Presentation

PROTEC FOUDRE

Protec Foudre

History

Created in 2008, Protec Foudre is based in Lille region – France. It all started with fundamental research on lightning rod tips shape. These theoretical researches were conducted for more than 5 years by a prominent French engineer. He actually came out with extremely innovative findings which have been patented.

Innovation

Protec Foudre is a new comer on the competitive lightning protection market but it brings a brilliant and original engineered lightning rod:

PRIMER

Business Development

Thanks to a business partnership with the world leading Early Streamer Emission manufacturer, Protec Foudre is now willing to develop its activities overseas.

Vision

Protec Foudre co-founders aim at allowing a vast majority of persons to access to an efficient yet reasonable-priced lightning protection system. Efficiency is proven by the astonishing test results of the PrimeR®; the cost effectiveness is granted by the brilliant piece of engineering and research that lead to this air terminal design.

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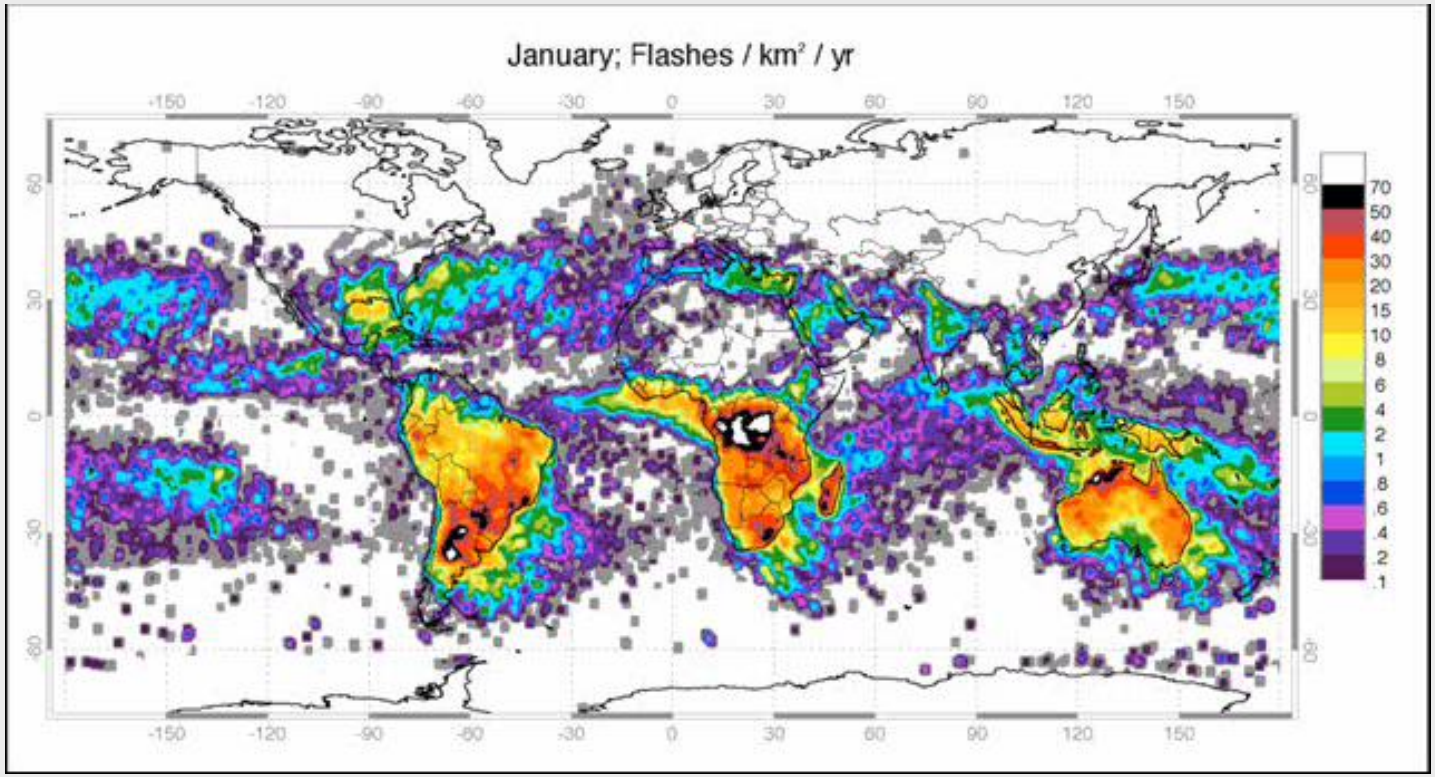
Lightning Facts

