Design of a lightning rod system through a ground system. A contribution to the safety of condominium inhabitants at INFONAVIT Buenavista in Veracruz, México.

Miguel Ángel Quiroz García[1], Tomás Martínez Arroyo[2] Gamail González Uscanga[3]

1 Ingeniería Eléctrica, Tecnológico Nacional de México, Veracruz, México
2 Ingeniería Eléctrica, Tecnológico Nacional de México, Veracruz, México
3 Ingeniería Eléctrica, Tecnológico Nacional de México, Veracruz, México

DOI: https://doi.org/10.56293/IJASR.2024.5806

IJASR 2024
VOLUME 7`
ISSUE 2 MARCH – APRIL **ISSN: 2581-7876**

Abstract: This work summarizes the research on the study of the various theories of the lightning phenomenon, as well as the different standards and their use in the development of protection methods to reduce the damage or complete loss of electronic devices. Due to the lightning discharge generated in electrical storms and which are of great magnitude, the use of lightning rod systems in condominiums is proposed; The protection systems against atmospheric discharges are designed considering the type of structure or equipment to be protected, the frequency rate of storms as is the case of the city of Veracruz, especially in the so-called "northern" seasons, other atmospheric loads, all of this for the proper selection of lightning protection as well as a ground system to dissipate the energy generated by the aforementioned discharges.

Keywords: Design, lightning rod system, land system, condominiums, protections.

1. Introduction

During electrical storms, it is very common for lightning to fall on the sea, trees, houses, and buildings, impacting them with a power that varies between 200 thousand and one million volts. When these fall on homes, appliances, and other electrical devices, they can suffer surges (see figure 1) that can cause irreparable damage, shorten their useful life, or become conductors of this discharge and endanger the lives of our family.

For this reason, you should always be protected with a lightning rod; it is vitally important to have one in our home. This device is placed on the roof of the house or building to direct any atmospheric discharge through a conductor to a ground system, preventing people from suffering accidents such as receiving electric shocks and protecting electrical devices from high voltages.

In general, many people are unaware of the importance of lightning rods, because they do not realize or do not pay due attention, since most houses are protected through this connection. However, not all lightning rods are the same since the appropriate one must be used depending on the needs of each structure, for example condominiums that are at greater risk due to their height.

These types of protections are established in the regulations of the electricity law and must be complied with when developing a domestic or industrial electrical installation. Some people do not know about these protections that provide the safeguard of their homes, for this reason it is carried out. this research to have information and share it with urban and rural communities about the protection that a lightning rod can provide in their homes.

Figure 1. Overvoltage are the increase in voltage above established values.
maximum between two points of an electrical circuit or installation
https://www.keybps.com/que-son-las-sobretensiones-y-que-danos-producen#iLightbox[gallery9133]/0

Method description

Description of the condominium to be protected at INFONAVIT Buenavista.

The condominium to which the protection system against electrical storms will be applied under the NMX-J-ANCE- 2005 standard is a condominium located in the INFONAVIT Buenavista in the port of Veracruz, a reference that will allow the identification of the lightning density at land.

Lightning risk analysis according to NFPA - 780 standard

The methodology proposed by the NFPA 780 standard is a simple analysis that consists of comparing 2 equations to determine whether the structure under study needs a lightning protection system. For this, the following factors are considered.

- Building environment.
- Type of construction
- Occupation of the structure
- Content of the structure

Consequence of lightning strikes

As a first step, an estimate must be made of the frequency of lightning strikes that could occur in the structure. For this, the equation is used.

Nd = (Ng) (C1) 10-6)

Where:

Nd: Annual frequency of lightning strikes on the structure.
Ng: Average lightning density in the structure in the place where it is located.
Ae: Collective equivalent area of the structure.

C1: Environment coefficient

The C1 coefficient determines whether there are smaller or equal taller structures surrounding the study structure within a radius of 3H, where H is the height of the analysis structure.

Because it is a high-rise condominium, the average annual permitted frequency of direct rays on the structure (Nd) is considered 0.02.

Figures 2 and 3 show the location of the condominium and its façade. The condominium has the dimensions shown in the following table 1, based on the INFONAVIT architectural plans.

Figure 2. Location of the condominium

Lightning Rod with Priming Device

It is a high-tech external lightning protection system. These PDC type lightning rods are also known as active lightning rods and must comply with the Standards or Regulations that apply to them, both national and international (mainly the standards UNE 21,186, NFC 17,102, Technical Building Code section SU8, and NP4426).

