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# Standards, regulations and environmental Responsibility in design of LPS

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**Abstract— this paper deals with the accumulated experience measured worldwide, by French actors (from research to industry through standards and laws . Also it deals with the choice of environmental responsibility and contribution to lower carbon print impact. First, this paper approaches the positive experience for reducing risk of ESEAT prescriptions, and evokes the various tests implemented all over the world. Then, the Lightning Protection Systems are associated to standard and to the regulations and law in force in France and some original installations of lightning protection implemented are briefly described. Last but not least, it mentions the first observations correlating the increase of lightning strikes, and storms occurrence, to global warning. Finally this paper draw attention of the lightning protection actors, to the necessary environmental responsibility on their choice of solutions.**

***Keywords—Early Streamer Emission; Air-terminal; Standard, Raw of material, global warning, carbon print – ESEAT devices***

## I. INTRODUCTION

Lightning is a phenomenon studied since the origin of mankind on Earth, and the first lightning protection solutions appeared more than 200 years ago.

Lightning is actually subject of large studies for long, and since, there is still a huge part to caracterise, on the behavior of lightning storms, attachement processes, upward and downward leaders and so on… Climatically speaking, it is considered as providing an a part of the electrical and electrostatic balance on Earth.

In France, to perform and invest in these issues, lightning professionals have organized themselves and use their expertise and experience return for the benefit of people and goods in order to reduce their vulnerability to lightning phenomenon. Nevertheless, it is important to keep in mind that there is no such thing as risk zero.

## II. WORLWIDE EXPERIENCE FEEDBACK

The development of lightning protection systems, specifically ESEAT, is, for decades now, validated by several laboratory and in situ experiments.

While it is impossible to replicate the whole lightning phenomenon, the combination of processes, lab means added to in situ experimentations, observations, expertises and investigations, have enable to ascertain a level of efficiency permitting to evidence a reduction of vulnerability with such lightning protection systems.

These experiments are, in laboratories, realized using:

- Marx generators supplying very High Voltage (until 1MV)
- Current generators supplying very high currents (until 200 kA)
- Different test platforms which can simulate wind, vibrations, rain, …

Science progress enable to provide devices more and more powerful and adapted for the replication of lightning phenomenon. The tests which can be carried are therefore more and more relevant, and are no more questioned for being too far from the lightning phenomenon.

The experiments, are, in real conditions, being realized throughoult the world, in high keraunic level areas, with ESEAT devices/simple rod devices, under specific both standard LPS installations, or more sophisticated ones, adding observation tools.

This worldwide experimentations, tests, campains, measures, statistics, expertises have been consolidated by the French Government through its Referential authority in Lightning Protection ‘’INERIS’’ in a book published in 2016.

The French lightning organization (industrial and research) is considered as far in advance it this field for its already structurated law, standards and controls together built up by both GIMELEC, AFNOR, and INERIS contributions.

## III. STANDARDS AND REGULATION

***S***tandardization

In France, lightning protection is regulated by different standards and guides. The official body which is in charge of standardization is AFNOR.

The available documents are sorted into different categories:

- Lightning Risk Analysis Standards
  - NF EN C 17-102:2011, lightning protection system by Early Streamer Emission Air Terminal [1]
  - NF EN 62305-2, Lightning protection Part 2: risks evaluation [2]
- « Products » Standards, which characterize the requirements for lightning protection material.
  - NF EN C 17-102:2011 (ESE)
  - IEC 62561 series (7 volumes) (components) [3]
  - IEC 61643 series (SPD) [4]
  - IEC 62793 standard (Storm detector) [5]
- Installation Standards, which characterize the implementation rules of the protections:
  - NF EN C 17-102:2011, lightning protection system by Early Streamer Emission Air Terminal
  - NF EN 62305-3, Lightning protection Part 3 : Physical damages on structures and life hazard [6]
  - NF EN 62305-4, Lightning protection Part 4 : Protection against lightning - Part 4: Electrical and electronic systems within structures [7]
- Some Practical guides which enable to describe, through examples, some installation standards or risk analysis

Certifications and requirements

France was among the first nations in the world to structure and to impose requirements and a certification system for lightning professionals.

Thus in 2001, the Qualifoudre certification was validated by the Ministry of Environment, through the implementation of an INERIS framework.

This certification allowed to professionalize the occupation, and to ensure an expertise of the certified companies, based on a framework continuously up-dated.

To build-up some datas, experimentations, and all necessary knowledge, practice, experience gathered, the GIMELEC organization brings its permanent support.

French regulation

Various French decrees require to implement a lightning protection or, in the first instance, to carry out a study regarding the site vulnerability.

The ICPE industrial sites (Installation classified for the Protection of the Environment) subjected to the modified decree from October 4th 2010 are obliged to:

- Carry out a Lightning Technical Study, if the site is declared vulnerable by a Lightning Risk Assessment
- Install the Lightning Protection Systems prescribed in the Lightning Technical Study
- Verify the installation via an independent organization.

The decree from December 30th 2011, related to the High-Rise Buildings, imposes the implementation of a lightning protection by means of air terminal for this type of building.

The modified decree related to Public-Access Buildings, from June 21st 1980, imposes the implementation of lightning protection for some sites:

The inter-ministerial Circular from February 22th 2016, confirms and clarifies these different decrees, expanding the ESEAT prescription, and put them together in one document.