Lightning Activity

Lightning Activity depends on two main factors:
- The location of the site (approximately 70% of lightning occurs in the tropics)
- The season



Lightning Density: Number of Discharges per year per square kilometer

Keraunic Level: Number of days thunder is heard per year

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Lightning Facts

Lightning Properties

Cloud-to-ground lightning bolts are a common phenomenon—about 100 strike Earth's surface every single second

Lightning is extremely hot—a flash can heat the air around it to temperatures five times hotter than the sun's surface. This heat causes surrounding air to rapidly expand and vibrate, which creates the pealing thunder we hear a short time after seeing a lightning flash.

Lightning discharges carry on average an electric current of 30 kA, and transfers fifteen coulombs of electric charge and 500 mega-joules of energy. The voltage involved is proportional to the length of the bolt.

Peak Current	Up to 500 kA
Average Peak Current (50%)	≈ 30kA
Polarity Negative	> 90%
Time between Flashes	> 10 seconds
Strokes per Flash	Up to 26
Time Between Strokes	10 to 30 ms
Duration (99%)	30 to 200µs

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Lightning Facts

Lightning Risks

Lightning is not only spectacular, it's dangerous. About 24,000 people are killed worldwide by lightning each year. Tens of thousands more survive strikes but suffer from a variety of lasting symptoms, including memory loss, dizziness, weakness, numbness, and other life-altering ailments.

In USA only, lightning strikes **cost more than $1 billion** in insured losses in 2010.

An analysis of homeowners insurance data found there were **more than 213,000 lightning claims in 2010**, up nearly 15 percent from 2009.

These losses ranged from damage to expensive electronic equipment to structural fires that destroyed entire homes and caused serious injury or death.

Four different types of Lightning Effects to be considered:

- **Direct lightning discharge**
- **Contact over-voltage**
- **Step potential lightning over-voltage**
- **Lightning spark over**

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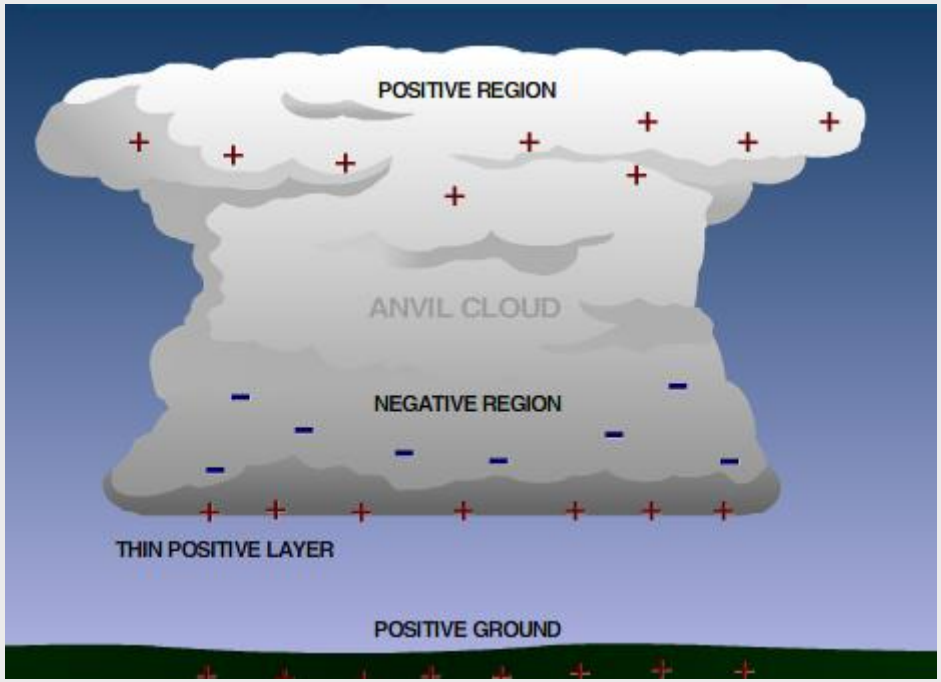
Lightning-caused Damages

For non-metallic structures, the lightning current is using the most conductive paths to earth which are usually the most humid components such a stones joints, trees sap … In such case, the heat and extra-pressure created by the lightning current flowing down to earth can cause an explosion of the structure.

Lightning current enters buildings through the most conductive paths, ie. metallic reinforcement, pipes or wires (water pipes, electrical/telephone wires…), devastating all the connected equipments and igniting fires.

