



**ENCORE**  
**LAND AND SEA**



# ***CMCE LIGHTNING SUPPRESSOR*** ***DEMONSTRATION OF EFFICIENCY***

***AND LABORATORY HIGH VOLTAGE TEST***

## **BASED ON STANDARDS:**

EN BS - IEC 62305

NFPA 780

NBR 13571/96, ABNT NBR 5419

NTC 4552

UL-467, UL 96 A

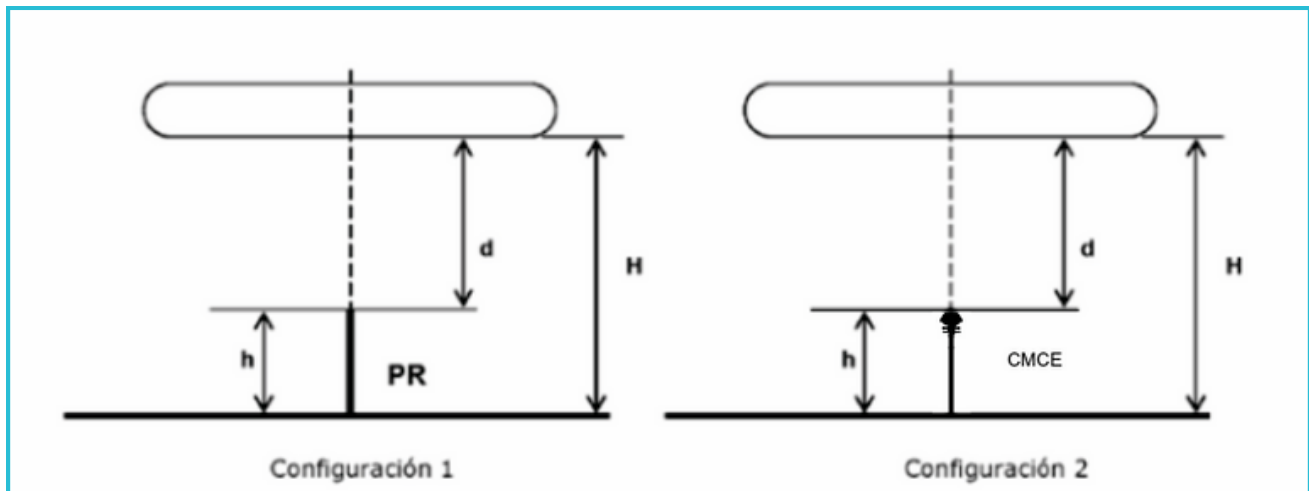
NFC 17102

# EFFICIENCY TEST

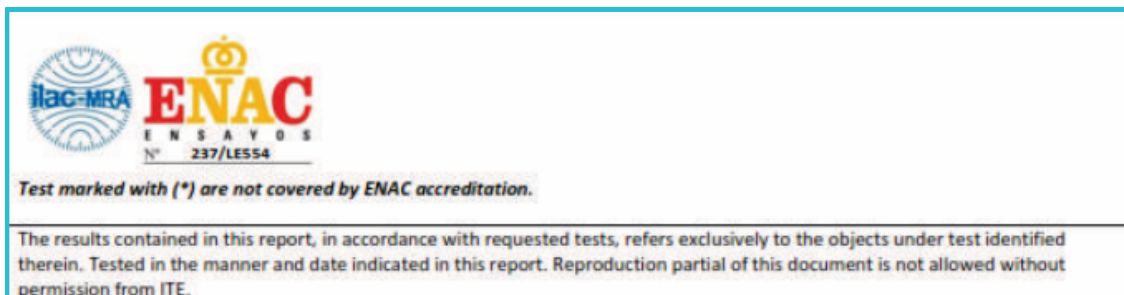
To carry out the effectiveness tests of the CMCE, the configuration of EN 21186 is used for the priming tests where there is an artificial cloud and the ground plane, by means of an impulse generator an electrical potential is generated in the artificial cloud, and the voltage at which electric discharges are formed in the reference Franklin point is sought.

With the presence and connection of the CMCE to the ground system, it must be demonstrated in the laboratory that no electrical discharges should be formed. To carry out the effectiveness tests of the CMCE, the configuration of EN 21186 is used for the priming tests where there is an artificial cloud and the ground plane, by means of an impulse generator an electrical potential is generated in the artificial cloud and the voltage at which electric discharges are formed in the reference Franklin point is sought.

## TEST SCHEME



Once the voltage at which the electric discharge is formed in the Reference Franklin tip is found, 50 shots are developed, programming the pulse generator at that voltage.



