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The Evolution of Lightning Protection

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Lightning protection has come a long way since Ben Franklin first invented the lightning rod in 1752. While the principles behind the science of lightning protection remain the same, today's structures and their amenities have presented several challenges. Electricity, gas, indoor plumbing, telecommunication systems and irrigation systems have created induction problems for modern structures, allowing lightning's access into a structure through energized lines or system grounds. The lightning protection safety standards address protection for these functions and systems, providing information and detailed installation procedures. These safety standards for installation have been reviewed and revised to not only address a building's needs for the structural lightning protection system, but to also provide requirements to protect the internal functions of the building. In other words, today's lightning protection systems provide practical and tested solutions for the interconnection of grounded building systems, surge suppression, requirements for communication and data lines and the coordinated bonding. This adds up to a total package protection approach-a lot more involved than the basic lightning rod, born from Ben Franklin's genius for invention.

Development of Safety Standards

When questions arise about lightning protection, it is important to know where to turn for accurate and up-to-date technical information. Whether the questions arise on the drawing table or on the job site, there are three nationally recognized authorities that can be consulted for technical information. These authorities are:

- Lightning Protection Institute (LPI); Standard of Practice, LPI-175
- National Fire Protection Association (NFPA); Standard for the Installation of Lightning Protection Systems, NFPA 780
- Underwriters Laboratories (UL); Installation Requirements for Lightning Protection Systems, UL96A, and UL96, Standard for Lightning Protection Components

NFPA 780

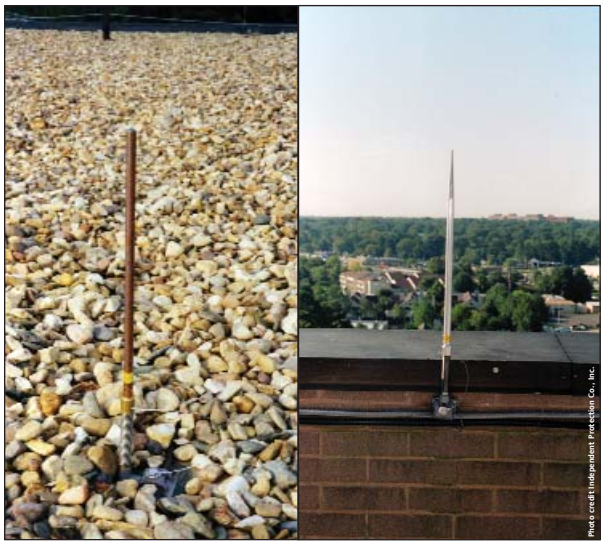
Of these three, NFPA 780 has the longest history and is the most comprehensive standard. The NFPA first adopted "Specifications for Protection of Buildings Against Lightning in 1904." Since its beginning, the NFPA Committee on Lightning Protection has continued to revise and update the standard. The most recent edition was published in 2004. Revisions were adopted on several occasions from 1905 to 1937, and in 1945 the NFPA Committee and a parallel American Safety Association (ASA) Committee shared sponsorship of the NFPA and the National Bureau of Standards. Revised editions of the code/standard continued to be adopted by NFPA from 1949 to 1995. In 1992 the numerical designation of the document was changed from 78 to 780, and the name was changed from "Lightning Protection Code" to "Standard for the Installation of Lightning Protection Systems." At this time, NFPA 780, was accepted as an American National Standard. While the name and number change has sometimes been a source of confusion for lightning protection specifiers, the NFPA Standards Council maintains that the administrative change was necessitated by the need to conform with the NFPA's usual method of naming documents. Since NFPA 780 contains installation requirements, it is more appropriately termed an installation "standard" rather than a "code." The NFPA Catalog of Fire Safety Products and Service describes NFPA 780 as "the latest industry developments and safety practices to help maximize the benefits of various types of protection methods and devices."

