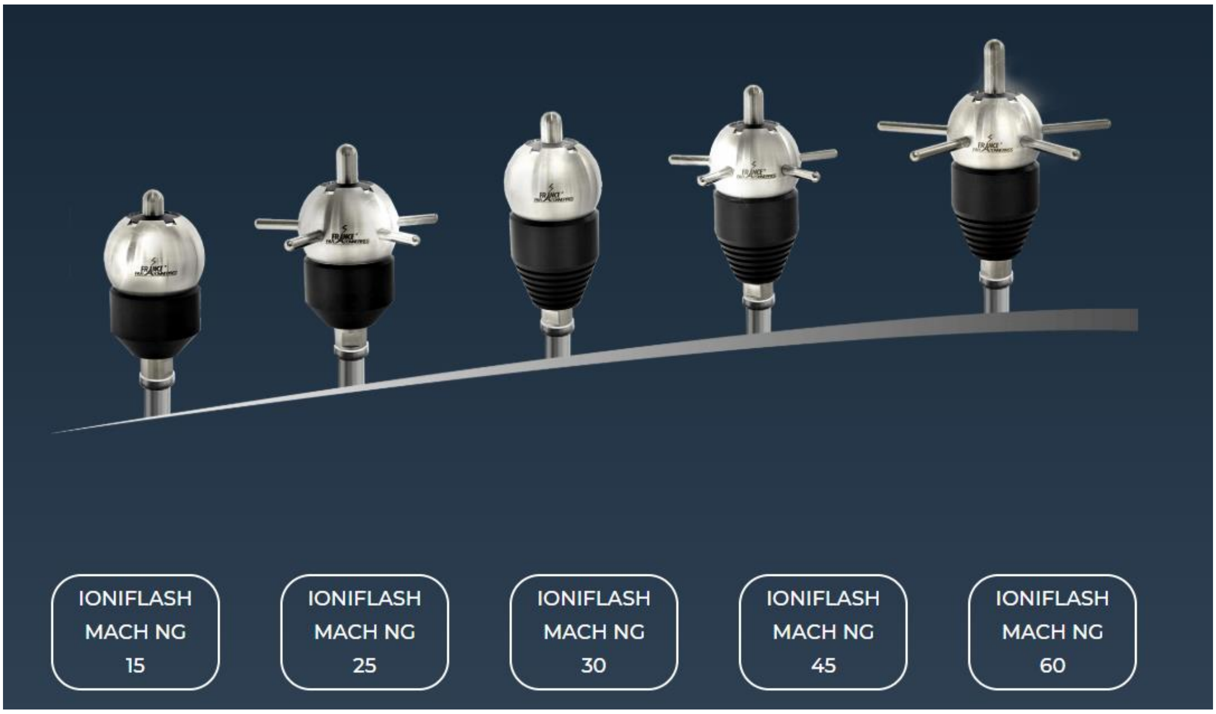
Installation Manual

Implementation of a Lightning Protection System



Sommaire

<u>Important:</u>

This document is a guide reminding the main installation rules for Early streamer emission lightning protection systems. It doesn't replace in anyway the standards and best practices. FRANCE PARATONNERRES disclaims any responsibility for any non-compliances installations realized with the help of this guide.

I. Early Streamer Emission (ESE) - IONIFLASH MACH NG

I.1. IONIFLASH MACH NG presentation

The Early Streamer Emission Air Terminals IONIFLASH MACH can operate for a positive or a negative lightning strike.

When the descending tracer is getting closer to the ground (around 100 meters above the peak), it generates an electric field underneath it that will grow until reaching values in the range of one hundred kilovolts per meter. From then on, the first electron until then located close to the tip of the air-terminal, is suddenly being transformed in a discharge or an ascending tracer.

Those ascending positive tracers are suddenly developing towards the descending tracer (this is the lightning). One of closest ascending tracers, the one that started first or the one that progressed the fastest, gets in contact with the descending tracer. The ionized channel is then continue from the ground until the cloud, and the arch can take place, producing a heavy lightning current of several kA.

The Early Streamer Emission IONIFLASH MACH® is an ESE rod on which is installed a spherical metallic mass aside the very top of the rod. This sphere is isolated from the rod by a collar made out of a material with high isolated electrical current. The body of the ESE contains two early streamer emission devices.

When the storm is approaching, the external electrode (sphere + potential stick) that is electrically conductive is getting charged with the influence of the electric field until its potential reaches a critical value from which a spark is being made in between the external electrode and the rod of the central electrode. This spark allows to create a plasma aside the rod.

