LINGHTNING

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What is lightning?

To put it simply, lightning is electricity. It forms in the strong up-and-down air currents inside tall dark cumulonimbus clouds as water droplets, hail, and ice crystals collide with one another. Scientists believe that these collisions build up charges of electricity in a cloud. The positive and negative electrical charges in the cloud separate from one another, the negative charges dropping to the lower part of the cloud and the positive charges staying in the middle and upper parts. Positive electrical charges also build upon the ground below. When the difference in the charges becomes large enough, a flow of electricity moves from the cloud down to the ground or from one part of the cloud to another, or from one cloud to another cloud. In typical lightning these are down-flowing negative charges, and when the positive charges on the ground leap upward to meet them, the jagged downward path of the negative charges suddenly lights up with a brilliant flash of light. Because of this, our eyes fool us into thinking that the lightning bolt shoots down from the cloud, when in fact the lightning travels up from the ground. In some cases, positive charges come to the ground from severe thunderstorms or from the anvil at the very top of a thunderstorm cloud. The whole process takes less than a millionth of a second.

What do you need to make Lightning?

You need cold air and warm air. When they meet, the warm air goes up. It makes thunderstorm clouds! The cold air has ice crystals. The warm air has water droplets. During the storm, the droplets and crystals bump together and move apart in the air. This rubbing makes static electrical charges in the clouds.

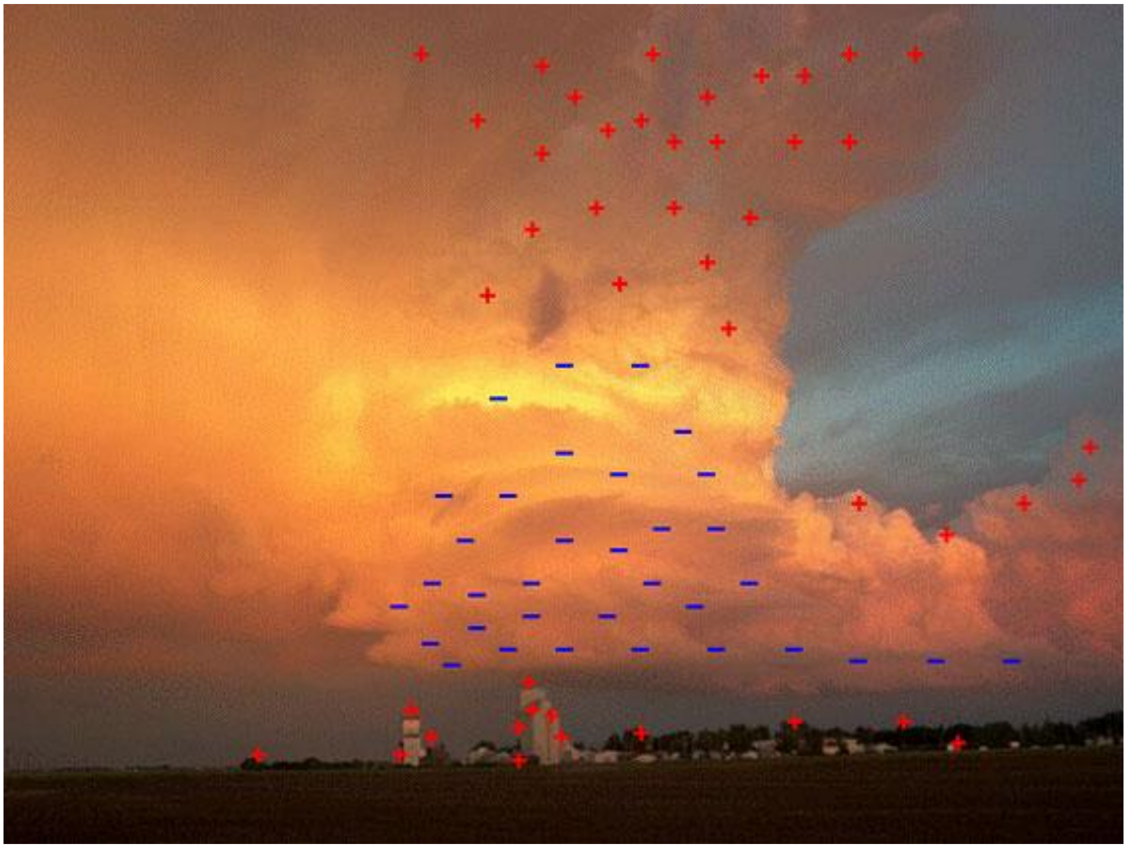
Just like a battery, these clouds have a "plus" end and a "minus" end. The plus, or positive, charges in the cloud are at the top. The minus, or negative, charges are at the bottom. When the charge at the bottom gets strong enough, the cloud lets out energy.

How Lightning Works

Although there is still some debate in the scientific community about how the electrification of clouds actually occurs, it is agreed that the separation of positive and negative charges must occur within a cloud for lightning to take place. It is also generally agreed that ice must be present within a developing storm for it to eventually form lightning.

The turbulent wind environment of a thunderstorm with its updrafts and downdrafts is an ideal environment to separate electric charges: negative charges generally gather near the base of the cloud, while positive charges build in the upper reaches of the cloud. This allows electric fields to form and grow between the cloud and the ground and within the cloud itself - all necessary conditions for lightning to occur.

Since similar-charged objects repel each-other and opposite-charged objects attract each other, negative charges then begin to spread out near the base of the cloud. At the same time, positive charges start to build underneath the storm. This region of positive charges travels underneath the cloud, almost like a shadow. The positive charges tend to concentrate on tall objects, like trees, poles and buildings.



A **cloud-to-ground lightning strike** starts as a channel of negative charges makes its path towards the ground. This occurrence is known as a stepped leader. The stepped leader continues towards the ground in a series of steps that are each about 50 to 100 meters in length. This stepped leader can branch out in many directions.

In response to the discharge of negative charges coming from the cloud base, currents of positive charges start moving upward from the ground, usually along elevated objects; these are called streamers or upward leaders.

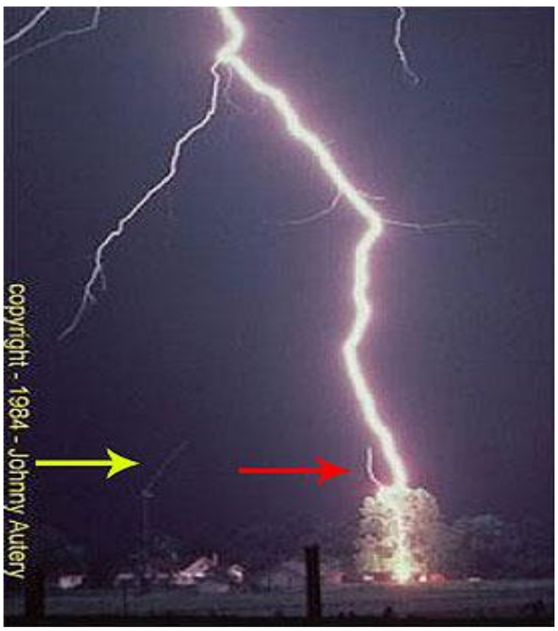
When the stepped leader and the upward leader meet, usually between 30 to 100 meters above the ground, the negative charges begin to flow downward. Almost instantaneously, a much larger and luminous electric current shoots up to the cloud, following the path taken by the stepped leader. This is known as the return stroke, and it is also what we see in the sky that is known as lightning. This whole process occurs so quickly (in less than one second!) that the lightning appears to travel from the cloud to the ground, when in fact, the opposite is true.

The Types of Lightning

- **Cloud-to-ground lightning**

As the negative charge grows inside a thunderstorm's base, positive charge begins pooling within the Earth's surface below, shadowing the storm wherever it goes. This is responsible for nearly all cloud-to-ground lightning — a stepped leader lurches downward from the negative cloud base, intercepted on its way by a column of ionized air called a "positive streamer" that shoots up to meet it from the positively charged ground. When the two connect, a violent electrical current roars between the cloud and the ground, forming the lightning bolt (see photo). Multiple positive streamers sometimes compete for the same stepped leader, such as in this photo, where you can see a tiny streamer that leapt up from a telephone pole in the bottom left corner, but was beaten to the punch by a nearby tree.

Almost any grounded object or organism under a thunderstorm may attract a stepped leader, but lightning is lazy, so the closer the better. Trees, tall buildings, towers and antennas are favorite targets, and, contrary to folk wisdom, lightning can strike twice.



Cloud-to-ground lightning

- **Intracloud and cloud-to-cloud lightning**

About three-quarters of all lightning on Earth never leave the cloud where it formed, content to find another region of oppositely charged particles within the storm. These strikes are known as "intracloud lightning," but they're also sometimes called "sheet lightning," when, from our vantage point, they light up a glowing sheet on the cloud's surface. "Spider lightning" (see photo below) occurs when branching bolts creep along the cloud's underside.

Lightning also sometimes leaves the cloud but stays in the sky, a phenomenon that can take many forms. It might jump to another cloud, or it might simply strike the air around the storm if enough charge has built up nearby.

While cloud-based lightning doesn't normally bother humans on the surface, it can wreak havoc with our airplanes, rockets and other flying machines. Flight paths often lead passenger jets directly through large thunderstorms, and while lightning normally passes along on the outside of the plane, it's hard to completely protect any electrical system in such conditions. Company officials have said Air France Flight 447 was probably struck by lightning before disappearing over the Atlantic— it flew into a tropical storm just before losing power in both electrical systems — although a variety of other factors likely compounded that. NASA engineers at Cape Canaveral also are regularly plagued by lightning from Florida's merciless summer thunderstorms, which can delay launches and damage expensive equipment.

Intracloud and cloud-to-cloud lightning

- **Bolt from the blue**

The majority of lightning strikes are negative, descending from the cloud base to the positively charged ground. But in large thunderstorms, a supercharged positive bolt may launch out from the cloud's upper regions (see photo), flying away from the storm before crashing into a distant section of negatively charged earth. Sometimes traveling up to 30 miles, these strikes can sneak up on people who don't even know a thunderstorm is nearby — hence the name "bolt from the blue." In addition to being stealthy and rare, bolts from the blue are also much more powerful than normal lightning strikes, and therefore cause more bodily and property damage.

Bolt from the blue

- **Ball lightning**

Floating orbs of electricity have been reported during thunderstorms around the world — and even recreated in a lab — but never scientifically verified in nature. If natural ball lightning does exist, it's fleeting, erratic and rare. Still, there are tantalizing hints, such as the IMAGE below, that it may be real.

Ball lightning

Ball lightning

- **Transient luminous events**

Lightning isn't the only electrical trickery thunderstorms have up their sleeves. There's another world of weird, ghostly lights that most humans never see, dancing around the upper atmosphere above storms. They aren't really lightning in the traditional sense — "transient luminous events" or "atmospheric optical phenomena" are the preferred terms — but they're such recent discoveries we know little about them.