# NF 17102 / UNE-EN 21186

In Annex 5, there is priming advance (C.3.5.3)

ME-ITE-210912/01

| Shoot no.                                                | Supported (o) Cut (x) | Shoot no. | Supported (o) Cut (x) |
|----------------------------------------------------------|-----------------------|-----------|-----------------------|
| 1                                                        | O                     | 26        | O                     |
| 2                                                        | O                     | 27        | O                     |
| 3                                                        | O                     | 28        | O                     |
| 4                                                        | O                     | 29        | O                     |
| 5                                                        | O                     | 30        | O                     |
| 6                                                        | O                     | 31        | O                     |
| 7                                                        | O                     | 32        | O                     |
| 8                                                        | O                     | 33        | O                     |
| 9                                                        | O                     | 34        | O                     |
| 10                                                       | O                     | 35        | O                     |
| 11                                                       | O                     | 36        | O                     |
| 12                                                       | O                     | 37        | O                     |
| 13                                                       | O                     | 38        | O                     |
| 14                                                       | O                     | 39        | O                     |
| 15                                                       | O                     | 40        | O                     |
| 16                                                       | O                     | 41        | O                     |
| 17                                                       | O                     | 42        | O                     |
| 18                                                       | O                     | 43        | O                     |
| 19                                                       | O                     | 44        | O                     |
| 20                                                       | O                     | 45        | O                     |
| 21                                                       | O                     | 46        | O                     |
| 22                                                       | O                     | 47        | O                     |
| 23                                                       | O                     | 48        | O                     |
| 24                                                       | O                     | 49        | O                     |
| 25                                                       | O                     | 50        | O                     |
| Average instant of initiation time ( $T_{i12}$ ) $\mu s$ |                       | N/A       |                       |
| Deviation ( $\sigma_{i12}$ )                             |                       | N/A       |                       |
| Initiation time ( $T_{i12}$ ) $\mu s$                    |                       | N/A       |                       |
| Advance time $\Delta T$ ( $\mu s$ ):                     |                       | N/A       |                       |

Reference rod (PR)

| Shoot no.                                                | Supported (o) Cut (x) | Shoot no. | Supported (o) Cut (x) |
|----------------------------------------------------------|-----------------------|-----------|-----------------------|
| 1                                                        | X                     | 26        | X                     |
| 2                                                        | X                     | 27        | X                     |
| 3                                                        | X                     | 28        | X                     |
| 4                                                        | X                     | 29        | X                     |
| 5                                                        | X                     | 30        | X                     |
| 6                                                        | X                     | 31        | X                     |
| 7                                                        | X                     | 32        | X                     |
| 8                                                        | X                     | 33        | X                     |
| 9                                                        | X                     | 34        | X                     |
| 10                                                       | X                     | 35        | X                     |
| 11                                                       | X                     | 36        | X                     |
| 12                                                       | X                     | 37        | X                     |
| 13                                                       | X                     | 38        | X                     |
| 14                                                       | X                     | 39        | X                     |
| 15                                                       | X                     | 40        | X                     |
| 16                                                       | X                     | 41        | X                     |
| 17                                                       | X                     | 42        | X                     |
| 18                                                       | X                     | 43        | X                     |
| 19                                                       | X                     | 44        | X                     |
| 20                                                       | X                     | 45        | X                     |
| 21                                                       | X                     | 46        | X                     |
| 22                                                       | X                     | 47        | X                     |
| 23                                                       | X                     | 48        | X                     |
| 24                                                       | X                     | 49        | X                     |
| 25                                                       | X                     | 50        | X                     |
| Average instant of initiation time ( $T_{i12}$ ) $\mu s$ |                       | N/A       |                       |
| Deviation ( $\sigma_{i12}$ )                             |                       | N/A       |                       |
| Initiation time ( $T_{i12}$ ) $\mu s$                    |                       | N/A       |                       |
| Measurement uncertainty ( $\mu s$ ):                     |                       | N/A       |                       |

The column with a red border represents the CMCE sample and the other column with a black border represents the reference Franklin lightning rod.

Where in the first 50 shots it is clearly identified that the equipment balances and compensates the electric field, not forming the lightning, represented by “o” and the Franklin tip receives all the impacts represented by “x”.

**NOTE:** Impulse supported (o) implies that the voltage curve applied to the plate raised above the sample is not conducted to ground through the object located at a distance “d”. On the contrary, the result indicated as cut (x) implies that the beam is primed and guided to ground through the test object.

# BEHAVIOR IN THE FACE OF INCREASING TENSION

After the 50 shots, 29 more shots were developed to demonstrate the behavior of the CMCE in the face of increased voltages, until reaching a record voltage of 840 KV WITHOUT THE FORMATION OF ELECTRICAL DISCHARGES.