Figure 3. condominium INFONAVIT

It is composed of a sensing tip, a priming device, a fixing element, and a connection to the down conductor. The protected zone of a PDC is determined by its effectiveness.

Effectiveness of a PDC.

A PDC is characterized by its ΔT efficiency, which is obtained in the evaluation tests. The maximum admissible value of ΔT is 60μs, although higher results have been obtained in the tests.

Protection radius:

The protection radius of a PDC depends on its height (h) with respect to the surface to be protected, its advance time and the selected protection level.

- R^P (h) (m) = It is the protection radius at a given height (h).
- h (m) = It is the height of the tip of the PDC above the horizontal plane of the farthest point to be protected.
- r (m) = 20m for protection level I.
- 30m for protection level II.
- 45m for protection level III.
- 60m for protection level IV.
- Δ(m) = ΔT x

This standard regulates the design, construction, review, and maintenance of installations made with lightning rods with priming devices. The purpose of these facilities is to protect people and material assets as effectively as possible.

"…The inspection frequencies indicated in the table should be applied when there are no specific requirements from the competent authorities.

In addition, this standard recommends carrying out periodic verifications in those installations that have a lightning rod with a priming device, whose periodicity is given by the level of protection of the installation according to the following table No. 1:

	Normal Frequency	Special periodicity
Level I	2 years	1 year
Level II	3 years	2 years
Level III	3 years	2 years

Table 1. Periodic Verifications
https://grupoica.eu/revision-de-pararrayos/

Area	Height	Structure side lengths:	
		Long	Broad
65 m^2	8 m	12 m	5 m

Table 2. Measurements in the structures

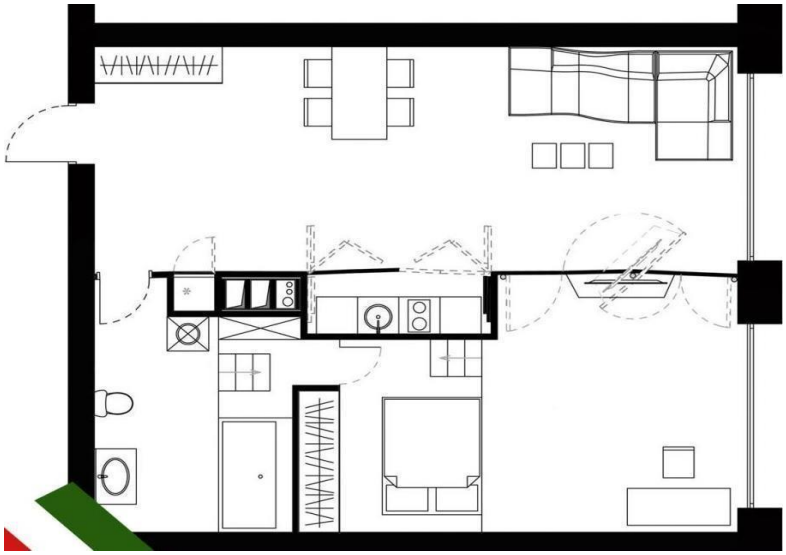

Figure 4. Sketch of the INFONAVIT condominium

With respect to the figure, the structure of the condominium is spacious so there is a variety of rooms such as bathrooms, living room, and other rooms. Each one of them needs the power supply for all its equipment, which is why protection against atmospheric discharges must be considered, since these, when impacting a condominium, can damage many of the electrical, control, force, among others, that make up homes and therefore the problem can reach the inhabitants' equipment, and even damage people.

Risk assessment.

The location of the condominium is important because it allows us to evaluate the level of risk in which the structure is located. When it is installed in areas where the density of lightning to Earth is greater than 2, an extensive protection system against atmospheric discharges must be developed. Therefore, in Based on the location of the condominium, the density of lightning strikes to Earth per year was identified with support from the previous figures.

The coordinates were obtained (in decimal 19.10º, -96.6º corresponding to what INFONAVIT Buenavista is in the port of Veracruz, where the condominiums are located.

The resulting annual ground lightning density (ng) for the condominium corresponds to 4 lightning strikes/km2/year, so an external protection system against atmospheric discharges must be installed.

To identify with what annual frequency the structure will be struck by direct lightning, I know that this probability will be calculated with the following equation.