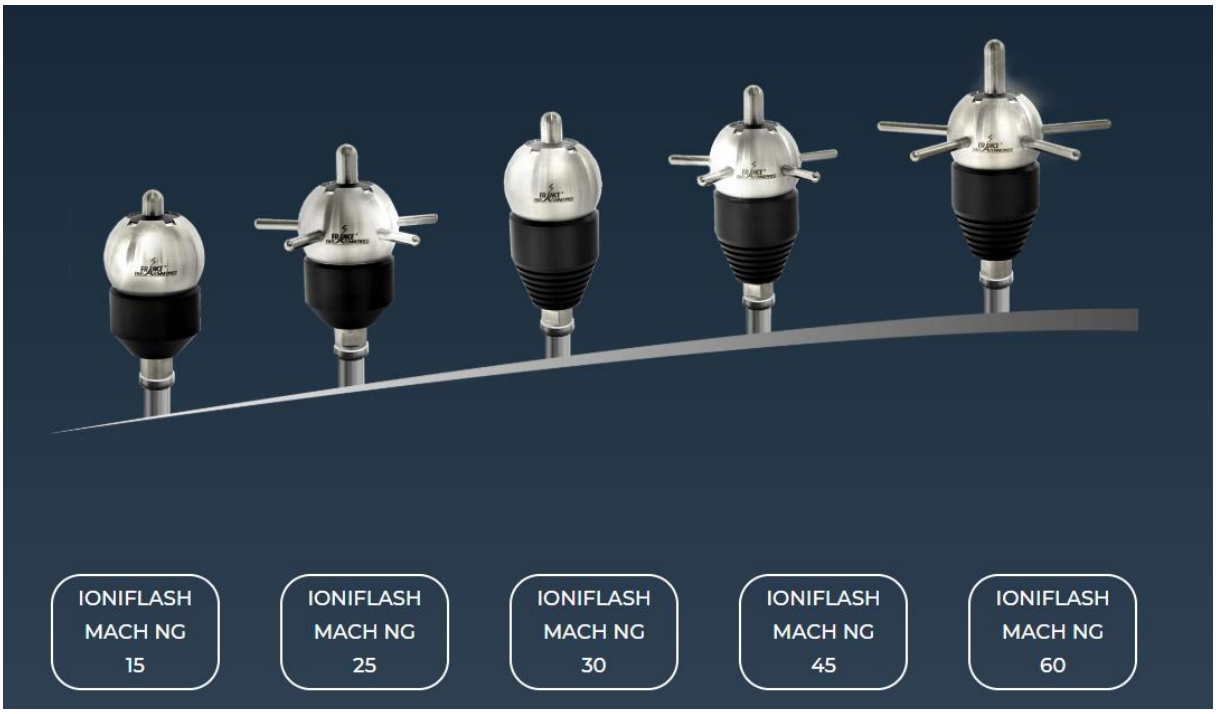
The plasma associated with the severe electrical current that is around the rod, is the first step of the development of the ascending tracer.

The spark produced at the tip of the rod of the IONIFLASH MACH® will initiate the early streamer emission, creating an ascending tracer towards the descending tracer.

I.2.Our range of ESE: the IONIFLASH MACH NG

We are offering a range of five Early Streamer Emission Air Terminals presenting an early streamer emission balanced from 15 µs, for the IONIFLASH MACH NG15 to 60 µs, for the IONIFLASH MACH NG 60.

This range meets all requirements, as shown below.



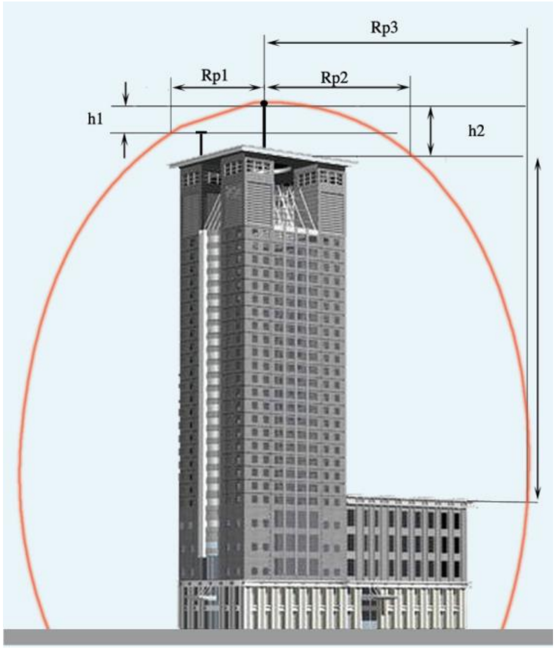
IONIFLASHMACH®		Mach NG15	Mach NG25	Mach NG30	Mach NG45	Mach NG60
Résultats sur onde de manœuvre expérimentale en laboratoire $<T'_{PTS}>$ (µs)	Temps moyen de claquage de référence $<T'_{PTS}>$ (µs)	252	252	186	186	199
	Temps moyen de claquage de référence $<T'_{PDA}>$ (µs)	222	213	150	138	140
	$<T'_{PTS}> - <T'_{PDA}>$	30	39	34	46	59
	Ecart type $_{PTS}$ (µs)	40	40	43	43	62
	Ecart type σ_{PDA} (µs)	25	31	32	19	18
	$k = \frac{\sigma_{PDA}}{\sigma_{PTS}}$	0.61	0.76	0,74	0,44	0,29
Avance à l'Amorçage pondérée		15 µs	25 µs	30 µs	45 µs	60 µs