## PRIMING ADVANCE TESTS

| Shoot no. | Programmed voltage (kV) | Measured voltage (kV) | Current (A) | Supported (o) Cut (x) |
|-----------|-------------------------|-----------------------|-------------|-----------------------|
| 1         | 595                     | 497,196               |             | o                     |
| 2         | 600                     | 500,378               |             | o                     |
| 3         | 605                     | 505,036               |             | o                     |
| 4         | 610                     | 509,28                | 0,8         | o                     |
| 5         | 620                     | 518,368               | 0,742       | o                     |
| 6         | 630                     | 525,786               | 0,703       | o                     |
| 7         | 640                     | 529,224               | 0,859       | o                     |
| 8         | 650                     | 541,262               | 0,82        | o                     |
| 9         | 660                     | 553,9                 | 0,859       | o                     |
| 10        | 670                     | 561,361               | 0,898       | o                     |
| 11        | 680                     | 567,685               | 0,507       | o                     |
| 12        | 690                     | 577,224               | 0,429       | o                     |
| 13        | 700                     | 585,938               | 0,82        | o                     |
| 14        | 710                     | 594,239               | 0,468       | o                     |
| 15        | 715                     | 599,963               | 0,781       | o                     |
| 16        | 720                     | 603,355               | 0,82        | o                     |
| 17        | 730                     | 611,563               | 0,625       | o                     |
| 18        | 740                     | 619,352               | 0,781       | o                     |
| 19        | 750                     | 627,684               | 0,781       | o                     |
| 20        | 760                     | 637,079               | 0,585       | o                     |
| 21        | 770                     | 645,844               | 0,625       | o                     |
| 22        | 780                     | 651,103               |             | x                     |
| 23        | 790                     | 661,165               |             | o                     |
| 25        | 800                     | 666,792               |             |                       |
| 26        | 810                     | 677,699               |             |                       |
| 27        | 820                     | 687,172               |             |                       |
| 28        | 830                     | 697,3                 |             |                       |
| 29        | 840                     | 643,898               |             |                       |

After 50 shots without formation of electric discharge. Another 29 shots increased without pause, increasing the tension. A fault occurred due to saturation in shot 22 and the artificial lightning was generated (reducing the electromagnetic effects to the maximum), after which the equipment continued to function without the formation of a discharge. For this reason, we recommend calculating the protection radius from the fault where a  $\Delta T = 139.417\mu s$  was obtained to provide the greatest possible safety.

The value  $\Delta T = 139.417\mu s$  was the discharge time of the device to the ground system, represented by the following graph.

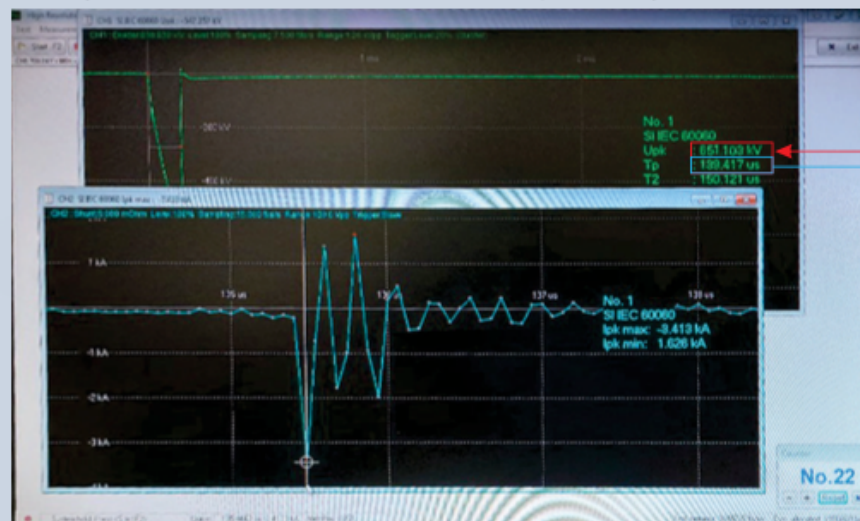
# RADIUS CALCULATION WITH SAFETY MARGIN IN CASE OF FAILURE

The value  $\Delta T = 139.417\mu s$  was the discharge time of the device to the ground system, represented by the following graph.

## STRESS TESTS APPLIED UNTIL FAILURE IS ACHIEVED

| Shoot no. | Programmed voltage (kV) | Measured voltage (kV) | Current (A) | Supported (o) Cut (x) |
|-----------|-------------------------|-----------------------|-------------|-----------------------|
| 1         | 595                     | 497,196               |             | o                     |
| 2         | 600                     | 500,378               |             | o                     |
| 3         | 605                     | 505,036               |             | o                     |
| 4         | 610                     | 509,28                | 0,8         | o                     |
| 5         | 620                     | 518,368               | 0,742       | o                     |
| 6         | 630                     | 525,786               | 0,703       | o                     |
| 7         | 640                     | 529,224               | 0,859       | o                     |
| 8         | 650                     | 541,262               | 0,82        | o                     |
| 9         | 660                     | 553,9                 | 0,859       | o                     |
| 10        | 670                     | 561,361               | 0,898       | o                     |
| 11        | 680                     | 567,685               | 0,507       | o                     |
| 12        | 690                     | 577,224               | 0,429       | o                     |
| 13        | 700                     | 585,938               | 0,82        | o                     |
| 14        | 710                     | 594,239               | 0,468       | o                     |
| 15        | 715                     | 599,963               | 0,781       | o                     |
| 16        | 720                     | 603,355               | 0,82        | o                     |
| 17        | 730                     | 611,563               | 0,625       | o                     |
| 18        | 740                     | 619,352               | 0,781       | o                     |
| 19        | 750                     | 627,684               | 0,781       | o                     |
| 20        | 760                     | 637,079               | 0,585       | o                     |
| 21        | 770                     | 645,844               | 0,625       | o                     |
| 22        | 780                     | 651,103               |             | x                     |
| 23        | 790                     | 661,165               |             | o                     |
| 25        | 800                     | 666,792               |             |                       |
| 26        | 810                     | 677,699               |             |                       |
| 27        | 820                     | 687,172               |             |                       |
| 28        | 830                     | 697,3                 |             |                       |
| 29        | 840                     | 643,898               |             |                       |

Source: A.1. Priming advance tests - IE-ITE-210912-03 Request study..