Lastly, due to the lightning current density, fusion of the metallic components are usually visible and are a common source of fire hazard.

Electrical charges partition

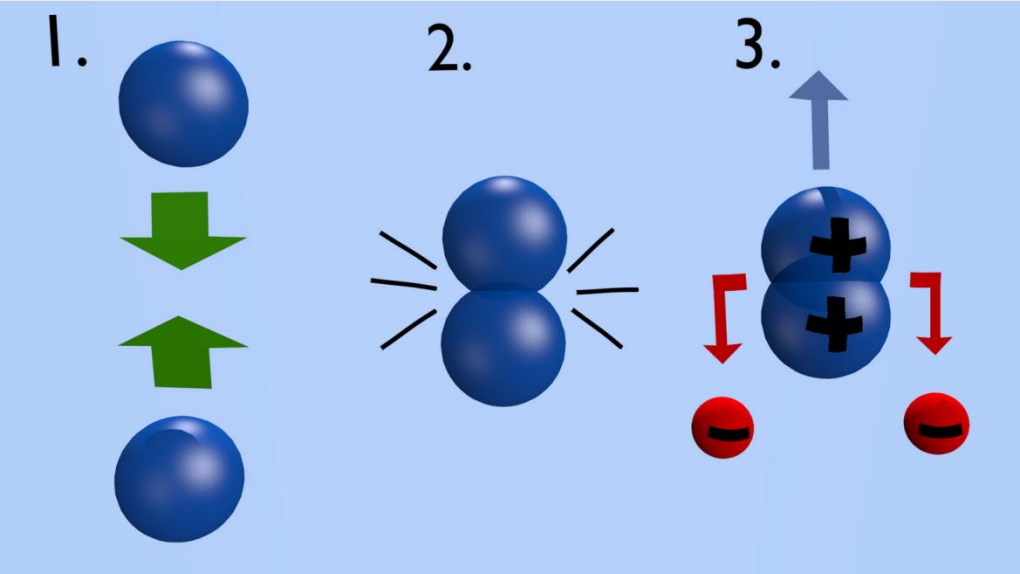


- 70% of the discharges are inside the clouds: intra-cloud (most common) or inter-clouds.
- Max 30% of the discharges are developing between the cloud base (negatively charged usually) and the ground.

Origins of charges partition

In the process of the water cycle, moisture can accumulate in the atmosphere. This accumulation is what we see as a cloud. Interestingly, clouds can contain millions upon millions of water droplets and ice suspended in the air.

As the process of evaporation and condensation continues, these droplets collide other moisture that is in the process of condensing as it rises. Also, the rising moisture may collide with ice or sleet that is in the process of falling to the earth or located in the lower portion of the cloud. The importance of these **collisions** is that electrons are knocked off of the rising moisture, thus creating a **charge separation**.



Development of the lightning discharges

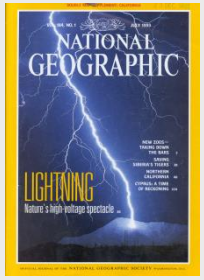
Lightning discharges will develop through four main steps:

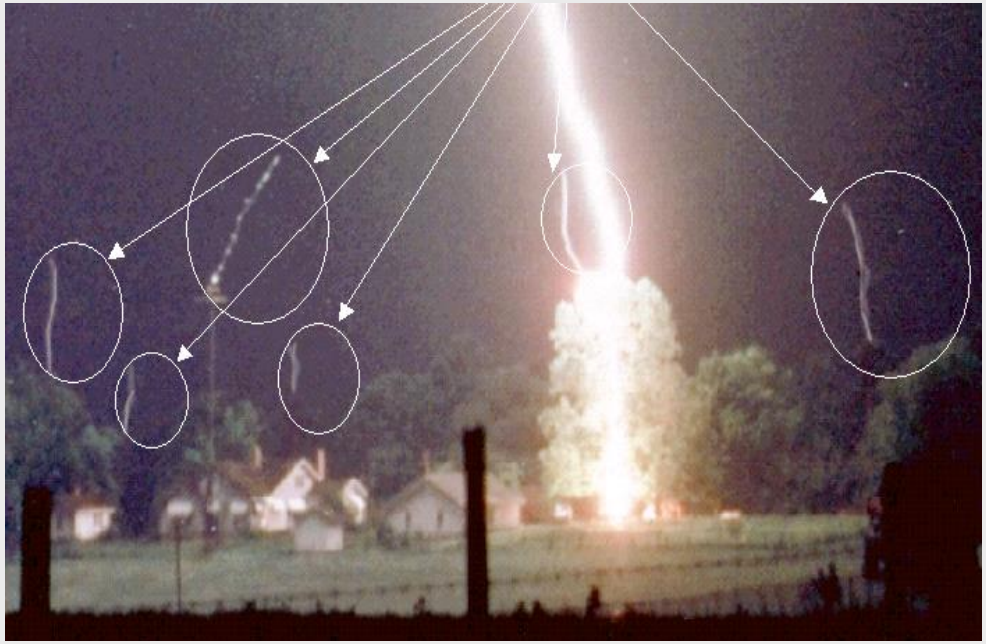
- Downward stepped leader from the Cloud to the Ground
- Upward streamers and leaders from Ground
- Connection of the a downward leader and an upward streamer
- Return strokes (current is flowing through the created ionized path)