## IV. FRENCH ORIGINAL ACHIEVEMENTS

It is worth mentioning that some protected sites are outstanding, and that some protection systems are innovative and different from mainstream installations.

Eiffel Tower

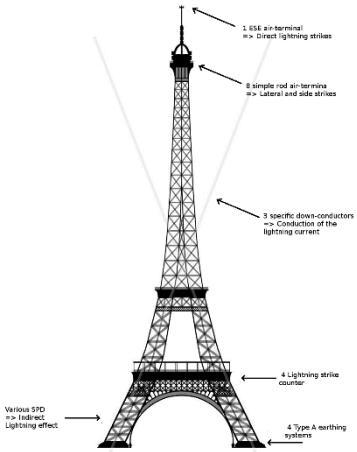
The Eiffel Tower is protected against lightning strikes through a protection system exceeding the standard requirements.

It is firstly made of several types of air terminals:

- 1 air terminal (ESE) at the top.
- 8 air terminals (Simple rods) installed in ring around the 3rd floor.
- Metal structure built in wrought iron, which serve as a faraday cage.

Three copper straps with section larger than 200 mm² (well beyond standard requirements) are installed on three out of the four edges of the Tower. These straps serve as down conductors. Their very good conductivity ($\sigma$ = 9,93x106 S/m) enables to carry the greater part of the current towards the ground.

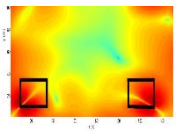
Moreover, the structure and the 3 down conductors are connected to 4 earthing systems at the 4 pillars. Equipotential connections link the pillars with each other, and prevent any potential difference and any possible unwanted earth potential rise.




4 lightning strike counter enable to register events and help the preventive maintenance of the EIFFE tower.

Surge protector devices (Class I/II) are installed in the different low-voltage boards as a supplement to the lightning protection.

A digital study [8] of the Eiffel Tower via a FDTD software confirmed that teh current intalled protection has:

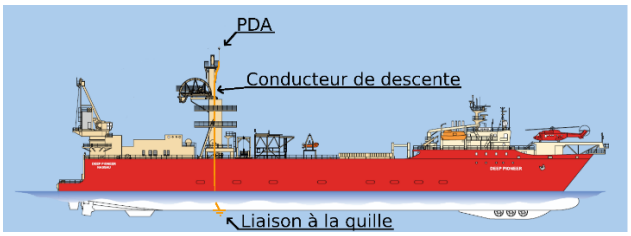


- An optimized flow of the lightning current.
- A control on the radiated electomagnetic field inside the Eiffel Tower.

The adjacent mapping shows the magnetic field at ground level and at the 4 pillars.

Cable ship

The Deep Pioneer cable ship is protected against direct lightning strikes thanks to an ESE type of air terminal installed on the tower and connected to the metal keel allowing to discharge the current in the water. In order to channel the current mainly on one path, a copper down conductor ensures this connexion. The coductivity difference between steel (σ = 9,93x106 S/m) and copper (σ = 59,6x106 S/m) allows a percentage distribution of the lightning current of 80/20.




## V. Conclusion, Environmental Responsibility when Choice of LPS is possible .

Both above protection of highly risk exposal sites, are made with ESEAT technology. Other sites are combining both ESEAT technology and mesh cage one, when necessary. The referent carbon print of the ESEAT devices is definitely lower.

Recent studies [9] shows an increasing of the lightning phenomena by the end of the century. Indeed, the thunderstorms frequency will increase due to global warming. These thunderstorms will cause more human casualties and more damages or forest fires.

Global warming implies an increase in water vapour in the atmosphere, which fuels the movement of hot air streams. The increase in these hot air streams towards the cold air masses trapped in the clouds will cause an increase in the electric charges inside the cumulonimbus.

The researchers who carried out this study believe that, for one degree from global warming, the number of cloud-ground lightning strikes hitting the Earth will increase by 12 %.

It is thus estimated that, by the end of the century, there will be 50% more lightning strikes on Earth approximatively.

Lightning protection systems consume fossil energy and raw materials such as copper and iron. The raw materials depletion must prompt the lightning professionals and the owner of sites in need of protection to favour ecological and less resources consuming protection systems. Up until now, protection systems through ESEat are known as more environment friendly systems, since less raw materials consuming. The duration of those devices is a key point, for reducing carbon print.

## VI. Conclusion,

Global warming and raw material depletion imply to raise now urgently the fundamental questions regarding the reducing of greenhouse gases, and thus the choice of the technology with the smallest carbon footprint, when it is possible.

If several solutions are possible, as mentioned above, the ESE technology is a large part of them, and take part in the reducing of greenhouse gases, with an emission of these gases very low. The lightning professionals who have not yet opted for an ecological policy regarding fossil energy and raw materials, will have to consider it.

Moreover, the development of stronger new products or lightning protection systems seems to be an issue given the increase of the number of cloud-ground lightning strikes in the years to come.

## References

[1] Lightning protection system by Early Streamer Emission Air Terminal, NFC 17-102 September 2011,

[2] NF EN 62305-2, Lightning protection Part 2: risks evaluation

[3] IEC 62561 series (7 volumes) (components)

[4] IEC 61643 series (SPD)

[5] IEC 62793 standard (Storm detector)

[6] NF EN 62305-3, Lightning protection Part 3 : Physical damages on structures and life hazard

[7] NF EN 62305-4, Lightning protection Part 4 : Protection against lightning - Part 4: Electrical and electronic systems within structures

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