Lightning Strikes to People and the Legal Duties to Warn and to Protect

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1. Introduction

In 1967, it was recognized that lightning killed more people in the USA than any other meteorological phenomena[1]. This conclusion has been confirmed by subsequent investigators[2]. The conventional perception that other meteorological phenomena are more dangerous than lightning comes from the fact that tornadoes, hurricanes, and floods can kill many people in a single storm, which is front-page news across the entire country. In contrast, lightning commonly does not kill many people in one location or in one day, so death from lightning is only local news, unless a famous person is killed.

On average, lightning kills approximately 110 people/year in the USA[3]. The number of people injured by lightning is between two and four times the number of people killed by lightning[4]. In Colorado during 1950 to 1991, about 52% of the people injured or killed by lightning were engaged in recreation at the time of the lightning strike, while 25% were struck during their employment[5]. Of these casualties in Colorado, 18% were "near or at the summit of a mountain or ridge" and 16% were near a tree. In Florida during 1978-1987, 30% were struck during their employment[6]. In North Carolina during 1972-88, 21% of the people killed by lightning during recreation (camping, at beach, boating, fishing, golf) and 20% were killed during

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[1] F.H. Zegel, *Lightning Deaths in the United States: a seven-year survey from 1959 to 1965*, 20 Weatherwise 168 (1967).

[2] E.P. Weigel, *Lightning: The Underrated Killer*, 6 NOAA Mag. 4 (1976). *But see* R.E. López and R.L. Holle, *Demographics of Lightning Casualties*, 15 Seminars in Neurology 286 (1995)(stating that flash floods and river floods, taken together, killed more people in the USA during 1963-1992 than lightning).

[3] P.J. Duclos and L.M. Sanderson, *An Epidemiological Description of Lightning-Related Deaths in the United States*, 19 Internat. J. Epidemiology 673 (1990).

[4] R.E. López and R.L. Holle, *Demographics of Lightning Casualties*, 15 Seminars in Neurology 286, 287 (1995); P.J. Duclos, L.M. Sanderson, K.C. Klontz, *Lightning-Related Mortality and Morbidity in Florida*, 105 Public Health Reports 276, 280 (1990).

[5] R.E. López and R.L. Holle, *Demographics of Lightning Casualties*, 15 Seminars in Neurology 286, 288 (1995).

[6] P.J. Duclos, L.M. Sanderson, K.C. Klontz *Lightning-Related Mortality and Morbidity in Florida*, 105 Public Health Reports 276 (1990).

their employment[7]. Data from many review articles show that recreation and employment activities together account for most of the people killed or injured by lightning[8]. These data only include people killed by electrical current of lightning, not those indirectly killed by lightning (e.g., in a fire caused by lightning)[9].

This paper discusses the legal obligation that employers and operators of recreational facilities (1) to use available technology to detect thunderstorm conditions and warn their employees/invitees and (2) to provide shelters that are protected against lightning.

The scope of this paper is restricted to warnings of cloud-to-ground lightning and protection of buildings and people from such lightning. This paper does *not* address the issues of aircraft in flight avoiding lightning or being protected from lightning. Liability for injury from lightning while using a telephone during a local thunderstorm has been discussed in a separate paper[10].

In this paper, the author uses the word *warning* for advice to seek shelter because of imminent danger of local lightning, as determined by scientific instruments. The author uses the word *notice* for general advice that lightning is dangerous, without informing people of specific times of imminent danger.

A simple sign posted on a golf course that says "lightning can kill you – play at your own risk" is *a notice, but not* a warning, since it does not contain any information from instruments to indicate which times are safe and when there is an imminent danger of lightning. Since there is no risk of lightning during most of the time, such broad notices will be ignored by people. A warning will use available technology to detect conditions that indicate that local lightning is likely to occur soon.

This essay is intended only to present general information about an interesting topic in law and is *not* legal advice for your specific problem. See my disclaimer at http://www.rbs2.com/disclaim.htm .

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7 R.L. Langley, K.A. Dunn, J.D. Esinhart, *Lightning Fatalities in North Carolina 1972-1988*, 52 North Carolina Med. J. 281, 282 (1991).

8 M.A. Cooper and C.J. Andrews, *Lightning Injuries, in* Wilderness Medicine 261, 262 (P.A. Auerbach, ed., 3d ed. 1995).

9 E.F. Weigel, *Lightning, The Underrated Killer*, 6 NOAA Mag. 4, 6 (1976); R.E. López, et. al., *The Underreporting of Lightning Injuries and Deaths in Colorado*, 74 Bull. Am. Meteorol. Soc. 2171, 2174 (1973).

10 R.B. Standler, *Lightning, Telephones, and Injuries: Legal Liability in the USA*, http://www.rbs2.com/ltgtele.pdf (1997).

2. Warning Technology

In 1752, Benjamin Franklin invented a simple apparatus that used corona discharge current from an elevated point (a lightning rod in Franklin's case) to ring a bell when there was an electrified cloud overhead[11]. Corona current detectors have been used in scientific research on thunderstorms[12]. Corona current detectors have two important advantages: they are inexpensive and they, in the author's experience, can provide a few minutes of advance warning of the first lightning strike. However, corona current detectors have two important disadvantages: they have a large number of false alarms, because not all electrified clouds produce lightning, and the elevated point is vulnerable to being struck by lightning[13]. Further, the magnitude of corona current is influenced by many variables, including wind speed[14] and rate of increase of electric field in the thundercloud[15].

There have been many inventions designed to give warning of approaching thunderstorms, by detecting either corona current, sudden changes in either the atmospheric electric or magnetic field from lightning current, light emitted from lightning, or even brief interruption of the ac supply mains (e.g., flickering electric lamps)[16].

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[11] I. Bernard Cohen, BENJAMIN FRANKLIN'S SCIENCE, 89 (1990).

[12] R.A. Cudney and C.T. Phelps, *A Phenomenon-Energized Point-Discharge Current Meter*, 40 The Review of Scientific Instruments, 965 (1969); T.W. Wormell, *Currents Carried by Point-Discharges beneath Thunderclouds and Showers*, A115 Proceedings Royal Society, 443-455 (1927).

[13] R.L. Johnson, D.E. Janota, and J.E. Hay, *An Operational Comparison of Lightning Warning Systems*, 21 Journal of Applied Meteorology, 703-707 (1982).

[14] J.A. Chalmers, *The Relation of Point-Discharge Current to Potential Difference and Wind Speed*, 24 Journal of Atmospheric and Terrestrial Physics, 339-344 (1962).

[15] R.B. Standler and W.P. Winn, *Effects of Coronae on Electric Fields Beneath Thunderstorms*, 105 Quarterly Journal Royal Meteorological Society, 285-302 (1979).

[16] M.A. Uman and R.B. Standler, *Lightning Activated Relay*, U.S. Patent 4,276,576 (30 June 1981); R.C. Murty and W.D. MacClement, *VHF Direction Finder for Lightning Location*, 12 Journal of Applied Meteorology, 1401-05 (1973); R.J. Clegg, *A Photoelectric Detector of Lightning*, 33 Journal of Atmospheric and Terrestrial Physics, 1431-39 (1971); S. Lundquist and V. Scuka, *Thunderstorm Warning System*, U.S. Patent 3,611,365 (5 Oct 1971); P.R. Leavitt and B. Vonnegut, *Corona Current Sensing Device*, U.S. Patent 3,215,997 (2 Nov 1965); E.T. Pierce, *The Influence of Individual Variations in the Field Changes due to Lightning Discharges upon the Design and Performance of*

In the mid-1970s, a reliable lightning location system was invented that accurately showed the location of cloud-to-ground lightning strikes for a range of hundreds of kilometers[17]. One of the first applications of lightning location system was accurate location of forest fires started by lightning[18]. However, lightning location systems also show the movement of thunderstorms, and give advance warning of many local thunderstorms. In many cases, one can obtain several hours of advance warning from lightning location systems, which is enough time to mobilize repair crews for electric utilities[19]. A comparison of six commercially-available thunderstorm or lightning detectors in the summer of 1979 showed that the lightning location system of Krider, *et al.* gave the best overall performance[20]. However, lightning location systems are complex instruments that are expensive and not trivial to operate.