I.3.Radius of protection

The radius of protection (Rp) of an ESE depends on the height (h) of which it is installed compared to the surface that needs to be protected, to its efficiency (Δt) and to the selected level of protection (Np).

$$Rp = \sqrt{h(2D - h) + \Delta L(2D + \Delta L)} \text{ pour } h \geq 5m$$

$$Rp(h) = h \times \frac{Rp(5)}{5} \text{ pour } 2 \leq h \leq 5m \ (2)$$



Where:

Rp (h) (m) is the radius of protection at a given height;

h (m) is the height of the ESEAT tip over the horizontal plane through the furthest point of the object to be protected;

r (m)

- 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) = ΔT x 106

Field experience has confirmed that Δ is equal to the efficiency obtained during the ESE assessment testing.

Chart of the radius of protection of the IONIFLASH MACH NG

	Hauteur en mètres	2	3	4	5	6	10	15	20	30	45	60
NIVEAU 1	MODELES											
	IONIFLASH MACH NG 15	13	19	25	32	32	34	35	35	34	24	
	IONIFLASH MACH NG 25	17	25	34	42	43	44	45	45	44	37	21
	IONIFLASH MACH NG 30	19	29	38	48	48	49	50	50	49	43	30
	IONIFLASH MACH NG 45	25	38	51	63	63	64	65	65	64	60	51
	IONIFLASH MACH NG 60	31	47	63	79	79	79	80	80	79	76	69
NIVEAU 2	MODELES											
	IONIFLASH MACH NG 15	15	22	30	37	38	40	42	44	45	42	34
	IONIFLASH MACH NG 25	20	29	39	49	49	51	53	54	55	53	46
	IONIFLASH MACH NG 30	22	33	44	55	55	57	58	59	60	58	52
	IONIFLASH MACH NG 45	28	42	57	71	71	72	73	74	75	73	69
	IONIFLASH MACH NG 60	35	52	69	86	87	88	89	89	90	89	85
NIVEAU 3	MODELES											
	IONIFLASH MACH NG 15	18	27	36	45	46	49	52	55	58	60	58
	IONIFLASH MACH NG 25	23	34	46	57	58	61	63	65	68	70	68
	IONIFLASH MACH NG 30	25	38	51	63	64	66	69	71	73	75	73
	IONIFLASH MACH NG 45	32	48	64	81	81	83	85	86	89	90	89
	IONIFLASH MACH NG 60	39	58	78	97	97	99	101	102	104	105	104
NIVEAU 4	MODELES											
	IONIFLASH MACH NG 15	20	31	41	51	52	56	60	63	69	73	75
	IONIFLASH MACH NG 25	26	39	52	65	66	69	72	75	80	84	85
	IONIFLASH MACH NG 30	28	43	57	71	72	75	78	81	85	89	90
	IONIFLASH MACH NG 45	36	54	72	89	90	92	95	97	101	104	105
	IONIFLASH MACH NG 60	43	64	85	107	107	109	111	113	116	119	120

Example:

For a site where the required radius of protection is a **Level 2**, a **IONIFLASH MACH NG 30** ESE, positioned at 5 meters height, will protect a surface of a 55 meters radius (diameter of 110m).

II. External Installation of a Lightning Protection

An external installation of a lightning protection allows to secure a site against direct lightning effects.

II.1. Capture device

First of all, the lightning current shall be captured. This is the job of the ESE.

II.1.a. Installation of an ESE

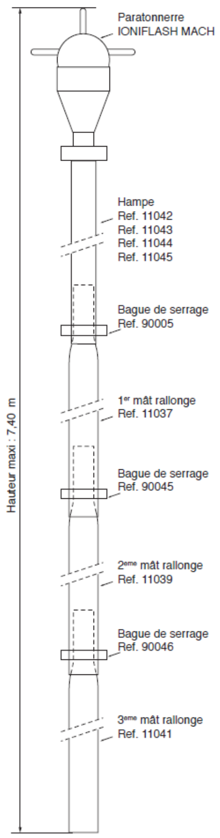
The top of the capture device, meaning the peak of the Early Streamer Emission, shall be installed at least 2 meters above the area that needs to be protected, including aerials, refrigerating towers, roofs, tanks etc.

In order to widen the area protected by an ESE, it is often recommended to increase its own height (see I.3. Radius of protection). Therefore, the optimum installation of an ESE is at 5 meters.

II.1.b. Raising of the head

The ESE IONIFLASH MACH is applied on a 1m, 2m or 3m pole. The assembly is secured by a gas threading ½ and a punch sight that allow a lasting and secured fastening.