Corona Effect & Upward Steamers

When a stepped downward leader approaches, the shorter distance to the ground enhances the strength of the electric field. The electric field is strongest on elevated ground-connected objects, such as trees and tall buildings, owing to the local electric field amplification.

If the electric field is strong enough, a conductive discharge (called a positive streamer) can develop from these points. As the field increases, the positive streamer may evolve into a hotter, higher current leader which eventually connects to the descending stepped leader from the cloud. It is also possible for many streamers to develop from many different objects simultaneously, with only one connecting with the downward leader and forming the main discharge path.





Principles

Lightning rods were originally developed by Benjamin Franklin and Dalibard: it's a pointed metal rod attached to the roof of a building. It connects to a large section conductive wire which is connected to an earth pit buried in the ground nearby.

The purpose of lightning rods is often misunderstood. Many people believe that lightning rods "attract" lightning. It is better stated to say that lightning rods provide a low-resistance path to ground that can be used to conduct the enormous electrical currents when lightning strikes occur. If lightning strikes, the system attempts to carry the harmful electrical current away from the structure and safely to ground. The system has the ability to handle the enormous electrical current associated with the strike.

The preliminary systems have been since then improved. Based on Faraday findings, the Belgian physicist MELLSENS, recommends protecting buildings by covering them with metal wires connected to a series of spikes on the roof and then well earthed. This was the very first meshed cage in the late 19th century.

In the early 1980's, a new generation of air terminal was developed: the Early Streamer Emission air terminals are now widely accepted and used worldwide.

Standards

The various lightning protection systems invented since Benjamin Franklin have been standardized:

Single Rod: **IEC 62 305 series (2006)**

Meshed Cage: **IEC 62 305 series (2006)**

Early Streamer Emission Systems: **NF C 17 102 (latest version: 2011)**

All standards are using the same methodology and theoretical base:

- Lightning Risk Survey to assess the risk and required protection level (I to IV)

- The Rolling Sphere Methodology for calculation of the rods protection radius and location on the protected structure.

Lightning Risk Survey

A Lightning Survey is a complex and detailed survey taking into account a large scope of site and structure specifications:

Geographical characteristics
- lightning density;
- topology;

Structure characteristics
- dimensions;
- construction materials;
- occupation of the structure;
- Building contains.

Consequence of lightning
- Environmental consequences;
- Continuity of service;

Networks
-Type and quantity

Interception criteria			Protection levels				
	Symbol	Unit	1+	I	II	III	IV
Rolling sphere peak current	I	kA	3	3	5	10	16
Rolling sphere radius	r	m	20	20	30	45	60
Maximum peak current		kA	200	200	150	100	100
Minimum peak current		kA	3	3	5	10	16
Additional measures		kA	Note 1				
Probability in which lightning parameters are lower to maximum values				0.99	0.98	0.97	0.97
Probability in which lightning parameters are lower to minimum values				0.99	0.97	0.91	0.84
Protection effectiveness	E		99%	98%	95%	90%	80%

1+ :The lightning protection system made of the ESE air terminal, the down conductor(s) and earthing system is connected to the building metallic structure or the reinforced concrete rebars, which serve as additional down conductors (natural components).
The connection between the ESEAT and the additional natural down conductors must be done both at the roof and the ground levels.
In case the additional natural down conductors cannot be interconnected at the roof level, a ring conductor fixed on the building roof perimeter can be used.
The natural down conductors must be interconnected at ground level, either via a dedicated separate conductor or via the building foundation earth loop.
In case there is no additional natural component down conductor available or all of the afore-mentioned condition are not met, the level 1+ cannot be obtained