Instruments that detect only atmospheric electric field changes often gave false indications, so Prof. Brook suggested in 1960 that a better method would be to detect the coincidence of optical flashes and electric field changes[21]. Thirty years later, Byerley[22] developed a commercial lightning

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Lightning Flash Counters, A9 Archiv für Meteorologie Geophysik und Bioklimatologie, 78-86 (1956); S.W. Dean, *Coordination of Direction-Finder Observations*, U.S. Patent 1,759,938 (27 May 1930).

17 E.P. Krider, R.C. Noggle, M.A. Uman, *A Gated, Wideband Magnetic Direction Finder for Lightning Return Strokes*, 15 Journal of Applied Meteorology, 301-306 (1976); E.P. Krider, R.C. Noggle, *Gated Lightning Detection System*, U.S. Patent 4,198,599 (15 Apr 1980); E.P. Krider, R.C. Noggle, M.A. Uman, *Detection System for Lightning*, U.S. Patent 4,115,732 (19 Sep 1978).

18 E.P. Krider, R.C. Noggle, A.E. Pifer, D.L. Vance, *Lightning Direction-Finding Systems for Forest Fire Detection*, 61 Bulletin of American Meteorological Society, 980-986 (1980).

19 R. Bernstein, R. Samm, K. Cummins, *et al.*, *Lightning Detection Network Averts Damage and Speeds Restoration*, 9 IEEE Computer Applications in Power, 12-17 (1996); B.F. Whitney, H. Asgeirsson, *Lightning Location and Storm Severity Display System*, 6 IEEE Transactions on Power Delivery, 1715-1720, (1991).

20 R.L. Johnson, D.E. Janota, and J.E. Hay, *An Operational Comparison of Lightning Warning Systems*, 21 Journal of Applied Meteorology, 703-707 (1982).

21 M. Brook and N. Kitagawa, *Electric Field Changes and the Design of Lightning-Flash Counters*, 65 Journal of Geophysical Research, 1927-31 (1960).

22 L.G. Byerley III, A.E. Pifer, K.L. Cummins, *An Electro-Optical, Lightning Detection, Classification and Ranging Sensor for Automatic Lightning Protection and Human Warning*, 21st International Conference on Lightning Protection, Berlin, September 1992; L.G. Byerley III, A.E. Pifer, K.L. Cummins, A.E Pifer, et al., *Autonomous Electro-Optical Lightning Identification and Ranging*

detector based on the principle of detecting *both* electric field changes with a certain signature *and* light emission from lightning. Such a detector is much simpler and much less expensive than a lightning location system.

No lightning detector can warn of the first lightning strike in an isolated, local thunderstorm. However, such imperfect warning is better than none, since an active thunderstorm can produce many dozens of cloud-to-ground lightning flashes and the risk to people from each flash is small.

During a local thunderstorm in 1987, a golfer took cover under a tree on a hill, where he was killed by lightning. His wife sued the state-operated golf course for, among other things, failing to provide a siren to warn golfers of thunderstorms. The commissioner who presided over the hearing made the following response to the wife's argument:

> No warning device could be louder or be more accurate than thunder. Thunder warns all persons that lightning is near. It just does not seem that man can devise any warning device which approaches the efficiency of thunder. The absences of a warning device would not create a dangerous condition on state-controlled real property.

Hames v. State of Tennessee, 808 S.W.2d 41, 43 (Tenn. 1991) (quoting Claims Commissioner). The Commissioner had a good point about thunder being an effective warning device, but one can sometimes hear thunder from lightning that is too distant to pose a significant risk, and thunder from the first flash of a local storm comes too late to warn. The real issue is whether society prefers (1) to *suffer*, then be reimbursed by insurance or an award in tort litigation, or (2) to use available technology to *prevent* injuries. A rational decision would be made on the basis of an economic analysis. However, in doing the economic analysis, one should consider the cost of both warning *and* protection, since a warning does no good if there is no nearby shelter that is protected against lightning. Further, if people ignore thunder, they will probably also ignore a warning from a scientific instrument.

Many golf courses have installed lightning detectors to automatically disconnect all of their electrically-controlled irrigation systems, to prevent damage to soil moisture sensors and electrically-controlled water valves from lightning[23]. For very little additional cost (i.e., the cost of a siren), an automatic warning may also be provided to people, in the hope that some personal injuries and deaths may be prevented.

Apparatus for, and Method of, Alerting Humans and Protecting Equipment, U.S. Patent 5,168,212 (1 Dec 1992).

[23] L.G. Byerley and J. Reed, *Lightning Protection by way of Thunderstorm Sensing and Automatic Electrical Isolation*, 1992 International Aerospace and Ground Conference on Lightning and Static Electricity (1992).

A commercially-available lightning warning system costs between $ 3,000 and $ 5,000 for a typical golf course, which should be contrasted with a median wrongful death award of $ 500,000 in Florida[24].

3. Protection Technology

Once someone is aware of an impending local thunderstorm, how should they protect themselves from a lightning strike? The most complete protection would be given by entering a Faraday Cage, a seamless metal enclosure on all sides, including top and bottom[25]. However, as a practical matter, the metal body and roof of an automobile offers reasonable protection. A building with concrete walls, which contain reinforcing steel, and lightning rods on the roof also offers reasonable protection to people inside the building.

The best way to protect a building and its contents from lightning is to make the building into an approximation of a Faraday cage. The reinforcing steel in the concrete walls, floors, and ceiling should be welded together to form a conducting mesh *before* the concrete is poured[26]. Such construction techniques are appropriate for buildings that contain electronic equipment, such as office buildings, or routinely contain people, such as hotels and residences. However, such construction techniques are too expensive to be appropriate for shelters in recreational facilities, such as beaches and golf courses.

Shelters in parks and golf courses are commonly of wood construction and open on all sides. Installing lightning rod(s) on such shelters may make them safer, but does not transform them into "lightning-proof" shelters, despite the fact that plaintiff's experts sometimes use the term "lightning-proof" for this application. To be truly lightning-proof, a shelter must have sheet metal on all sides, roof, and floor.

A review of injuries from lightning contains the following wisdom:

> A common belief is that a person who is inside a building is safe from injury by lightning. Unfortunately side flashes strike people through plumbing fixtures, telephones, and other appliances attached to the outside of the house by metal conductors. ... In addition, taking shelter in small sheds, such as those on golf courses or hikers' lean-tos, especially above the

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24 M. Flynn, *Lightning: A Double Hit for Golf Course Operators*, 6 Marq. Sports L.J. 133, 146, n.101 (1995).

25 J.C. Maxwell, *On the Protection of Buildings from Lightning*, 14 Nature 479 (1876).

26 P. Hasse, *EMV-Orientiertes Blitz-Schutzzonen-Konzept mit Beispielen aus der Praxis*, Elektromagnetische Verträglichkeit, VDE Verlag, Offenbach, Arbeitsgemeinschaft Energietechnik (1991).

> tree level on a mountain, can be especially dangerous because lightning splashes onto the inhabitants.[27]

It is conventional wisdom that lightning rods attract lightning[28]. Such a statement is not precisely correct. *Any* grounded, elevated object (e.g., tree, chimney, wood utility pole, wood-frame building) can serve as the source of an upward-propagating streamer that connects with the downward propagating stepped leader from a thundercloud and establishes the object as "struck by lightning"[29]. The advantage of using lightning rods is that they are designed to carry lightning current safely, instead of exploding or burning.

