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AREA OF PROTECTION

ELECTRO-ATMOSPHERIC FIELD PROTECTOR

CMCE SERTEC

ELECTRO-ATMOSPHERIC FIELD PROTECTOR

DUN & BRADSTREET
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Coverage and protection design of Multiple compensator of electric field CMCE

Different methods of calculation of the protection area of the device

It should be noted that all the calculation methods described below were validated through the study of real installations distributed throughout the world and in different types of structures, at different heights; at high sea, in high mountains, and at high levels of keraunic risk.

Calculation of the radius of coverage of the CMCE by the impulse current method according to IEC 62305

The calculation of the protection area of the CMCE SERTEC is based on the requirements of the UNE-EN- IEC 62305 standard (part I).

The CMCE SERTEC, according to the laboratory tests of short and long current impulses 10/350, obligatory tests that all lightning protection devices have to pass, shows that in the first short current impulse of 89,906 KA, it does not suffer any damage.

According to UNE-EN-IEC 62305 (part I) page 40, point A4, the capture efficiency of an LPS (Lightning Protection System) depends on the minimum values of the lightning current and the radius of coverage of the corresponding imaginary sphere. By means of the imaginary sphere method, the geometrical limits of the areas protected against direct discharges can be determined. Following the electromagnetic model, the radius of the imaginary sphere is correlated with the current peak value of the first short impact, as follows::

$$R_{fic} = 10 \cdot I^{0.65}$$

R_{fic}= radius of fictional sphere (m)
I= Value of the current slope (kA)

OBS: Table extracted from TEST REPORT IE-ITE- 180789 LIGHTNING CONDUCTOR CMCE SERTEC

$r=10 * (89,906)^{0,65}$

r= 186,192m

According to UNE-EN-IEC 62305(part I), the first current pulse is used as the value.

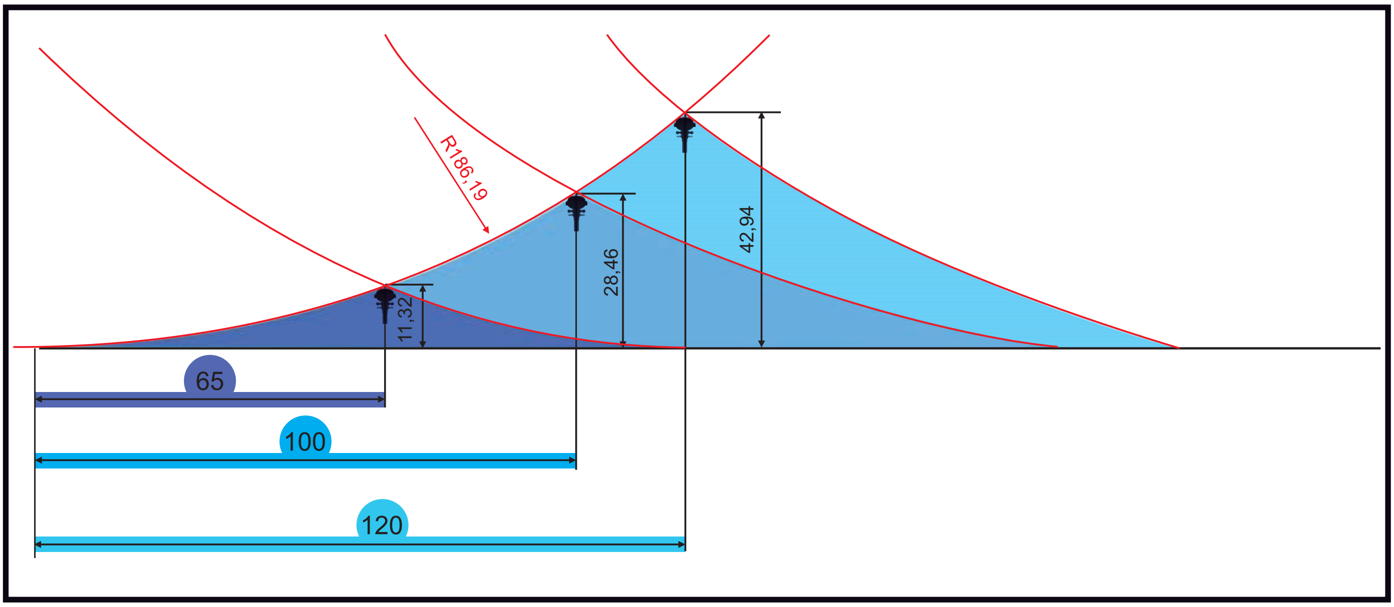
Sample Tested	No. Impulse	I_{peak}(kA) [100 kA ± 10%]	Q (A .s) [50 A·s ± 20%]	W/R (kJ/Ω) [2500 kJ/Ω± 35%]
	The parameters of the current curves applied to the sample are as follows			
ME-ITE-180789/01	1	89,906	35,0	1693,00
	2	89,62	31,1	1485,00
	3	88,53	32,4	1550,00
	4	89,3	32,6	1560,00
	5	90,44	32,5	1576,00
	6	96,656	32,5	1669,00
	7	89,688	30,6	1465,00