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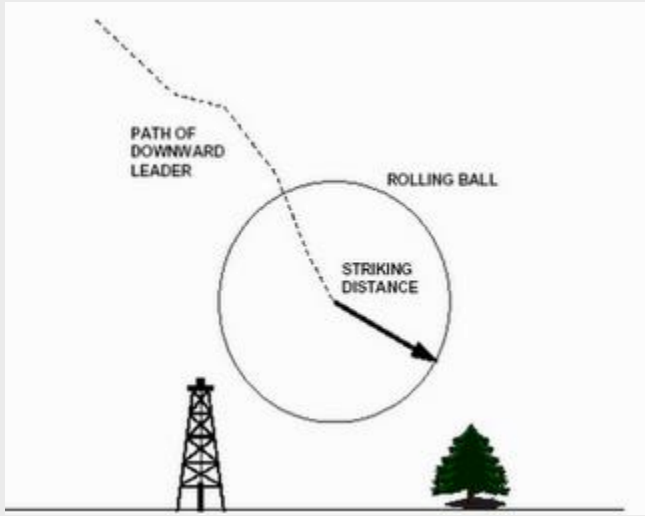
Electro-Geometrical Model EGM

The Rolling Sphere Methodology is based on the **electro-geometrical model** which takes into account:

- the relation between the downward leader current and the electromagnetic field value;
- the relation between the downward leader current and the estimated peak current (I) of the first return stroke (in kA)
- the electromagnetic field value at ground level allowing the development of an upward streamer : 300 kV/m.

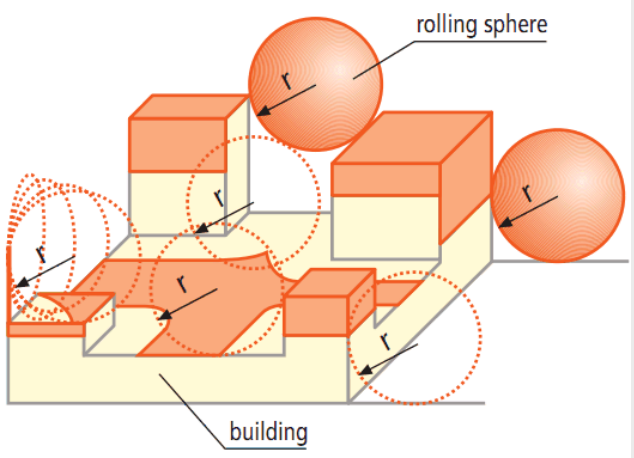
Based on these figures, a "striking distance" D(m) is calculated: this is the minimum distance for an upward streamer to develop from the ground in direction of the downward leader $D=10\times I^{2/3}$

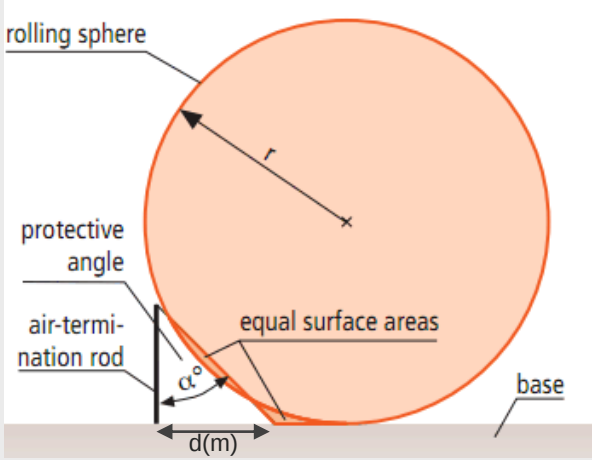
Thanks to this model, the LPS standards define theoretical values D depending on the specified protection level (cf risk assessment method):



Rolling Sphere Methodology

Based on the Rolling Sphere Methodology, the IEC 62 305 Part 3 standard proposes the following Protection Area provided for Conventional lightning protection system:





height h of air-termination (m)	Distance d(m) and protection angle α ° (rounded down to nearest degree)							
	LPL I		LPL II		LPL III		LPL IV	
	Distance	Angle	Distance	Angle	Distance	Angle	Distance	Angle
1	4,12	76	5,09	79	6,26	81	7,25	82
2	5,69	71	7,08	74	8,76	77	10,17	79
3	6,80	66	8,54	71	10,62	74	12,36	76
4	7,65	62	9,70	68	12,14	72	14,16	74
5	8,33	59	10,66	65	13,42	70	15,71	72
6	8,87	56	11,47	62	14,54	68	17,07	71
7	9,30	53	12,17	60	15,53	66	18,29	69
8	9,64	50	12,78	58	16,42	64	19,39	68
9	9,89	48	13,30	56	17,21	62	20,40	66
10	10,07	45	13,75	54	17,93	61	21,32	65

