

Proposal of LPS Implementation in Popular Buildings in Manaus City

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Abstract

This research proposes a study about a lightning protection system - LPS applied to popular buildings in the city of Manaus-AM, considering its importance for the protection of the whole structure, as well as the people who circulate in it. Atmospheric discharge is a force of nature, so it is almost impossible to stop this process from occurring or flowing with you. However, measures can be taken to avoid damage to the population, such as risk of death to living beings, as well as problems with electronic equipment and compromise of the building structure, with the adoption of lightning protection system in the most efficient way. . In addition, an atmospheric discharge, when it hits a structure, can cause internal systems to fail, considering that each structure is subject to damage determined by certain factors, such as: type of construction, function of the structure, power lines and metal pipes, among others. . The region and its intrinsic characteristics should also be considered as an indicator of climate change, indicating an increase in the region's occurrence.

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1. Introduction

A Lightning Protection System (LPS) has as its basic objective to prevent the direct incidence of lightning in the structure to be protected, by constituting preferential points of incidence for the discharges that would eventually reach the structure in the absence of the system. For this purpose, in addition to capturing any atmospheric discharge, the LPS should be able to direct the associated current flow directly to the ground, according to defined paths, consisting of the conductors of the protection system [1].

The decision to use a lightning protection system on a structure may be a legal requirement (in municipal

building codes), it becomes a homeowner's precaution to prevent damage or a requirement from insurance companies as lightning strikes are causes of physical damage and fire [2].

With regard to building safety, specifically in the electrical part, the technical standards [3] and [4] can be cited, dealing with low voltage electrical installations and protection of structures against lightning, respectively. [4] sets a number of criteria for the development of an LPS project. This standard divides the components of an LPS into three parts: catchment subsystem, descent subsystem and grounding subsystem [4]. In addition to Brazilian standards, there are several international standards that have in recent years established a number of new criteria, such as [5] and ASE 4022: 2008, ANSI / IEEE std. 142: 2007 [6].

Lightning is a phenomenon of nature that since the beginning has been puzzling man, both the fear caused by noise, as the damage caused. For some primitive civilizations, lightning was a godsend, for with it comes rain and abundance in the fields. For other civilizations it was considered as a punishment, the person who died in a lightning accident had probably irritated the Gods, being the punishment deserved. There were also civilizations that glorified the lightning-struck deceased, for he had been chosen from so many human beings, entitled to a funeral, with special honors.

After so many civilizations man has come to discover that lightning is a phenomenon of nature, of electrical characteristics and so must be conducted as quickly as possible to the ground in order to minimize its destructive effects [1].

The first scientist to realize that this was an electrical phenomenon was Benjamin Franklin (1752), who at the time stated that after placing a metal rod, grounded beneath a storm cloud, as he brought the body closer to the charged cloud, the body it provided the path of contact between the soil and the cloud, flowing to the earth the energy contained in the cloud [7].

After a few years, he became aware of buildings that had been hit and the lightning had not fallen on the metal end. Therefore, it reformulated the theory and stated that the metal tip would be the safest way to safely take the beam to the ground if the tip is struck by lightning. From then on, the region to which this tip would have influence began to be defined (18th century - Gay Lussac) and the first protective cones were started, whose generatrix was a function of a predefined angle, resulting in a cone. with a radius of protection.

The formation of charges in the clouds and their consequent discharge (lightning) to the earth is a normal and natural phenomenon that plagues the earth and afflicts mankind, causing material damage and death, given that the atmospheric discharge is a rapidly spreading electric spark. on land causing irreversible damage [8].

According to [9], which studies the lightning, through the atmospheric electricity group - ELAT, the phenomenon causes damage mainly to the electric sector with the burning of equipment, loss of revenues, increased maintenance expenses and penalties. Its loss is estimated at about 600 million reais, followed by telecommunications companies, with about 100 million reais, and insurance and electronics companies, with about 50 million reais each. Considering that about 60 million lightning strikes occur every year in the country, on average each ray represents a loss of 10 reais in the electricity sector.