N0 = Ng x Ae x 10-6

The equivalent area will be calculated with the data obtained with the architectural plan of the condominium and with the support of the following equation where the condominium is located on the ground and roof of the plans.

$$Ae = ab + 6h(a + b) + 9\pi h2$$

Substituting the values into the equation:

$$Ae = (12m \times 5m) + 6(8m)(12m + 5m) + 9(3.1416)(8)2$$

$$Ae = 2685.56m2$$

Proceeding to replace No:

No = (4 rays/km2/year) x 2685.56m2 x 10-6 No = 0.010 per year

Another way to consider whether to install an external thunderstorm protection system in the condominium is to estimate the need for protection.

Since No (0.010) is < Nd (0.02), an external protection system against atmospheric discharges should not be installed.

Developed the analysis of the risk assessment in the condominiums and considering that the implementation of an external protection system against atmospheric discharges is not necessary, considering the municipal multi-family condominium that is located in the center on 5 de Mayo Street between Montesinos and constitution in the port of Veracruz, Mexico, has a height of 18m, the choice of the elements that make up this system is developed based on the protection radius.

Figure 4. Sketch of the INFONAVIT condominium

Protection radius calculation.

The calculation of the protection radius must be carried out using the rolling sphere method. To determine the radius of the sphere it is necessary to identify and select the protection level. Because it is a condominium structure, damage to electrical installations, panic, failure of electronic devices, loss of communication link, computer failure and loss of information are considered the effects of electrical storms, therefore, the level of protection What is recommended with respect to the standard table is Protection Level 1.

The protection level allows identifying the radius of the rolling sphere (rs), showing the results in table 3.

Posicionamiento del sistema de captura (pararrayos)

			Nivel de protección de rayo (LPL)			
	Símbolo	Unidad	I	II	III	IV
Corriente pico mínimo	I	kA	3	5	10	16
Radio de la esfera rodante	R	m	20	30	45	60

Table 3. Minimum values of lightning current and radii of the rolling sphere for each lightning protection level (LPL), according to IEC 6235.

Taken from: https://electrica.mx/metodo-de-la-esfera-rodante/

Corroborating the results of the radius of the sphere obtained from the previous table, the radius of the rolling sphere is calculated based on the following equation.

Identifying that k and c are factors obtained through field studies of potential gradient of large electric arcs generated in the laboratory, we have that k = 9.4 and c = 2/3, taking I = 6kA.

Substituting the data we obtain:

$$rs = (9.4)\ sx\ (3)2/3$$
$$rs = 19.55 \approx 18m$$

Considering that the rolling sphere will have a diameter of 36m, a lightning rod will be located in the center of the circumference. The installation of which must be considered around the entire condominium, lightning rod tips marked in magenta and 76 points of intersection with the horizontal conductor for the protection of the condominium throughout the roof of the building, marked in blue, figure 5.

Selection of lightning rods.

The height of the terminals is limited with respect to the standard to 3m above the object to be protected, considering the protection radius in the design. For this reason, Franklin tips 60cm high are proposed for installation. To calculate the number of air terminals and their location, it should be considered to additionally install horizontal conductors around the condominium, forming closed loops at every 20m of height with bare conductor gauge 4/0, 107.21m$m2$, 28 wires, provided that the height of the condominium is at 20m high.

Reading and interest in reading

Internal protection system against electrical storms.
Arrangement of the grounding system.

Every protection system against electrical storms must be connected to a grounding system (STP) to reduce step and contact potentials, trying to reduce the risk of electrocution and formation of electric arcs in metal parts that endanger people. people and the team.

Each down conductor will have an arrangement of 3 electrodes with the configuration shown in the following figure. When these are not interconnected with each other, it must maintain a level no greater than 10Ω as a ground resistance value for each electrode arrangement. of the down conductors. The electrodes must be joined with buried horizontal bare conductors, in addition to each one being in a register with dimensions of 32cm x 32cm x 3