Lightning protection in the USA was often sold by peddlers who did unsatisfactory installation, took the customer's money, and then vanished. To protect the public from such frauds, several states had statutes requiring that sellers of lightning rods be licensed[30]. The comments in the Ohio Annotated Statute on Fraud specifically mentions, as an example,

> a bunco artist who poses as a "lightning rod inspector," convinces a farmer than his lightning rod has "lost its charge," and induces him to have the rod recharged for a fee, using a Rube Goldberg contraption[31].

Regarding lightning protection as a subject suitable for peddlers has tainted lightning protection in the USA, and may be responsible for the reluctance of physicists and electrical engineers in the USA to get involved with research and applications of lightning protection. When the author did scientific research during 1973-75 on the difference in performance between blunt- and

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[27] M.A. Cooper and C.J. Andrews, *Lightning Injuries, in* Wilderness Medicine 261, 264 (P.A. Auerbach, ed., 3d ed. 1995)(C.J. Andrews is a physician who also earned a Ph.D. in electrical engineering).

[28] *E.g., Citizens Independent Telephone Co. v. Davis*, 94 N.E.2d 495, 497 (Ind.App.Ct. 1950). *See also Kermit Construction v. Banco Credito*, 547 F.2d 1, 3 (1976)(using "lightning rod" as a metaphor for a target that attracts).

[29] D. Müller-Hillebrand, *The Protection of Houses by Lightning Conductors – An Historical Review*, 274 J. Franklin Institute 34, 43 (1962); H. Norinder, *Experimental Lightning Research*, 253 Journal Franklin Institute 471, 500 (1952); R.H. Golde, *Occurrence of Upward Streamers in Lightning Discharges*, 160 Nature 395 (1947); K.B. McEachron, *Lightning to the Empire State Building*, 227 Journal Franklin Institute 149, 201 (1939).

[30] Alabama Code § 40-12-120 (1996); Mo. St. § 150.470 (1996); N.H. Rev. Stat. Ann. § 323:1-7 (1995); S.C. Code Ann. § 40-11-100, § 40-41-60 (1995); Vt. Stat. Ann. tit. 9, §§ 3201-05 (1995). *See also* La. Rev. Stat. 47:381 (1934)(repealed in 1977); Me. Rev. Stat. Ann, tit. 32, ch. 25, §§ 1701-1705 (1954) (repealed 1985).

[31] Ohio Rev. Code Ann. § 2913.44 (1996).

sharp-tipped lightning rods[32], little scientific research had been published on this topic, despite the then 200 year history of the controversy on this topic.

More recently, several lightning protection companies have claimed to "eliminate" lightning or have claimed that their special lightning rods are better than ordinary rods. There is no evidence reported in peer-reviewed scientific journals to support such claims and good reasons to believe that such claims are false[33].

4. Engineering Standards

There are no engineering standards in the USA for systems to warn of thunderstorms or lightning.

There are *two* engineering standards for installation of lightning rods in the USA: one by the National Fire Protection Association[34], the other by Underwriter's Laboratories[35]. These standards describe minimum requirements for the installation of lightning protection on buildings (i.e., lightning rods, grounding, and "down conductors" to connect these two). Before discussing details of *how* to protect, one should first consider whether protection is necessary.

There is generally no requirement in either statute or building codes that lightning rods should be installed on buildings in the USA. However, *if* lightning rods are installed at the option of the building owner, as a general rule, the installation should comply with the recognized engineering standards, to help protect the installer from a later charge of negligence. As discussed in more detail below, several states require lightning rod installers to get a UL Master Label for every

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[32] R.B. Standler, *The Response of Elevated Conductors to Lightning*, M.Sc. thesis, New Mexico Institute of Mining and Technology, 194 pp. (1975).

[33] D. Mackerras, M. Darveniza and A.C. Liew, *Review of Claimed Enhanced Lightning Protection of Buildings by Early Streamer Emission Air Terminals*, 144 IEE Proceedings Science, Measurement and Technology 1 (1997); D. Mackerras, M. Darveniza and A.C. Liew, *Standard and Non-Standard Lightning Protection Methods*, 7 Journal of Electrical and Electronics Engineering Australia 133 (1987); D. Müller-Hillebrand, *Beeinflussung der Blitzbahn durch radioaktive Strahlen und durch Raumladung* 83 Elketrotechnische Zeitschrift 152 (1962). *See also* D.W. Zipse, *Comments on "Lightning and Surge Protection of Substations"*, 31 IEEE Transactions on Industry Applications 171 (1995). *Protection of Structures Against Lightning*, IEC 1024-1 7 (1990)(The first sentence of this international engineering standard says "It should be noted that a lightning protection system cannot prevent the formation of lightning.").

[34] *Lightning Protection Code*, NFPA 780 (1995)(approved as an American National Standard).

[35] *Installation Requirements for Lightning Protection Systems*, UL 96A (1991).

installation[36], which means compliance with UL 96A standard and inspection by an agent of UL.

The role of engineering standards in establishing a duty of care in tort litigation has been discussed in a separate article[37]. Standards that are incorporated by reference into statutes or local building codes establish a duty of care[38].

For the special case of golf courses, the Tennessee Supreme Court noted that "no recognized standard existed that golf courses be equipped with lightning-proof shelters or with warning devices...." and, therefore, the golf course had no obligation to install shelters or warning devices[39].

technical criticism of American standards

The leading expert on physics of the lightning discharge, Prof. Uman, has criticized engineering standards for recommending inappropriate parameters of lightning:

> Many of the standards that do exist for ground-based systems have not kept pace with he advances in the knowledge of lightning physics an interaction mechanisms. For example, the 8/20 μs current waveform found in most surge arrester performance specifications is widely recognized as having too short a time duration and too long a risetime. Yet protection designs for a variety of commercial products continue to be based on this waveshape.[40]

Most working groups that wrote lightning standards in the USA do not have a single member with credentials in scientific research on lightning and thunderstorms, but these groups are heavily loaded with members who are employed by manufacturers of lightning protection equipment.

There are numerous defects in American lightning protection standards, some of which are mentioned in the following paragraphs.

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36 N.H. Ann. Stat. § 323:2 (1995); S.C. Code Ann. § 40-11-100 (1995); Vt. Stat. Ann. tit. 9, § 3201 (1995)(requires test by Underwriters Laboratories "or by some other agency making equally thorough tests").

37 Ronald B. Standler, *Lightning, Telephones, and Injuries: Legal Liability in the USA*, http://www.rbs2.com/ltgtele.pdf (1997).

38 Restatement (Second) Torts §§ 285-286 (1965); *Raymond v. Baehr*, 163 N.W.2d 51, 54 (Minn. 1968). Standards not referenced in statutes may still be admissible as evidence that defendant met an appropriate standard of care. *Hansen v. Abrasive Engineering and Mfg., Inc.*, 856 P.2d 625, 628 (Or. 1993).

39 *Hames v. State of Tennessee*, 808 S.W.2d 41, 43 (Tenn. 1991).

40 M.A. Uman, *Natural and Artificially-Initiated Lightning and Lightning Test Standards*, 76 Proc. IEEE 1548, 1562 (1988).

Both the NFPA[41] and UL standards require copper lightning conductors to have a cross-sectional area of at least 29 mm^2. The relevant international engineering standard[42] requires copper down conductors to have an area of at least 16 mm^2. Calculations show that a single copper wire with area between about 7 and 10 mm^2 is adequate to carry most lightning currents[43]. Requiring larger lightning conductors needlessly increases the cost of protection[44]. Given the high price of copper, it is reasonable to use small diameter conductors, except for buildings that either (1) are likely to be struck by lightning, because of their height or exposure on a hill, (2) contain explosives, flammable materials, valuable irreplaceable objects (e.g., Gutenberg Bible or Stradivarius violin), or (3) are located a long distance from the nearest fire department (e.g., rural house). As the need for lightning protection increases, then it is reasonable to spend more money on materials for the protection. With the present standards, all buildings with lightning protection must conform to high standards, which makes the protection too expensive to afford for most buildings. The realistic result is that building owners choose to "protect" with insurance, instead of with technology[45]. Standards need to include a *low-cost* method that will provide substantial

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[41] For buildings with a height greater than 23 meters (75 feet), NFPA 780 requires a minimum cross sectional area of 58 mm^2 of copper.