Atmospheric discharge (lightning) is a phenomenon of unpredictable nature both in terms of its destructive effects in relation to its electrical characteristics (duration, current, etc.), and when it affects buildings, transmission lines, towers, among others. others may have irreversible damage to the affected locations.

Currently, it is possible to determine the ray density per region more simply through the ceramic index, as well as a range of modern software that accelerate the knowledge of parameters such as waveforms, loads and current amplitudes [7].

The moment the ray is seen with the naked eye, one sees a strong light created by the electric arc of the ray. The noise or thunder called "thunder" is produced by the displacement of the air due to the sudden heat generated by the lightning. According to [10], the formation of the rays occurs by the friction of the water particles, which form the clouds, caused by the strong rising winds giving rise to a large amount of electric charges. The air behaves like a dielectric with a potential difference between the cloud more electrically negative than the earth. There are two forms of discharges: one that originates from the cloud towards the earth (descending) and one that exits from the earth to the cloud (rising).

The lightning protection system (LPS) consists of three subsystems: pickup, descent and grounding [11]. The captor subsystem is basically composed of conductive elements located in the highest part of the building the place to be implanted the system, responsible for the direct contact of the lightning. The descent subsystem has exposed or uncovered conductive elements that allow electrical continuity between the pickups and the grounding subsystem [10]. The grounding subsystem consists of conductive elements buried in the ground or embedded in the foundations of buildings, having the main role of draining the electric current in the ground, where each subsystem is subclassified in "natural" and "unnatural" systems. The structure to be protected determines the basic requirements for installing an LPS and the elements necessary for its composition, must follow ABNT regulations. The standard [4] states that before any application of the standard is to be protected with the LPS, a risk management study is required so that by calculating the need for the LPS in place. Some sites have a low probability of lightning strikes per km², but it cannot be based on this fact alone, numerous factors are considered for this study to be completed correctly.

The number of lightning strikes that influence the structure depends on the dimensions and characteristics of the structures and the connected lines, the environmental characteristics of the structure and the lines, and the density of lightning strikes to the earth in the region where the structure is located. and the lines [4].

This study assures in a clear and demonstrative way through probabilistic calculations, offering the certainty of the usefulness of the system in place, promoting the reduction of unnecessary expenses.

In compliance with the location and its need as the LPS is due to the level of protection adopted. This level will vary from I to IV, which will result in adequate protection efficiency for a given building. The required LPS class should be selected based on a risk assessment [4].

With the new edition of the lightning arrester standard, [4] the efficiency of the Protection Systems has been substantially increased, proving to be as efficient as the standards of other countries, including the fact that it has the standard [6] as a reference.

There are currently three sizing methods: Franklin Method, but with limitations depending on height and level of protection; Faraday cage or mesh method; e Rolling, electrogeometric or dummy ball method.

Franklin's lightning arrester is the most widely used model, consisting of a metal rod where the pickups are located and a conductor cable that goes to the ground and the energy of the electric discharge is dissipated through the grounding [11]. The cable leading from the antenna to the ground must be insulated so as not

to come into contact with the walls of the building, a method commonly used in small buildings [12].

In his experiments, Faraday found that by wrapping a volume through a metal cage, it was shielded from the effects of electromagnetic fields [1]. The method consists of wrapping the upper part of the building with a mesh that captures naked electrical conductors, whose distance between them and according to the desired level of protection. Landing the Faraday Cage it is observed that any upward discharge induced by a downward leader occurs through one of the metal parts of the cage.

The discharge current flows only through the cage, protecting what is inside it [12]. This method is suitable for buildings with a large horizontal area, and is the only method accepted by [4] to protect structures over 60m in height.

The rolling-ball method of the 1980s is an evolution of the Franklin method, being widely used for power transmission line protection, and simplifies application in buildings, serving both for dimensioning the LPS and for checking protection against neighboring buildings, gaps and specific structures such as antennas, solar heating plates, billboards etc., usually placed on top of buildings. The radius of the ball is adopted according to the selected protection level and corresponds to the meeting distance between the rising leader and the steep leader. The Franklin method, due to its limitations imposed by the Standards, is becoming less and less used in buildings and is ideal for small buildings [12].