Using the maximum current pulse as a value

$r=10 * (96,656)^{0,65}$

r=195,163m

*See Figure on the next page.



HEIGHT (m)	RADIUS OF COVERAGE (m)
11,32	65
28,46	100
42,94	120

Calculation of the radius of protection of the CMCE according to UNE 21186 and NFC 17.102 with the CMCE short-circuited (damaged) acting as a conventional franklin type system.

Standard UNE 21186 explains how the RADIUS OF PROTECTION (Rp) of a lightning conductor is calculated according to its height. This equation can be used for h≥ 5 m.

Taking into account the priming time of the according to tests carried out in the ITE laboratory (Instituto Tecnológico de la Energía, Valencia-Spain) and applying the corresponding equation:

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

Since:
Rp: Radius of protection
h: Height of the sensor above the reference point of the area to be protected
D: radius of rolling sphere as a function of LPS class
ΔL: V (m/µs) x Δt (µs)
V: propagation speed of the tracers (m/µs)

For a calculation we use the speed of the tracers is calculated between 0.9 and 1.1m/µs according to Annex A.1.2 of the standard.
We will use the average of V= 1m/µs.
The CMCE priming advance time is Δt=145,55µs, but Δt=60µs is used because it is the maximum admissible value of the standard, although superior results were obtained in the tests.
See table below

OBS: Table extracted from
TEST REPORT IE-ITE- 180789
LIGHTNING CONDUCTOR
CMCE SERTEC

Shoot No.	T_{PDC} (µs)	Peak Tension(Kv)	Supported (o) Cut (x)
21	247,10	478,10	o
22	244,88	494,86	o
23	244,39	502,71	o
24	246,49	512,15	o
25	244,75	515,41	o
26	**145,55**	**500,67**	**x**

Radius of coverage according to protection levels

h (m)	Level I (Rfic=20m)	Level II (Rfic=30m)	Level III (Rfic=45m)	Level 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

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IMPORTANT NOTE
Section 5.2.2 (Placement) of UNE-EN-IEC 62305 (Part 3) describes the accepted methods for determining the position of sensor systems (CMCE). These are:

- Protecting Angle Method
- Rolling Sphere Method
- Mesh Method

In ANNEX A of standard UNE-EN-IEC 62305 (PART 3), explains these 3 methods for the placement of capture systems.

The volume protected by a sensor system by means of the protection angle method suitable for buildings of simple shapes but subject to limitations by the height of placement of the sensor (table 2), as mentioned in standard UNE-EN-IEC 62305 (PART 3) on page 18, will depend on variables such as the height of the sensor system above the reference point of the protected area, as well as the protection angle according to table 2 of the described standard.

The volume protected by a sensor system using the rolling ball method is appropriate for all cases, as mentioned in standard UNE-EN-IEC 62305 (PART 3) on page 18, will depend on the radius of the rolling ball (table 2 depending on the level of protection required).