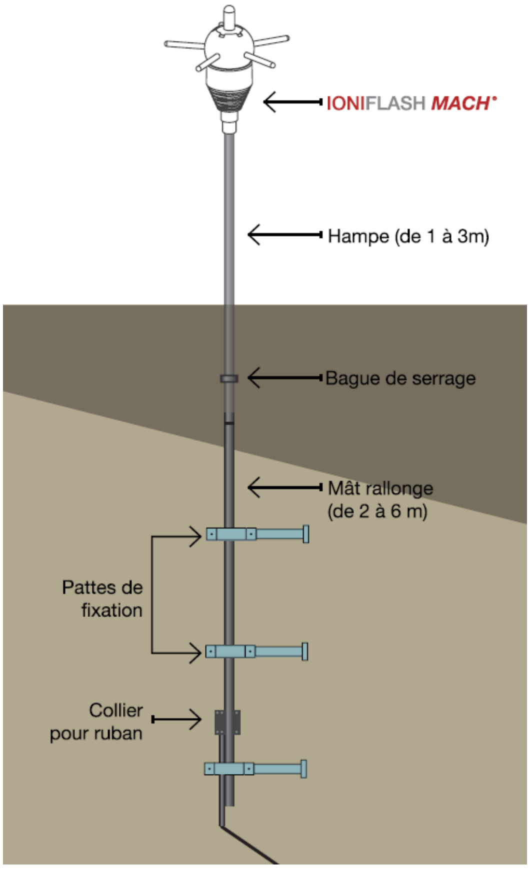
2 meters extension masts allow to raise the height of the ESE. Masts can be combined according to the required height. They need to interlock them together and to tighten up the collar's screw so that they are maintain together.



II.1.c. Fastening

The fastening of the ESE IONIFLASH MACH shall be performed in a secure and lasting way thanks to the numerous accessories from FRANCE PARATONNERRES.

The set containing the ESE as well as the pole and the masts have to be fixed to the building. It can be done:



- On the frontage with supporting brackets to be embedded or screwed
- On a mast thanks to offset and lateral supporting brackets
- On a chimney thanks to a strap
- On a roofing terrace thanks to a tripod
- On a wood structure thanks to anchor bolts
- On any other support thanks to universal supporting brackets

When the ESE is installed at such a height that the strenght of the wind is likely to impact the efficiency of the system, a strutting kit has to be implemented to stabilize the installation.

II.2. Down conductors

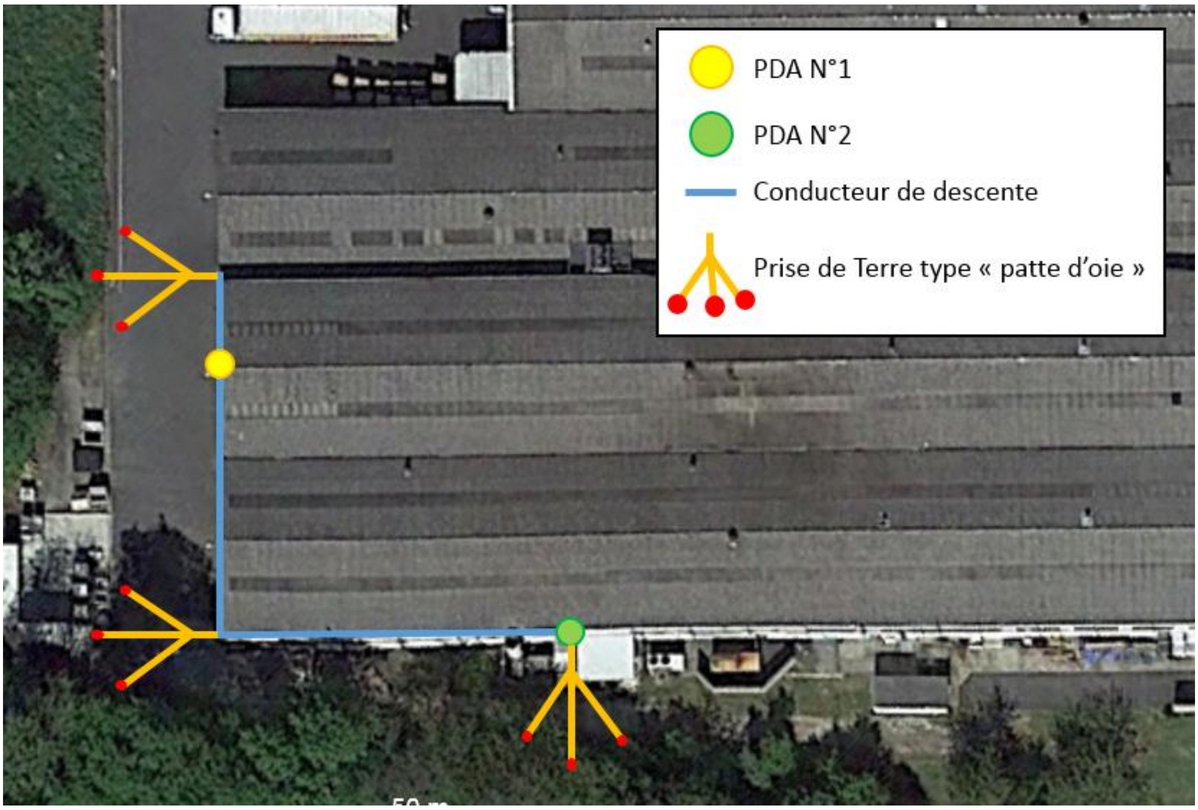
After the lightning current has been captured by the ESE, it needs to be redirected to the ground.