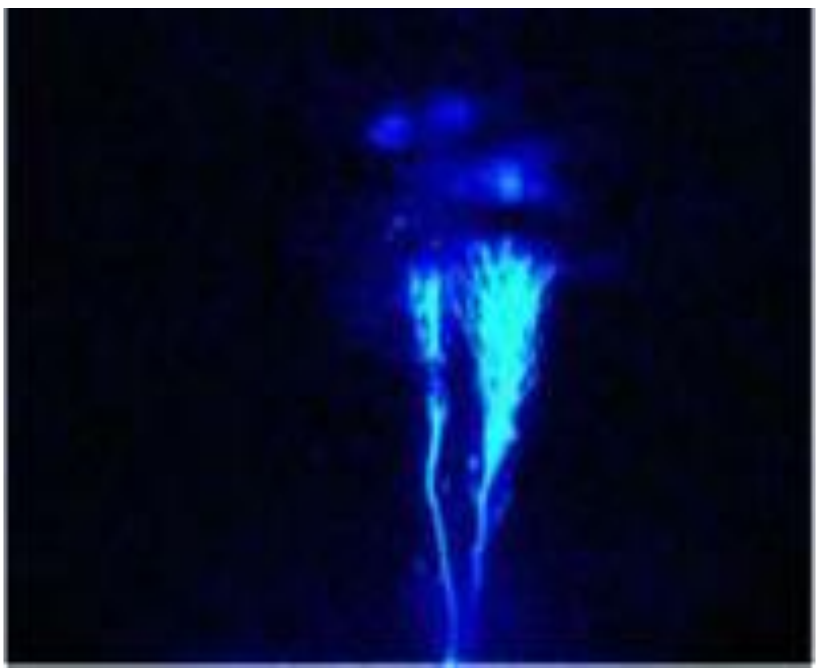
- **Sprites**

Sprites are huge flashes of light that appear directly above active thunderstorms, usually corresponding with powerful, positively charged cloud-to-ground lightning below. Also known as "red sprites" since most of them glow red, these wispy flares can shoot up to 60 miles from the cloud's top, although they're weakly charged and rarely last more than a few seconds. Sprites' shapes have been compared to columns, carrots and jellyfish, but their faint charge and soft glow means they're rarely spotted with the naked eye — in fact; there was no photographic evidence of them until 1989. Since then, however, thousands of sprites have been photographed and filmed from the ground, from aircraft and from space.

Sprites

• **Blue jets**

Blue Jets are what they sound like: beams of blue energy that blast out of a thunderstorm's top into the surrounding sky. But despite the straightforward name, they're one of the more mysterious transient luminous events, since they're not directly associated with cloud-to-ground lightning and aren't aligned with the local magnetic field. As the glowing blue-and-white streaks emerge from a cloud, they extend upward in narrow cones, gradually fanning out and dissipating at heights of about 30 miles. Blue jets last only a fraction of a second but have been witnessed by pilots and even caught on video.

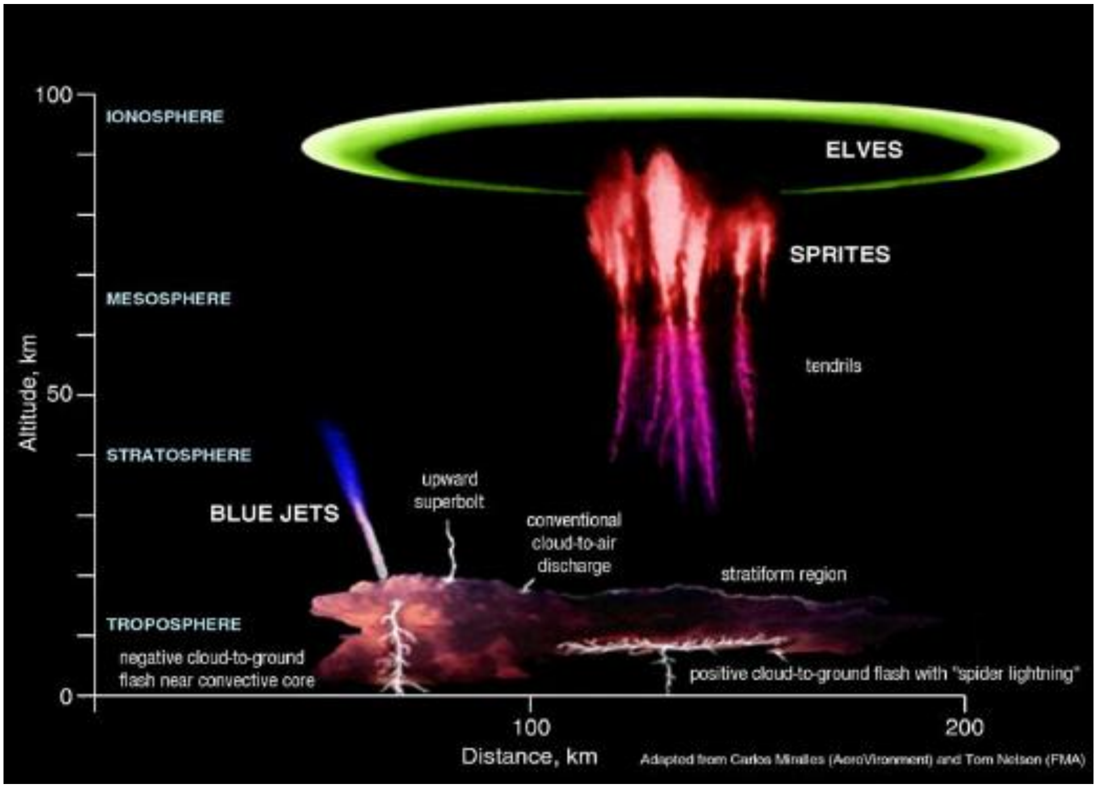


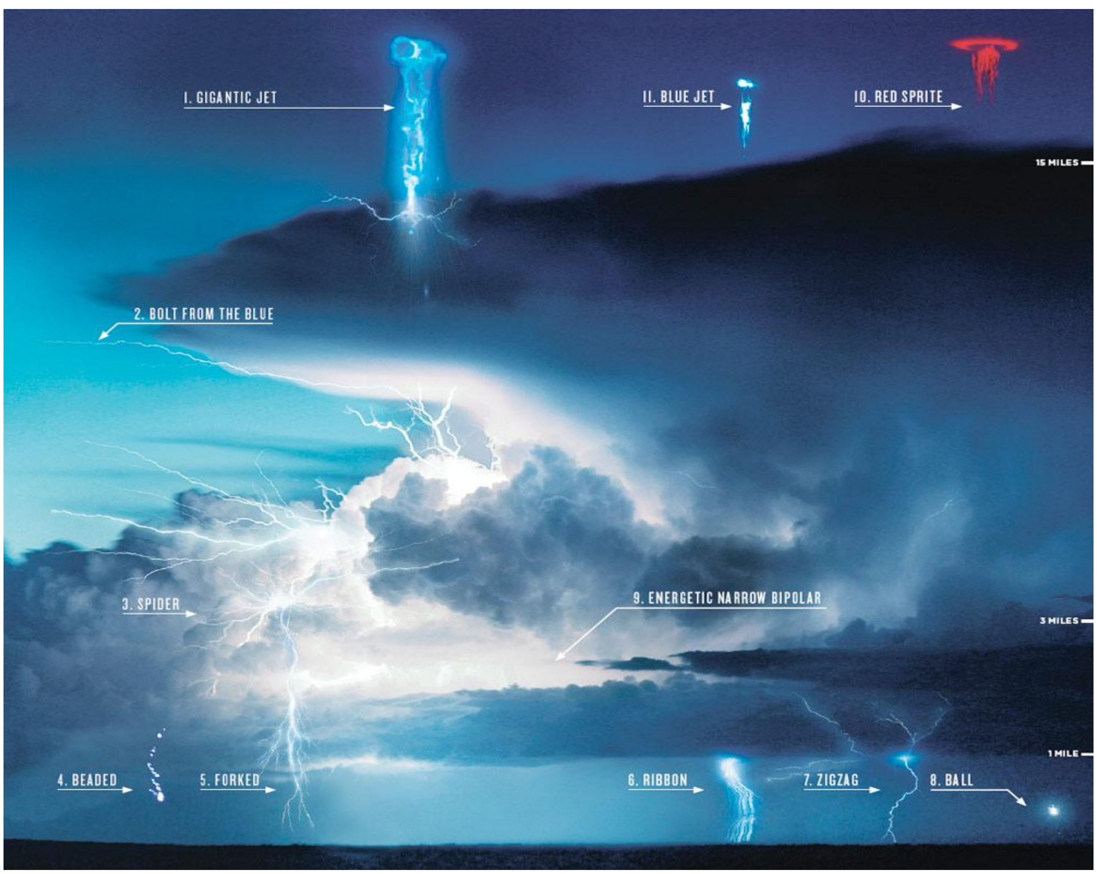
Blue jets

• **Elves**

Elves like sprites, occur over an area of active cloud-to-ground lightning, and are also found in the ionosphere. These glowing, quickly expanding discs can stretch out for 300 miles, but they last less than a thousandth of a second, which would make spotting them difficult even if there wasn't a thunderstorm in your way. NASA discovered elves in 1992 when a low-light video camera on the space shuttle taped one in action, and scientists believe they're caused by an electromagnetic pulse shot up from a thunderstorm into the ionosphere.

Elves


100
IONOSPHERE
ELVES
SPRITES
MESOSPHERE
tendrils
Altitude, km
50
STRATOSPHERE
BLUE JETS
upward superbolt
conventional cloud-to-air discharge
stratiform region
TROPOSPHERE
negative cloud-to-ground flash near convective core
positive cloud-to-ground flash with "spider lightning"
0
100
200
Distance, km
Adapted from Carlos Miralles (AeroVironment) and Tom Nelson (FMA)


1. GIGANTIC JET
11. BLUE JET
10. RED SPRITE
15 MILES
2. BOLT FROM THE BLUE
3. SPIDER
9. ENERGETIC NARROW BIPOLAR
3 MILES
1 MILE
4. BEADED
5. FORKED
6. RIBBON
7. ZIGZAG
8. BALL

LIGHTNING AND IT'S RELATED HAZARDS

lightning is a natural electrical phenomenon that consists of high current short time discharge that neutralizes the accumulation of charge in the atmosphere. In other words, lightning is the transient passage of electrical current between a cloud and either the surface of the earth, another cloud or an object in or near a cloud. Lightning is most commonly associated with thunderstorms, but can also occur in snow storms and from the ash cloud of volcanic eruptions. The phenomenology of lightning strikes to earth, as presently understood, follows an approximate behavior, the downward Leader from a thundercloud pulse towards earth seeking out active electrical ground targets. Ground-based objects (fences, trees, blades of grass, corners of buildings, peoples, lightning rods, etc.) emit varying degrees of electric activity during this event. Upward streamers are launched from some of these objects. A few tens of meters off the ground, a collection zone" is establishes according to the intensified local electrical field. Some leader(s) likely will connect with some streamers. Then, the switch" is close and the current flows and lightning occurs.

MECHANISM OF LIGHTNING STRIKES

At any given time, there are cluster of ions of both polarities in the earth's atmosphere, produced by Cosmic rays, many of which attached themselves to small dust and water particles. Of course, lines of electric field must start on a positive charge and terminate on a negative charge. Hence, electric field of considerable strength exist in the earth's atmosphere which is directed downward towards the earth (Fig. 1). However, both the positive and negative charges mixed up thereby producing essentially a neutral space charge.

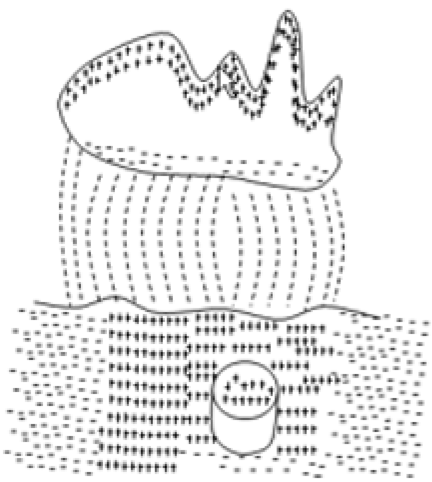


Fig. 1

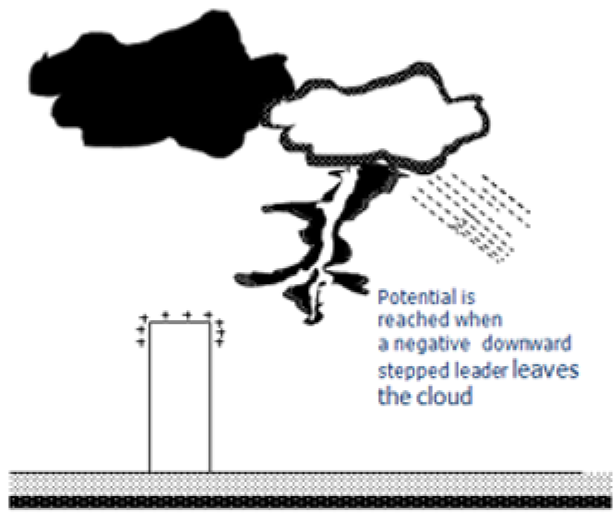


Fig. 2 The Discharge Process of Lightning

During a thunderstorm, charge separation builds up within and around the cloud due to the upward motion of air currents. The charge separation or charging action within the storm cell usually leaves the base of the cloud with a negative charge and the upper region with a positive charge. Since the base of the cloud is negatively charged, the earth surface concentrated directly below the cloud and any grounded objects are positively charged by induction to about the same size and shape as the cloud.