[42] *Protection of Structures Against Lightning*, IEC 1024-1 Table 5 (1990).

[43] As a matter of elementary physics, the energy deposited in the wire by the electrical current, I, causes an increase in temperature, ΔT, according to the following equation:

$$\int I^2 R \, dt = c \, \rho \, \pi \, r^2 \, \ell \, \Delta T$$

where t is the time, c is the heat capacity per unit mass, ρ is the mass per unit volume of the wire, r and ℓ are the radius and length of the wire, and the electrical resistance, R, is given by:

$$R = \ell / (\sigma \, \pi \, r^2)$$

where σ is the electrical conductivity of the wire, here copper. The lightning current is approximately:

$$I = I_0 \exp(-t/\tau) \qquad 0 \leqq t < \infty$$

where I_0 is arbitrarily set to 100 kA, about five times the peak current in a typical lightning flash, and where τ is chosen to give a total charge transfer of 40 coulombs, about twice the charge transfer in a typical lightning flash, whereby τ = 400 μs. Not only are these parameters conservatively chosen, but this calculation assumes that *all* of the lightning current will flow in a single wire, while a typical installation has at least four vertical wires connecting the lightning rods on the roof with the ground terminals. Solving these equations for ΔT = 200 °C gives a value of cross-sectional area, $\pi \, r^2$, of 7 mm^2. If the initial temperature of the wire is 50 °C (a hot day!), the final temperature will be 250 °C, which is well below the melting temperature of copper wire, 1080 °C. Considering the increase of R with temperature will slightly increase the area of the wire, but this is an effect that is too complex to consider here.

[44] D. Müller-Hillebrand, *The Protection of Houses by Lightning Conductors – An Historical Review*, 274 Journal Franklin Institute 34, 51-52 (1962).

[45] *Id.* at 48.

protection from, say, 95% of lightning strikes. Such a low-cost protection method, while not perfect, would be far superior to the zero protection used on most buildings today in the USA.

The standards require installation of lightning rods on structures with sheet metal roofs, which provides no additional protection, but does sell more rods.

There are good reasons to delete from standards the antique measure of the number of days each year that thunder is heard at a location (e.g., thunderdays or keraunic levels) and use instead the number of lightning flashes per square kilometer per year, as measured with a network of lightning location systems[46].

A Swedish scientist who did substantial research on lightning protection commented about the use in the U.S.A. of lightning rods ("air terminals") with sharp tips:

> Some awe-inspiring objects included in the [NFPA] Code for Protection Against Lightning (1959) in the U.S.A. are probably of most use on the psychological plane[47].

Several states require lightning rod installers to get a UL Master Label for every installation[48], which means compliance with UL 96A standard and inspection by an agent of UL. In passing such laws, the legislatures may have acted with intent to protect the public from unscrupulous peddlers, but the effect of such legislation is to increase the price of lightning protection and to prevent competent installers from using professional judgment and trying innovative ideas. Not every situation requires the full treatment specified by UL 96A, which is expensive[49]. If lightning protection is too expensive, then building owners will "protect" their property with insurance, instead of with engineering technology that could avoid most damage. Further, UL 96A specifically refuses to grant Master Label certification to buildings that contain explosives, ammunition, or flammable liquids (e.g., gasoline)[50], although such buildings certainly deserve comprehensive lightning protection. NFPA 780 does contain information on protecting structures that contain flammable liquids or vapors, but this document is not referenced in state statutes.

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46 L.G. Byerley III, K.L. Cummins, J. Tuel, et al., *The Measurement and Use of Lightning Ground Flash Density*, 1995 International Aerospace and Ground Conference on Lightning and Static Electricity, Williamsburg, VA, (1995).

47 D. Müller-Hillebrand, *Lightning Protection*, Montreux Conference, 407, 424.

48 N.H. Ann. Stat. § 323:2 (1995); S.C. Code Ann. § 40-11-100 (1995); Vt. Stat. Ann. tit. 9, § 3201 (1995)(requires test by Underwriters Laboratories "or by some other agency making equally thorough tests").

49 The full-treatment costs about $ 2000 for a small picnic shelter in a park, more for a typical house.

50 UL 96A, § 1.1 (1991).

5. Legal Duty to Warn and to Protect

It is well established law that a person owes a duty of reasonable care toward a licensee or an invitee, including warning them of any hazardous condition that is not obvious to them[51]. As explained in more detail below, courts generally do not require employers or operators of recreational facilities to provide notices or warning technology, because it is well known that lightning is dangerous and because thunder gives an effective warning.

There are several general legal principles that may be useful to plaintiffs who seek recovery for injuries because no shelter was provided or because the shelter did not have lightning protection. An actor *may* be negligent in not protecting against a force of nature that is both foreseeable and creates an unreasonable risk of harm[52]. The possessor of land that is open to the public has a duty to protect invitees against unreasonable risk of physical harm[53]. And the possessor of land may be liable to invitees for failure to protect them from known or obvious dangers, when "the possessor should anticipate the harm despite such knowledge or obviousness"[54].

There are only a few publications on legal consequences of lightning. The most recent American Law Reports annotation that discussed personal injury from lightning was published more than ten years ago, despite significant developments in both technology and law since that time[55]. One recent law review article reviewed liability of golf course owners for injuries and deaths from lightning[56].

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51 Restatement (Second) Torts, §§ 341, 341A, 342, 343 (1965).

52 Restatement (Second) Torts, § 302(b) (1965).

53 Restatement (Second) Torts § 314A(3) (1965).

54 Restatement (Second) Torts § 343A(1) (1965).

55 J.M. Draper, *Annotation: Personal Injury or Property Damage Caused by Lightning as Basis of Tort Liability*, 46 ALR4th 1170 (1986).

56 M. Flynn, *Lightning: A Double Hit for Golf Course Operators*, 6 Marq. Sports L.J. 133 (1995).

6. Cases

In 1961 a plaintiff was in an open wooden shelter on a golf course during a thunderstorm when she was struck by lightning[57]. Plaintiff argued that golf course was negligent in failing to provide lightning rods on the shelter, which was the highest object for a distance of 87 feet, and therefore more likely to be struck by lightning. The trial court set aside the jury verdict for plaintiffs and the appellate court affirmed, because "the danger of the shelter being struck by lightning was so remote as to be beyond the requirement of due care...."[58]

In 1980 a plaintiff rented a shelter in a city-owned park for a picnic. One person was killed and several were injured by lightning, when they were in the shelter during a local thunderstorm. The trial court granted summary judgment because lightning was an "Act of God." The Ohio Supreme Court remanded the case to the trial court, and held that "if proper care and diligence on a defendant's part would have avoided the act, it is not excusable as the act of God."[59] Before the case could be tried again, the parties settled[60].

During a local thunderstorm in 1984, a lifeguard ordered everyone from the lake, then the plaintiff walked to a hill, where he was struck by lightning. Plaintiff sued the town, because the town had not prevented plaintiff from playing on the hill. Both the trial court and appellate court ruled for the defendant. The appellate court held:

> (1) municipality discharged its duty to patrons of recreation area by providing lifeguard and beach director who, upon commencement of rain and thunder, directed all swimmers to get out of water, leave beach area, and take cover; and (2) municipality's duty to provide general supervision for patrons of municipal recreation area did not include obligation to maintain constant surveillance of son's movements and activities to make certain that son took proper shelter from rain, thunder, and lightning.

