XIX INTERNATIONAL ELECTRICAL ENGINEERING SYMPOSIUM

Title

Earlier Streamer Emission terminals (E.S.E.) homologation in Cuba, an experience that began more than 20 years ago.

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Abstract

This paper analyzes the convenience of the decision taken in 1997, in the Cuban Republic, to authorize the use in the country of Lightning Rods with Early Streamer Emission (E.S.E. rods), through a process of homologation. Such action was carried out by the Fire Department, in the figure of the Fire Protection Agency (APCI), who was given the task of studying and broadening the knowledge of such technologies.

Following 24 years from that decision, this document analyzes the background; the reasons that led to its homologation, homologation requirements, as well as the standardization process. In order to complete this, the analysis of results carried out by the APCI based on the data and information taken from the ESE's systems projected and installed in Cuba, for which the number of devices installed was considered, the calculation of the expected frequency of lightning strikes, the average annual distribution of ground discharges, and the dimensions of a typical building.

The economic importance that the great difference in cost per installed protection system has had for our country is also analyzed, where the prices of passive systems are compared with ESE systems. Specifically, when it comes to protection in large and complex areas, ESE systems have allowed for a much larger number of installations with the available investment.

Keywords: Lightning rods; E.S.E. air terminals; Homologation process; Lightning Protection

1. Introduction

Integral protection against lightning is a subject of the utmost importance in Cuba, due to the elevated number of thunderstorm days per year, which makes the island one of the countries with the highest lightning incidence in the world and, therefore, where the death and injury rate is higher.

In addition to these already elevated indicators, during the last years Cuba has suffered an increase of around 40 storm days (ceraunic level) in practically all territories. Therefore, values between 110 and 170 thunderstorm days per year are reached throughout the country. The following figure shows the distribution of this parameter according to the most recent study [1] made in the island in the year 2020.

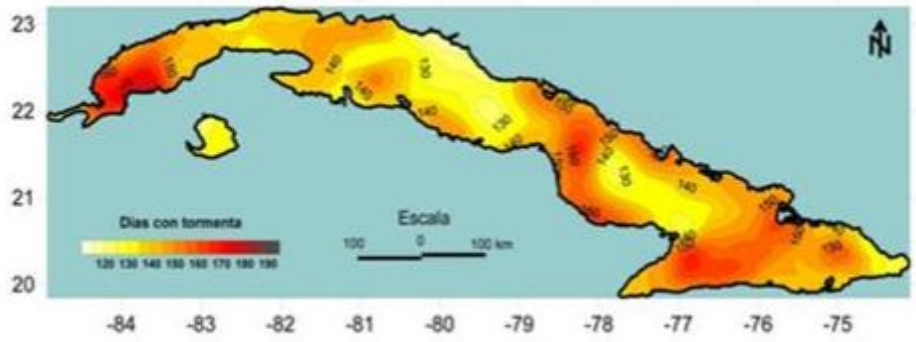

Fig.1 Spatial distribution of the average annual [1] thunderstorm days (ceraunic level) in Cuba (chart scale base 1:250000)

In spite of the institutional control and monitoring of lightning protection carried out, today lightning is the first cause of death by natural phenomenon, highlighting priority to the attention that should be given to this phenomenon.

2. Background

In 1995, the Cuban Fire Protection Agency (APCI) was created, an entity that belongs to the Cuba Republic Fire Protection System, whose identity Manual motto is *"the only wise decision"*. This points out directly to the aims of protection, highlighting that the best option is not to fight against fire but to avoid its occurrence, taking the necessary measures to achieve it.

Two years later, in 1997, as no regulation existed for works related to lightning protection, the Fire Department, through APCI, took the decision to establish the required system, since the great demand of protection against such frequent and destructive phenomenon in Cuba had led to the installation of an important number of Early Streamer Emission (ESE) lightning air terminals in our country.