II.2.a. Number of down conductors

Each ESE shall be connected to at least two down conductors. Those need to be specific or, in certain cases, use natural components.

If the ESE is installed on an isolated structure (cf. the norm's definition), only one down conductor is necessary.

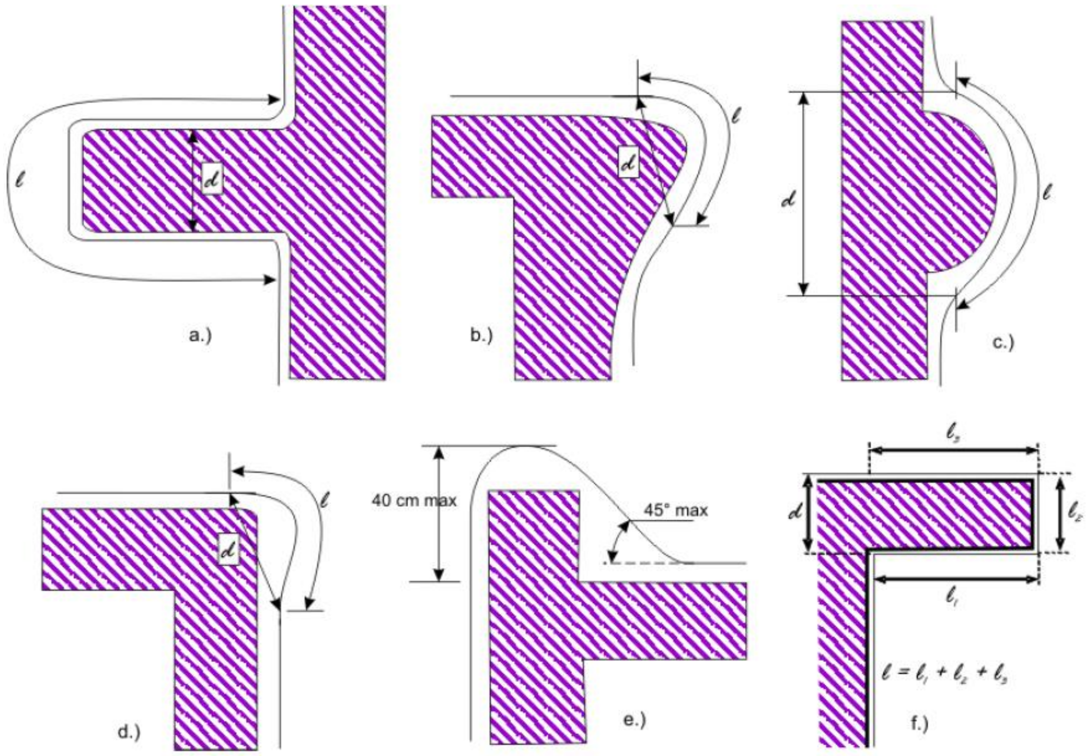
If a site is protected with several ESE, the down conductors can be shared, however, the number of down conductors needs to be at least equal to the number of ESE.



Example of shared down conductors
In this case, there are 3 down conductors for 2 ESE

II.2.b. Routing

The routing of the down conductors shall be as direct as possible and preferably outside the building. The down conductors need to be installed as straight as possible and with curves.



ℓ : longueur de la boucle, en mètres
d : largeur de la boucle, en mètres
Le risque de rupture du diélectrique est évité si la condition $d > \ell/20$ est respectée.

Down conductors' curve shapes

II.2.c. Fastening

A down conductor shall be fixed at a rate of three fasteners per meter (every 33 cm approximately).

It is necessary that the installation is well fastened and hermetic, and for this, it is essential to choose fastening compatible with conductors and supports. They can be fixed:

- On a brick facade with clamps and dowels or plastic fasteners
- On a metallic facade and roofing with clips and rivets
- On a roofing made of tiles, slates, fiber cement etc. with staples and specific flanges
- On a roofing terrace with ballasted cones and welded flanges, in order not to alter the impermeability
- On gutters and ridges with specific fasteners

II.2.d. Connection

All conductors need to be connected together thanks to specific connectors that are made of the same material as the conductor. The conductors shall not be drilled.