McAuliffe v. Town of New Windsor, 577 N.Y.S.2D 942, (N.Y.App.Div. 1991).

The court noted that "there is no duty to warn against a condition that is readily observable by the reasonable use of one's senses."[61]

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[57] *Davis v. The Country Club, Inc.*, 381 S.W.2d 308 (Tenn.Ct.App. 1963).

[58] *Id.* at 311.

[59] *Bier v. City of New Philadelphia*, 464 N.E.2d 147 (Ohio 1984).

[60] Douglas J. O'Meara, counsel for plaintiff, personal communication, 14 Mar 1997.

[61] *McAuliffe v. Town of New Windsor*, 577 N.Y.S.2d 942, 944 (N.Y.App.Div. 1991) *cited with approval in Kelly v. Academy Broadway Corp.*, 615 N.Y.S.2d 123, 125 (N.Y.App.Div. 1994).

In 1986, a hiker was injured by a lightning strike to Moro Rock in Sequoia National Park. The hiker sued the National Park Service for failing to provide any notice of the danger of lightning, for failing to warn of the impending storm, and for failing to provide lightning protection. There was no prior history of lightning striking this location. The judge ruled that such notice, warning, and protection was within the discretionary function exception to the Federal Tort Claims Act, 28 USC § 2680(a) and dismissed the case for lack of subject matter jurisdiction[62].

During a local thunderstorm in 1987, a golfer took cover under a tree on a hill, where he was killed by lightning. His wife sued the state-operated golf course for failing (1) to warn golfers of thunderstorms and (2) to provide lightning-proof shelters on the course. The hearing commissioner ruled against the wife, holding that the danger of lightning "is commonly known" and the state did not negligently create or maintain a dangerous condition. In response to wife's argument that the state should have installed warning sirens, the commissioner said that thunder itself was an adequate warning. The wife appealed and the first appellate court agreed with wife and awarded her the value of the remainder of the decedent's life, which was reduced to $ 300,000 due to a statutory limitation on claims[63]. Then the Tennessee Supreme Court overturned this award, by ruling that lightning itself was the proximate cause of death[64]. The Tennessee Supreme Court took note of the United States Golf Association's (USGA's) rules that warn of the dangers of lightning and recommends posting of notices and precautions, but concluded that "the rules govern primarily tournament play and thus they are not applicable here."[65] The Tennessee Supreme Court's judgment misses the point: the relevant part of the USGA rules are not the rules for tournament vs. friendly golf games, but the description of hazards to all golfers from lightning. While a tournament player's life might be worth more than the decedent, who the court described as "a musical genius"[66], but questions of value of a man's life should be considered only in determining the value of an award, not in deciding if there is a duty to warn or a duty to protect. The Tennessee Supreme Court also noted some issues of contributory negligence or assumption of risk by the decedent: he was killed about 800 yards from the clubhouse, it would have taken less than two minutes to reach the clubhouse in a golf cart, and nearly everyone else had gone to the

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62 *Schieler v. United States*, 642 F.Supp. 1310, 1314 (E.D.Cal. 1986).

63 *Hames v. State of Tennessee*, 1990 WL 6317 (Tenn.Ct.App. 1990).

64 *Hames v. State of Tennessee*, 808 S.W.2d 41, 45 (Tenn. 1991).

65 *Id.* at 42, 46.

66 *Id.* at 42.

clubhouse during this storm[67]. The cost of providing one so-called "lightning-proof shelter" was estimated to be about $ 4,500 and funds for such shelters had been requested during the ten years preceding this death[68]. However, the court did not mention any calculation of the probability of avoiding injury by installing the shelters.

A spectator at a basketball game in a public street was paralyzed by a falling tree limb, while the spectator was running for shelter during a local thunderstorm[69]. The spectator sued the organizers of the basketball game and two financial sponsors, despite the fact that the spectator paid no admission fee for the game. The trial court granted summary judgment for the defendants, because the defendants owed no duty to the spectator, and the appellate court affirmed. The appellate court noted[70] the general rule that there is no duty to protect another person, with exceptions for "special relationships". The appellate court gives a list of examples of special relationships: common carrier-passenger, innkeeper-guest, employer-employee, landlord-tenant, and invitor-invitee[71]. The appellate court concluded[72] that was no special relationship in the instant case, because "plaintiff paid no admission fee to observe the tournament, and no contractual or business relationship was shown to exist between plaintiff and defendant. Nor do we perceive any other type of special relationship from which a duty to warn could arise with regard to inclement weather." This reasoning raises a yet unanswered question: does a golf course have a duty to protect players who pay a fee to play golf?

A major victory for plaintiffs occurred in a recent case[73], in which three people were injured and one was killed by lightning in July 1990. Lightning stuck a stone hut on the summit of Mt. Whitney in California, injuring people in October 1985, and again in 1987, 1988, and 1989, which was constructive notice of the hazard. The National Park Service (NPS) owned the hut. After the 1985 injuries, the NPS asked for and promptly received recommendations on how to protect the hut from lightning. While NPS rules require abatement of hazardous conditions not later than 60 days after detection and verification of the hazard, the NPS did not install the recommended

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67 *Id.* at 43.

68 *Id.* at 42.

69 *Dykema v. Gus Macker Enterprises, Inc.*, 492 N.W.2d 472, 473 (Mich.Ct.App. 1992).

70 *Id.* at 474.

71 *Id. See* Restatement (Second) Torts §§ 314, 314A, 323 (1965).

72 *Id.* at 474.

73 *MacLeod, et al. v. United States*, CV 91-3652-WJR, 1994 WL 860798 (C.D.Cal. 1994).

protection during the 58 months after the October 1985 injuries, so the NPS did not follow their own rules. Further, a NPS safety official testified that "members of the public would be drawn to the Hut during a storm, because it presented an illusion of safety"[74], so it was important to make the shelter as safe as possible. The judge held that the NPS's actions constituted "willful misconduct" and awarded plaintiffs a total of $ 1,700,000.

The plaintiff in a New Jersey case[75] played golf in rain during March 1993. When lightning began, the golfers walked approximately one mile to the clubhouse. The plaintiff was struck by lightning during this walk; he sued the golf course for failure to protect him from lightning. The trial court granted summary judgment for the golf course, because there was no duty to protect against lightning. The appellate court reversed and remanded for trial. The golf course's "protection" against lightning consisted of monitoring radio reports of the weather and ordering golfers to vacate the course during thunderstorms, although there was no warning to plaintiff[76]. The golf course had no equipment for detecting local lightning and there were no shelters on the golf course[77]. Instead of having shelters, the golf course instructed its employees to direct golfers to private homes bordering the course during a "severe storm," but there was no evidence that golfers would be welcome there[78]. Plaintiff's expert, a recreation and sports consultant, gave an opinion that the golf course could have prevented plaintiff's injury[79], by, among other things, installing an electronic warning system to detect local lightning and sound a siren, and providing shelters on the course. The appellate court noted[80] that this duty to protect "has not been recognized in any jurisdiction." However, the appellate court noted that technological progress, specifically the development of electronic instruments to warn of lightning, *might* produce a duty

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74 *Id.* at *4.

75 *Van Maussner v. Atlantic City Country Club*, 691 A.2d 826 (N.J.Super. 1997).

76 *Id.* at 828-829.

77 *Id.* at 828.

78 *Id.*

79 *Id.* at 829.