As the storm builds in intensity, charge separation continues within the cloud resulting to increase electric field between the cloud and the earth or other adjacent clouds. A point is reached within the cloud locally where the electric field become so excessive that the air dielectric of the intervening space between the cloud and earth can no longer support the electric stress (i.e. act as an insulator). Hence, a breakdown or lightning discharge occurs. The specific breakdown point varies with atmosphere conditions.

The air dielectric breakdown initiates the development of low intensity sparks called the "stepper leader" strokes, characterized by a family luminescent channel, which progresses rapidly in some what a random fashion by series of short steps from the base of the cloud towards the earth seeking out active electrical ground targets (Fig.2). These steps are nearly of equal length and the length is related to the charge in the storm cell and the peak current in the strike and varies in length from about 10m to over 160m for a negative stroke.

As the stepped leader strokes approaches the earth, the electric field between them increases with each step. Finally at about one step distance from the earth or an earth bound facility a "strike zone" is established (Fig.3). This strike zone is approximately hemispherical in shape, with radius equal to one step length.

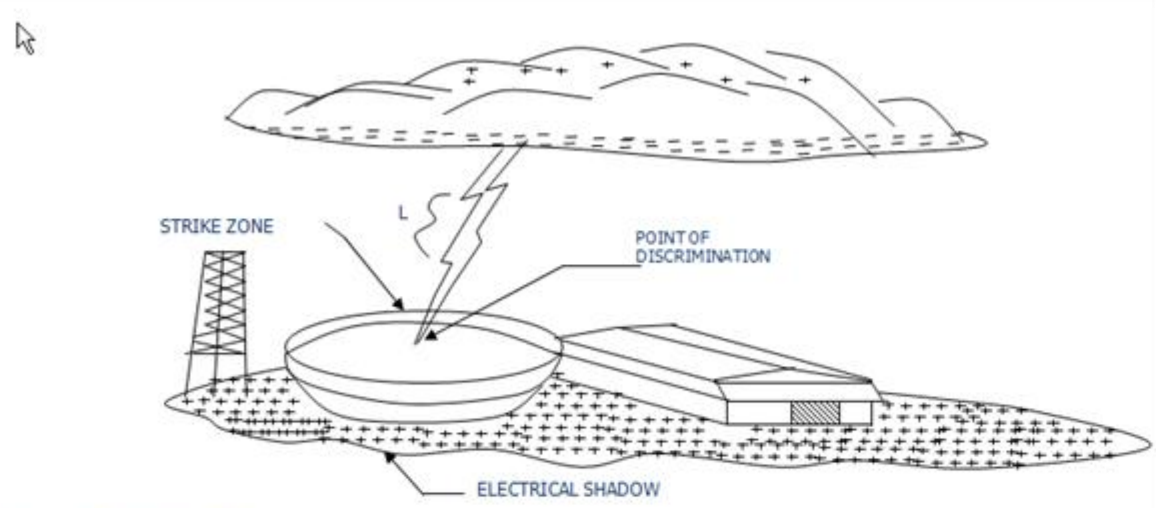


Fig. 3: The Strike Zone

The rapidly escalating electric field within the strike zone is so high that it launches upwards moving streamers, a discharge which moves up swiftly from the ground or earthbound objects to the already ionized channel prepared by the stepped leader strokes to complete the path between the cloud and the ground (Fig.4). The first streamer that reaches the stepped leaders strokes closes the circuit or the gap between the earth and the cloud and charge neutralization process starts. In other words, the negative charge of the cloud is being neutralized by the positive induced charge of the earth as both combine together (Fig. 4).

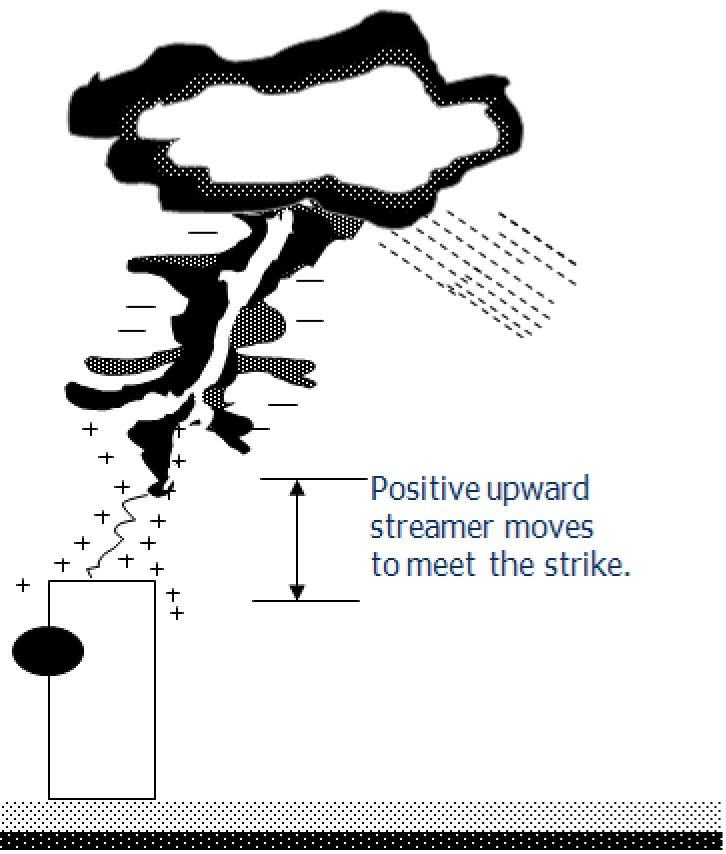


Fig. 4: Active Power of Electrode

Once the stepped leader established contact with earth or earth bound object, a conducting arc channel to ground is formed and a main discharge or return stroke commences (Fig.5). The main discharge is a process of the progressive neutralization of the charge of the channel. The return stroke is very intense and the current varies between 1kA to 200kA with speed of about 10percent that of light. The neutralizing front of the return stoke moves up the channel with speed of about one-thirds the velocity of light. The rate of propagation, the quantity and disposition of the charge involves determine the magnitude and shape of the current which is of practical concern when lightning stroke terminate on any earthbound structure.

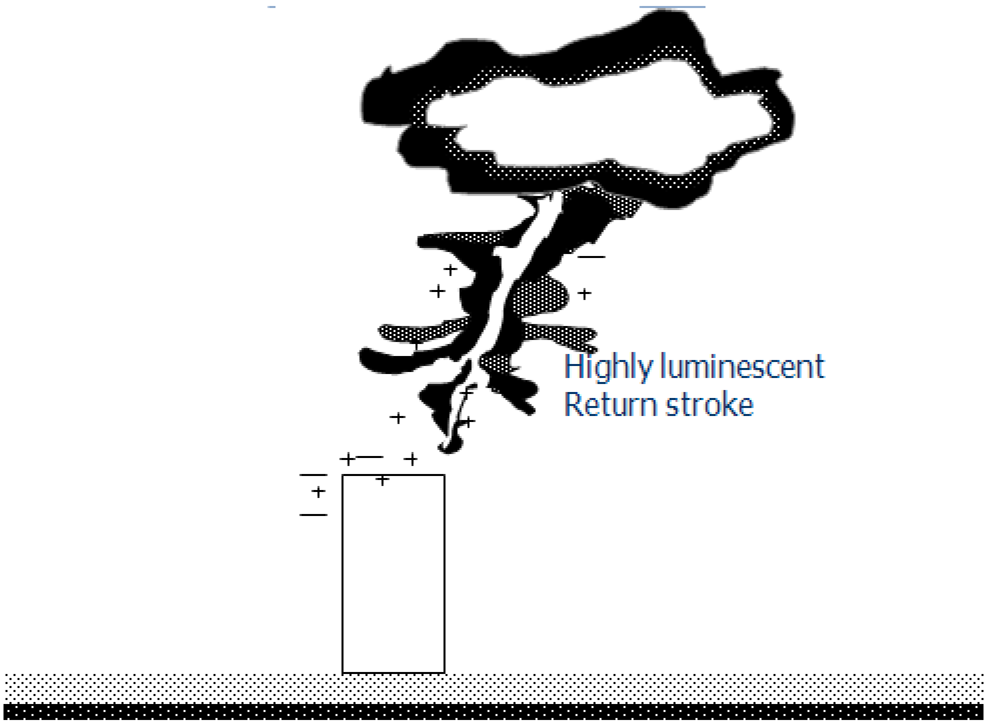


Fig. 5 Return Stroke

EFFECTS OF LIGHTNING

Lightning effects can be direct and/or indirect (or secondary). Once the stroke terminates, a series of events, called "indirect or secondary effects" takes place. The physical characteristics of the stroke itself can vary in a number of parameters over several orders of magnitude as listed in Table 1.

Temperatures	Upward of 50,000^{0}F
Storm Cell Charge	40 Amp – Sec
Peak current	2 kA to 500 kA
Time to Peak Current	50nsecs to 10μsecs
Peak Energy	Up to 10^{10} Joules
Stroke Duration	10 to 1000 μ Sec.
Propagation Speed	2 to 25 x 10^7 m/s
Number of current surges	
Per Lightning Flash	1 to 26
Power released	In order of 100 MW per meter

Direct Effects of lightning

Direct lightning strike is capable of producing a force capable to rip through roof, explode walls of brick and concrete, ignite deadly fires, and produce high electrical surges in electrical power circuits and equipment. And will cause dead for peoples

INDIRECT (SECONDARY) EFFECTS OF LIGHTNING

There are at least five secondary effects that result from lightning terminating on some earthbound system.

Electromagnetic Pulse (EMP)

Electrostatic Pulse (ESP)

Earth Current Transients (ECT)

Bound Charge (BC)

Ground Surface Arcing (GSA)

Any or all of these have caused damage to communication, data, electronic, and computer facilities.

These effects may be categorized as

Those that cause fires and explosion

Those cause loss of instrumentation and control.

Who Needs a Lightning Protection System?

As we mentioned before there are two type of effects of Lightning

1-Direct effect

2-Indirect effects

Everyone needs protection from direct effect (Buildings, Houses, Factories, and electrical stations….etc).

For Indirect protections all electrical and electronic equipments need protection because as we know annually we are losing billons dollars from lightning effects. So everyone needs lightning protection .and the way of protection depend on the effect of the lightning for direct lightning there different types of the lightning protection ,for indirect(secondary) effects there are another protection equipments

Everyone Needs Lightning Protection!

Lightning can strike anywhere on earth - even at the North and South Poles! Thunderstorms occur virtually everywhere and that puts any building at risk. State-of-the-art certified lightning protection systems are a part of the structural design of thousands of commercial and public facilities worldwide. These systems are designed to maximize protection to both life and property. Risk factors including your location, frequency of thunderstorms, soil composition and building occupancy determine the need for lightning protection system.
Lightning storms can occur in any place in world geographical location and can occur from 5-100 times per year. The Northeast US has some of the most violent thunderstorms in the country because that area has extremely high earth resistivity (the earth's resistance to conduct current) which increases the potential of a lightning strike. Structures in these areas will generally sustain more damage, when struck by lightning, when there is no lightning protection system present.
Thousands of homes and other properties are damaged or destroyed by lightning each year. Lightning strikes account for more than quarter billion dollars in property damage annually in the United States. Lightning strikes are responsible for more property loss and deaths than all the hurricanes, tornadoes and floods combined. Lightning is the only violent force of nature that on we can economically afford to protect ourselves against.