The CMCE SERTEC could be applied to the above equation, as the radius of the imaginary sphere has been calculated according to UNE-EN-IEC 62305 (PART 1). This is the placement model recommended by SERTEC S.R.L. for all types of structures. In the case of CMCE for structures over 100 meters, lateral lightning protectors must be installed, following the criteria of the standard itself (point A2 of ANNEX A UNE-EN-IEC 62305 (PART 3), pages 39 and 40). It should be remembered that this model fixes of the rolling sphere depending on the level of protection (LEVEL I, II, III and IV). In any case, the CMCE can be applied to the radius referring to the different levels of protection.

In the case of using the mesh method to protect flat surfaces, the prescriptions and requirements marked in point A3 of ANNEX A UNE-EN-IEC 62305 (PART 3), pages 40 and 41, shall be followed. The volume protected by the CMCE, in this case, will depend on the requirements of paragraphs a, b, c, d and e of point A3 of the described standard.

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Manufacturer's Method CMCE SERTEC

As long as the requirements of the Installation Manual, made by SERTEC SRL are fulfilled, the CMCE SERTEC has a coverage radius of 120m.

Based on electric field reduction tests in its environment and charge drain performance in the different installations, a load absorbed by the device of at least 5μC is ensured.

To analyze the radius of protection, we will use coulomb's law, take into account the distance 121.25 meters (without rounding) which is the diameter of the rolling sphere according to the IEC 62305 Standard that comes out from the study of the first short discharge impact where there are the following annexes.

A.4 Fixing the minimum lightning current parameters

The interception efficiency of an air-termination system depends on the minimum lightning current parameters and on the related rolling sphere radius. The geometrical boundary of areas which are protected against direct lightning flashes can be determined using the rolling sphere method.

Following the electro-geometric model, the rolling sphere radius *r* (final jump distance) is correlated with the peak value of the first impulse current. In an IEEE working group report[5], the relation is given as

$$r = 10 \times I^{0,65} \quad \text{(A.1)}$$

where

r is the rolling sphere radius (m);

I is the peak current (kA).

For a given rolling sphere radius *r* it can be assumed that all flashes with peak values higher than the corresponding minimum peak value *I* will be intercepted by natural or dedicated air terminations. Therefore, the probability for the peak values of negative and positive first strokes from Figure A.5 (lines 1A and 3) is assumed to be the interception probability. Taking into account the polarity ratio of 10 % positive and 90 % negative flashes, the total interception probability can be calculated (see Table 5).

Table 4 – Minimum values of lightning parameters and related rolling sphere radius corresponding to LPL

Interception criteria			LPL			
	Symbol	Unit	I	II	III	IV
Minimum peak current	*I*	kA	3	5	10	16
Rolling sphere radius	*r*	m	20	30	45	60

From the statistical distributions given in Figure A.5, a weighted probability can be determined that the lightning current parameters are smaller than the maximum values and respectively greater than the minimum values defined for each protection level (see Table 5).

Table 5 – Probabilities for the limits of the lightning current parameters

Probability that lightning current parameters	LPL			
	I	II	III	IV
– are smaller than the maximum values defined in Table 3	0,99	0,98	0,95	0,95
– are greater than the minimum values defined in Table 4	0,99	0,97	0,91	0,84