UL96A, UL96

UL's experience in the safety testing field since its beginnings in 1894, has earned the organization worldwide recognition and respect. A UL mark on a product or system means that it complies with UL's internationally recognized standards for safety. UL has been testing equipment and inspecting lightning protection systems in the US since 1908. UL's extensive group of field representatives are trained in lightning protection to inspect sites including horse barns, missile silos, homes and high-rise buildings. Some of the most famous buildings in the world are protected by UL Master Label certified lightning protection systems, including the White House and the Sears Tower.

UL has eliminated the previous use of a metal tag mounted to structures and changed to a paper certificate. Today, the "Master Label Certificate Program," is serviced and tracked online through their website. As in years past, UL field representatives visit a site and inspect the lightning protection system after the installation is completed. A certificate of conformance is issued to the owner through the UL listed installing contractor for those projects that comply with the UL96A safe-

ty standard. The UL96 component standard regulates manufacturers of products used in lightning protection systems through on-site factory inspections which are required to qualify components for UL listings and labels.



Air terminals designed with blunt tips and spring-mount bases meet UL-listing requirements for lightning protection and are suitable for high-traffic roof areas.

LPI-175

While NFPA, UL and LPI are all not-for-profit organizations publishing safety information and installation standards for lightning protection, LPI is the only organization which was founded specifically to study lightning protection. LPI started promoting lightning protection education, awareness and safety in 1955. LPI membership is comprised of manufacturers, contractors, scientists, architects, engineers and safety directors-all who are interested in improving the science of lightning protection and promoting lightning safety. In addition to publishing the LPI Standard of Practice to help ensure the best possible quality in lightning protection materials and installation techniques, the institute offers certification and education programming. The LPI's "Master Installer" and "Certified System" programs qualify competence and quality control in the lightning protection industry.

"The Master Installer Program is designed to raise the bar for excellence in lightning protection installation and design, while the Certified System program responds to the quality control requests of government agencies, facility managers, architectural and engineering firms, and insurance underwriters," said Bud VanSickle, executive director for the LPI.

LPI also collects and reviews statistical information and scientific data on the nature and behavior of lightning on a routine basis. The organization presents an "information warehouse" on the web at www.lightning.org.

"We encourage professionals who are not directly or actively involved in the lightning protection industry to join our organization under our Professional member division," said VanSickle. "These members come from fields such as architecture, engineering, insurance, recreational management, government and science. We've learned that lightning safety and risk management are concerns that affect just about everyone."

Risk Assessment and Loss Mitigation

The National Oceanic and Atmospheric Administration's (NOAA) web site (www.noaa.gov) describes lightning as, "the most dangerous and frequently encountered weather hazard that most people experience each year." According to UL, "Lightning accounts for more than one billion dollars annually in structural damage to buildings in the United States. What's not reported is the loss of business, downtime, and liability when business or commercial tenants are forced to shut down to repair lightning damage."

Risk management has led many insurers to require higher levels of safety for commercial structures, hospitals, schools, institutions, sports arenas, and other public facilities. At a time when our world is conditioned by risk evaluation and management, lightning is categorized as a preventable loss. The issue of risk assessment in terms of lightning protection was recently reviewed by the General Accountability Office (GAO). In May of 2005, the GAO released results of a five month evaluation of the Federal Government's approach to protecting its facilities from lightning strikes. The study focused on four Federal agencies, which according to the GAO, represent over 80 percent of government properties. The agencies included in the study were, the General Services Administration (GSA), the United States Postal Service (USPS), the Department of Defense (DoD), and the Veterans Health Administration (VHA). The GAO found that all these agencies require that lightning protection system installations conform to the requirements of the National Fire Protection Assoc. Standard 780 and Underwriters Laboratories

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Standard UL96 and UL96A. The GAO also noted that the referenced standards not only provide material and installation guidelines, but also mandate the use of certified lightning protection installers.

"Lightning protection systems are critical in protecting our national infrastructure and various governmental agencies rely heavily on nationally recognized specifications for lightning protection," said John Kennelly, spokesman for the Lightning Safety Alliance (LSA). This sentiment is echoed by Mitchell Guthrie, technical advisor for the US National Committee Advisory Group to the International Electrotechnical Commission (IEC) TC 81 Panel (lightning protection). "Federal agencies such as the Navy, the VHA, the GSA and the USPS all require the use of the NFPA's Risk Assessment Guide when considering lightning protection," explained Guthrie. "The Risk Assessment Guide evaluates whether or not lightning protection should be installed for both new construction and renovation projects."