ESE Protection Radius calculation

The NF C 17 102 version 2011 is giving two calculation formula for the evaluation of an Early Streamer Emission rod.

$$R_p\,(h) = \sqrt{2rh - h^2 + \Delta(2r + \Delta)} \quad \text{if } h \geq 5 \text{ m}$$

and

$$R_p = h \times R_p(5) / 5 \quad \text{if } 2 \text{ m} \leq h \leq 5 \text{ m}$$

R_p (h) (m) is the protection radius at the height h;

h (m) is the ESE rod tip height relative to the horizontal plane passing through the top of the structure to be protected.

r (m) is :
20 m for protection level I ;
30 m for protection level II ;
45 m for protection level III ;
60 m for protection level IV ;

Δ (m) Δ = $\Delta T \times 10^6$
Where ΔT is the triggering advance determined by the High Voltage Laboratory assessment tests (NF C 17 102 Annex C).

Protection Radius

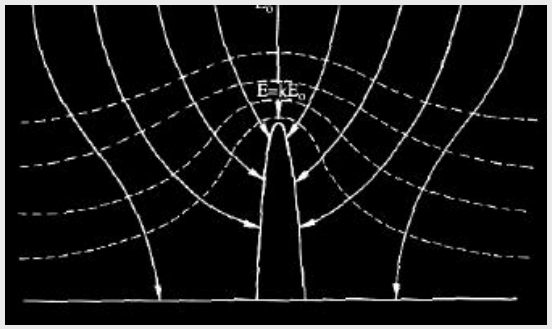
Protection Level / Height	Level I	Level II	Level III	Level IV
h=2m	25	28	32	35
h=3m	37	42	48	53
h=4m	50	56	64	71
h=5m	63	70	80	89
h=10m	64	72	83	92
h=20m	65	74	86	97

Influence of the rod shape

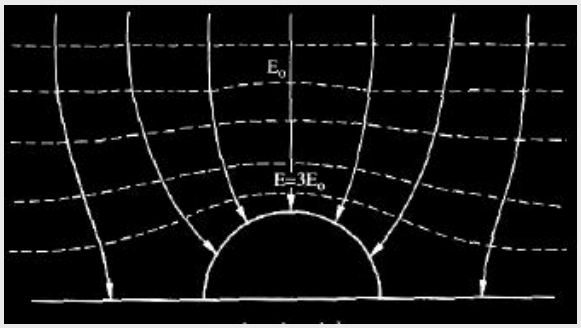
The controversy between the use of sharp or blunt rods is almost as old as the lightning rod itself.

Benjamin Franklin found that the application of strong electric fields to an exposed, sharp electrode such as a lightning rod causes an electric current to flow into the air ; we now know that this current is a result of ionization processes in the air around the tip.

So the rod shape has an impact on the ionization process and, consequently, the corona phenomenon and the triggering of the upward streamer.



Concentration of electrical charges on a pointed rod



Concentration of electrical charges on a blunt rod

Sharp pointed rod shape

Pros

- Fast generation of electric charges at the tip when the leader starts.
- Ionization of the tip starts as soon as the electrical field intensifies.
- No influence on ionization capabilities from rain, drops on the rod surface.

Cons

- Initial streamers die out because the intensity of the E-Field is too weak to sustain the streamer's propagation.
- These aborted streamers are creating a charge induced **shielding effect.**

Blunt rod shape

Pros

- The range of the amplified electric field is larger.
- The Corona effect is more stable.
- Upward streamer is **more sustainable.**