Protection systems for direct lightning effect

How Lightning Protection Systems Work (For direct effect of lightning)

Lightning is the visible display of a discharge of static electricity within a cloud, between clouds, or between the earth and a cloud. Scientists still do not fully understand what causes lightning, but most experts believe that different kinds of ice interacting a cloud. Updrafts in the cloud separate charges so that positive charges end up at the top of the cloud while negative flow to the bottom. When the negative discharge moves down from the clouds, a "pilot leader “forms. This leader rushes down towards the earth in 150 ft. steps, ionizing a path in the air as it moves. The final breakdown generally occurs to a high object on the earth and the major part of the lightning discharge current is then carried in the return stroke which flows along the ionized path.

A lightning protection system provides a way for this discharge to enter or leave the earth without passing through and damaging non-conducting parts of a structure, such as those made of wood, brick, tile or concrete. A lightning protection system does not prevent lightning from striking; however it provides a means for controlling it and preventing damage by providing a low resistance path for the discharge of lightning energy into the earth.

A direct hit to a building, nearby strike to a power line or even a voltage surge origination from your utility company can cause a fire in electrical service panel boxes or seriously damage equipment by frying insulation and sensitive microprocessor components. The combined technology of structural protection (lighting rods) and surge protection minimize damage, while providing the highest level of protection for properties.

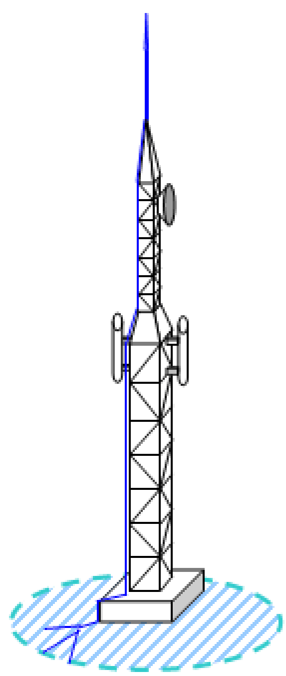
The types of Protection from direct effect of lightning

1-Lightning rod :

Benjamin Franklin invented the Lightning Rod in 1753. This lightning conductor is made up of a 2 to 8 m high tapered metal rod that dominates the structure to be protected and which is connected to a conductor and an earthen system.

As the protection radius of this type of lightning conductor is limited to around 30 meters environ (Protection level IV, height = 60 meters), it is normally only used to protect small structures or zones such as pylons, chimneys, tanks, water towers, aerial masts, etc...

Typical example : Protection of a pylon using a lightning rod



2-Meshed cage lightning conductor :

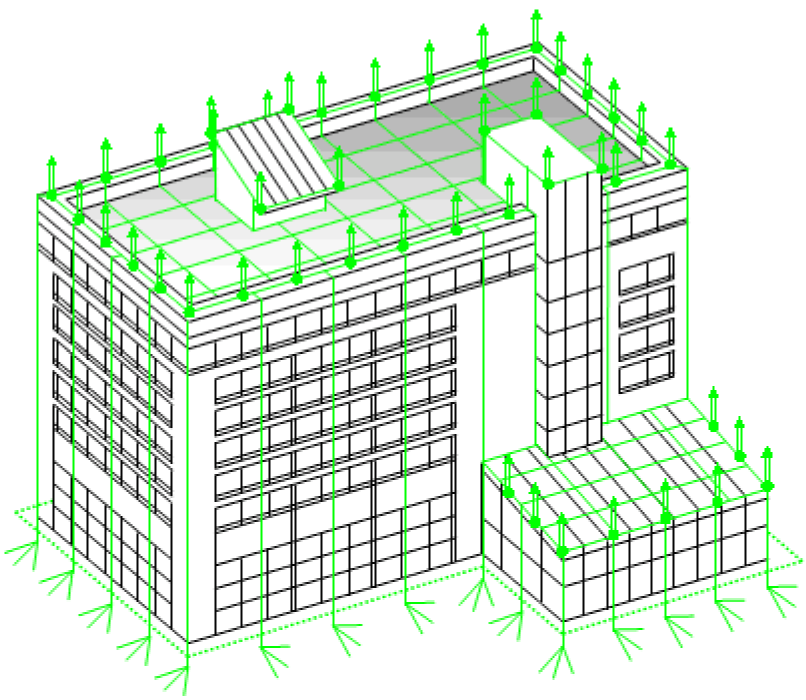
This lightning conductor, derived from the Faraday cage, consists of a mesh that covers the roof and walls of the structure to be protected.

Air terminals are positioned around the edge of the roof and on high points. A network of conductors follows the external perimeter of the roof. This network is completed with transverse elements. The mesh size is between 5 and 20 meters depending upon the effectiveness required.

The top of the down conductors fitted to the walls are connected to the roof mesh, and the bottom to dedicated earthen systems. The distance between two down conductors is between 10 and 25 meters depending upon level of protection required.

The majority of lightning current is conducted and dissipated by the conductors and earthen systems closest to the point of impact of the lightning strike.

Typical example :
Protection of a building using a mesh cage lightning conductor



3-Catenary wire lightning conductor :

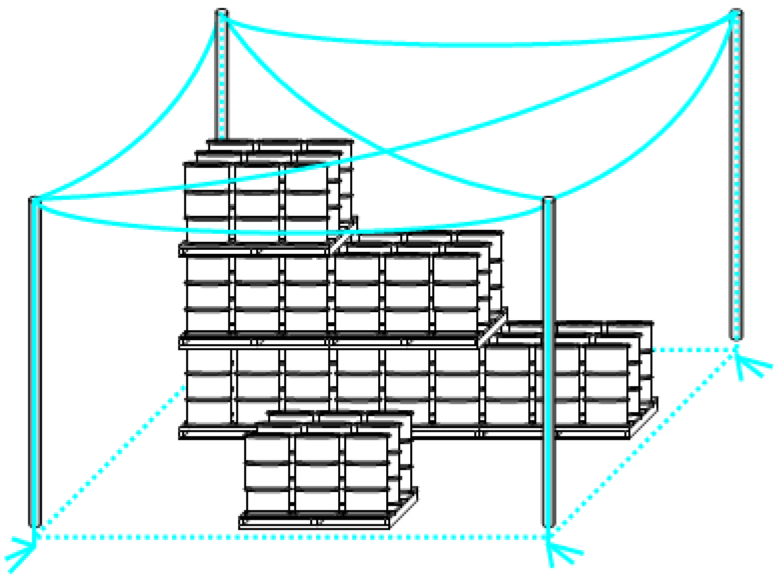
This lightning conductor, using a similar principle to that of the mesh cage, consists of a mesh of conductors, but at a distance from the structure to be protected. The aim is to avoid the lightning current coming into contact with the structure.

Catenary wire conductors placed above the structure to be protected are connected to down conductors and dedicated earthen systems. The size of the mesh and the distance between down conductors are subjected to the same rules as for the mesh cage lightning conductor.

This protection requires that additional mechanical studies (resistance of materials: calculation of sag, resistance to weather conditions, etc.) be carried out and insulation distances defined.

The catenary wire lightning conductor is particularly used to protect open areas when there is no architectural support.

Typical example :
Protection of an external barrel storage area by a catenary wire lightning conductor



4-Protection using «natural» components

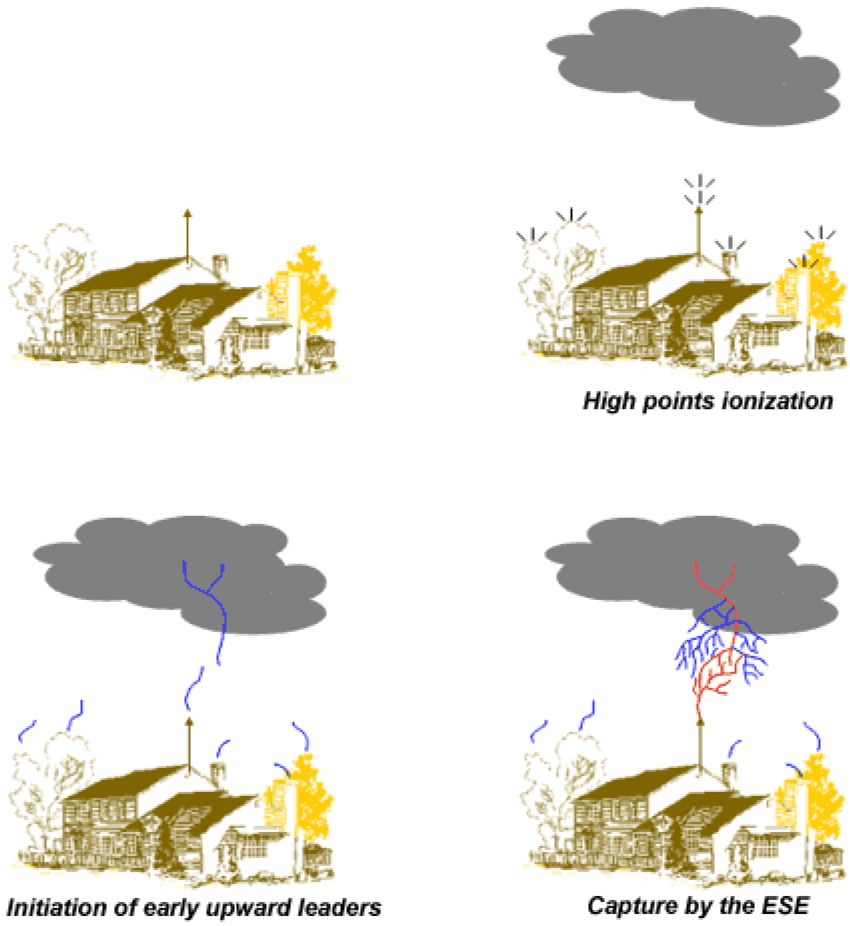
Components that have a lightning protection function but that were not installed for this purpose.
Comment: these are conducting parts of a structure or building that are able to participate in the external protection through their capacity to capture a lightning strike or to conduct lightning current. They can be used to replace all or part of a down conductor or in addition to an external installation.
These components may be made up of:
- The frame of metal constructions;
- Metal coatings of walls or metal cladding
- Sheet metal covering the volume to be protected, provided there is no risk of them being perforated by an impact
- Metal components of a roof structure (interconnected steel frames, etc.), even if covered with non-metallic materials, provided that these may be excluded from the volume to be protected
- Metal rods in reinforced concrete, provided that there is electrical interconnection between them, and particularly with the capture means and earthen system
- Metal parts such as gutters, decoration, guardrails, etc, provided that their cross-section is not less than that specified for normal components
- Metal pipes and tanks, provided they are at least 2.5 mm thick and if perforated, do not cause a dangerous or unacceptable situation

These elements must comply with thickness, cross-section and continuity constraints, thus making their use a delicate affair.

5-Early streamer emission lightning conductor

The principle of an early streamer emission lightning conductor is to artificially generate, with the aid of an ionization mechanism, an early upward leader occurring before the other «natural» upward leaders, in order to establish a privileged impact point of the lightning strike.