After 50 shots without formation of electric discharge, another 29 shots increased without pause, increasing the tension. A fault occurred due to saturation in shot 22 and the artificial lightning was generated, after which the equipment continued to function without discharge formation. For this reason, we recommend calculating the protection radius from the fault where  $\Delta T = 139.417\mu s$  was obtained to provide the greatest possible safety.

# PROTECTION RADIUS BASED ON UNE 21186

The UNE 21186 Standard explains how the Radius of Protection (Rp) of a priming is calculated based on its height. This equation can be used for  $h \geq 5\text{m}$ .

Taking into account the priming advance time of the CMCE according to tests carried out in the ITE laboratory (Technological Institute of Energy, Valencia-Spain) and applying the corresponding equation:

$$R_p = \sqrt{2Dh - h^2 + \Delta L(2D + \Delta L)}$$

**Being:**

**R<sub>p</sub>:** Radius of protection

**h:** Height of the collector above the reference plane of the area to be protected

**D:** Radius of the rolling sphere as a function of the SPCR class

**ΔL:**  $V \text{ (m/}\mu\text{s)} \times \Delta t \text{ (}\mu\text{s)}$

**V:** Tracer propagation velocity (m/μs)

For a calculation, the speed of the tracers is between 0.9 and 1.1 m/μs according to Annex A 1.2 of the standard. We will use the average of  $V = 1\text{m/}\mu\text{s}$ . The CMCE priming advance time is  $\Delta T = 139.417\mu\text{s}$ , but  $\Delta t = 60\mu\text{s}$  is used because it is the maximum admissible value of the standard, although superior results were obtained in the tests.