With this aim, a process for the homologation of these air terminals was organized and executed, which would be employed for regulating their commercialization and use in the country. Those devices were demanded to accomplish with the established quality requirements, to present laboratory tests and to follow the requirements of the relevant standards for these devices, mainly the Spanish standard UNE21186, since there were no Cuban standards for the same.

On another side, since Cuban standards for passive lightning protection [2] were not updated, international standards [3] were being employed.

3. Standardization process: the Cuban Standard NC 1185

The homologation process was not enough for solving the problematics related to the use of lightning protection technologies. It became evident that there was a need for a national, mainly practical standard to unify all lightning protection criteria and technologies, both passive or conventional and active (with ESE air terminals) systems.

Both systems had been used in Cuba for lightning protection with good results, though recognizing that ESE technology was the one mostly installed. Such preference of active systems was due, essentially, to two reasons: on one side, the cost difference for the installation of those technologies and, on another, to the difficulties in the application of technical criteria of the standards [4] [5] to existing structures, with limited space and architectural restrictions. In such buildings, it becomes very complex and costly to achieve a solution that guarantees compliance with the requirements of those standards, perhaps relating more to new buildings.

The National Standard was pretended to be intensively used by project **designers** in general and also for those devoted to these specialized systems, for **installers** (companies

duly certified by APCI), **auditors** (competent authorities such as Fire Department and APCI) and **end users** (entities where lightning protection systems are installed).

With those precedents, a draft of the demanded standard was developed with the participation of experts from APCI, the Fire Department, different Governmental entities, public design and installation companies and large users. The document was approved by the CTN #13 (Fire Protection), presented to the National Standardization Office (ONN) and approved as Cuban Standard with the Resolution Nr. 111 of 2017 of ONN General Director. The result was NC 1185: 2017 Protection against lightning — Integral security in front of lightning. [8] (Obligatory), which superseding NC 96-02-09:1987 was an important step in the standardization and control of lightning protection systems.

4. Revision of the Standard NC 1185

After more than one year of validity of the Standard NC 1185, and being used by a great part of the specialists in the country, a revision of the document was required by the president of the Standardization Technical Committee Nr. 64 "Lightning", suggesting that the clauses referring ESE installation should become informative, claiming that:

- ✓ the use of ESE air terminals is not considered in the requirements of NC-IEC 62305 standards.
- ✓ the use of ESE air terminals increases the damages to electronic equipment inside the buildings.
- ✓ there is no theoretical basement that justifies the functioning of ESE air terminals, though recognizing the existence of thousands of such installations in Cuba with good results and an advantageous relation cost/benefits, provided the low cases of unwanted events.

After this, there was a process of revision, made by the Standardization Technical Committee Nr.13 (CTN #13) of the Fire Department, together with other competent experts of governmental organisms and university study and research centers, which by majority coincided about keeping the original standard, since there were no actual reasons

for modifying the text when considering the positive experience in the use of ESE air terminals during more than 20 years.

As a summary of that revision process, the Standardization Technical Committee Nr.13 (CTN #13) and the National Standardization Office (ONN) met on Monday 29th July 2019 with the assistance and participation of APCI, the Cuban Fire Department, the Ministries of Interior, Army, Tourism, Internal Trade, Health, Energy and Mines and Communication, the Central University of Las Villas; public companies, installers and large end users, which by unanimity claimed to maintain the standard. With this result, ONN decided to keep the standard with the same original number and name NC 1185: 2020 Protection against lightning — Integral security in front of lightning. [9], due to:

- ✓ The positive experience of the use in Cuba for lightning protection of all kind of structures, using ESE air terminals with no significant failure events
- ✓ The lack of empirical or technical base supporting the statement that the use of ESE air terminals increases the damages to electronic equipment inside the buildings
- ✓ The non-existence of technical contradiction with other existing standards in the country
- ✓ The strict process that APCI had established for the use and monitoring of those devices, referred to product homologation and for the certification of entities and their staff.

This last point embraces the design, installation and maintenance of Lightning Protection Systems. Also includes their Certification and Commissioning once they are installed, as well as their posterior Verification. All this guarantees the control and monitoring of the safety conditions that has been previously established, comprising from design, evaluation and employed products to the commissioning.