80 *Id.* at 830.

to use this technology[81]. The appellate court was influenced[82] by a law review article[83] that reviewed proprietary literature from some manufacturers of lightning warning systems, but ignored the scientific literature on this subject. In conclusion, the appellate court held[84] that "when a golf course has taken steps to protect golfers from lightning strikes, it owes the golfers a duty of reasonable care to implement its safety precautions properly." This means that (1) "all golf courses have a duty to post a sign that details what, if any, safety procedures are being utilized by the golf course to protect its patrons from lightning", (2) *if* a golf course provides shelters, then the shelters must be "lightning-proof", and (3) *if* a golf course uses a weather forecasting system, then the system must be "reasonable under the circumstances." In addition, plaintiff alleged that five other golf courses near the Club where he was injured had both warning sirens and shelters on their courses, which the appellate court noted was a customary practice in the industry[85]. It is important to note that the appellate court did *not* rule on the issue of negligence by the golf course, but only noted that it was a question to be decided by the jury, not a matter for summary judgment[86]. The appellate court noted that plaintiff might be comparatively negligent for playing in the rain[87].

There is a higher obligation to warn and protect people against lightning when hazardous materials are used, for example (1) gasoline storage, (2) explosives in mining and construction industries, (3) manufacture and storage of munitions, because the duty of care increases as the hazards increase[88]. Such higher obligations are often expressed in safety regulations and statutes. In one case, the government was found negligent in not following its own rules that required

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81 *Id.* at 835.

82 *Id.* at 832, 835.

83 Michael Flynn, *Lightning: A Double Hit for Golf Course Operators*, 6 Marq. Sports L.J. 133 (1995).

84 *Van Maussner* at 835.

85 *Id.* at 836.

86 *Id.* at 836-837.

87 *Id.* at 836.

88 Restatement (Second) Torts § 298 (1965). *See also* Restatement (Second) Torts, §§ 293, 297(b), 300 (1965).

evacuation of a plant where munitions were manufactured during a local thunderstorm[89]. Another case awarded compensation to survivors of fire caused by a lightning strike to a storage tank that contained crude oil[90].

Act of God ?

The defendant will probably argue that lightning is an "Act of God", for which the defendant is not responsible. While it is true that lightning is a natural occurrence that is not under the control of anyone, technology does provide ways to avoid injury from lightning. The defendant's failure to provide shelters with lightning protection, or to use appropriate warning technology, is an act of Man that is the basis for plaintiff's litigation[91]. The modern trend is to have a jury determine if defendant's failure to use appropriate technology was negligence[92].

In the analogous area of so-called lightning arresters on telephone wires that enter a customer's premise, courts in the USA since the early 1900s have required the telephone company to install a lightning arrester and ground connection[93].

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[89] *McMichael v. U.S.*, 856 F.2d 1026 (8thCir. 1988)(lightning strike caused an explosion that killed seven employees and seriously injuring give other employees).

[90] *Tex-Jersey Oil Corp. v. Beck*, 292 S.W.2d 803 (Tex.Ct.Civ.App. 1956), *aff'd liability,* 305 S.W.2d 162 (Tex. 1957)(fire killed three people, oil tank was in violation of city ordinance by not being vapor-proof, so court found negligence per se).

[91] Restatement (Second) of Torts § 302 (1965)("A negligent act or omission may be one which involves an unreasonable risk of harm to another through ... the foreseeable ... force of nature."). The failure to use appropriate technology is an intervening force that interrupts the Act of God defense. *See* Restatement (Second) of Torts §§ 441, 442A, 442B (1965).

[92] *van Maussner*, 691 A.2d 826, 833-834, 836-837 (N.J.Super. 1997); *Bier*, 464 N.E.2d 147, 148 (Ohio 1984); *Macedonia Baptist Church v. Gibson*, 833 S.W.2d 557, 560 (Tex.Ct.App. 1992). *But see Hames*, 808 S.W.2d 41, 45 (Tenn. 1991)(holding that lightning was the proximate cause of a golfer's death).

[93] *General Telephone Co. of Alabama v. Cornish*, 280 So.2d 541 (Ala. 1973); *Southwestern Telegraph & Telephone Co. v. Abeles*, 126 S.W. 724 (Ark. 1910); *Rletveld v. Mountain States Telephone and Telegraph Co.*, 485 P.2d 525 (Colo.Ct.App. 1971); *Peninsular Telephone Co. v. McCaskill*, 60 So. 338 (Fla. 1912); *Cohen & Stryck v. Home Tel. Co.*, 200 S.W. 344, 345 (Ken.Ct.App. 1918); *Chesapeake & Potomac Telephone Co.*, 199 A. 832, 834-5 (Md. 1938); *McDowell v. Southwestern Bell Telephone Co.*, 546 S.W.2d 160 (Mo.Ct.App. 1976); *Robinson v. Southwestern Bell Telephone Co.*, 434 S.W.2d 249 (Mo.Ct.App. 1968); *Warren v. Missouri & Kansas Telephone Co.*, 196 S.W. 1030, 1032 (Mo.Ct.App. 1917); *Southern Telegraph & Telephone Co. v. Evans*, 116 S.W.

Does one have a legal duty to provide warning or protection? Because it is possible to warn and to protect, economics provides the best answer. Judge Learned Hand's famous test[94] states that one does have a duty to protect if

$$B < P \times L$$

where B is the cost of protection, P is the probability of injury without protection, and L is the magnitude of the loss without protection. The values of B and L are relatively easy to calculate. Data from the network of lightning location systems in the USA, gives the expected number of lightning flashes to a square kilometer in a typical year[95]. But we do not know the probability of lightning hitting a hill, instead of a tree, utility pole, or other elevated object in the vicinity. Nor do we know the probability of a person being on the hill when lightning strikes the hill. Therefore, precise calculations of P are not possible.

Referring again to the analogous issue of lightning arresters and grounds on telephone wires, the cost[96] of an arrester for one pair of telephone wires and its ground connection to the electrical circuit breaker panel is about $ 20, which is much less than the cost of a lightning warning system or lightning rods on a shelter. However, if there are perhaps 2000 pairs of telephone wires entering buildings in a town that has only one golf course, then the financial burden would be similar for the local telephone company and golf course. It would appear that consistency in law would mandate that golf courses provide shelters with lightning rods, since telephone companies have long been required to provide lightning protection to their customers. But the issue is not so simple: a telephone is an essential service, while golf is a nonessential recreation, so the duty of care might be different. People can choose not to play golf during local thunderstorms, while it is not always possible to avoid using the telephone during a local thunderstorm. Further, self-help is not available for users of telephones, while everyone knows they should go indoors during a local thunderstorm.

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418 (Tex.Civ.App. 1909); *Griffith v. New England Telephone & Telegraph Co.*, 48 A. 643 (Vt. 1900); *Keilhamer v. West Coast Telephone Co.*, 118 P.2d 173 (Wash. 1941); *Lobermeier v. General Telephone Company of Wisc.*, 349 N.W.2d 466 (Wisc. 1984).

94 *U.S. v. Carroll Towing Co.*, 159 F.2d 169 (2dCir. 1947).

95 L.G. Byerley III, K.L. Cummins, J. Tuel, et al., *The Measurement and Use of Lightning Ground Flash Density*, 1995 International Aerospace and Ground Conference on Lightning and Static Electricity, Williamsburg, VA (1995)(noting more than ten-fold variation in number of lightning flashes/(km^2 y) for horizontal distances of tens of km).

96 If the telephone company uses their own ground, the cost of installing a ground rod in 1970 was between $ 10 and $ 15. *General Telephone Co. of Alabama v. Cornish*, 280 So.2d 541, 543 (Ala. 1973). However, the National Electrical Code requires the connection of such a ground rod to the ground in the electrical system in the building. NEC § 800-40(d) (1996).

when victim is employee

When an employee is injured by lightning, there is an additional issue: the employer may be liable for the injuries under Workers' Compensation statutes. There are many reported cases[97] in which Workers' Compensation was awarded for people struck by lightning during their employment.

The plaintiff must produce evidence to show that the conditions of employment increased the probability of the injury[98] compared to the general population. For example, an unemployed person could stay indoors during a thunderstorm. However, when the employer or manager directs an employee to work outside during a local thunderstorm, then the employer has placed the employee at increased risk of injury. If the employee must work in an exposed location during a thunderstorm, such as on a rooftop or on a tower, there is a significantly increased risk of lightning striking the employee. An employer with a fixed location, such as a golf course, *might* also have an obligation to install shelters with adequate lightning rods and grounding, for the protection of employees (and also invitees) who were caught outdoors during a thunderstorm[99].