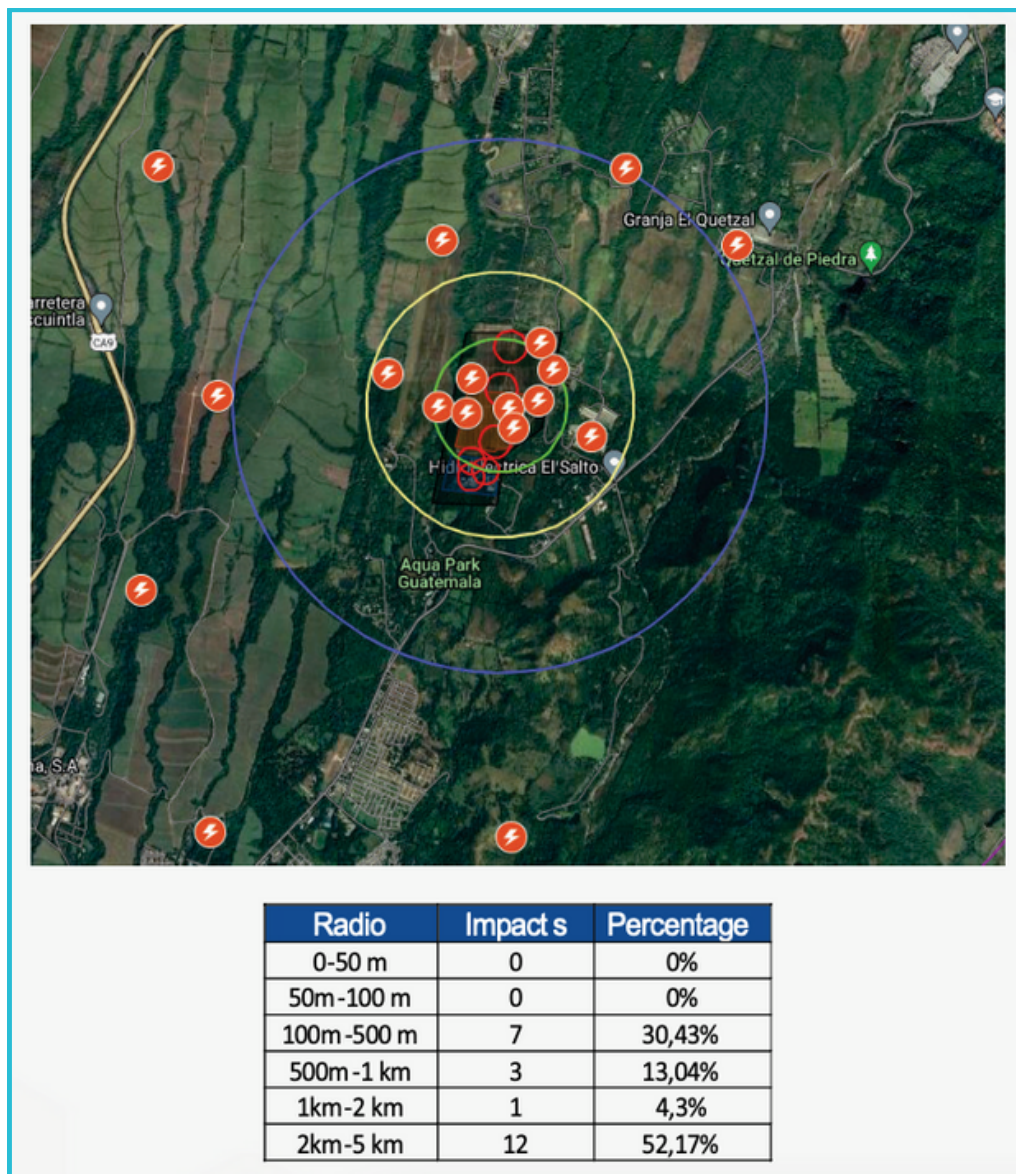
**See previous table (Table 1).**

## Coverage radius according to protection levels

| h (m) | Nivel I (Rfic=20m) | Nivel II (Rfic=30m) | Nivel III (Rfic=45m) | Nivel IV (Rfic=60m) |
|-------|--------------------|---------------------|----------------------|---------------------|
| 5     | 78,58              | 86,45               | 97,08                | 106,65              |
| 10    | 79,37              | 87,74               | 99                   | 109,08              |
| 18    | 79,97              | 89,19               | 101,46               | 112,4               |
| 25    | 79,8               | 89,86               | 103,07               | 114,78              |

# TESTS BASED ON PROJECTS IN THE FIELD

The following summary is a field test based on the effectiveness of CMCEs installed at different points on the ground where each location corresponds to locations that experienced nearby lightning strikes prior to installing our technology. Once our technology is installed, the absence of downloads in your environment can be verified.

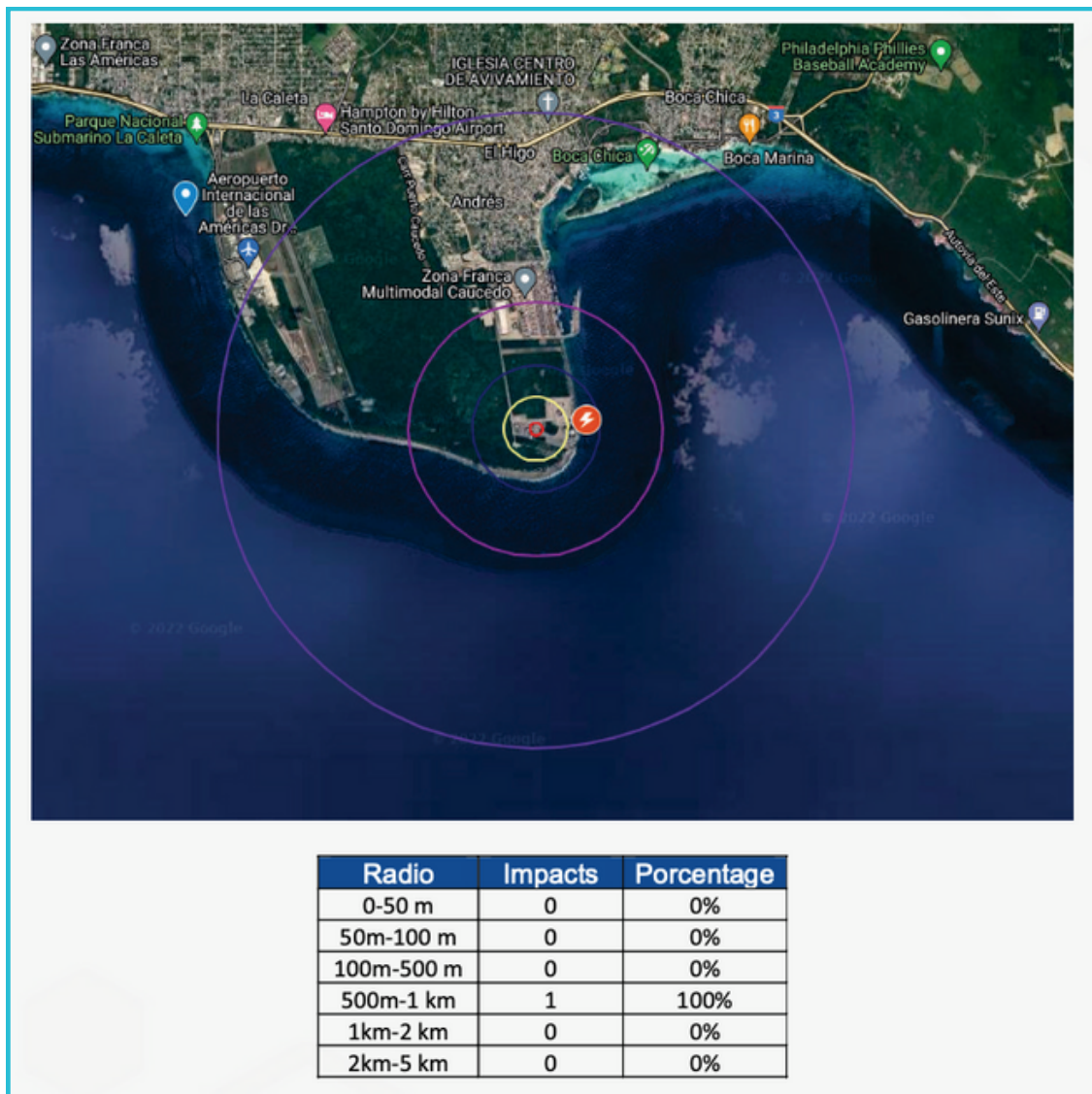


This project is a particular case since around the CMCE's primer lightning rods were installed in the photovoltaic plant.