While the Risk Assessment Guide is a good rule of thumb for measuring the potential for a strike and damage, sometimes the presence of a single risk or consequence factor is enough to render a structure a potential lightning target or a significant risk worth protecting. Often the cost of installing lightning protection is considered minimal as compared to the potential for loss.

How the Network System Protects

Lightning is electricity. When electricity is confined to a properly designed conductive path, damage can be minimized. Destruction results when electricity encounters resistance, similar to the resistance used in arc welding. When electrical current runs through an arc welder, the resistance it encounters when arcing through air, generates the heat necessary to melt steel. The highly conductive copper and aluminum materials used in a lightning protection system provide a low resistance path for lightning to travel without resistance. When the lightning protection network is in place, a lightning strike is intercepted and directed to ground without impact to a structure or its contents. Without the presence of the low resistance path provided by a lightning protection system (network), the lightning will fight its way through non-conductive building materials like wood, brick, rubber membranes, glass, plastic, etc., on its way to the earth ground. The resistance the lightning encounters will produce heat, fires and even explosions. It is also common for lightning to travel via conductive matter it finds along the way, including plumbing, gutters, flashing, structural members and/or wiring for power, communication or data. None of these systems is designed to provide a safe path to ground for lightning. Providing this safe path to ground is the first focus of a lightning protection system design.

Roof and Ground Network

While the concept behind the lightning protection is relatively simple, the requirements for proper installation are specific and often complex. The single best way to ensure proper system design and installation is to specify compliance with ANSI safety standards for lightning protection (NFPA 780, UL96, UL96A). Strict compliance with the requirements of these standards for the roof system, grounding and surge protection are essential to proper system performance. A lightning protection system includes the following elements:

- A network of prominent strike termination devices
- A network of ground terminations
- A network of conductors or qualified structural steel members interconnecting the strike and ground terminations
- Interconnections with other metallic grounded building systems
- Surge protection devices on all incoming power, data and communication lines

The first three elements of the system intercept, conduct and dissipate the lightning discharge, while the fourth addresses the secondary effects of a strike by limiting the dangers of the harmful current caused by side flashing. The last element protects connected equipment and wiring from damaging currents and surges that can travel on utility lines. Specialized techniques are often needed for specific applications, such as connections across insulated joints, bonding, grounding strips, ground grids and/or ground plates. Failure to make proper provisions for special grounding techniques, or for any of the above five elements can result in inadequate protection.

While it is true that lightning protection is not a new concept, our modern structures have prompted updates and revisions to the safety standards to address problems with lightning entering along energized lines or system grounds. It is not enough to simply provide a lightning path for a structure. Today's lightning protection systems must be designed to cover the contents, equipment, operations and functions housed in a given facility.

"Interconnecting all grounded systems at grade level and roof level to equalize potential and keep lightning on a preferred path is the goal of today's lightning protection system," said Dan McMenamin, longtime international telecommunications consultant. "All power, communication and data lines that enter a structure must be addressed to avoid potential differences and suppression equipment must effectively bond active lines to the ground system. Most lightning hazards can be prevented by using this multi-step approach," he explained.

It is this multi-step approach which led to significant revisions in the 2004 Edition of the NFPA 780 standard, under the section covering surge protection (found under The Protection of Ordinary Structures). Wording in the previous NFPA editions was vague and unclear. The current standard now covers installation information in detail, while also providing the following:

- product requirements to achieve acceptable levels of protection at entrances
- indications for additional needs for internal equipment protection
- specifications regarding addition of grounds specific to surge protection device installation for remote entrances