The rolling sphere method is the latest of the three mentioned and consists of rolling a sphere throughout the building. This sphere will have a radius defined according to the level of protection, the places where the sphere touches the building are the places most exposed to discharges. In summary we can mention that the places where the sphere touches the ray must be protected by metallic elements (Franklin pickups or metallic conductors).

The LPS is a mandatory condition in facilities and buildings as preventive measures, aiming at the protection of people, animals and buildings. It is important to be aware of the obligations and civil and criminal responsibilities related to the LPS, making it possible to identify the attributions of the owners, landlord, administrator, trustee and professionals responsible for the design and maintenance of the building or installation.

International and Brazilian safety technical standards address the implementation of the LPS. It is worth remembering that technical standards are intended to guide, while regulatory ones are mandatory.

The [4] prepared by ABNT, aims to define the minimum and acceptable conditions for: design, implementation, installation and maintenance of the LPS, in structures used for purposes: residential, commercial, industrial, administrative and agricultural. It also standardizes and legally enforces the NR-10 regulatory standard. In addition to these, there are municipal decrees and international standards aimed at overseeing the application of appropriate protections.

NBR [4] replaced NB 165 and set the conditions required for the design, installation and maintenance of lightning protection systems (LPS) of common structures used for commercial, industrial, agricultural, administrative or residential purposes. This standard does not apply to rail, electrical, telecommunications, ships and marine platforms.

The mentioned NBR introduced important modifications: the need to calculate the risk of the building being hit by an atmospheric discharge; establishment of four levels of protection, according to risk and type of structure; permission for the calculation of the Faraday (cage) and electrogeometric (fictitious sphere)

captors in addition to the Franklin method; possibility of using gutters or bluffs as natural catchers; permission for fixing the captors and downconductors directly to the ceiling and walls.

Some observations about LPSs are important: an LPS does not prevent lightning from occurring; An LPS designed and installed to the standard cannot guarantee absolute protection of a structure, people and objects. However, application of the standard greatly reduces the risk of damage; with the new edition of the lightning protection standard, [4] and the science of protection systems has been substantially increased, leaving nothing to be desired in relation to standards in other countries, including the fact that it had the standard [6], as reference.

As described in [4], the LPS is designed to intercept direct lightning strikes to the structure, including lateral discharges to the structures, and conduct the lightning current from the point of impact to earth. The external LPS is also intended to disperse this current into the earth without causing thermal or mechanical damage, or hazardous sparks that may initiate fire or explosion, and must be designed and installed in such a way that, in the event of a direct impact from lightning, There is no melting or fragmentation of material except at the point of impact.

From the premise that the site needs LPS it is necessary to pay attention to the level of protection adopted for the site. This level will vary from I to IV, which will result in adequate protection efficiency for a given building. The required LPS class should be selected based on a risk assessment [4].

According to [1], these four levels of protection can be briefly related to the structures as follows:

- Level I: Applied to structures where a failure of the protection system may cause damage to surrounding structures or the environment, such as explosive, toxic, radioactive factories or deposits, hazardous area industries;
- Level II: applied to structures whose damage in the event of failure will be high or destruction of irreplaceable and / or historical assets, as well as in cases of structures with large crowds of public, therefore, there is a risk of panic;
- Level III: Applied to commonly used structures such as homes, offices, factories (other than hazardous areas) and others.
- Level IV: applied to structures constructed of non-flammable material, with little access by people, and with non-flammable content. As an example, we can highlight reinforced concrete deposits, masonry or metal structure used in the storage of non flammable agricultural products.

In the state of Amazonas alone, 54 million lightning strikes hit the ground in 2017. Given several lightning incidents and poor access to lightning protection systems by the Amazonian population, we sought to raise and raise awareness about importance for use in popular buildings, seeking to protect a particular structure through measures that can mitigate its effects and also reflect on the concern of a portion of the population, to avoid material and personal damage as lightning causes damage and fire [9].