This data is extracted by NASA satellite: <https://lightning.nsstc.nasa.gov/isslisib/lisfound.exe?origin=ST&lat=14.5&lon=-91&alat=2&alon=2&donob=both&2019.1=on&2019.2=on&2019.3=on&2019.4=on&2019.5=on&2019.6=on&2019.7=on&2019.8=on&2019.9=on&2019.10=on&2019.11=on&2019.12=on>

# TESTS BASED ON PROJECTS IN THE FIELD

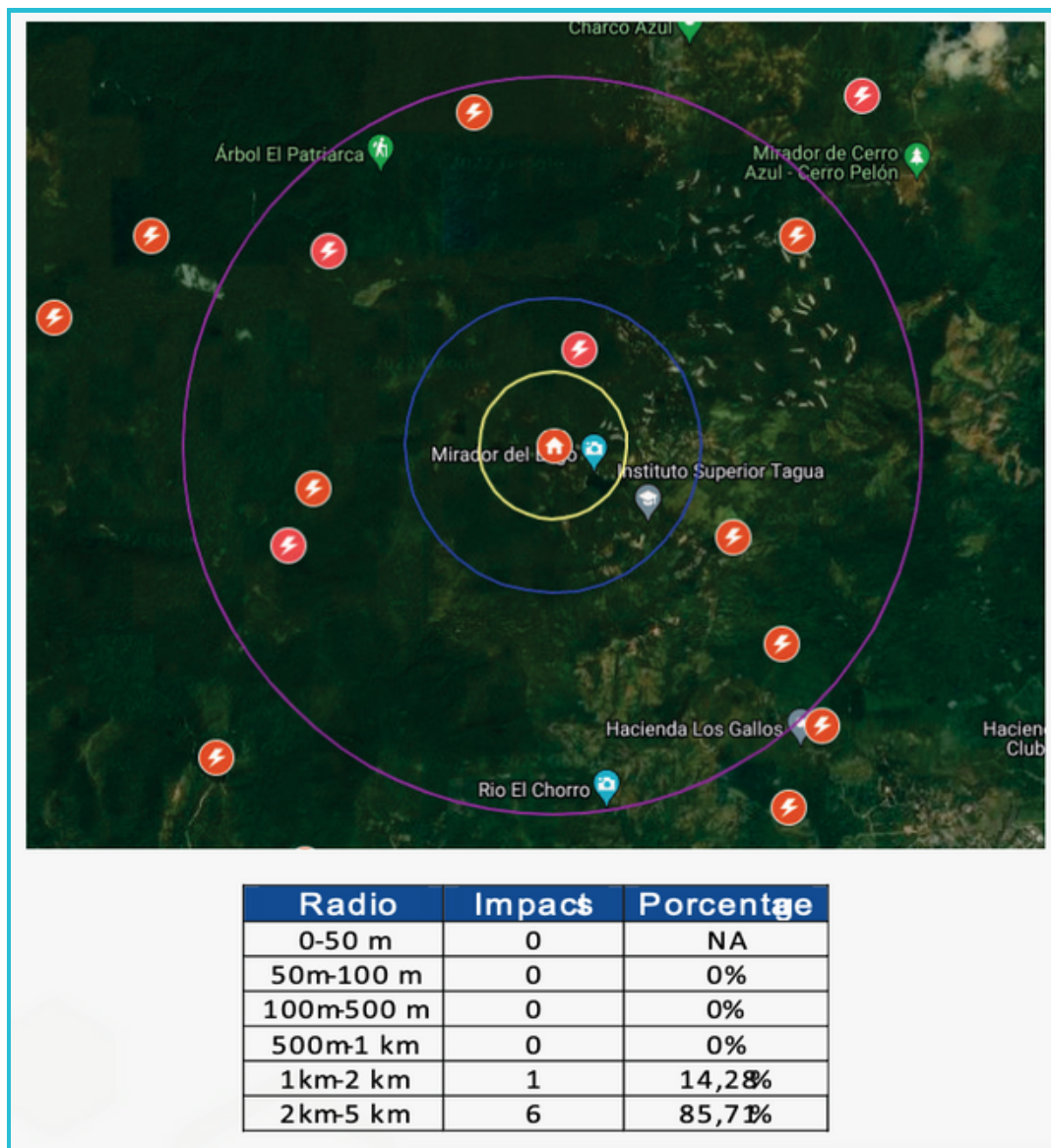
The following summary is a field test based on the effectiveness of CMCes installed at different points on the ground where each location corresponds to locations that experienced nearby lightning strikes prior to installing our technology. Once our technology is installed, the absence of downloads in your environment can be verified.