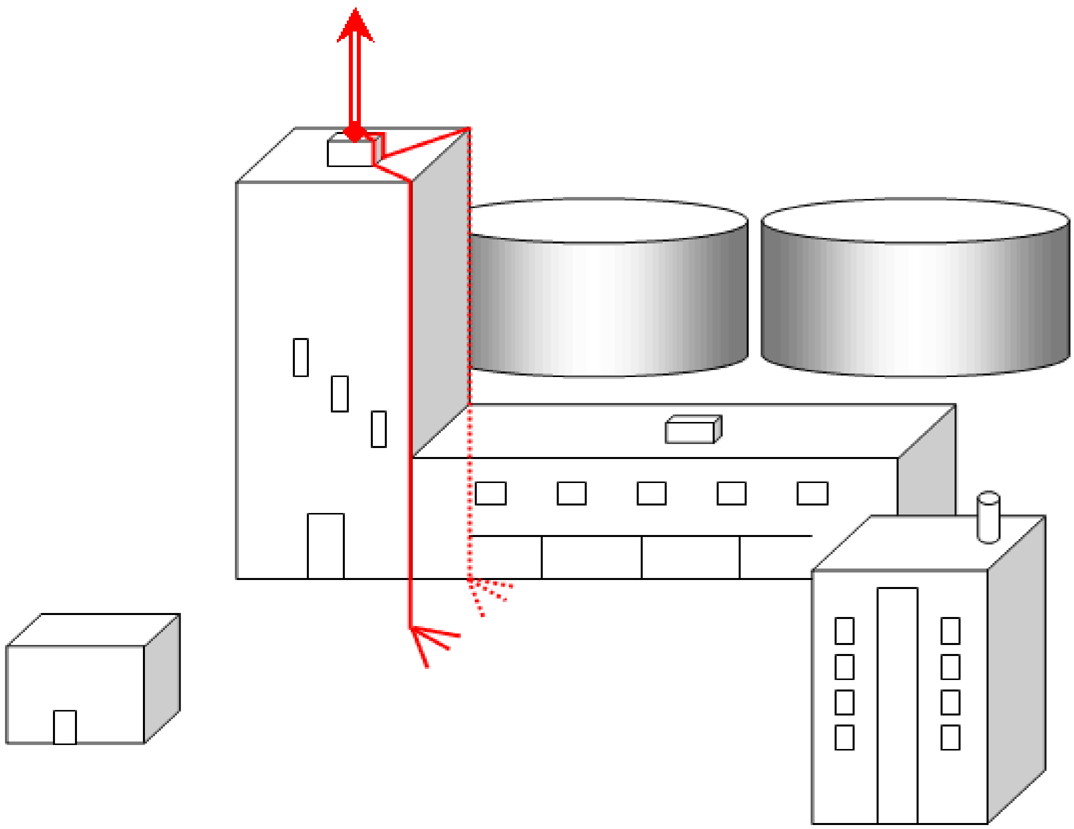
Diagram showing the operating principle for capturing a lightning strike using an early streamer emission conductor



Because the capture of a lightning strike is quicker than with a lightning rod, this technology can be used to protect zones spread over a wider area, thus ensuring the protection of large structures.

The protection radius generated depends on the lightning conductor's triggering advance value (Δt in μs), its height and the effectiveness of the protection, the maximum value being 120 meters (Level III, height = 60 meters).

Typical example :
Protection of an industrial site using an early streamer emission lightning conductor



Advantages and disadvantages of the different protection types

Lightning rod :

Advantages	Disadvantages
- Ease of installation.	- Limited to protecting small size structures.
- Economic	- Mechanical withstands constraint of the masts.
- Can be integrated into the building's architecture without changing its aesthetics	

Mesh cage lightning conductor

Advantages	Disadvantages
- Reduction of electromagnetic radiating effects within the protected structure. Spreading of lightning currents over several down conductors.	- Complex and costly to install.
- Contributes to overall equipotential between the conducting structures and ground.	- Often not aesthetic due to the complexity of the structure.

Catenary wire lightning conductor

Advantages	Disadvantages
- Reduction of electromagnetic radiating effects within the protected structure. Spreading of lightning currents over several down conductors.	- The catenary wires can be a danger in handling areas where lifting equipment is used.
- Contributes to overall equipotential between the conducting structures and ground.	- Complex and costly to install.
- Protection of open zones	- Often not aesthetic due to the complexity of the structure

Protection by «natural» components

Advantages	Disadvantages
- Simplifying of the installation and reduction of costs	- Maintenance is difficult (checking of electrical continuity, identification of «natural» structures participating in the protection, etc.)
	- Possible partial or total removal of «natural» elements participating in the protection when the building is modified.

Early streamer emission lightning conductor

Advantages	Disadvantages
- Lightning conductor can be installed outside of a dangerous zone.	- Minimum lightning conductor height of 2 meters.
- Possible to protect several buildings with the same lightning conductor.	- Mechanical withstand constraint of the masts.
- Economic	
- Possible to protect a structure and its surrounding environment at the same time.	
- Protection of open zones.	
- Can be integrated into the building's architecture without changing its aesthetics.	

COPMARITION BETWEEN THE TYPES OF PORTECTONS

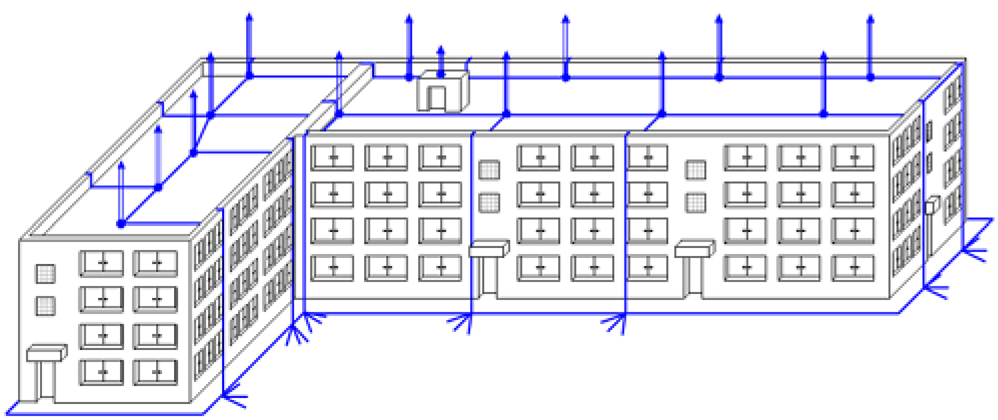
Protection of a school :

- Lightning rod protection
- Mesh cage protection
- Early streamer emission protection

1- Lightning rod protection

Protection level : II as defined in NF C 17-100
Description : 6m high lightning rods installed on the roof.
Protection radius Rp = 12 meters at level II protection.
On the roof: equipotential interconnection of the lightning rods.
On the walls: each lightning rod is connected to a down conductor fitted with a dedicated earth rod.

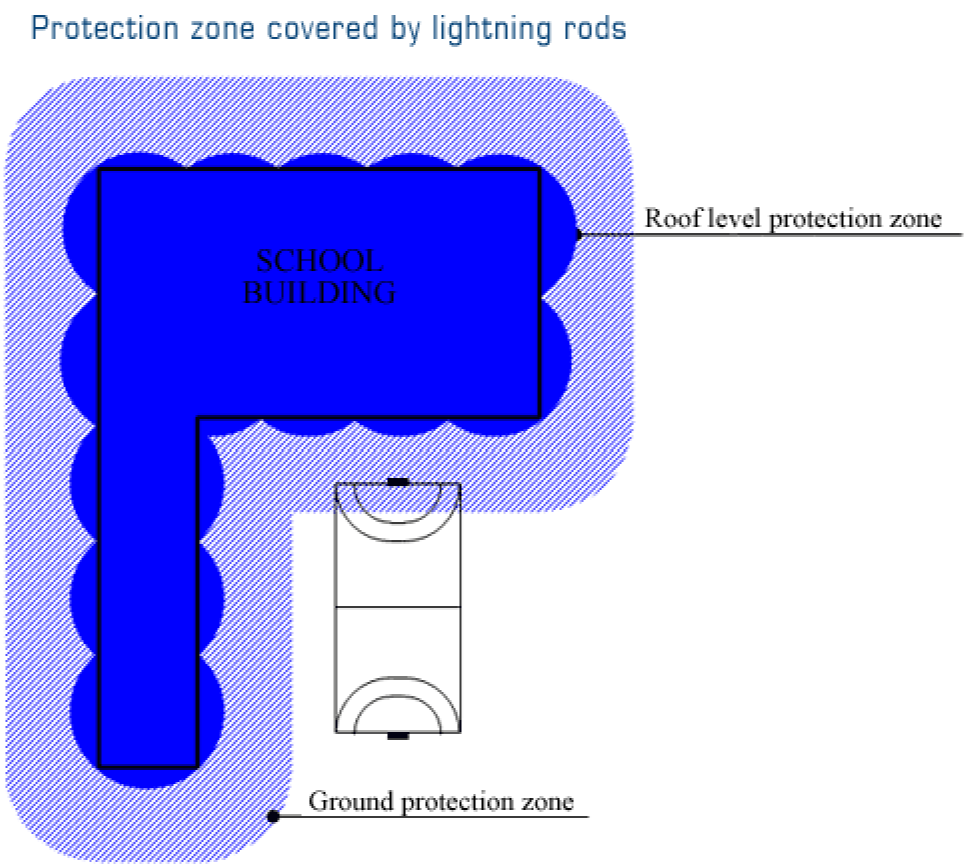
Installation schematic :



II Compare to mesh cage protection
III Compare to Early streamer emission protection

Estimated cost: €33,000 (exc. tax) (including installation)

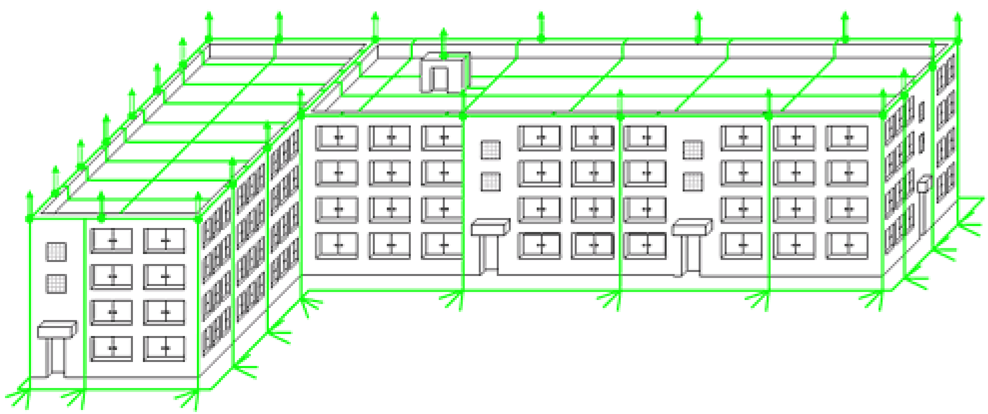
Block plan:


Protection zone covered by lightning rods
SCHOOL
BUILDING
Roof level protection zone
Ground protection zone

2- Mesh cage protection

Protection level: II as defined in NF C 17-100
Description: 50 cm capture points installed around the roof perimeter every 15 meters and on the lift cage.
10 meter roof mesh grid.
On the walls: down conductors every 15 meters, the bottoms of which are connected to a series of dedicated earth rods..