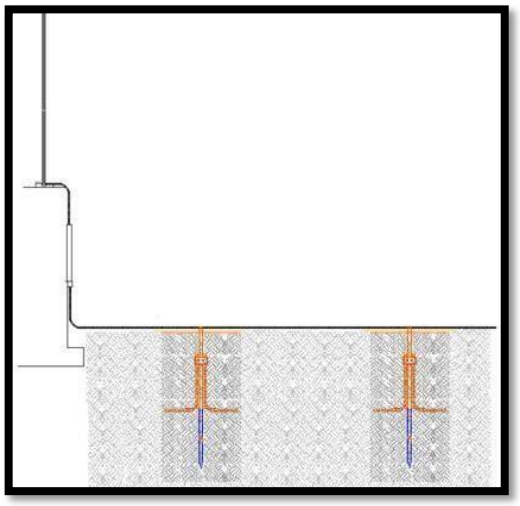

Figure 5. Grounding

The grounding electrodes will be steel rods with copper coating to provide protection against soil corrosion. Their length is proposed to be 3m, 16mm (5/8 in). For installation, care must be taken to ensure their separation. It will be twice the length of the electrode. For horizontal electrodes, their installation will be at a minimum depth of 0.6m at a minimum distance of 1m from the structure.

In this case, the area around the structure is covered with concrete, therefore, it is not necessary to install additional arrangements of grounding systems to protect the traffic of people against the risk of electrocution.

Actions for the conservation of lightning rods.

The conservation of lightning rods is very important, since it allows the External System of Protection against Electrical Storms and the Internal System of Protection against Electrical Storms to be in good condition for their proper functioning, as well as avoiding other types of risks for people that occur when mall. For this reason, it is necessary that it be properly maintained by trained personnel, around every six months of the year.

Mainly qualitative tests are carried out, where the state of all the elements of the system are reviewed, another test is quantitative, in this some measurements are carried out and finally preventive maintenance must be given, some of these procedures are listed below. continuation.

Qualitative tests.

- Check the head of the lightning rods.
- Check the mooring and possible oxidation of the mast.
- Check the condition of the lightning rod conductor cable.
- Check mooring, connectors, and protection tube
- Check that no new element has changed the conditions of the original lightning rod installation study.
- Check the status of the voltage suppressor.
- Check the physical condition of the mast.

Quantitative tests.

o Grounding. Check ties, connectors, and measurement of ground resistance, remembering that it must not exceed 10Ω.
o Measure the resistance of the grounding electrode; it should not exceed 10Ω.
o Measure the continuity of the electrode-cable connection.
o Measure the continuity of the cable-cable connection.

Preventive Maintenance.

- Clean the ground register.
- Retighten the electrode-cable connections.
- Check the grip and connection points of the tensioners.
- Check the lightning rod support insulation.

Verification and maintenance

The maintenance of any SPCR is essential, in fact certain components can lose their effectiveness over time, due to corrosion, atmospheric influences, mechanical shocks and lightning strikes. The mechanical and electrical characteristics of a lightning protection system must be maintained throughout its life, to satisfy regulatory requirements.

Economic analysis in the installation of the lightning rod system.

In a condominium it is important to invest in a protection system since due to its dimensions and application it is necessary to provide security for both its inhabitants and the electronic devices, in addition to the equipment that is

installed inside. Below, figure 6 shows the economic budget of the main elements needed for the installation of the Electrical Storm Protection System, considering for each one the indirect costs, labor, and the engineering project.

COMENTARIOS FINALES

In protection against atmospheric surges, it is important to consider the installation of protection against direct atmospheric discharges because condominiums are at greater risk due to their height and some do not have any type of protection against this type of phenomena, leaving very vulnerable people present in the same an therefore risking interruptions due to failures in the operation of this equipment.

A correct design, selection, and installation of protection devices against atmospheric surges due to direct impacts, combined with the already existing lightning rods and ground systems of the condominiums, will allow any discharge current to be quickly and reliably dispersed; It will also bring with it a continuous and lasting operation of the substation, but above all that the personnel will be adequately protected.

The grounding system serves to protect electrical and electronic devices, but the main objective of this internal protection system is to protect the life of living beings. The value of the resistivity of a ground can vary according to certain factors. In the installation of a grounding system, an important factor is the resistance it offers to the passage of current. This resistance varies according to some elements. Limit the voltages of the metal parts of the equipment or machines to values that are not dangerous for humans.

For the protection of the condominium, it is important to recognize the work carried out by electrical engineering since the work carried out by engineers when developing an electrical installation project is very important. These people should not lose the objective of their work, but above all, safety. of people: In this case, the protection of maintenance personnel is also considered, since they are the ones who enter the main areas of all types of installations.

The NMX-J-549 standard presents the considerations and the necessary method for the protection of people since it governs how to carry out the installation of a protection system against atmospheric discharges depending on the domain to be protected and its location.

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