II.2.e. Protection

The bottom part of the down conductors shall be protected from any mechanic choc. The protection shall be made with a 2m height protection sheaths.

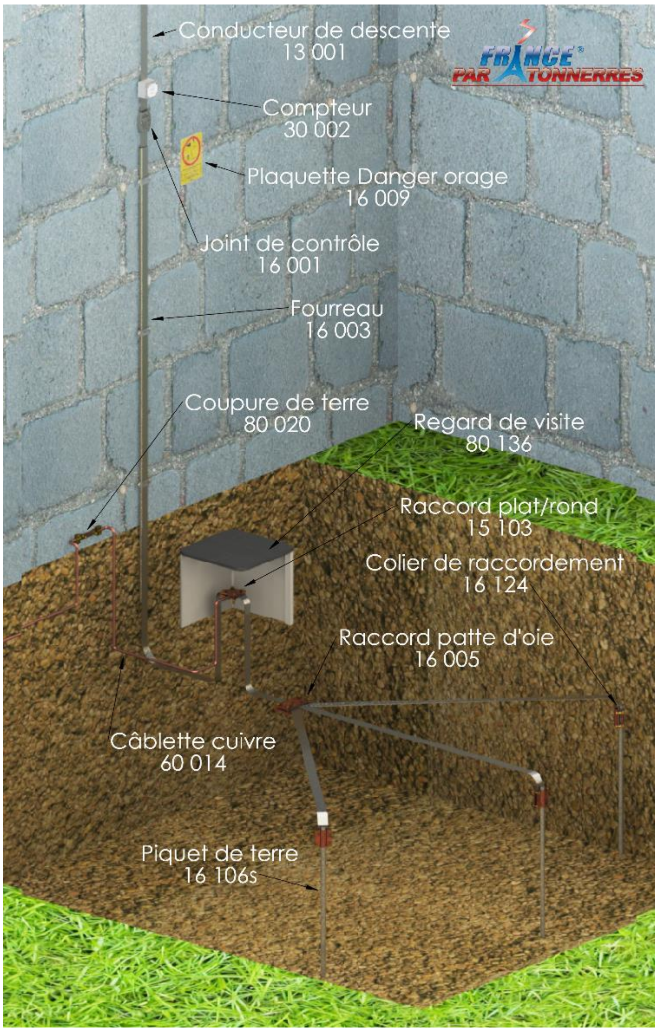
II.2.f. Disconnection

Each descent shall have an inspection joint allowing to disconnect the down conductor from the earthing system. This disconnection allows to measure the earthing system independently from the conductor.

It is recommended to install the inspection join above the protection sheath, approximately at a 2 meters from the ground. If the down conductor is installed on a metallic wall, the inspection joint shall be placed inside the inspection pit in order to disconnect the earthing system on the metallic structure of the building.

II.2.g. Warning

It is asked to implement signaling plates aside the down conductors that advise of risks and hazards during storms.



II.3. Lightning Impulse Counters

A lightning impulse counter allows to keep a record of the number of lightning strikes that have impacted the installation. Its presence on an installation allow to register all lightning events on the site.

II.3.a. Electro mechanic Counter

The electro mechanic counter **IONICOUNT** allows to keep a record of the number of lightning strikes. Its technology without embedded electronic assures its reliability.

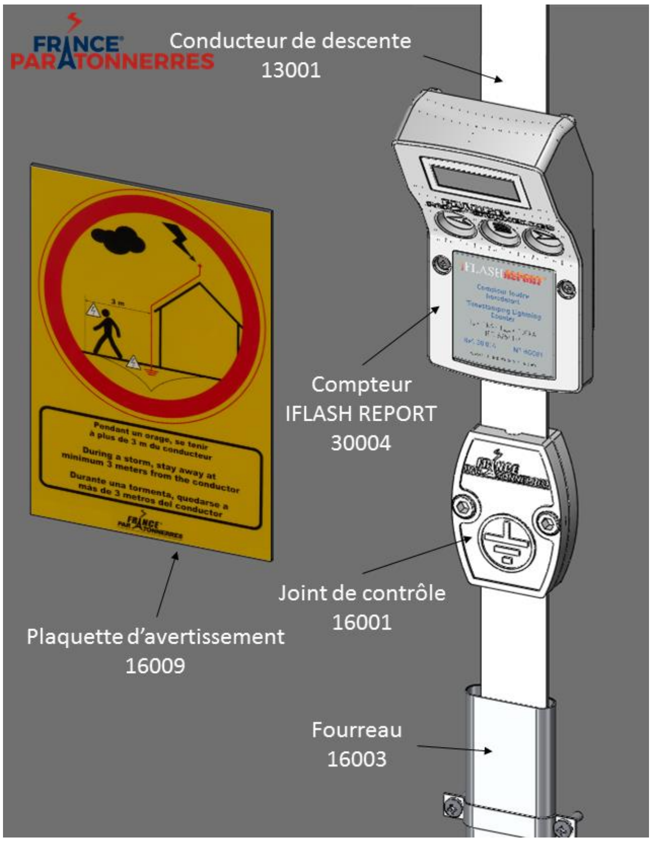
II.3.b. Metering and Communicating Counter

The metering and communicating **IFLASHREPORT** allows to register lightning events. Those data are remotely accessible via a Bluetooth® communication system through the app « FPT » or directly onto the screen.