One case held that an employer was not liable for death from lightning, because there was no causal connection between the employment and lightning. After reviewing cases and treatises, this court summarized:

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[97] *DeLuca v. Board of Park Commissioners*, 107 A. 611 (Conn. 1919); *McKiney v. Reynolds & Manley Lumber Co.*, 54 S.E.2d 471 (Ga.Ct.App. 1949); *E.I.DuPont De Nemours Co. v. Lilly*, 79 N.E.2d 387 (Ind. 1948); *Citizens Independent Telephone Co. v. Davis*, 94 N.E.2d 495 (Ind.App. 1950); *Bowser Const. Co. v. Kowalski*, 605 So.2d 885 (Fla.Ct.App. 1992); *Bales v. Covington*, 228 S.W.2d 446 (Ky.Ct.App. 1950); *Stout v. Elkhorn Coal Co.*, 160 S.W. 31 (Ken.Ct.App. 1942)(victim 112 ft. underground in mine); *Bauer's Case*, 49 N.E.2d 118 (Mass. 1943); *State v. District Court*, 153 N.W. 119 (Minn. 1915); *Reich v. Reich Gardens, Inc.*, 485 S.W.2d 133 (Mo.Ct.App. 1972); *Madura v. City of N.Y.*, 144 N.E. 505 (N.Y. 1924); *Oman Construction Co. v. Hodge*, 329 S.W.2d 842 (Tenn. 1959); *Mason-Dixon Lines v. Lett*, 297 S.W.2d 93 (Tenn. 1956); *State Highway Dept. of Texas v. Kloppenberg*, 371 S.W.2d 793 (Tex.Civ.App. 1963); *Newman v. Industrial Commission*, 234 N.W. 495 (Wisc. 1931); *Carey v. Schroeder Mining Co.*, 283 P.2d 1005 (Wy. 1955).

[98] *Netherton v. Lightning Delivery Co.*, 258 P. 306, 308 (Ariz. 1927); *Case Co. v. Industrial Commission*, 223 N.E.2d 847, 849-850 (Ill. 1966); *Illinois Country Club v. Industrial Commission*, 56 N.E.2d 786, 788 (Ill. 1944); *Citizens Independent Telephone Co. v. Davis*, 94 N.E.2d 495, 497 (Ind.App. 1950); *Caswell's Case*, 26 N.E.2d 328, 330 (Mass. 1940).

[99] *DeLuca v. Board of Park Commissioners*, 107 A. 611, 611 (Conn. 1919)(Noting in passing that decedent took shelter under a tree because "no other shelter had been provided" by the employer.).

> The general rule in all these cases would seem to be that the employer cannot ordinarily be held liable to pay compensation for injury caused by forces of nature which he cannot reasonably foresee and guard against, where the employee is no more subject to injury from such forces than others [in the community], but that the employer is liable where the work or method of doing it exposes the employee to the forces of nature to a greater extent than he would be exposed if not so engaged, or to a greater extent than others in the community are exposed.

Alzina Const. Co. v. Industrial Commission, 141 N.E. 191, 193 (Ill. 1923).

One might say that the victim would not be where he was struck by lightning if the victim had not been there in the course of employment, but this argument is not adequate for recovery under Workers' Compensation.

> As was said by the English court, it is not enough for the applicant to say: "The accident could not have happened if I had not been engaged in the employment, of if I had not been in this particular place." The applicant must go further and say: "The accident arose because of something I was doing in the course of my employment, and because I was exposed by the nature of my employment to some particular danger."

Thier v. Widdifield, 178 N.W. 16, 19 (Mich. 1920) following *Andrew v. Failsworth Industrial Society*, 2. K.B. 32 (1904).

There is a troublesome grey area in deciding if Workers' Compensation should be granted. The Illinois Supreme Court held that a golf caddy stuck by lightning could *not* recover, because there was nothing that placed the caddy at a higher risk than nonemployees on the golf course[100]. But this decision seems wrong, because the caddy would have gone indoors during the thunderstorm, except that he was employed as a caddy and required to remain with the golfer. Indeed, twenty-two years later, a dissent criticized this holding[101]. Courts in other states generally construe Workers' Compensation statutes liberally in favor of workers[102], a policy which makes sense when resolving difficult cases.

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[100] *Illinois Country Club v. Industrial Commission*, 56 N.E.2d 786 (Ill. 1944).

[101] *Case Co. v. Industrial Commission*, 223 N.E.2d 847, 850 (Ill. 1966) (Schaefer, J., dissenting).

[102] *Lyng v. Rao*, 72 So.2d 53, 56 (Fla. 1954); *McCutcheon v. Tri-County Group XV, Inc.*, 920 S.W.2d 627, 631 (Mo.Ct.App. 1996); *Carey v. Schroeder Mining Co.*, 283 P.2d 1005, 1006 (Wyo. 1955).

duty to rescue

It has been known for more than thirty years that it is often possible to use cardio-pulmonary resuscitation (CPR) to revive people who have been "killed" by lightning[103]. Someone who has been struck by lightning and is without a pulse and respiration should *not* be assumed to be dead, instead victims should receive immediate and prolonged resuscitation efforts. Employees who work outdoors should receive instruction in CPR, because of the duty of care to render competent first aid[104]. There is the possibility that a single lightning flash can cause many casualties[105], which could overwhelm a single rescuer.

scientific nonsense

Despite considerable scientific research on the physics of the lightning discharge, judges still take judicial notice of bizarre views of why an object is struck by lightning. For example, one judge ruled at trial that a steel shovel with a wooden handle attracted lightning to the decedent[106]. Another judge held that "steel particularly attracts lightning"[107]. Both a trial judge and an appellate court held that an expert witness was qualified, after the so-called expert witness testified that nails with a length of 3.25 inches in decedent's apron "played an important part" in attracting the

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[103] M.A. Nesmith, Jr., *A Case of Lightning Stroke*, 58 Journal of Florida Medical Association, 36-37, (1971); H.B. Taussig, *'Death' from Lightning – and the Possibility of Living Again*, 68 Annals of Internal Medicine, 1345-1353 (1968); M.R. Ravitch, et al., *Lightning Stroke: Report of a Case with Recovery after Cardiac Massage and Prolonged Artificial Respiration*, 264 The New England Journal of Medicine, 36-38, (1961).

[104] Restatement (Second) Torts § 314B(2) (1965).

[105] G.J. Myers, M.T. Colgan, D.H. VanDyke, *Lightning-Strike Disaster Among Children* 238 J. Am. Med. Assn. 1045 (1977)(group of 47 people, of whom 16 knocked to ground by one lightning flash to a nearby tree, of whom 4 admitted to hospital); J.E. Pakiam and A. Rajaratnam, *An Unusual Lightning Incident in Singapore*, 106 Meteorological Magazine 372 (1977)(one soldier killed and 24 men thrown to ground by one lightning flash); R.H. Golde and W.R. Lee, *Death by Lightning*, 123 Proc. IEE 1163, 1179 (1976)(describing a group of 23 people who were climbing a mountain, of whom 11 were killed by one lightning flash); G.P. Arden, S.H. Harrison, et al., *Lightning Accident at Ascot*, 1 British Med. J. 1450 (1956)(46 people taken to hospital, two of whom died, from one lightning flash).

[106] *Industrial Commission of Ohio v. Carden*, 195 N.E. 551 (Ohio 1935).