5. Results

After this analysis, and in order to corroborate the efficiency of the decision taken in 1997 of homologating ESE air terminals in Cuba, reference data is taken from an interesting

study [9], where the comparative between the number of passive and ESE systems in Cuba, as well as the negative incidences in both, considering the cumulative years of service of all the installations. The following table belongs to the mentioned study:

Total nr of installations	Installations with ESE	Passive installations	Incidents in ESE installations	Incidents in passive installations	Cumulative years of service of all the installations
9271	8433	838	19	5	101981

Table 1. LPS distribution in Cuba

The former exposed records show a total of 24 incidences, which are approximately 0.26% of all installations. From these incidences, 19 occurred in LPS based on ESE air terminals, which means 0.23% of the whole ESE installations, and 5 in conventional LPS, that is, 0.6% of all conventional installations. That is, the rate of incidences in ESE installations is lower than in passive installations.

Two types of incidences were found:

- Damage to the structure: identified damages include small cracks, as well as minor damage to roofs and corners.
- Damage to the air terminal: related to the air terminal breakage, getting out of service, although the discharge was attached and driven to earth with no damages to the structure.

For the particular case of Villa Clara province, up to October 2011 there were 790 installations protected with ESE air terminal, that is 11.38% of all ESE LPS in Cuba. Up to that date, only 2 incidents with damages were reported, both at the hotel zone of the northern keys, which has a high lightning density and many hotels protected with ESE air terminals. One of them was in Hotel Villa Las Brujas, although later the analysis of the assurance company demonstrated that there was a direct strike to the air terminal and the damages were caused by the secondary effects (overvoltages), since no surge protection had been installed at that time. The other incident occurred in Hotel Ensenachos, causing

the rupture of an exterior decoration of the Lobby in the Main Building, placed inside the air terminal protected volume. The report of damages showed that the air terminal was not six meters above the roof to be protected, so the protection zone was not correct. None of the two cases, therefore, point to a failure of the interception device.

6. Installation cost difference between different lightning protection technologies

The drastic reduction of costs, both in materials and in installation labors, has been long evidenced when using ESE systems.

The result of a study and the comparative analysis for a real installation is presented below. Data are taken from two examples of the same installation, i.e., using one technology or the other.

For the analysis, the following points were taken into account:

- ✓ Amount of material to employ for identical structure dimensions (A (length) x B (width) x H (height)),
- ✓ Lightning Protection Level guaranties for lightning protection (external, internal and earthing) with passive technology and ESE air terminals,
- ✓ the fact that there were real installations, worked and tendered for installation in 2016.

The comparative study gives a cost of 38 494.92 USD for the passive or conventional system, while the cost with ESE is 6 134.69 USD. Therefore, results in a decrease of 32 360.23 USD in direct costs of the employed materials.

The full calculations should include the costs of the installation works, which would be also significantly higher for the passive systems, since more material obviously implies more work and therefore more costs of labor, transport and insurance in general.

The comparation of those costs, maintaining the guaranties and quality of the protection, made that the ESE option was chosen, which is now installed and in use with no evidence of unwanted events there.

7. Conclusions

After the analysis of the information collected during all these years about the protection systems and the installed types, together with the existing normative development, our conclusions are the following:

i. The decision, made in 1997, of homologating ESE air terminals in Cuba, was correct in view of the protection results obtained.

ii. Considering all the time that has passed, 24 years, the consolidation of the practice and the effectiveness of this technology should be ratified.

iii. The evident lower cost per installation when using ESE in comparison to the passive or conventional systems, has allowed for a significant increment of the protected structures in our country. In the above commented example, the cost reduction, considering only material, is 84%.

iv. In general terms, the cost of a conventional installation compared with an active one, depending on the extension and complexity of the structures to be protected, rates between two and ten times higher.

v. The number of installations protected with ESE systems has grown approximately 60% in the last 10 years, with no unwanted event reports.

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