II.3.c. Setting up

The counter shall be installed onto the more direct down conductor. Ideally, it shall be installed above the protection sheath and the inspection join, approximately 2 meters above the ground level.

The I FLASH REPORT and IONICOUNT counters from France Paratonnerres, can be installed easily and directly onto the down conductor, with no need to modify it.



II.4. Earthing systems

When the lightning current has been captured and conducted through the down conductors, it needs to be evacuated into the ground.

One or several earthing systems, with a resistance as low as possible, need to be put in place.

II.4.a. Earthing system - Type A

An earthing system shall be realized for each down conductor.

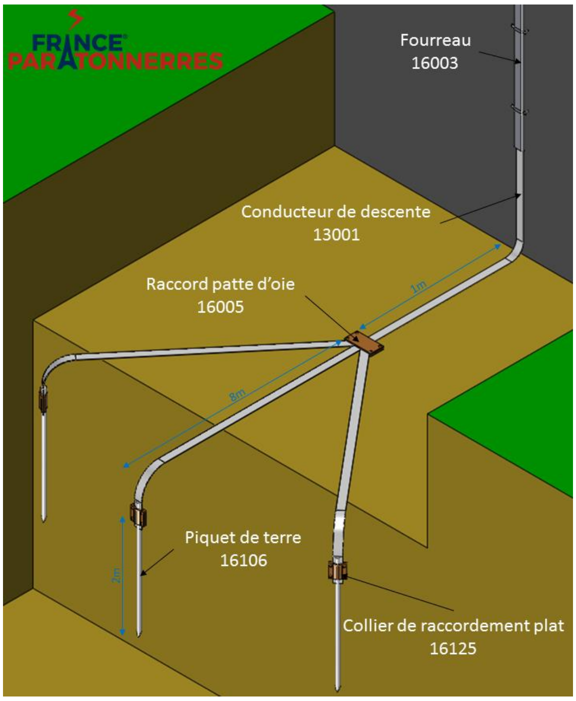
Earthing systems of type A, shall have a resistance below 10 Ω and contain at least two electrodes.

If this 10 Ω value is not reachable, the total length of the buried electrodes shall be at least 160m for the level of protection 1 and 100m for the other levels of protection (the length of the vertical electrodes being considered as doubled).

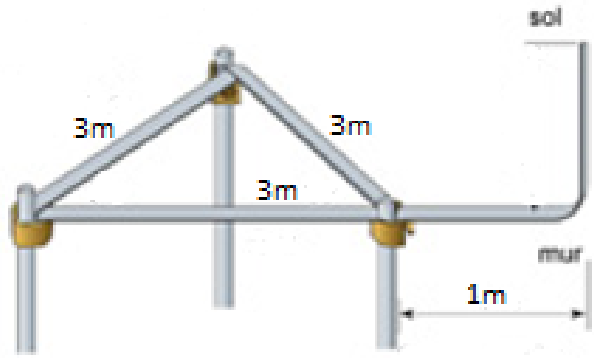
The conductors shall be buried at a minimum depth of 50 cm.

It is recommended to use conductors in copper or in stainless steel so that it lasts longer.

Example of an earthing system of Type A1, called “duck foot”



Example of an earthing system of Type A2, called « Triangle »



II.4.b. Earthing system - Type B

Earthing systems of type B, called “Earthing Loop”, are made of either a ring conductor external to the structure, and in contact with the soil for at least 80% of its total length or a foundation earth electrode provided it is based on a 50 mm² conductor. The bottom of each down conductor should at least additionally be connected to either a 4 m minimum radial or a 2 m minimum rod.

II.5. Equipotential bonding

In order to avoid electrical arcs within and outside the lightning protection system, some security precautions need to be taken. It is essential to isolate elements or to insure the balance of the potentials.

II.5.a. Earthing equipotentiality

All the lightning and electrical earthing systems of the protected structures need to be interconnected through the disconnectable connections.

Those connections shall have a section of at least 25mm².