In order to determine the degree of hazardousness inherent in the installation as well as the maintenance of electrical, electronic and telecommunication systems in a particular region, we must first observe the frequency of lightning in that region. The indicators responsible for providing this information are respectively the lightning density and the ceraunic index.

Lightning density can be defined as the number of lightning strikes that reach an area of one (1) km² over a time period of one year, and the ceraune index is defined as the number of days that observed lightning

storms for one year [13].

The value assumed by the lightning density may vary significantly from region to region due to the intensity of latitude rainfall, as well as the relief of the region to be analyzed. Places with high relief tend to have a much higher ray density compared to other regions, and the same situation is observed in places of intense rainfall activity.

The Atmospheric Electricity Group (ELAT) develops research on atmospheric electricity through experimental techniques, numerical models and theoretical studies, this emphasis is given to lightning research in Brazil [14].

Studies published by ELAT analyze data from 1910 to 2010 and clearly show the increased incidence of lightning in large urban centers such as São Paulo, Belo Horizonte, Campinas and Manaus, with the higher frequency of lightning being attributed to temperature increase. (heat islands) and pollution.

With 2014 data, [14] has been conducting studies that address analysis of lightning deaths in Brazil. The historical series from 2000 to 2014 presented, for the first time, the city of São Paulo as the record in number of lightning deaths in the country. In the period, there were 25 lightning deaths in the state capital, against 22 fatalities in Manaus (AM) by 2013, the first placed in the ranking.

Still in 2014, urbanization in the Manaus region is directly related to the increase in lightning in the region. It is estimated that there has been a 50% increase in the lightning rate in this city in the last 30 years, and the current rate of lightning in Manaus is 13.5 rays per km² / year. Moreover, there is an increase of 3 ° C in the maximum temperature of the urban area of Manaus, in relation to the temperature found in the surrounding Amazon Forest, and this factor is responsible for the increase in lightning [14].

The aim of this study is to analyze the implementation of LPS in popular buildings seeking protection against the effect of this natural activity. Presenting a lightning protection system and its particular characteristics, describing the proposal of the need to use the LPS and the adaptations in popular buildings.

2. Materials and Methods

From the point of view of technical procedures, this study sought information from: bibliographic research, as it was prepared from material already published, consisting mainly of books, periodical articles and currently with material available on the Internet. From the point of view of its objectives, this research was framed in a descriptive, explanatory research [15], as it identified the factors that determine and contributed to the occurrence of phenomena and the deepening of knowledge of reality.

Considering that lightning strikes are responsible for damage to structures, telecommunications systems, and electrical transmission and distribution systems, as well as outbreaks and failures that directly impact the proper functioning of the systems as a whole.

Basically the purpose of this work is to present the LPS as proposed by surveying a structure and detailing its degree of risk, assessing the need for protection, scaling the LPS, separating the stages for development, determining the ideal model of risk. protection and grounding system, the evaluation of the necessary criteria for the project following the ABNT norms [4], which has undergone several changes since its last version of 2005. Adequate all conditions for the safety of people and the integrity of structures.

LPS is intended to significantly reduce the effects and propagation of lightning strikes. This can prevent

accidents of major impact and burdens on organizations, further damage to infrastructure, and also protects areas with flammable products within their protective radius. If well idealized is one that is thought from the beginning of the construction of structures. When properly implemented, it tends to reduce costs, as well as increase efficiency, but other cases do not dispense with it, since for their installation, metal cables are installed in meshes or wires ensuring a safe grounding in case of an electric discharge.

3. Results and Discussion

Lightning can cause mechanical damage, damage to persons due to step and touch voltages, and failure or damage to internal system equipment caused by interference from electromagnetic waves generated by such lightning. The effect generated by these electromagnetic waves is called temporary induced overvoltages, which are discharges near the conductor [16].

Failures caused by lightning strikes affect the normal functioning of industries, homes, buildings and other consumer points, causing losses in the production of goods and services. Employing a lightning protection allows a kind of shielding in the structure, both in the external and internal structural part, and for the occupants of this building, against thermal, mechanical and electrical effects associated with these rays [17].