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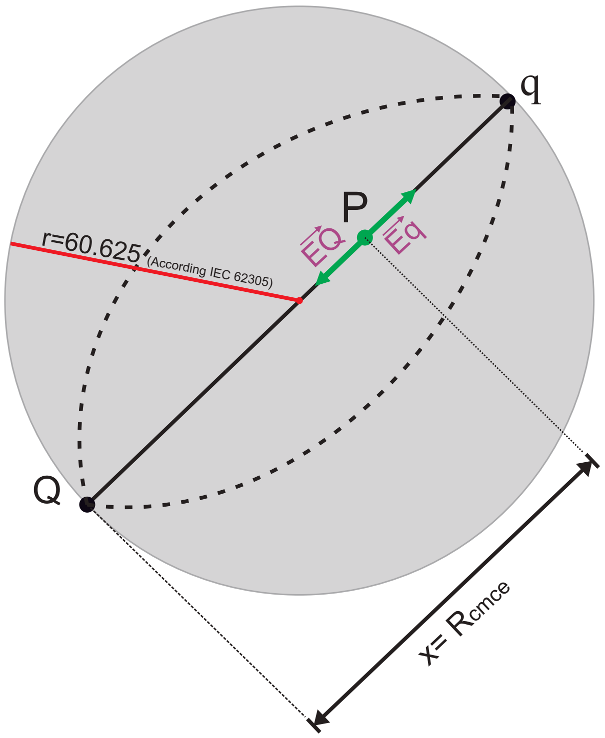
Once this distance is determined, we will study the charge of the device and the charge of an electron or proton (which would be the minimum charge in the atmosphere) located at 121.25 meters (diameter of the rolling spheres) which would be the maximum distance from which a lightning could be formed as detailed previously, we will analyze the electric field at a point where the resulting electric field is zero, at this point the maximum action distance of the device will be given. For the analysis we will only concentrate on the modules of the electric field.



$$E_{cmce} - E_q = 0$$

$$E_{cmce} = E_q$$

$$\frac{Kq}{x^2} = \frac{Kq}{(121{,}25 - x)^2}$$

$$\frac{5\mu C}{x^2} = \frac{1{,}6x10^{-19}}{(121{,}25 - x)^2}$$

$$(121{,}25 - x)^2 = \frac{1{,}6x10^{-19}x^2}{5x10^{-6}}$$

$$\sqrt{(121{,}25 - x)^2} = \sqrt{3{,}2x10^{-19}x^2}$$

$$121{,}25 - x = 1{,}788x10^{-7}x$$

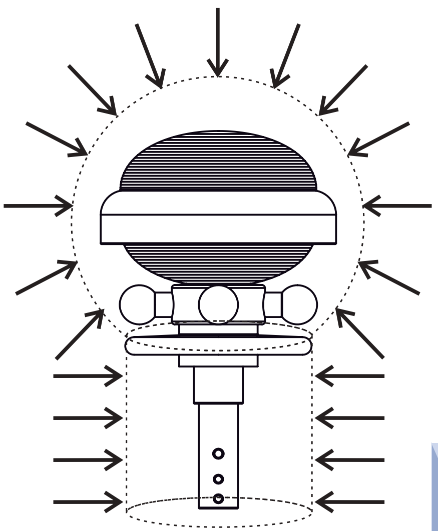
$$121{,}25 = 1{,}000000179x$$

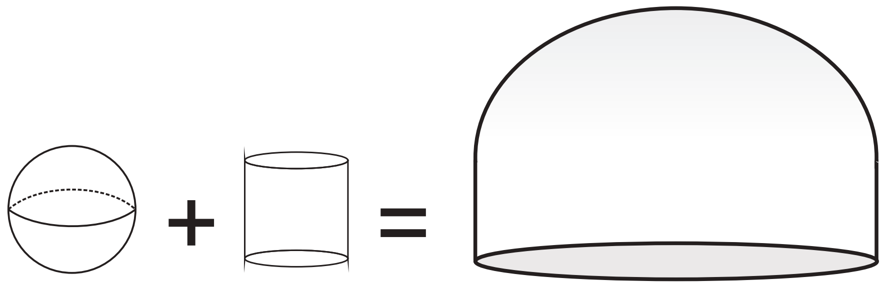
$$121{,}24 = x$$

$$120 = x$$

$$\boxed{E_{CMCE} = x = 120}$$

With this, it is concluded that the protection radius is 120 meters The geometry of the protection resembles a sphere by absorbing loads in all directions through a system of multiple condensers.





Effectiveness of the CMCE Sertec as a function of LPS grounding resistance

At lowest ground resistance, a higher lightning protection efficiency and a greater radius of protection coverage.. In the event of a lightning strike on the CMCE SERTEC for reasons of "cases of working at the limit of its possibilities", the LIGHTNING Protector CMCE SERTEC, will behave like a thermal fuse, absorbing the lightning energy in the form of heat by fusing its components, minimizing electromagnetic effects and the appearance of current circulation in the protected installation.