Quality Control

Lightning protection technology is a specialty discipline and expertise is required for system design and installation. An experienced lightning protection specialist who is certified through LPI will take into account the architecture and contents of a structure without compromising industry safety standards for installation. Installation requirements according to the safety standards are specific and often complex-even for ordinary structures. Requirements for miscellaneous structures, special occupancies, heavy-duty stacks and structures containing flammable vapors, gases or liquids can be stringent with special considerations dictated by NFPA 780. In addition, the safety standards mandate that metal rooftop equipment, such as ventilators, skylight frames, air conditioning units and railings be incorporated into the lightning pro-

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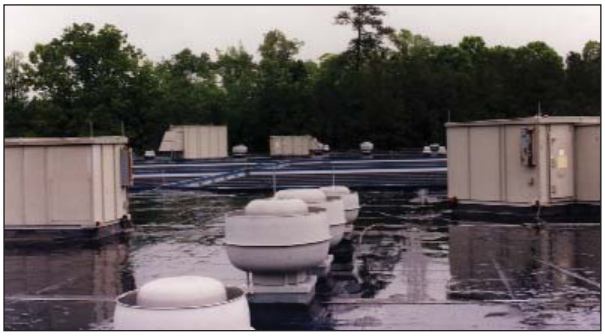
tection system. Connections for these objects depend on their construction, location and skin thickness. A bonding connection might be sufficient to ensure lightning conductivity, or the object may require cable conductors and air terminals, as well as the bonding connection. The experienced and certified lightning protection specialist will know how to interpret the safety standards to meet all requirements with the completed installation.



Bonding metallic bodies and roof components to ensure continuity is a requirement of the lightning protection safety standards.

Lightning Protection Requirements

Studies on lightning protection from scientists, engineers and safety experts have helped increase support for technically valid safety standards and led to specifications of systems for a variety of occupancies. Organizations like the Federal Aviation Administration, NASA and the Department of Defense have long recognized the risks of lightning-induced damage and routinely call for lightning protection systems for their facilities. Lightning protection is routinely installed on correctional facilities, EMS buildings, hotels, schools, hospitals and telecommunication structures. In Florida-the so-called Lightning Capital of the US -state building codes mandate the installation of lightning protection systems for health care facilities, schools and hospitals.

Lightning protection is the focus of a two-year research project at the University of Florida's International Center for Lightning Research and Testing. The study conducted by lightning experts, Dr. Vladimir Rakov, Dr. Martin Uman and Keith Rampo, from the University's Department of Electrical and Computer Engineering, involves triggering natural lightning to strike a full-scale test home equipped with a lightning protection system installed in accordance with NFPA and UL safety standards. To date the test house has been struck numerous times and in each instance the lightning protection system performed as expected, with no damage whatsoever to the structure or its contents. Research continues to quantify the capabilities of direct strike components and monitor indirect effects on internal building systems.

Rakov and Uman are also co-authors of "A Critical Review of Non-Conventional Approaches to Lightning Protection," published in the December, 2002 Bulletin of the American Meteorological Society (BAMS). Rakov and Uman's paper disputes the technical validity of various non-standard lightning protection methods, while touting support for NFPA 780. "The conventional lightning protection technique has proven its effectiveness as evidenced by the comparative statistics of lightning damage to protected and unprotected structures," explained Rakov and Uman. A January 2003 paper titled, "AMS Statement of Lightning Protection Systems," also issued by BAMS reflects a consensus, "The members of the AMS Committee on Atmospheric Electricity have reviewed the modern practices of lightning protection and have concluded that NFPA 780 is a useful standard with a sound scientific basis."

Assessments of when and where lightning protection is needed should ultimately consider the basic principles of lightning, risk assessment for the structure and the fundamentals of the protection system. "The decision to purchase lightning protection is a lot like buying an insurance policy," explains LPI's VanSickle. "Facility owners purchase a system knowing that they will not use it every day, but it will be there to protect them when needed."

The Lightning Protection Institute is a not-for-profit organization founded in 1955. Thier members are dedicated to insuring that today's lightning protection systems are the best possible quality - in design, materials and installation - so that precious lives and property can be protected from the damaging and costly affects of one of nature's most exciting phenomenons - lightning. LPI can be contacted at www.lightning.org or (800) 488-6864.

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