Installation schematic :

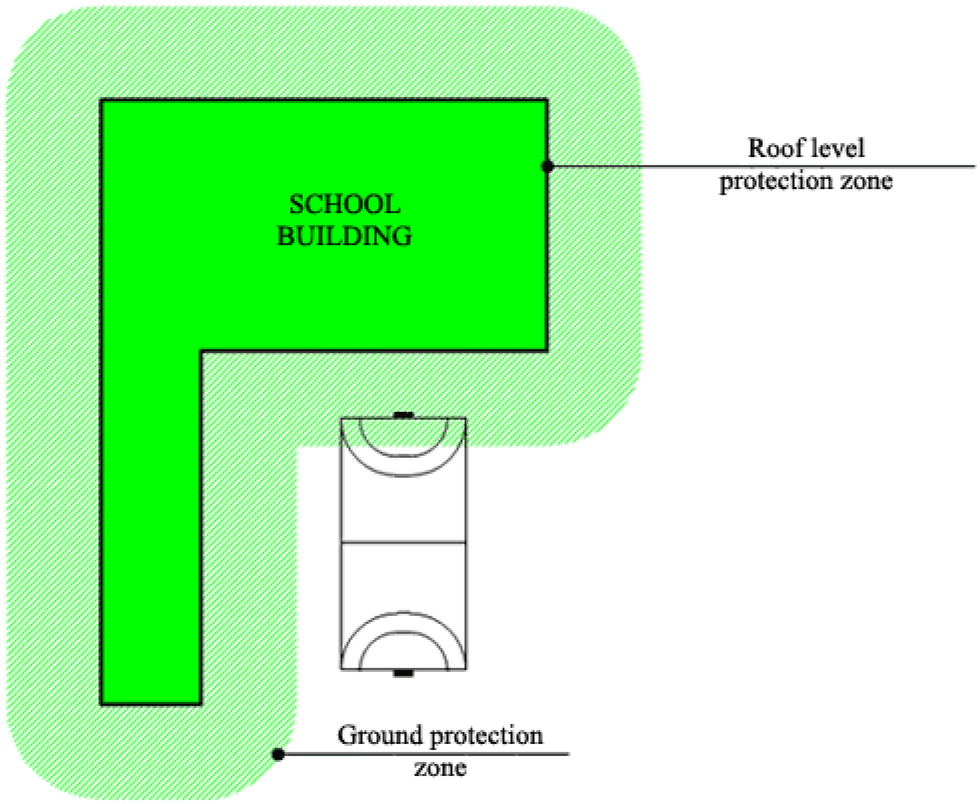


I Lightning rod protection
III Compare to Early streamer emission protection

Estimated cost: €36,000 (exc. tax)(including installation)

Block plan :

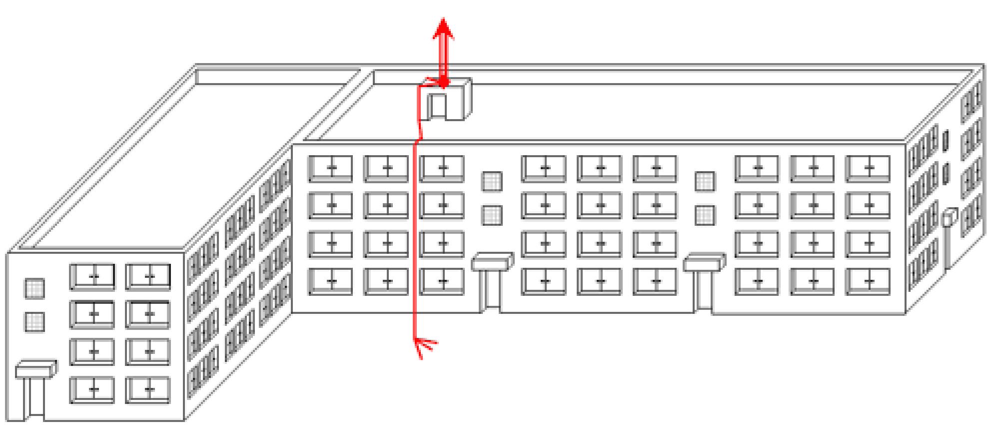
Protection zone covered by the mesh cage lightning conductor



3- Early streamer emission protection

Protection level : II as defined in NF C 17-102
Description : 5m high early streamer emission lightning conductor on the roof of the lift cage.
Protection radius Rp = 83.5 metros (Δt = 47μs minimum) at level II protection.
The lightning conductor is connected to two down conductors (see NF C 17-102 § 2.3.2), each fitted with a dedicated earth rod..

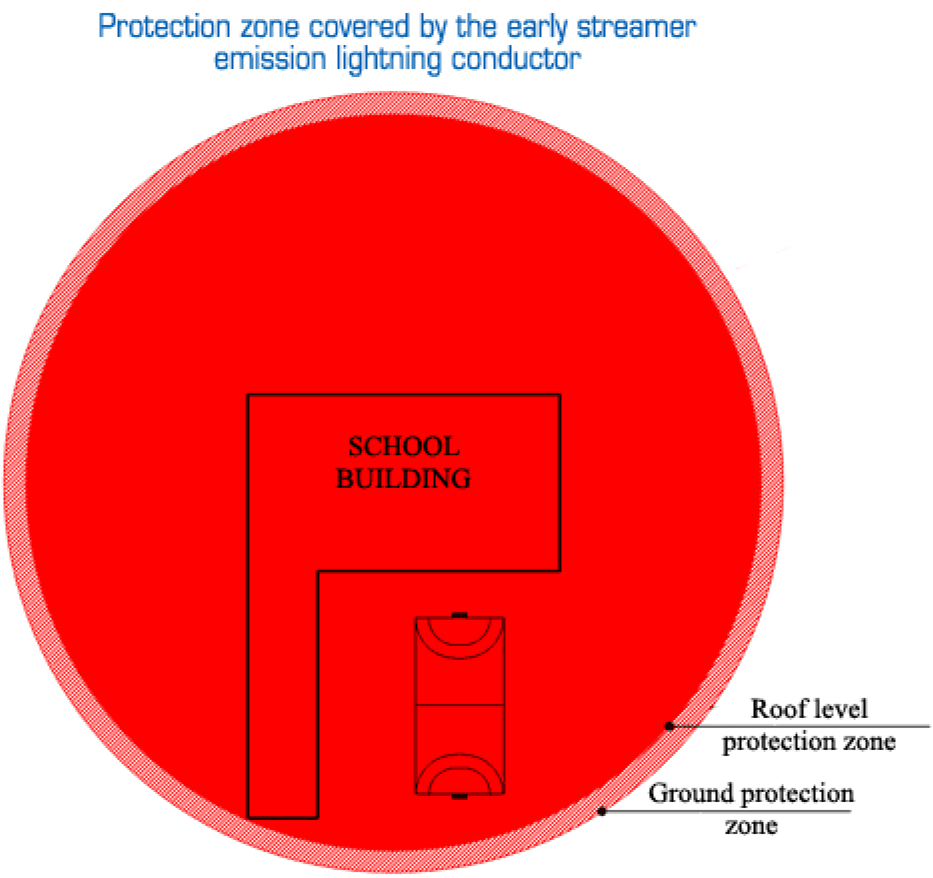
Installation schematic



I Lightning rod protection
II Compare to mesh cage protection

Estimated cost: €7,000 (exc. tax) (including installation)

Block plan :

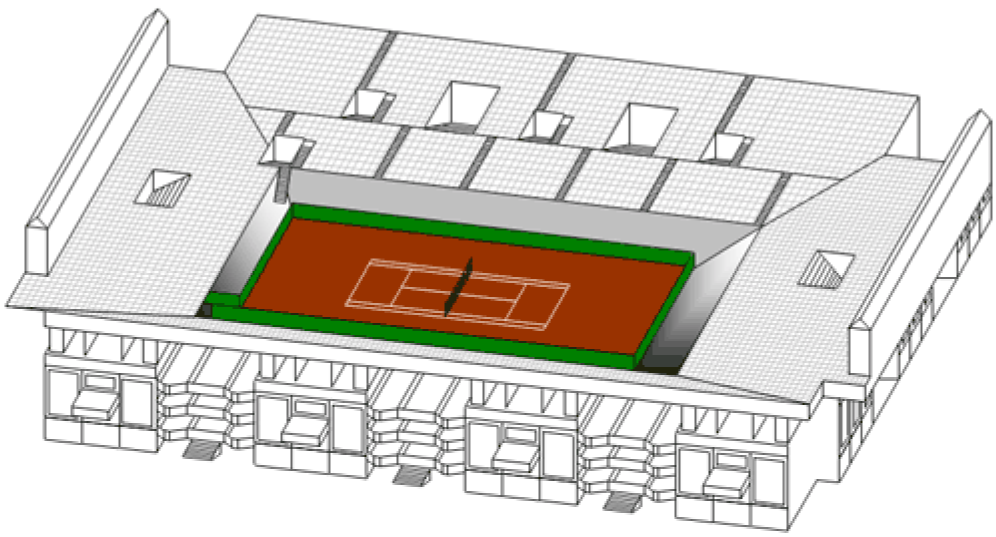


Protection of a tennis court :

1- Lightning rod protection

2- Mesh cage protection

3- Early streamer emission protection



2- Lightning rod protection

Protection level : II as defined in NF C 17-102
Description of the installation that would have to be implemented : 6m high lightning rods installed on the roof to protect the stands and the court. On the roof: equipotential interconnections between the lightning rods. Each lightning rod is connected to a down conductor fitted with a dedicated earth rod.
Remarks : The tennis court design is such that lightning rods are not able to provide complete protection of the structure in compliance with the standard. This solution must be rejected.

2- Mesh cage protection

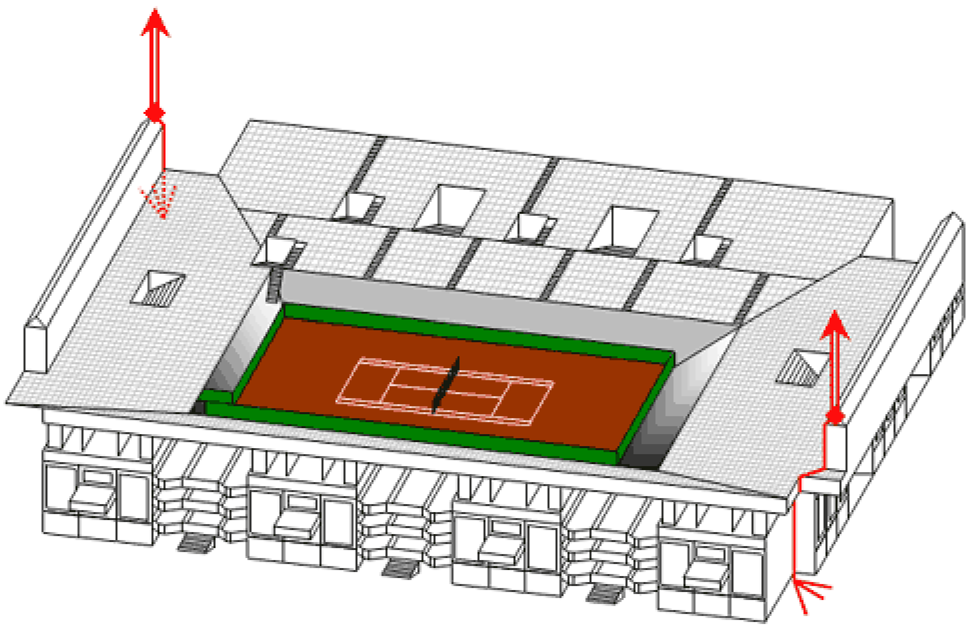
Protection level : II as defined in NF C 17-102
Description of the installation that would have to be implemented : 50 cm capture points installed around the roof perimeter every 15 meter. 10 meter roof mesh grid. On the walls: down conductors every 15 meter, the bottoms of which are connected to a series of dedicated earth rods.
Remarks: The tennis court design is such that a mesh cage lightning conductor is not able to provide complete protection of the structure in compliance with the standard. This

solution must be rejected.

3- Early streamer emission protection

Protection level : II as defined in NF C 17-102
Description : 5m high early streamer emission lightning conductors installed on the roof. Protection radius Rp =97 meters (Δt = 60µs) for level II protection. Each lightning conductor is connected to a down conductor fitted with a dedicated earth rod.