This data is extracted by NASA satellite: <https://lightning.nsstc.nasa.gov/isslisib/lisfound.exe?origin=ST&lat=19&lon=-69.5&alat=2&alon=2&donob=both&2022.1=on&2022.2=on&2022.3=on&2022.4=on&2022.5=on&2022.6=on&2022.7=on>

# TESTS BASED ON PROJECTS IN THE FIELD

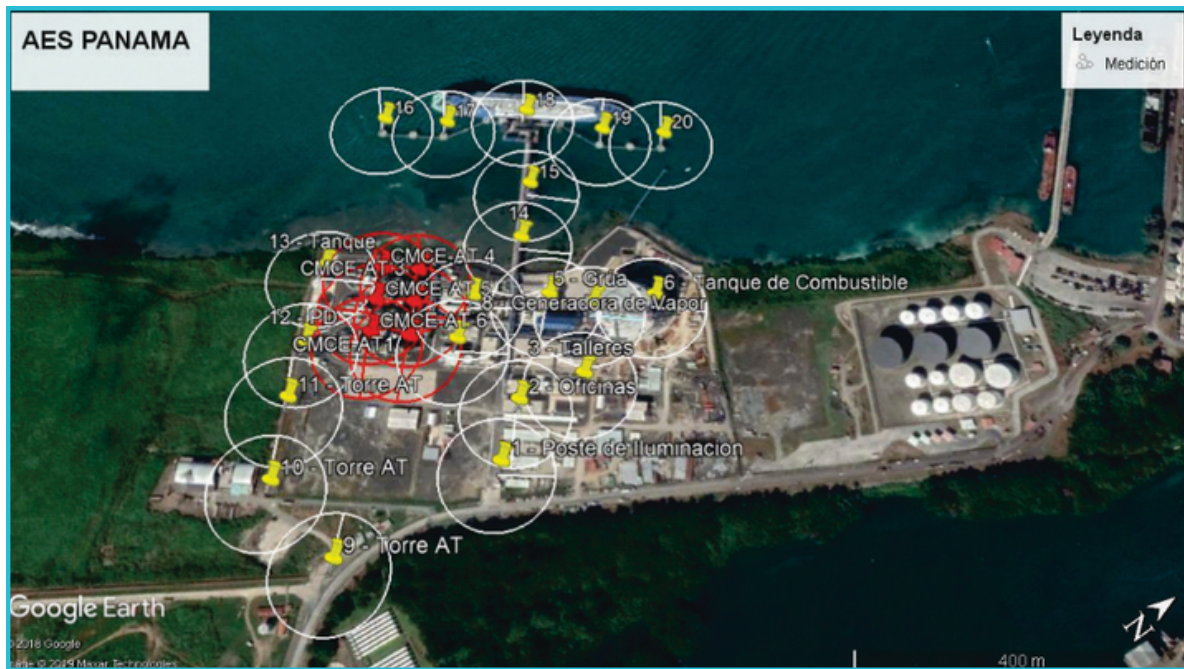
The following summary is a field test based on the effectiveness of CMCes installed at different points on the ground where each location corresponds to locations that experienced nearby lightning strikes prior to installing our technology. Once our technology is installed, the absence of downloads in your environment can be verified.



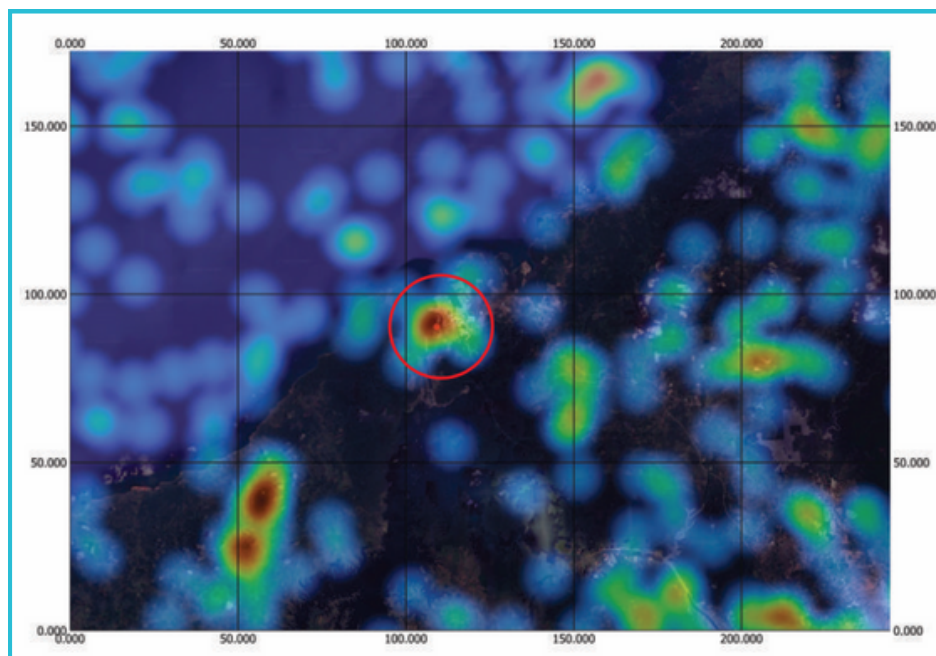
This data is extracted by NASA satellite: <https://lightning.nsstc.nasa.gov/isslisib/lisfound.exe?origin=ST&lat=9&lon=-79&alat=2&alon=2&donob=both&2018.1=on&2018.2=on&2018.3=on&2018.4=on&2018.5=on&2018.6=on&2018.7=on&2018.8=on&2018.9=on&2018.10=on&2018.11=on&2018.12=on>

