprehensive inspection should be conducted by a qualified electrician every five years.

It is imperative to recognize the threat. Besides what you can actually experience (that is, seeing lightning and/or hearing associated thunder), we suggest detection methods such as the Weather Channel, an inexpensive weather radio or subscription services such as *www.lightningstorm.com*.

We do not recommend expensive dedicated lightning detectors. (See the National Lightning Safety Institute's Web site for more details on lightning detection. Go to: *www.lightningsafety.com/nlsi_lhm/overview2002.html*)

Identify in advance safe and unsafe places. *Safe:* dry areas inside large, permanent buildings. *Unsafe:* near electrical conductors, electrical equipment, metal objects (lifeguard stands, ladders, diving board stanchions) and water, including showers.

When lightning is within six to eight miles, evacuate people to safe areas. Lifeguards should secure the entrance to the pool deck. When should activities be resumed? Wait 30 minutes after the last observed lightning or thunder because lightning may visit from the back end of the passing thunderstorm.

There is a built-in conflict between indoor pool activities and lightning safety. Both recreational swimming and competitive swimming events are based upon the three icons of entertainment, health and pleasure. Lightning safety is founded on stopping all those forms of enjoyment. A risk-management/safety professional will err on the side of caution every time and will be found harmless from allegations or claims of negligence.

Such a conservative approach will find many objectors. Safety, however, is the prevailing directive.

For additional online reading, visit:

- *NATA: www.nata.org/publications/otherpub/lightning.pdf*
- NCAA: *www.ncaa.org/library/sports_sciences/sports_med_handbook/2002-03/1d.pdf*
- ACEP: *www.acep/1,5223,0.html*
- USA Swimming: *www.usa-swimming.org/coaches/sq_lightning.htm*
- *YMCA: www.yservicescorp.com/Docs/Guidelines/LightningPoolGuide.doc*

References

Waters, W.E., 1983: *Electrical Induction From Distant Current Sources*, Prentice Hall, Englewood Cliffs, N.J.

Caixeta, G.P., and Pissolato, Fihlo, J., 1998: *Electromagnetic Field Induced in the Interior of a Building by Lightning*, Proceedings Intl. Conference on Lightning Protection, Birmingham U.K.

Uman, M.A., et al, 2002: "Correlated time derivatives of current, electric field intensity, and magnetic flux density for triggered lightning at 15 m," *Jrnl. Geophysical Res.*, Vol 107, No. D13.

Richard Kithil is president of the National Lightning Safety Institute. He may be reached at rkithil@lightningsafety.com. Kevin Johnston is senior consultant of Professional Aquatics Consultants International.