Installation schematic :

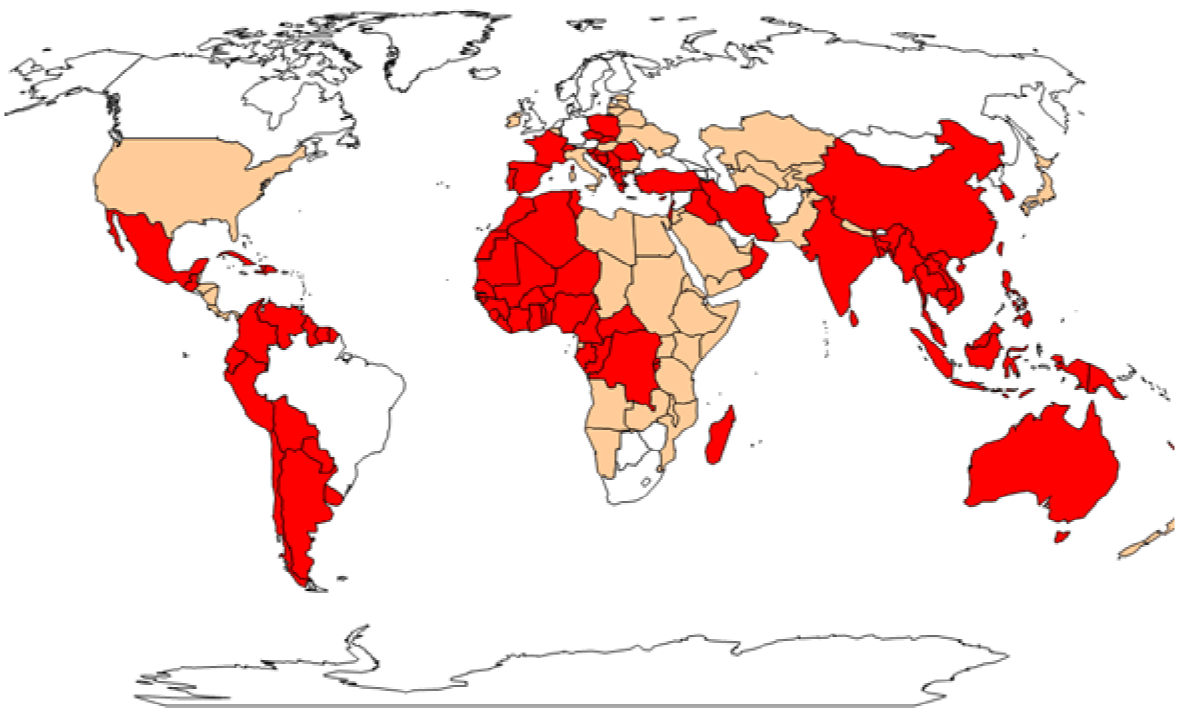


Use of Early Streamer Emission (ESE) lightning conductors throughout the world

ESE widely used

ESE used

ESE rarely used



Lightning protection for indirect lighting effects

As we mentioned previously that lightning have five indirect affects any or all of these indirect effects caused damage to communications , data, electronic, and computer facilities, and it will cause losing a lot of money's in different fields, But Most indirect effect of lightning is causing Surge so we can use surge protection for protecting this equipments from indirect effects of lightning and we can connect surge protection in different position in our electrical circuits according to sensitivity and type of our equipments because there special type of surge protections for different type of equipments

We can connect surge protection on:
1) Surge protectors on the AC power wiring;
2) Additional surge protectors on signal wiring;
3) "Supplementary protection" (also called "Point-of-Use" protection) at the equipment to be protected.

How can we choose SPD (Surge protection device) Normal Conditions?

Primary factors in choosing an SPD should be to have a long life and satisfactory Performance. In order to assess these needs, the normal service condition must be understood. This includes the electrical and mechanical environment. The SPD must match the existing electrical and physical environment and each rating should be checked to ensure that the product will work in the intended location.
On the electrical side, a short summary of certain critical items is shown below:
• Nominal Voltage
• Frequency
• Phases and transformer type (such as y or delta, split phase)
• Current
• SPD Ratings
• Monitoring Desired

For the mechanical side, there are a similar number of issues that need to be
Determined:
• Indoor or Outdoor
• Altitude
• Temperature Range
• Mounting Type and Location
These requirements will determine some of the primary features and performance required of the SPD.

There a lot of company's producing surge protection for different type of electrical and electronic equipments according to protection and it is position and those are some examples of surge protection devices

FOREND LIGHTNING PROTECTION & EARTHING SYSTEMS

High-Power Lightning Arresters

FBB-80

*FBB-80=Encapsulated Gas Discharge Tube 80 kA

FBB-100

*FBB-100=Encapsulated Gas Discharge Tube 100 kA

Spark Gap

FBS-55

*FBS-55= Encapsulated power spark gap I_{imp}=60kA (L/N)

FBS-100

*FBS100= Encapsulated power spark gap I_{imp}= 120kA (N/PE)

12.2.SURGE ARRESTERS CLASS I + II (PARALELL PROTECTION)

High-Power Varistor + Remote Control - Single Phase

F1BC

*F1BC-60=1 pole lightning arrester for TNS 60 kA(8/20)
*F1BC-90=1 pole lightning arrester for TNS 90 kA(8/20)
*F1BC-120=1 pole lightning arrester for TNS 120 kA(8/20)
*F1BC-150=1 pole lightning arrester for TNS 150 kA(8/20)

F1BC.1

*F1BC.1-60=1 pole lightning arrester for TNC 60 kA(8/20)
*F1BC.1-90=1 pole lightning arrester for TNC 90 kA(8/20)
*F1BC.1-120=1 pole lightning arrester for TNC 120 kA(8/20)
*F1BC.1-150=1 pole lightning arrester for TNC 150 kA(8/20)

*F1BC.0-60=1 pole lightning arrester for TNS L/N 60 kA (8/20) N/PE 80 kA (10/350)

*F1BC.0-90=1 pole lightning arrester for TNS L/N 90 kA(8/20) N/PE 80 kA (10/350)

*F1BC.0-120=1 pole lightning arrester for TNS 120 kA(8/20) N/PE 80 kA (10/350)

*F1BC.0-150=1 pole lightning arrester for TNS 150 kA(8/20) N/PE 80 kA (10/350)

FOREND LIGHTNING PROTECTION & EARTHING SYSTEMS

High-Power Varistor + Remote Control - Three Phase

F3BC

*F3BC-60=3 poles lightning arrester for TNS 60 kA(8/20)
*F3BC-90=3 poles lightning arrester for TNS 90 kA(8/20)
*F3BC-120=3 poles lightning arrester for TNS 120 kA(8/20)
*F3BC-150=3 poles lightning arrester for TNS 150 kA(8/20)

F3BC.1

*F3BC.1-60=3 poles lightning arrester for TNC 60 kA(8/20)
*F3BC.1-90=3 poles lightning arrester for TNC 90 kA(8/20)
*F3BC.1-120=3 pole lightning arrester for TNC 120 kA(8/20)
*F3BC.1-150=3 pole lightning arrester for TNC 150 kA(8/20)

*F3BC.0-60=3 poles lightning arrester for TNS L/N 60 kA (8/20) N/PE 80 kA (10/350)

*F3BC.0-90=3 poles lightning arrester for TNS L/N 90 kA(8/20) N/PE 80 kA (10/350)

*F3BC.0-120=3 poles lightning arrester for TNS 120 kA(8/20) N/PE 80 kA (10/350)

*F3BC.0-150=3 poles lightning arrester for TNS 150 kA(8/20) N/PE 80 kA (10/350)

12.3.SURGE PROTECTION CLASS II (PARALLEL PROTECTION)

Lightning Arresters

FC-20

*FC-20=Encapsulated gas discharge tube
12 kA (10/350)

Varistor

FCM

FCM-D

FCC

FCC-D

*FCM-60 / FCM- 230 / FCM-400 / FCM-500 / FCM-720= Surge Arresters 20 kA (8/20)

*FCM-D60 / FCM -D230 / FCM-D400 / FCM-D500 / FCM-D720= Surge Arresters 20 kA (8/20)+ sig.

*FCC-60 / FCC -230 / FCC-400 / FCC-500 / FCC-720= Surge Arresters 15 kA (8/20)

*FCC-D60 / FCC -D230 / FCC-D400 / FCC-D500 / FCC-D720= Surge Arresters 15 kA (8/20)+ sig.

FOREND
FOREND LIGHTNING PROTECTION & EARTHING SYSTEMS

F1CU

F1CU-120=Surge Arresters+Encapsulated Gas Discharge Tube-1 Pole,U_N=120 V

F3CU

*F3CU-240=Surge Arresters+Encapsulated Gas Discharge Tube-3 Poles,U_N=3x400/230V/50Hz

FCR-100

*FCR-100=Helping connection module

12.4.DECOUPLING ELEMENTS

FDE-16

Decoupling Element 6 mH, Nominal Current 16 A

FDE-63

Decoupling Element 6 mH, Nominal Current 63 A

FDE-63/15

Decoupling Element 15 mH, Nominal Current 63 A

FDE-120

Decoupling Element 6 mH, Nominal Current 120 A

12.5.1.SURGE ARRESTERS CLASS III + HIGH FREQUENCY FILTER (SERIES PROTECTION)

FDK-150

Surge Arrester 8 kA (8/20), 230 V, 150 A

FDK-32

Surge Arrester 8 kA (8/20), 230 V, 32 A

FOREND
LIGHTNING PROTECTION & EARTHING SYSTEMS

12.5.2.SURGE PROTECTION CLASS III (PARALLEL PROTECTION)

FIDP-16

*FIDP-16:Protected socket with high freq.filter,8 kA(8/20),16 A

FDP-16

*FDP-16:Protected socket, 8 kA(8/20),16 A

F-FAX

*F FAX=Combined protection of supply and telephone network

FDR-4

*FDR-4=Fourfold protected socket, 8kA(8/20),10 A

FDR-8

*FDR-8=Eightfold protected socket, 8kA(8/20),10 A

12.6.COAXIAL PROTECTION

FKO-1G

*FKO-1G= for BNC Connector

FKO-1P

*FKO-1P= for BNC Connector

FKO-9P

*FKO-9P= TV Connector

FKO-10P

*FKO-10P= TV Connector

FKO-3GN (M/F)

*FKO-3GN (M/F)=for N Connector

FKO-3GN(F/F)