# PROTECTING AES PANAMA

By opting for the CMCE Lightning Suppressor technology, AES Panama seeks to solve the problem by avoiding the formation of atmospheric discharges. Previously, they had conventional systems that discharged the lightning to the ground and, along the way, affected the most sensitive electronic components, such as PLC, CCTV, ETC.

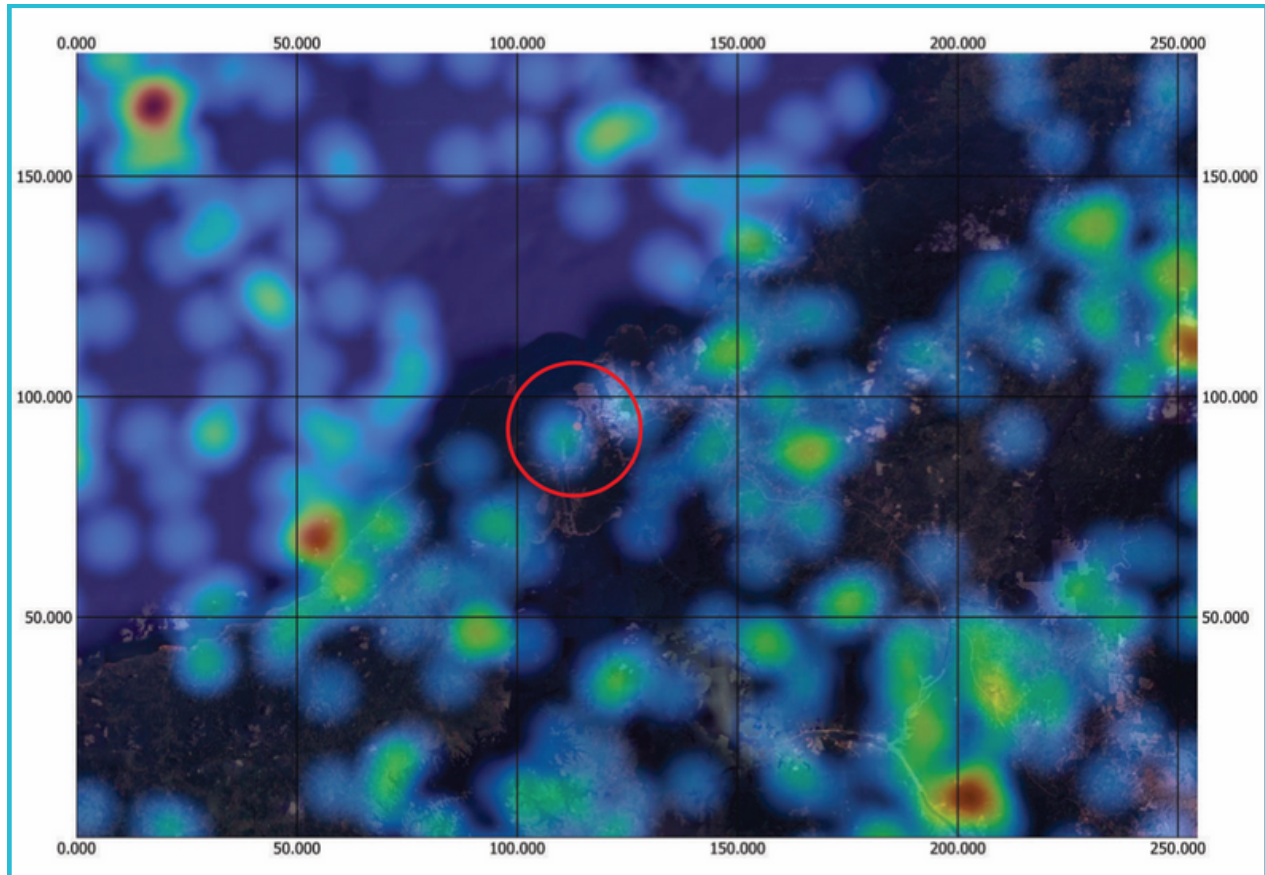


## BEFORE



# PROTECTING AES PANAMA

## AFTER



In the following image, you can see a notable decrease in the ceramic level in the AES area due to the existence and operation of the CMCE Lightning Suppressor.

The data is extracted from a NASA satellite.