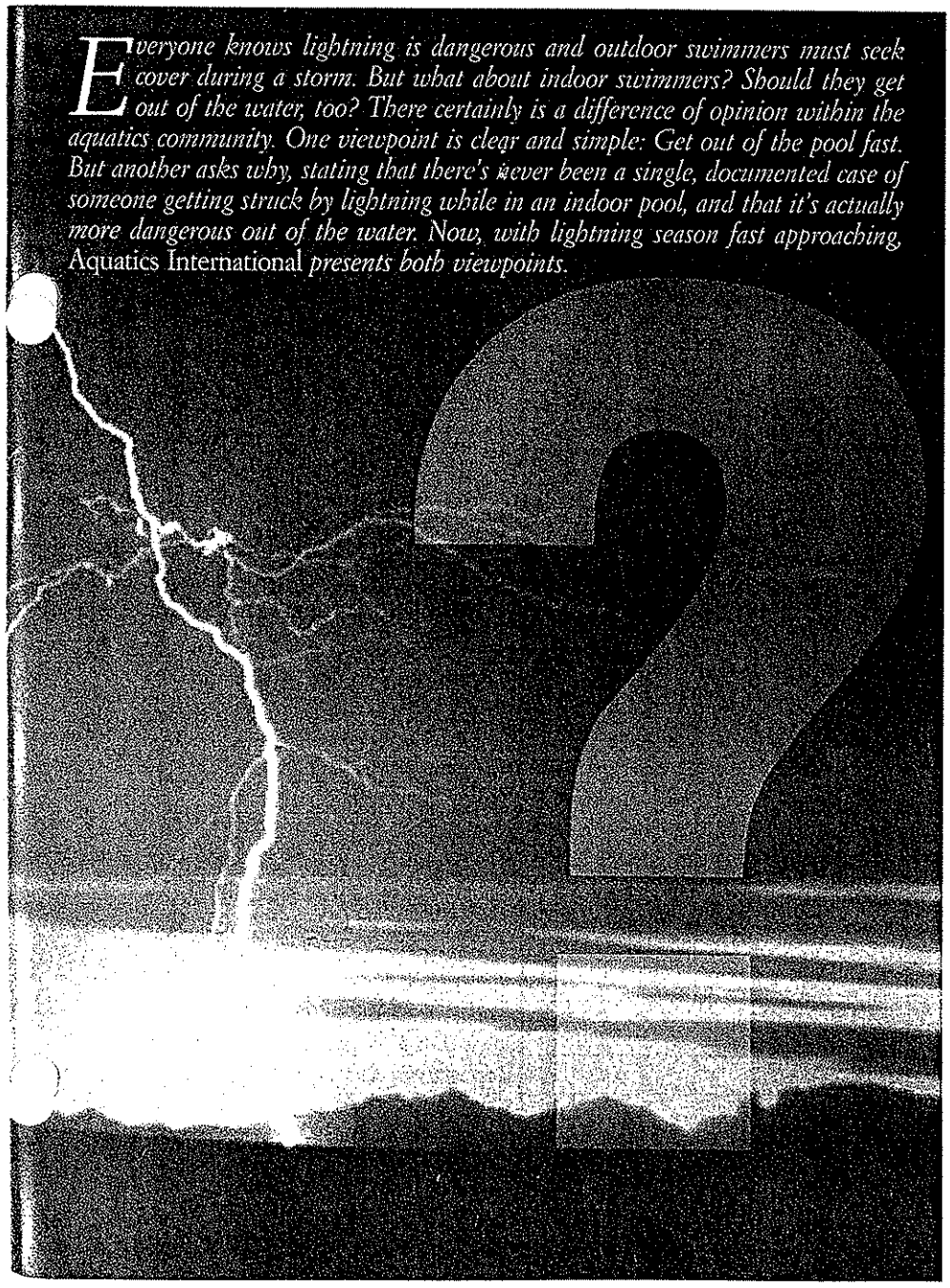
Circle 22 on Postage-Free Card

COUNTERPOINT: It's Safer in the Water

by Tom Griffiths, Ed.D., with Richard S. Harris, P.E., and Walter J. Griffiths, M.D.

Special to Aquatics International

Everyone knows lightning is dangerous and outdoor swimmers must seek cover during a storm. But what about indoor swimmers? Should they get out of the water, too? There certainly is a difference of opinion within the aquatics community. One viewpoint is clear and simple: Get out of the pool fast. But another asks why, stating that there's never been a single, documented case of someone getting struck by lightning while in an indoor pool, and that it's actually more dangerous out of the water. Now, with lightning season fast approaching, Aquatics International *presents both viewpoints.*



Because I oversee four indoor pools at a major university and also serve as the safety officer for intercollegiate athletics at Penn State University, I thought it would be prudent for me to closely examine the discussion and rationale for closing indoor pools during lightning storms, and to consult with close colleagues, including an electrical engineer. We're limiting the discussion to indoor pools totally enclosed in structural steel buildings and not pools under fabricated domes or pools mostly glass-enclosed.

During this era of high-tech data collection, we find it odd that there are absolutely no statistics for catastrophic strikes to swimmers in indoor pools. We believe the reason for this is that there are none. This is because the shielding effect provided by the structure and its frame protects people in the water and the building.

Consider that in the past 50 years or so, we have exposed perhaps millions and millions of indoor swimmers to lightning strikes. Indoor pool structures provide a frame along with the roof that intercepts lightning strikes and directs the current to the foundation around the building. As long as there is no current path through the person in the pool, there is no shock.

In addition, the grounding and bonding required by the National Electric Code and other building codes, although intended to protect against electric shocks from ordinary electrical systems and appliances, pretty much ensures that differences in potential do not occur across the pool even when lightning does strike. These inspections must take place every three years. In rare instances, some indoor facilities, particularly older ones, may have grounding problems due to corrosion and leaks. So, when in doubt, retest the pool grounding.

While we are unable to document catastrophic lightning strikes to swimmers in indoor pools, by comparison, we do have information concerning lightning strikes to humans elsewhere. A summary of estimates for annual electrocutions of Americans in numerous locations and activities are shown below, as reported by the associations. Note that while the variance is large, even the greatest estimate of fatal strikes is small indeed.