[107] *State Highway Dept. v. Kloppenberg*, 371 S.W.2d 793, 795 (Tex.Civ.App. 1963).

lightning to decedent, by furnishing a path of least resistance[108]. Verdicts for plaintiff might be avoided if the defense called an expert witness with experience in scientific research in lightning, to refute such nonsense.

protect equipment

While the focus in most lightning litigation is on injuries to people, there is also economic value in electronic equipment (e.g., computers). The consequential damages from loss of data and failure of equipment to operate after the thunderstorm is often much greater than the cost of replacing the damaged equipment. Thunderstorm warning technology can be used to prevent injuries to both people and electronic equipment. When it is not economical to protect electronic equipment with surge arresters and power conditioning equipment, then disconnecting the equipment from power and telephone lines during a local thunderstorm will prevent damage to the equipment and avoid loss of data stored on hard disks inside computers. For example, the owner of a large office building could provide automatic warning to all tenants in the building of an incipient local thunderstorm, so that the tenants could make more frequent backups of their computer data[109]. In situations where interruptions of commercial utility power are not tolerable, warning systems could be used to start local generators (e.g., powered from diesel oil or propane gas) and then switch critical equipment from utility power to local power[110]. Electronic warning circuits can also be used to disconnect vulnerable, noncritical loads (e.g., water pump motors) from utility networks during local thunderstorms, thereby protecting the loads [111].

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[108] *Pope v. Goodson*, 107 S.E.2d 524, 529 (N.C. 1959).

[109] D.R. Shakarjian and R.B. Standler, *AC Power Disturbance Detector Circuit*, 6 IEEE Transactions on Power Delivery, 536-540 (1991).

[110] L.G. Byerley III and J. Reed, *Lightning Protection by way of Thunderstorm Sensing and Automatic Electrical Isolation*, 1992 International Aerospace and Ground Conference on Lightning and Static Electricity, Atlantic City, NJ, October 1992; L.G. Byerley III, A.E. Pifer, K.L. Cummins, *An Electro Optical, Lightning Detection, Classification and Ranging Sensor for Automatic Lightning Protection and Human Warning*, 21st International Conference on Lightning Protection, Berlin, September 1992.

[111] L.G. Byerley III and J. Reed, *Lightning Protection by way of Thunderstorm Sensing and Automatic Electrical Isolation* 1992 International Aerospace and Ground Conference on Lightning and Static Electricity, Atlantic City, NJ, October 1992; M.A. Uman and R.B. Standler, *Lightning Activated Relay*, U.S. Patent 4,276,576 (30 June 1981); B.J.F. Schonland, *Protection of Apparatus from Lightning Disturbances*, U.S. Patent 2,265,868 (9 Dec 1941).

7. Undertakings

One feature of tort law is that a person may increase his liability by undertaking to provide additional services[112]. For example, there is no duty for a parking garage also to provide security services. However, if a parking garage does hire a security officer, then the garage may be liable for failure of the security officer to prevent a battery on the premises[113]. This part of law makes little economic sense, because the heightened duty of care will discourage people from spending money to provide limited protection, and limited protection is better than no protection.

Would erecting a shelter on a golf course obligate the course also to install lightning rods on the shelter? Should the shelter have walls that would help protect occupants from lightning strikes? By increasing the requirements, we can make the shelters uneconomical. By demanding perfect protection, we can be persuaded not to attempt imperfect protection.

There are also consequences of defective warning systems. Consider a hypothetical situation where a golfer generally goes immediately to the clubhouse whenever he hears thunder. However, this particular golf course is known to have a lightning warning system, so the golfer relies on the warning system and ignores the thunder[114]. Unknown to anyone at the golf course, an electronic component inside the warning system has failed and no warning is issued, although there is an active thunderstorm above the golf course. The golfer is killed by lightning. In this hypothetical, the golfer would have been better to trust his senses (i.e., listen to the thunder) than to rely on technology. This hypothetical emphasizes that if technology is used, it must be inspected and tested periodically[115]. It has been suggested that golf course owners should require the manufacturer of a lightning warning system to contractually assume liability for failure of the warning system[116].

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[112] Restatement (Second) Torts §§ 323, 324A (1965).

[113] Restatement (Second) Torts § 324A (1965); *Erickson v. Curtis Investment Co.*, 447 N.W.2d 165 (Minn. 1989).

[114] Perhaps the golfer assumes the thunder is from lightning too distant to threaten anyone at the golf course.

[115] Restatement (Second) Torts, §§ 300, 307 (1965).

[116] M. Flynn, *Lightning: A Double Hit for Golf Course Operators*, 6 Marq. Sports L.J. 133, 148-149 (1995).

8. Conclusion

The author suggests three ways that employers and managers of recreational facilities should avoid injuries from lightning.

First, any existing shelter in the employer's facility or in recreational areas (e.g., picnic shed) should be protected against lightning. People reasonably expect such shelters to be safer than standing under a tree or standing in an open area. However, a truly lightning-proof building would have sheet metal sides, roof, and floor, with no windows[117]. Such a lightning-proof building would be both expensive and socially unacceptable. Therefore, one must recognize that there may be injuries to people inside shelters that are "protected" against lightning. Practical lightning protection reduces the probability of injury, but does not guarantee zero injuries, while also keeping both the cost of protection reasonable and the appearance of the building socially acceptable.
If shelters are not protected against lightning, then at least a prominent notice should be posted on the shelter that it is not safe during a thunderstorm. And, given the litigious climate in the USA, shelters that are only partially protected against lightning should also have a notice that they are safer than an *un*protected shelter, but not completely safe, during a thunderstorm.

Second, lightning-protected shelters should be constructed where people would expect to be stranded during a thunderstorm. "Stranded" means that the travel time to the nearest public building, building owned by employer, or the parking lot for the facility is more than, for example, three minutes. However, shelters do not need to be constructed in wilderness areas and other remote locations, where reasonable people would not expect to find modern conveniences — the risk of injury from lightning there is part of the experience of "roughing it."

Third, devise a plan for protection of people from lightning and notify all invitees/employees of the plan. This recommendation is similar to the fire evacuation notice that is posted inside doors of hotel guest rooms and similar to safety instructions given to employees. If a lightning warning system is provided, the notice should instruct people to seek shelter if they hear *either* thunder *or* a warning, so that people are not lead to rely on a possibly defective warning.

Wrongful death or personal injury actions involving lightning are often unsavory: the victim often did something *un*reasonable (e.g., play golf during a local thunderstorm or stand under a tree during a local thunderstorm), but now the plaintiff seeks to blame someone else. The use of tort law to evade personal responsibility troubles the author. This general observation notwithstanding, there are many cases in which an employer or operator of recreational facility has behaved negligently and should be liable in tort.

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[117] J.C. Maxwell, *On the Protection of Buildings from Lightning*, 14 Nature 479 (1876).

The author believes that it is good engineering practice, and also beneficial to society, to use technology to prevent injuries to people. Injuries caused by lightning can be avoided by having both (1) electronic warning systems that warn people of imminent hazard from lightning and (2) lightning-protected shelters, where people who have been warned can seek refuge. Based on the author's personal experience in the 1970s, electronic warning systems provide significantly better warning than hearing thunder or seeing dark clouds overhead. Golfers, swimmers, and other invitees who fail to heed a warning siren[118] should be unable to collect damages in tort for injuries caused by lightning, because they have assumed the risk of lightning by failing to seek shelter.

About the Author

Dr. Standler did scientific research in atmospheric electricity and lightning during 1971-79, including two years investigating the differences in response to lightning of blunt- and sharp-tipped lightning rods, and he earned a Ph.D. in physics in 1977. During 1983-93, he did engineering research on protection of electronic circuits and systems from transient overvoltages, such as caused by lightning. After the annihilation of financial support for research in all of his areas of science and engineering, he attended law school during 1995-98, where he wrote this article in 1997. Since 1998, Dr. Standler has been an attorney in Massachusetts.

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[118] Golfers struck by lightning often play during rain and stand on the course during a local thunderstorm. Golfers ignore thunder, so they might also ignore a warning siren.