*FKO-3GN (F/F)=for N Connector

Lightning Facts

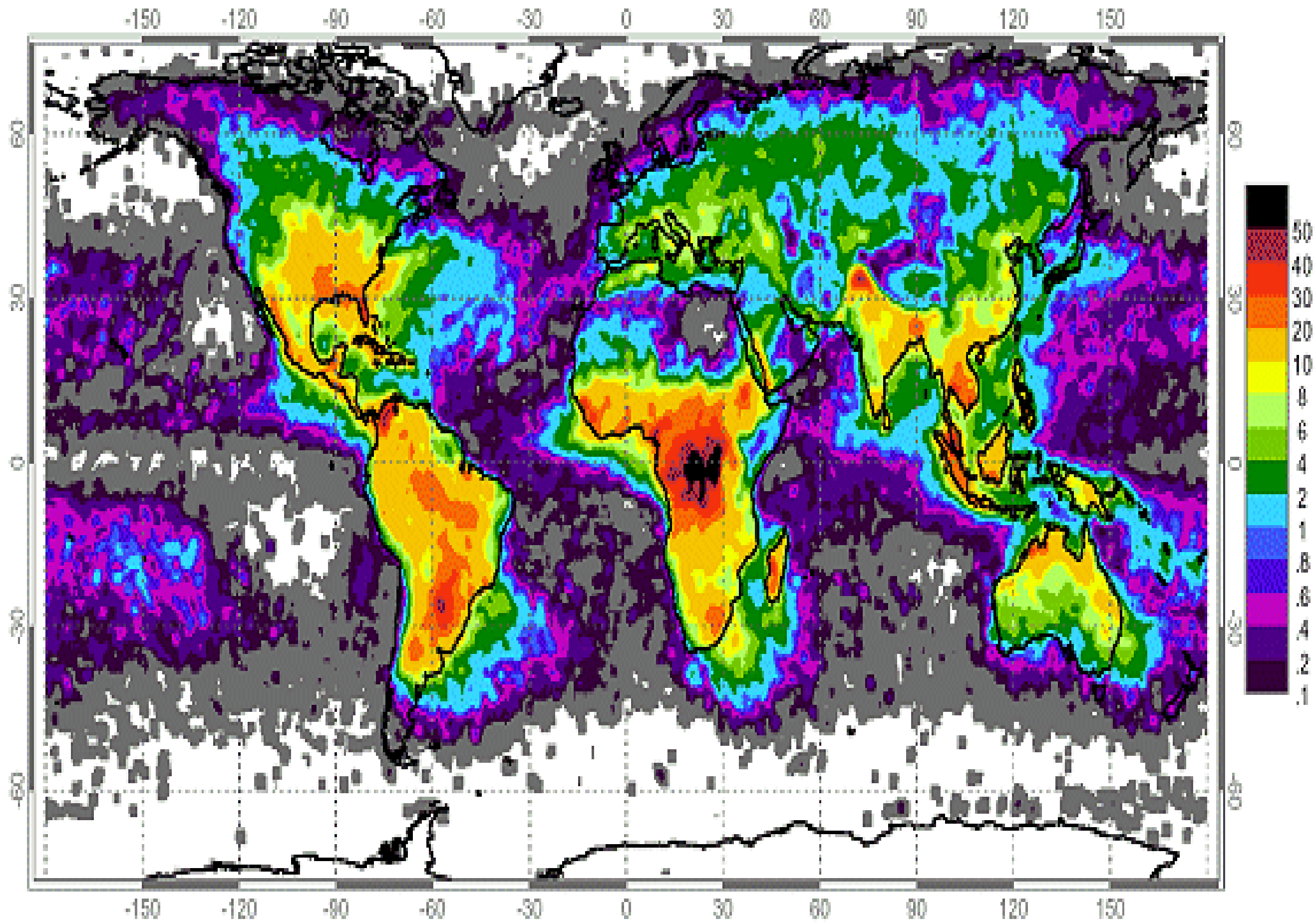
At any given moment, there are approximately 1,800 thunderstorms occurring over the Earth. It is estimated that 100 lightning flashes occur each second somewhere on the Earth, adding up to nearly 8 million lightning flashes per day. During your lifetime, you have a one in 600,000 chance of being struck by lightning.

All lightning is dangerous and even the weakest thunderstorms produce lightning. Most people in recent years have been killed by lightning while swimming, golfing, or hiking. But they have also been killed doing less dangerous activities, like talking on the telephone, playing soccer or baseball, fishing on a lake, taking a shower, or loading laundry in clothes dryer.

Lightning starts over 15 thousand fires to structures, and burns down about 2 million acres of forest each year in the United States.

Figures about Lightning Facts

- The important facts of lightning are:
  - It must be respected at all times, not just during the peak periods of a thunderstorm.
  - It is the result of high voltage currents.
  - It is unpredictable. This makes researching natural organic strikes very hard.
  - Most characteristics of lightning are intelligent estimates of typical values formed from other data.
  - A properly installed lightning protection system will help to protect a property or structure from lightning damage.
- There is estimated to be around 2,000 lightning storm active around the global at one time creating over 100 strikes per second. These thunderstorms generate a potential difference of 200,000 to 500,000 volts between the Earth’s surface and the ionosphere, with a fair weather current of about 2×10-12 amperes/meter2.



Data from NASA's space-based optical sensors revealing the uneven distribution of worldwide lightning strikes.
Units: flashes/km2/yr. Image credit: NSSTC Lightning Team.

- Approximately 300,000 lightning strikes hit the ground in Britain each year with 30 percent of reported lightning strikes causing severe damage. Each year 30 to 60 people are recorded as being struck by lightning, 3 of whom, on average, die (14 in 1984 compared to 2 in 2005). In the USA around a 100 residents are killed by lightning every year. These figures are dropping with time as working practices change and we become more aware of the dangers of lightning and how to protect ourselves to reduce its risks. Using a lightning protection system is a good way to protect buildings and structures from the damaging effects of a lightning strike. As global warming makes lightning storms more prevalent the necessity to have lightning protection will rise.
- A majority of lightning occurs in the storm cloud itself and only 10 to 20 percent of all lightning reaches the ground.
- Even though a lightning strike (lightning flash or stroke) appears continuous it is really a series of short bursts following the paths of ionized air called stepped leaders. Typically they are about 30 meters in length, however they can be anything from 10 to 100 meters in length. The initial lightning strike can also be followed by secondary strokes utilizing the same ionized air channel. Up to 4 secondary strokes can be expected, though much higher counts have been recorded. Each lightning stroke typically lasts only last 10 to 50 microseconds (0.000050 sec) and carries hundreds to thousands of amps.
- The air around a lightning strike is typically superheated to about 20,000 degrees Celsius or over 3 times hotter than the surface of the sun (estimated at 5,500 C). The air temperature can range from 8,000 to 30,000 degrees Celsius.
- The rumbling sound of thunder is caused by shock waves from multiple stepped leaders that make up a lightning stroke. As the air in each leader is super heated by the immense current it rapidly expands creating a supersonic shock wave. Differently timed shock waves are created from the different stepped leaders at varying attitudes in quick succession along the path of the lightning. This causes the thunder clap from each stepped leader to arrive at your ears at differing times generating the rumbling effect.
- The estimated peak power per lightning stroke is 10^12 watts (1,000,000,000,000 watts or 1,000 Giga Watts). The total energy in a large thunderstorm is thought to be enough to power the whole of the USA for 20 minutes.
- A tall thunderstorm cloud can hold over 100 million volts of potential. The voltage potential in a lightning bolt is proportional to its length, and varies depending on the diameter of the bolt, air density and impurities of the air (humidity, dust, ash). The electrical breakdown of air (ionization) normally take 3,000,000 volts per meter, however with the ambient electric fields of a charged thunder cloud and impurities in the air, ionization normally takes place at much lower voltages during a storm. Lab tests have shown a leader will advantage if the tip of the streamer is about 4.5kV (4500v) for a negative charge and 5.5kV (5500v) for a positive charge.
- An average lightning strike discharges about 30,000 amperes (20,000 amperes in the UK). The current in a lightning strike typically ranges from 5,000 to 50,000

amperes depending on the strength of storm. NASA has recorded strikes of 100,000 amperes and there are other reports of strikes over 200,000 amperes.

- The resistivity of clear, fair-weather air ranges from around 4 x 10^13 ohm meters at sea level, to around 1.3 x 10^16 at 12km elevation. Typically air is considered an electrical insulator; however with impurities (water, dust ash) its resistance is lowered and varies further. Unlike metals whose resistance increases with temperature, when the temperature of air increased it has similar characteristics to semiconductors in that its resistance lowers. So when air is ionized into a plasma state and then superheated to 25000 degree Celsius it conductors electricity very well.
- Lightning can and does strike the same place twice. On average lightning strikes the Empire State Building in New York City (USA) about 100 times every year. 49 strikes have been recorded in a single day.
- A finger of charge called a positive streamer can reach upwards from the ground 15 to 50 meters in an attempt to join stepped leaders from a storm cloud. This normally happens just before a lightning strike.
- Benjamin Franklin in 1752 is believed to be the first to show that lightning was electricity using his now famous kite experiment. He is certainly the inventor of lightning rods and used them in creating lightning protection for important buildings. Following a series of experiments at his own home, lightning rods were installed to the Academy of Philadelphia and the Pennsylvania State House in 1752 giving both these buildings lightning protection.
  - May 10 1752, Thomas-François Dalibard of France successfully conducted Franklin's first experiment before him using a 12 meter tall iron rod instead of a kite, and he extracted electrical sparks from a cloud.
  - June 15 1752, Franklin is said to have conducted his famous kite experiment in Philadelphia and also successfully extracted sparks from a cloud, though this was not written up until 1767 some 15 years later by Joseph Priestley.
- In the northern hemisphere lightning occurs more during the summer months, however in equatorial regions, lightning appears more often during the fall and spring.
- Arctic and Antarctic have very few thunderstorms and, therefore, almost no lightning at all.
- The open oceans do not experience as many thunderstorms and lightning strikes as land due to water's higher heat capacity preventing the heating of low-lying air which is crucial for thunderstorm formation.
- Most cloud to ground lightning strikes are generally the transfer of a negative charge from the cloud to earth, these are identified by the downward pointing branches of lightning and are called negative flashes. Ground to cloud lightning is far less frequent, however they can occur where leaders propagate from tall earth bound objects toward the storm cloud, and these are identified by upward pointing branches of lightning and are called positive flashes.
- Lightning does not travel straight down to earth due to impurities in the air like dust causing it to breakdown more easily in one direction than another. The shape of the electric field generated by the charge in the cloud also has an effect.

Lightning may not always strike the top of the tallest object in an area; it is possible for lightning to strike very close to the base of a tall object.

- When lightning strikes the ground radial currents spread out from the site of the strike causing damage to anything nearby.
- Storm clouds called cumulonimbus clouds, can tower 12-15 miles high (Mount Everest is 5.5 miles high.). They form at altitudes of 150 to 4000 meters and typically have peaks 6100m, though in extremes cases they can be as high as 24000m.
- Lightning does strike twice in the same place. A number of secondary lightning strokes (possibly 30 to 40) can quickly follow the ionized path of the first strike giving the impression of the lightning lasting longer.
- Research shows that proximity to water (e.g. pool, lake or sea) increases the risk of being struck by lightning.
- Stepped leaders are normally 2 to 5 cm in diameter; however they can be over a meter.
- The frequency and strength of thunderstorms varies for different geographical locations. The average current passed in a lightning strike is 20,000 amperes, in Florida (USA) the average is over 45,000 amperes per lightning strike. Researchers believed this is due to the hot and wet conditions in Florida (USA) being ideal for creating tall and highly charged storm cloud formations.
- Positive lightning from the top of storm clouds is normally over 6 times stronger than negative lightning due to the longer distances it typically has overcome. Sometimes referred to as “bolts from the blue” they can occur when there is very little cloud activity compared to the thunderstorms associated with negative lightning. The unexpectedness and the greater strength make positive lightning the most dangerous type of lightning. Positive lightning makes up less than 5% of all lightning strikes.
- Lightning strikes most frequently in the Democratic Republic of the Congo.

SUMMERY:

Lightning will quire from natural effectives and it have a great effects direct or indirect effects and can cause damage a lot of facilities and kill peoples, so we need protection for our homes, buildings and all electrical and electronic equipments.

There are different types of protection from lightning according to is effects and type of facility or equipment that we need to protect it.

There are five types of protection for direct lightning effects:

- ✓ Lightning rod.
- ✓ Meshed cage lightning conductor.
- ✓ Catenary wire lightning conductor.
- ✓ Protection using «natural» components.
- ✓ Early streamer emission lightning conductor.

The most effective and cheaper type of protection is (ESE) Early streamer emission lightning conductor.

There are five types of indirect effects of lightning also there are different special equipments for protecting our equipments from it,

The type and e position of the protecting device depend on the level of protection

The most elective type of indirect effect of the lightning is Surge and there are different type of surge protection for different type of equipments and positions.

So in a result of this facts and according to standards which globally depending we have to calculate and to chose the way of protection of our building and equipments in our electrical designs in Kurdistan specially in Sulaimaniyah city because it is very clear that our city will strike annually more than thousand times by lightning, as we know at 15th November 2011 child have been killed by lighting (direct effect)(see www.awena.com site 15th November) and during last five years different electrical and electronic equipments like computers ,navigation aid instruments ,constant current regulators CCR's in Sulaimaniyah international airport have been damaged by lightning (Indirect effects) (personally I have seen this effects)