- *National Oceanic & Atmospheric Administration* . . .106
- *National Safety Council* 100
- *National Center for Health Statistics* 80
- *National Climate Data* 41

More importantly, the National Lightning Safety Institute, which posts 35 years of lighting deaths and injuries on its Web site, states that it knows of NO lightning fatalities at indoor pools. By comparison, approximately 5,000 people drown each year and another 800 catastrophically break their necks while swimming and diving, with a large percentage occurring in year-round, indoor pools.

While the lightning experts claim lightning strikes near an indoor pool building may follow electrical and water lines back to the pool, there are no published findings or reports to substantiate this hypothesis. Keep in mind that these same individuals can tell you how often lightning strikes people doing other things.

Critics suggest that closing pools is the right thing to do when guests are faced with even the slightest risk. Sorry, but that is just plain silly and irresponsible.

Driving automobiles is risky, too, but we all do it because we try to manage the

Continued on page 35 ▶

COUNTERPOINT continued from page 33

risks associated with driving as best we can. Speaking of automobiles, we find it ironic that lightning experts who urge us to close our pools during electrical storms also recommend hiding in our automobiles surrounded by glass, metal and water. It's not bad advice, however, because the car acts like a metal cage around the person. As long as the person in the car does not touch the external metal shell of the car, he probably won't get shocked. In fact, if you read enough on "weather safety," they will tell you to keep windows closed and to stay away from leaning on the side of the vehicle.

It is our belief that an indoor pool with steel beams shunt the electric current around the swimmers in the same fashion people in cars are protected.

Many aquatics administrators agree that sudden changes in schedules and programs often lead to a lack of group control, which, in turn, can cause accidents. Clearing an indoor pool during an electrical storm moves our patrons from safe, guarded and grounded environs of the pool and places them in danger on phones, in showers and in cars on rain-soaked roads. When it comes to controlling and channeling swimmers into a safe portion of the building during a severe storm, that's easier said than done.

Accidents will continue to happen at indoor pools in spite of our best efforts, but again we must balance benefits vs. risks. People have yet to be killed by lightning in an indoor pool and while there are no guarantees that this will never occur in the future, the relative risk appears to be minimal at best.

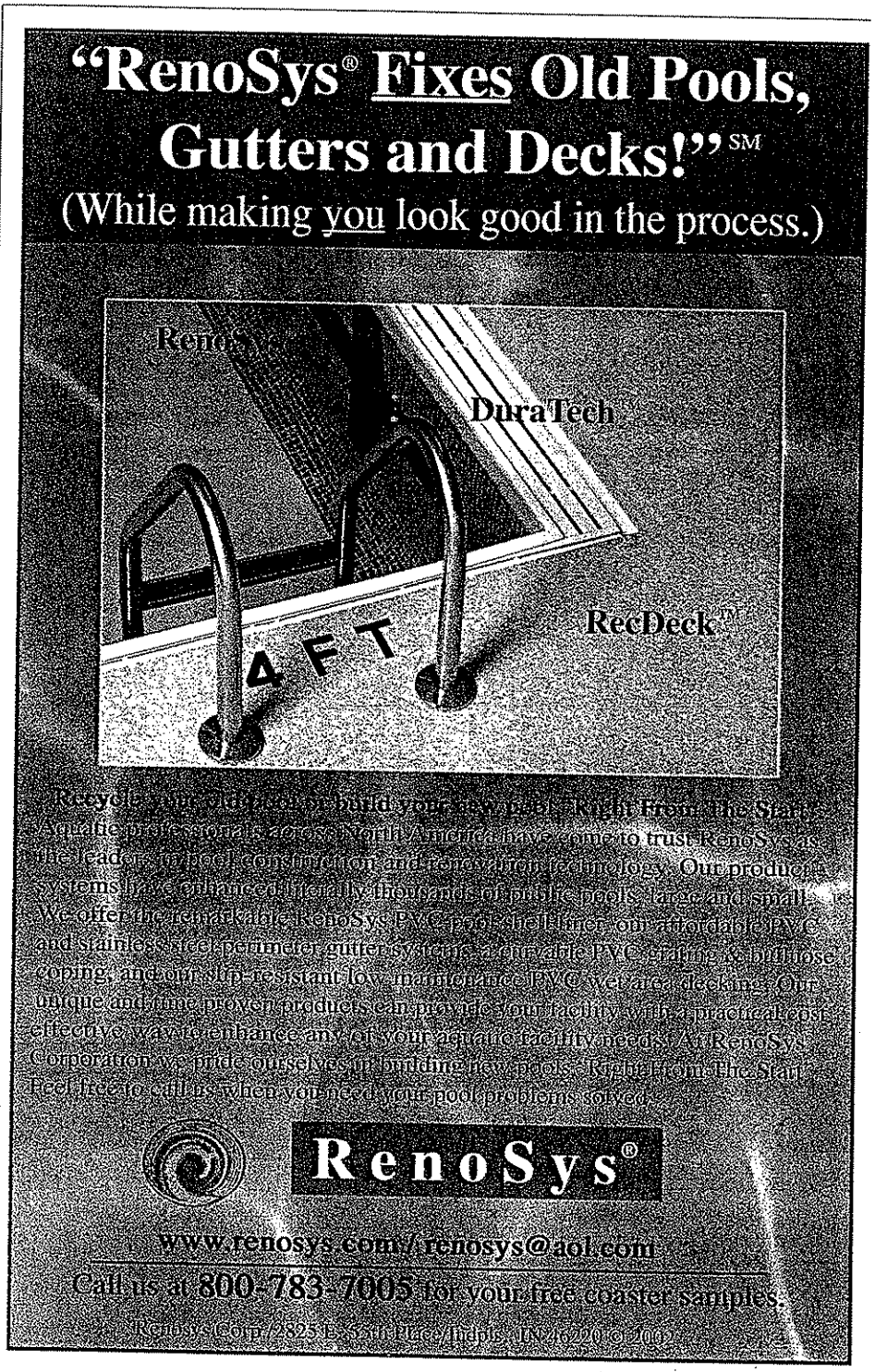
We do offer a compromise position, however. If concerned about lightning affecting your patrons, perhaps the most prudent compromise in this debate is to make the following announcement when a storm is imminent:

"An electrical storm is fast approaching. If you fear for your safety, please exit the water immediately and sit in the bleachers. DO NOT shower or talk on the phone."

Having said this, why are so many individuals and agencies, such as the National Collegiate Athletic Association, following the recommendations of the lightning experts and closing indoor pools during storms? As aquatics experts, not electrical engineers, we all tend to concentrate on the soft sciences of dealing with people rather than the hard sciences. As a result, we defer these decisions to more knowledgeable authorities. The lightning experts, who are as passionate about their vocation as we are about ours, want to enlighten us with all the remote possibilities in their field, including the improbable. When it comes to safety, few wish to question experts even when their suggestions lack common sense.

Fear is also a big factor. When they're scared, people often react emotionally rather than rationally. In this case, we truly believe too many are jousting at windmills. ← AI

Tom Griffiths, Ed.D., is director of aquatics & safety at Pennsylvania State University in University Park, Pa.. He may be reached at 814.863.4000 or tjg4@psu.edu. Richard S. Harris, Professional Engineer (P.E.), is Penn State's utility systems engineer, primarily responsible for electrical power distribution. Walter J. Griffiths is a family physician in Bellows Falls, Vt.



Circle 72 on Postage-Free Card

Teach this safety slogan: "If you can see it - flee it; if you can hear it - clear it."

Section 4.7.1:

LIGHTNING AND AQUATICS SAFETY: A CAUTIONARY PERSPECTIVE FOR INDOOR POOLS

by Richard Kithil (President, National Lightning Safety Institute) and Kevin Johnston (Senior Consultant, Professional Aquatics Consultants International)

1. **Abstract**. Lightning behavior is arbitrary, capricious and random. A first flash to earth can travel tens of miles from a distant cloud to a grounded object. Statistically, more lightning originates from the back edge of a thundercloud than from the front side, making recreation activity resumption decisions difficult. Risk management of the lightning hazard necessarily calls for a cautious and conservative approach. This paper describes lightning pathways to interior structures and provides references to recent national codes and standards. It recommends guidelines for decision-making in order to maximize lightning safety for indoor pools.

2. **Physics of Lightning.** There are some 22 million cloud-to-ground lightning flashes in the USA annually. A helpful lightning flash density map can be seen at **www.lightningsafety.com/nlsi_info/lightningmaps/US_FDightning.html** Lightning travels at about 1000 feet in a millionth of a second. A typical flash is as thick as one's thumb. Lightning's currents average about 25,000 amps with voltages in the hundreds of millions. Lightning follows Benjamin Franklin's maxim of Path of Least Resistance through the air and along or through the ground. According to insurance information, the ratio of damage due to indirect effects vs. direct effects is a ratio of some 2000:1. This means that if lightning strikes the ground near to an indoor pool, depending upon localized circumstances, it may be conducted into the building via low resistance conductors. These can be:

- Buried or Pole-Mounted Telephone and Electric Wires
- Buried Metal Water Lines or Gas Lines
- Metal Light Masts in Parking Lots with AC Power Fed from the Building
- Fences which are Contiguous to the Building
- Cable TV Lines, both Aerial and Buried
- Root Systems of Nearby Trees
- Wet Ground and Wet Paved Parking Lots (from rain) Adjacent to Buildings

3. **Statistics**. Observable lightning effects inside pool buildings have included: main circulation pump destroyed; injuries to employees touching electrical panels; concrete footing of slide blown apart; and visible lightning inside natatorium. The authors know of no databases recording deaths to persons in indoor pools. Lightning studies from NOAA over a 35-year period are not detailed and show only generalized activities or locations of lightning victims as below:

- Under Trees = 13.7%
- Water related (fishing/boating/swimming) = 8.1%
- Golfing = 3.9%

- Driving machinery = 3.0%
- Telephone-related = 2.4%
- Open fields/ballparks = 26.8%
- Radios/antennas = 0.7%
- All others/unknown categories = 40.4%

However, lightning incidents to persons in non-pool buildings such as houses, apartments, office buildings, small shelters, etc. are well characterized with examples in the thousands. Such incidents describe lightning insults to people indoors on telephones, in contact with domestic water (sinks, tubs, showers, etc.) and touching metal doors, windows and other outside-to-inside conductors.

4. **Codes and Standards.** An internet search in "Google" under "indoor pools and lightning" will display more than 2,700 citations. Many of them describe swimming pool safety procedures when under lightning threat. Six states have recommendations or regulations for suspending indoor pool activities when under lightning threat: Delaware; North Dakota; South Dakota; Maryland; Rhode Island; and Michigan. Delaware's state code reads "during electrical storms the use of a pool (indoor or outdoor) shall be prohibited." Several large national groups describe building interior pool hazards (*) or have recommended indoor pool activity suspension (**) when nearby thunderstorms threaten. See:

- National Athletic Trainers Assn.** (NATA)
  www.nata.org/publications/otherpub/lightning.pdf
- National Collegiate Athletic Assn.* (NCAA)
  www.ncaa.org/library/sports_sciences/sports_med_handbook/2002-03/1d.pdf
- American College of Emergency Physicians ** (ACEP)
  www.acep/1,5223,0.html
- US Swimming, Inc. **
  www.usa-swimming.org/coaches/sq_lightning.htm
- YMCA Services Corporation**
  www.yservicescorp.com/Docs/Guidelines/LightningPoolGuide.doc

All pool buildings should be equipped with lightning protection as specified in the most recent version of National Fire Protection Association NFPA-780 Standard for the Installation of Lightning Protection Systems. Special attention should be paid to surge protection and bonding issues. A comprehensive inspection should be conducted by a qualified electrician every five years.

5. **Recommendations for Lightning Safety at Indoor Pools.**

5.1 Recognize the threat. We suggest detection methods such as: the TV Weather Channel; an inexpensive weather radio; seeing lightning and/or hearing associated thunder; or subscription services such as www.lightningstorm.com We do not recommend expensive dedicated lightning detectors. (See more **details on lightning detection**).

5.2 Identify in advance SAFE/NOT SAFE places:
SAFE = dry areas inside large permanent buildings.
NOT SAFE = near electrical conductors, electrical equipment, metal objects (lifeguard stands, ladders, diving board stanchions), and water, including showers.

5.3 Action to suspend activities. When lightning is within 6-8 miles, evacuate people to safe areas. Guards should secure the entrance to the pool deck.

5.4 When should activities be resumed? Wait thirty minutes after the last observed lightning or

thunder, since lightning may visit from the back end of the passing thunderstorm.

6. **Conclusion.** There is a built-in conflict between indoor pool activities and lightning safety. Both recreational swimming and competitive swimming events are based upon three icons of Entertainment, Health, and Pleasure. Lightning safety is founded on stopping all those forms of enjoyment. A Risk Management/Safety Professional will err on the side of caution every time and will be found harmless from allegations or claims of negligence. Such a conservative approach will find many objectors. Safety, however, is the prevailing directive.

7. **References**

7.1 Waters, W.E., 1983: Electrical Induction From Distant Current Sources, Prentice Hall, Englewood Cliffs, NJ

7.2 Caixeta, G.P. and Pissolato, Fihlo, J., 1998: Electromagnetic Field Induced In The Interior of a Building by Lightning, Proceedings Intl. Conference on Lightning Protection, Birmingham UK.