Currently, the use of electrical and electronic equipment is already part of everyday life, being applied in many systems facilitating processes, in turn these equipment, especially electronics are sensitive to electrical disturbances caused by the effects of atmospheric storms that commonly discharge lightning. on or near power grids causing irreversible interference or damage [16].

Brazil is the most lightning struck country in the world. About 50 million lightning strikes a year, according to data from the National Institute for Space Research - [18]. The explanation is geographical: Brazil is the largest country in the tropical zone of the planet, ie the central area where the climate is warmer and therefore more favorable to the formation of storms and lightning.

Lightning can be life-threatening, failure of electrical installations and electronic devices, thus requiring the design of lightning protection systems (LPS), contributing to increased safety, avoiding interruption problems, interference from communication systems and reduces physical damage to structures.

Considering that lightning strikes are responsible for damage to structures, telecommunication systems, power transmission and distribution systems, as well as surges and failures that directly impact the proper functioning of the systems as a whole.

There are no devices or methods capable of modifying natural weather phenomena to the point of preventing lightning from occurring. Lightning strikes on structures (or power lines and metal pipes entering the structures) or on nearby earth are dangerous to people, the structures themselves, their contents and installations.

Therefore, lightning protection measures should be considered in any type of structure or building. The need for protection, the economic benefits of installing protective measures and the choice of appropriate protective measures must be determined in terms of risk management. The risk management method is contained in [4]. Also included are the protective measures considered in [4], which have been shown to be effective in reducing the risks associated with lightning.

All lightning protection measures form the complete lightning protection. For practical reasons, the criteria for design, installation and maintenance of protective measures are considered in two separate groups [4] NBR 5419 (ABNT, 2015):

- The first group refers to protective measures to reduce physical damage and life-threatening hazards within a structure.
- The second group refers to protection measures to reduce electrical and electronic system failures within a structure.

According to the basic criteria for protection of structures, part eight of [4] part one, it is defined in a general aspect, to obtain the ideal protection of a structure, it is necessary to wrap the structure in a shielded and perfectly conductive circuit, that is grounded, of the correct thickness and has adequate equipotential bonding to the electrical lines and metal pipes that the structure has, in order to prevent the discharge current and electromagnetic field from invading internal systems, causing sparks, overvoltages, electromagnetic effects and others. Dangerous disturbances.

It is often considered unfeasible to obtain full protection following these measures, and when poorly designed these protection systems can become an imminent risk, lack of continuity in the shielding of the conductive system or inadequate thicknesses may allow the current to enter lightning, which can cause damage to structures, internal circuits, electronic equipment and life-threatening people. To avoid such problems, protective measures must be taken and designed according to the current parameters and lightning protection levels prescribed in the standard.

An assessment of the need to install a Lightning Protection System is something that has to be done in any building. After this assessment, if it is proved that the building needs such a system, it will need to be designed. To do so, it must be performed by a qualified professional duly registered with CREA.

4. Conclusion

The focus of the study was to evaluate the need to apply the lightning protection system in a structure, demonstrating the criteria used by NBR 5419, since the characteristics of lightning formation, with great incidence in Brazil and the risks and probabilities of damage, which can be caused in sensitive structures, people and systems, causing loss of human life, loss of public service, loss of cultural and economic values. Lightning protection methods and their characteristics, such as catchment subsystems, descent subsystems, and grounding subsystems, internal LPS and equipotentialization systems, bill of materials and positioning, fixing and connection methods have been demonstrated.

The standard that deals with LPS has changed recently, from 42 pages to 309, so also its great importance, given by its update by professionals who work directly with this type of project, mainly due to the existence of many buildings that have poorly designed systems.

From these observations, it should be noted that popular buildings may adapt to their structure according to the referenced standard, which deals with lightning protection, and, from this, a reduction in the value of insurance may be claimed and also request AVCB (Fire Department Appraisal Report), which, together with the fire and panic project, certifies that the building complies with safety standards and is able to fully operate all activities present in the building.

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