Cons

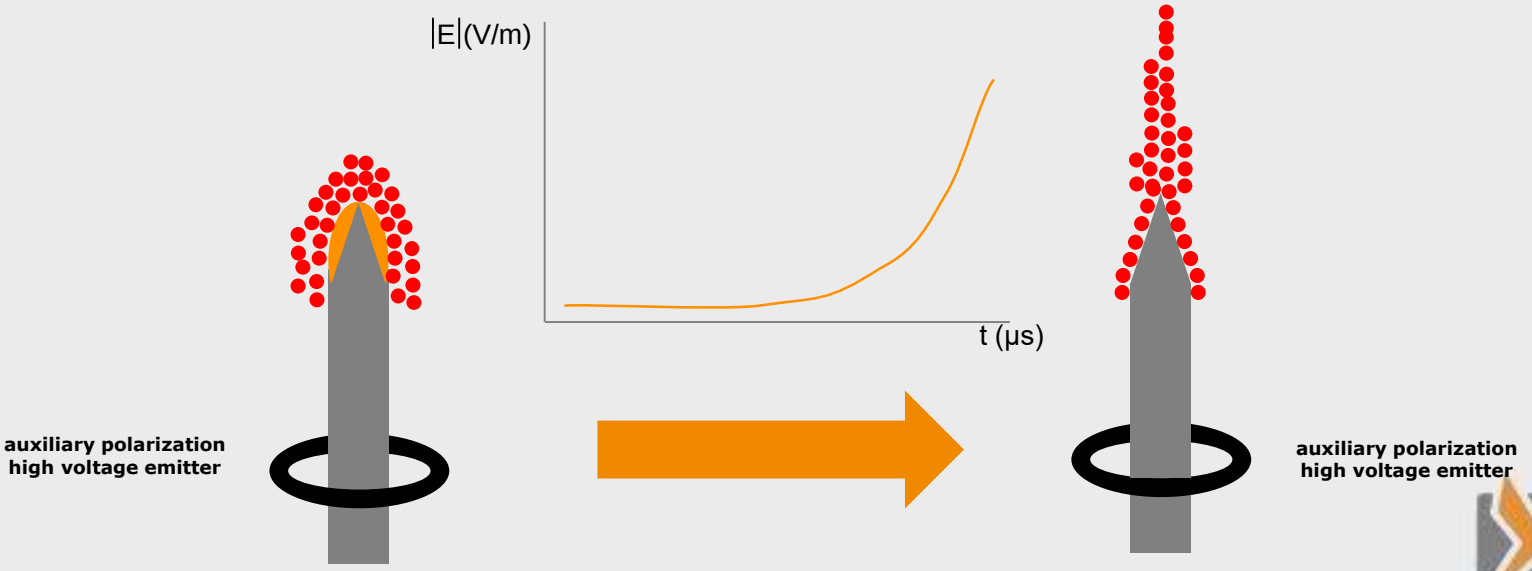
- Initial streamers are triggered later than from sharp rods.
- Sharp shaped objects close by can generate competing streamers earlier.
- Influence on ionization capabilities from rain, drops on the rod surface.

PrimeR® Innovation: electronic variation of the tip configuration

Based on these research findings, the PrimeR® is the first Early Streamer Emission lightning rod to propose an electronically-controlled variation of the tip shape.

The working principle deals with the variations of the tip amplification ratio using an auxiliary polarization high voltage emitter: thanks to this amplification ratio, the tip can virtually evolve from a rounded to a sharp shape.

The tip electronic variation obtained is applied in line with the electrical field evolution. The round rod configuration supports the concentration of electric charges without "pulses"; the sharp one is entertaining the early triggering of a powerful and sustainable upward leader.



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PrimeR® : new generation of ESE air terminal

The PrimeR® is based on latest research findings on lightning physics.

It is also the first Early Streamer Emission to be designed and manufactured in accordance with the new 2011 version of the ESE standard NF C 17 102.

- Fully autonomous lightning rod (no battery required); Power supplied by thunderstorm electrical field.
- Solid construction, tested in most constraining environmental conditions, ensures the PrimeR® ability to withstand the most powerful lightning discharges.
- Lightning rod only becomes active when the electrical field increases.
- Full continuity from the tip to the earthing termination with an active unit installed in parallel to the main rod.
- Testable unit owing to a specific test box.

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PrimeR® : full compliance to the new NF 17 102 Annex C

The September 2011 NF C 17 102 includes a completely revised **Annex C** "ESE Lightning Conductor assessment procedures".

Firstly, the Annex C is from now on **normative** while it was "informative" only in the previous standard version.

Secondly, the test requirements are much more complex and detailed.

Thirdly, the test procedures covers a much larger scope:

- Marking tests
- Mechanical tests
- Environmental tests
- Electrical test (100kA mini – 10/350µ)
- Advanced triggering (Δt in µs and standard deviation)

All test certificates are available on request

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PrimeR® : advanced triggering time – 60µs / 45µs / 20µs

The "Advanced Triggering Time" assessment remains an extremely important test: it is dedicated to the measurement and definition of the Δt (µs) value that is used for the calculation of the air terminal protection radius.

The effectiveness of an E.S.E. lightning conductor is assessed by comparing the upward leader initiation time emitted by the E.S.E. lightning conductor against the upward leader initiation time emitted by an single "standardized" rod.