7.3 Uman, M.A., et al, 2002: Correlated time derivatives of current, electric field intensity, and magnetic flux density for triggered lightning at 15 m, Jrnl. Geophysical Res., Vol 107, No. D13.

Training in Lightning Safety can be provided by the National Lightning Safety Institute

National Lightning Safety Institute, 891 N. Hoover Ave., Louisville, CO 80027

LIABILITY

Called Strikes

The early evening sky brightened last June 3 as Daniel Rice and Martin Magida, coaches of the Buffalo Grove (Ill.) Recreation Association baseball teams whose 10-to-12-year-old players were riding out a game-threatening thunderstorm in their parents' parked cars, walked onto the outfield grass to check playing conditions. That's when lightning struck Rice, 47, in the head. He died two days later.

Months earlier, a referendum calling for installation of $75,000 worth of lightning prediction technology in Buffalo Grove parks had failed. Warnings weren't there for Rice, but clear indications of lightning's danger weren't far off. Five miles away, in Park Ridge, recreation officials became the first in the nation to introduce to city parks such technology. It seemed a reasonable response to the June 1996 death of Scott Wade, 20, who was struck by lightning while officiating a youth soccer game. During a dedication ceremony held on that tragedy's one-year anniversary, the $49,000 system, manufactured by Thor Guard Inc. of Sunrise, Fla., and funded by community members and end-user groups, alerted onlookers to take cover minutes before a bolt hit the field's scoreboard. To date, some 40 park districts in Greater Chicago have purchased Thor Guard equipment, including last year's $200,000 installation that covers all 53 parks in Elk Grove, which also neighbors Park Ridge.

Lightning, the deadliest of all weather events, has been dealt with in several ways over the decades, from lightning rods designed to attract, direct and dissipate charges in the ground to ion generators designed to repel lightning by altering conditions in the air. Technology that has gained the most attention in recent years (a History Channel special on the subject premieres this month) includes lightning-detection and lightning-prediction systems. One pinpoints where lightning strikes have occurred within a predetermined radius; the other assesses atmospheric conditions likely to produce future lightning strikes within a given area.

"We tell you where the strikes are, where they're coming from, what time they hit, and we warn you about them," says Nancy Roth, marketing supervisor of Vaisala Inc., which last year acquired Global Atmospherics Inc. The company's Tucson, Ariz.-based Lightning Specialty Division markets the TSS 928, a $12,000-to-$20,000 lightning-detection system that can be packaged with alarm software to serve golf courses, water parks and educational institutions. Lightning Observer 2.0, meanwhile, provides online access to Vaisala's National Lightning Detection Network, for a $900 annual fee. Both products can be set up to send warning messages to an individual's text-ready pager or cell phone.

Thor Guard's prediction technology, which has been applied to all PGA Tour events and the 1996 Atlanta Olympics, not to mention several NFL facilities and dozens of colleges and high schools (a $5,000 self-contained prediction and warning unit called Thorguardian also is available), takes the guesswork out of game and practice management in the face of threatening weather, according to company president Bob Dugan. When the system detects electrostatic energy conditions conducive to lightning activity, it blows a horn for 15 seconds and flashes a strobe light, signaling for immediate evacuation of the area. (Lightning is likely to strike within a 2-mile radius of the sensor.) The strobe remains activated until the threat no longer exists.

"Sometimes you clear two or three times a weekend," says Jim Lange, director of parks and recreation in Park Ridge, which hasn't had a lightning tragedy since installing three sensors and 15 remote horns in its parks. "We'd love to keep it that way."

Many sports and recreation professionals believe that lightning's proximity in miles can be calculated by dividing by five the number of seconds that elapse between a visible lightning flash and its corresponding audible thunderclap (a method that appears in NCAA guidelines, even though Thor Guard is used at NCAA championships). Another common perception is that it's safe to resume activity 30 minutes removed from the last observed lightning flash. Not so, says Dugan, whose system will sound an all-clear signal only as atmospheric conditions dictate. It may take an hour or more, even amid clear skies.

Merely witnessing lightning, which can strike the ground from a storm cloud 10 miles away, is reason enough to clear athletic fields. Today's detection and prediction technology alerts those in charge of games and practices to lightning threats they can't see. "To have people standing out in the field — seeing lightning and trying to figure out how far away it is — is like having a gun at your head, pulling the trigger and hoping the next chamber doesn't have a shell in it," Dugan says. "It's deadly."

— *Paul Steinbach*