II.5.b. Separation distance

The electrical insulation in between the capture device or the down conductors and the metallic parts of the structure, the metallic installations and the internal systems, shall be made with a distance ***d*** in between the greater parts compared to the separation distance ***s***:

$$s = k_i \times \frac{k_c}{k_m} \times l$$

With:

- The coefficient ***ki*** directly related to the level of lightning protection :

Level of protection chosen	*ki*
I	0,08
II	0,06
III & IV	0,04

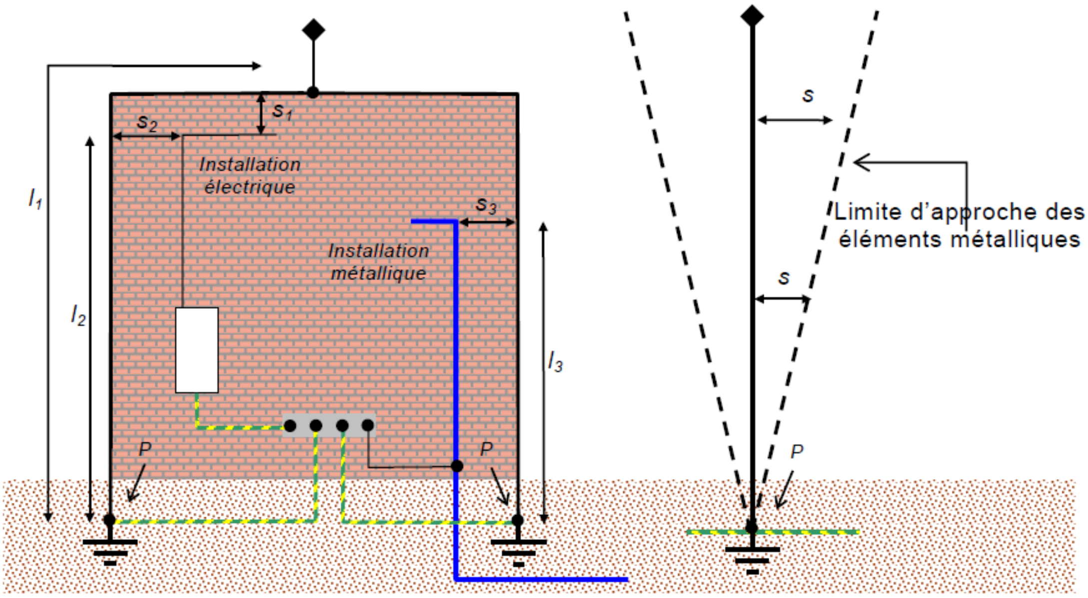
- The coefficient ***kc*** directly related to the number of down conductors :

Number of down conductor	*kc*
1	1
2	1 … 0,5
4 & plus	1 … 1/n

- The coefficient ***km*** directly related to the separating material :

Material	*km*
Air	1
Concrete, Brick	0,5

- The lenght ***l*** (in meter) match the length in between the point where the separation distance is taken into account and the closest equipotentiality connection point



Drawing of the separation distance according to the considered lenght

II.5.c. Equipotentiality of the metallic parts

When technical constraints are no allowing to respect the separation distance, calculated as above, it is necessary to implement equipotentiality connections.

Those connections, implemented in between the captured device and the external metallic parts of the lightning protection system, shall be as direct and straight as possible. It is recommended to use a conductor of 50mm² able to support the lightning current passage.

In the case of the implementation of the equipotentiality of sensitive elements (sensitive electrical cabinet, antenna' mast, satellite dish…), it is recommended to implement equipotentiality spark gap. They allow to insure the balance of the potentials and the flow of the static loads, while insuring the isolation of the two parts.

III. Inspections

In order to check the well-functioning of the lightning protection system and thus the protection of the goods and people, inspections need to be done:

- Initially, after the installation of the lightning protection system
- Periodically
- Exceptionally, if there is a modification

III.1. Initial inspection

The initial inspection shall be done at the end of the installation work, with an aim to insure that the entire lightning protection system is in compliance with the norms in effect, as well as with the technical study and the document describing the performed work.

III.2. Periodical inspection

The frequency of the inspections is defined as per below:

Protection level	Visual inspection (year)	Complete inspection (year)	Critical systems complete inspection (year)
I and II	1	2	1
III and IV	2	4	1

NOTE Lightning protection systems utilized in applications involving structures with a risk of explosion should be visually inspected every 6 months. Electrical testing of the installation should be performed once a year.

An acceptable exception to the yearly test schedule would be perform the tests on a 14 to 15 month cycle where it is considered beneficial to conduct earth resistance testing over different times of the year to get an indication of seasonal variations.

III.3. Exceptional inspection

Every time that the protected structure is modified, repaired or when the structure has experienced a lightning strike, a complete inspection needs to be performed.

IV. Appendices

IV.1. Reference standard

- **NF C 17-102** dated September 2011 : Lightning Protection – Early streamer emission lightning protection system
- **NF EN 62305-1** dated November 2013 : Lightning Protection - Part 1 : General Principles
- **NF EN 62305-2** dated December 2012 : Lightning Protection - Part 2 : Risks assessment
- **NF EN 62305-3** dated December 2012 : Lightning Protection - Part 3 : Physical damages on the structures and human risks
- **NF EN 62305-4** dated December 2012 : Lightning Protection - Part 4 : Power and Communication Networks into the structures

IV.2. Drawing of a typical installation