For this purpose, the single rod and E.S.E. lightning conductor are assessed one after the other under the same electrical and geometrical conditions during laboratory tests simulating the natural conditions of the upward leader initiation (positive upward leader).

The advanced triggering time (**Δt**) is the average measured time difference of initiation of the upward streamer between the ESE air terminal and the single rod (50 discharges minimum).

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New NF 17 102 installation specifications changes

Besides the much more constraining test procedures, the new NF C 17 102 version has also introduced some new requirements in terms of LPS design, installation and Maintenance:

- New Annex A: Lightning Risk Assessment
- Four protection levels I to IV
- Two down conductors minimum per air terminal according to the separation distance calculation
- Special requirements for the buildings between 60m and 120m high, and then for high rise buildings >120m
- Detailed control and maintenance procedures, periodic functional test of the air terminal.

PrimeR® Installation

Installation basic specifications on Buildings

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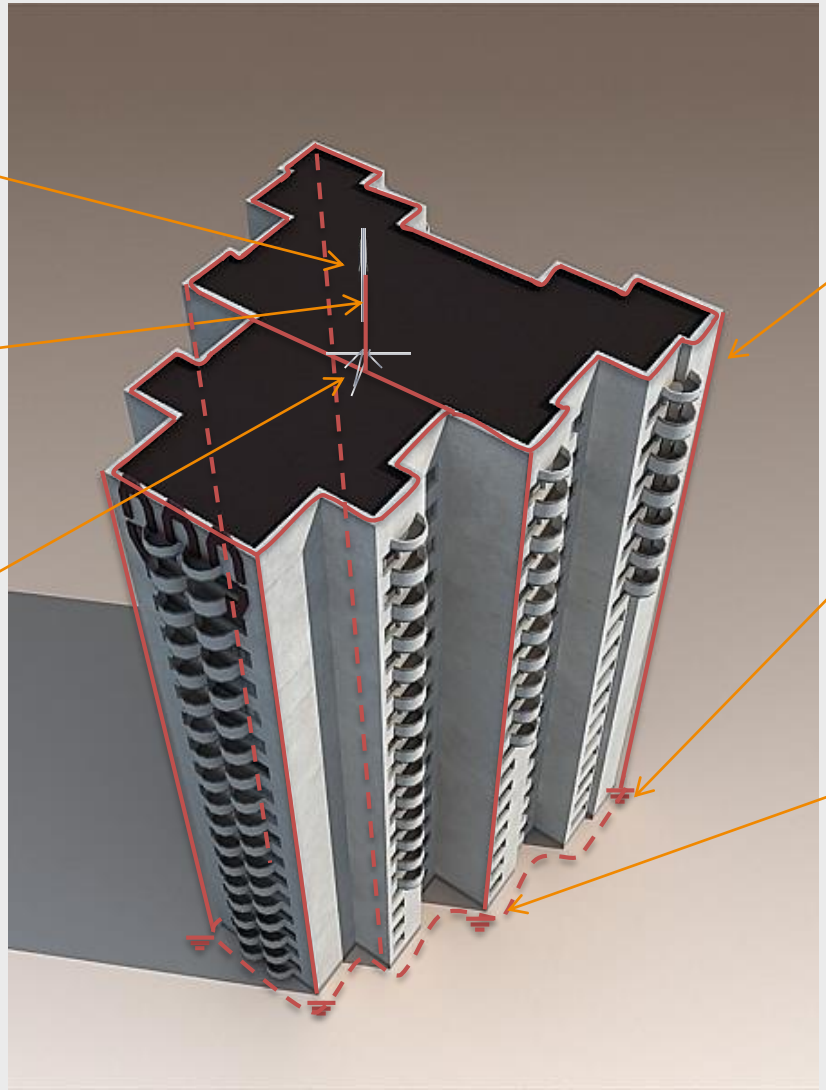
PrimeR® Installation

Installation basic specifications on High-Rise Buildings



Minimum
4 down conductors
h>60m

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PrimeR® choice

Why choosing a PrimeR® air terminal ?

- Innovative technology based on the latest Lightning physics findings and researches.
- Highest quality of design and manufacture: it's a problem-free air terminal, robust and safe.
- The first Early Streamer Emission lightning rod that full complies with the new NF C 17 102 version 2011 requirements.
- Thanks to its innovative technology, the PrimeR® sets new standards in the industry, in terms of quality, reliability and cost effectiveness.

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