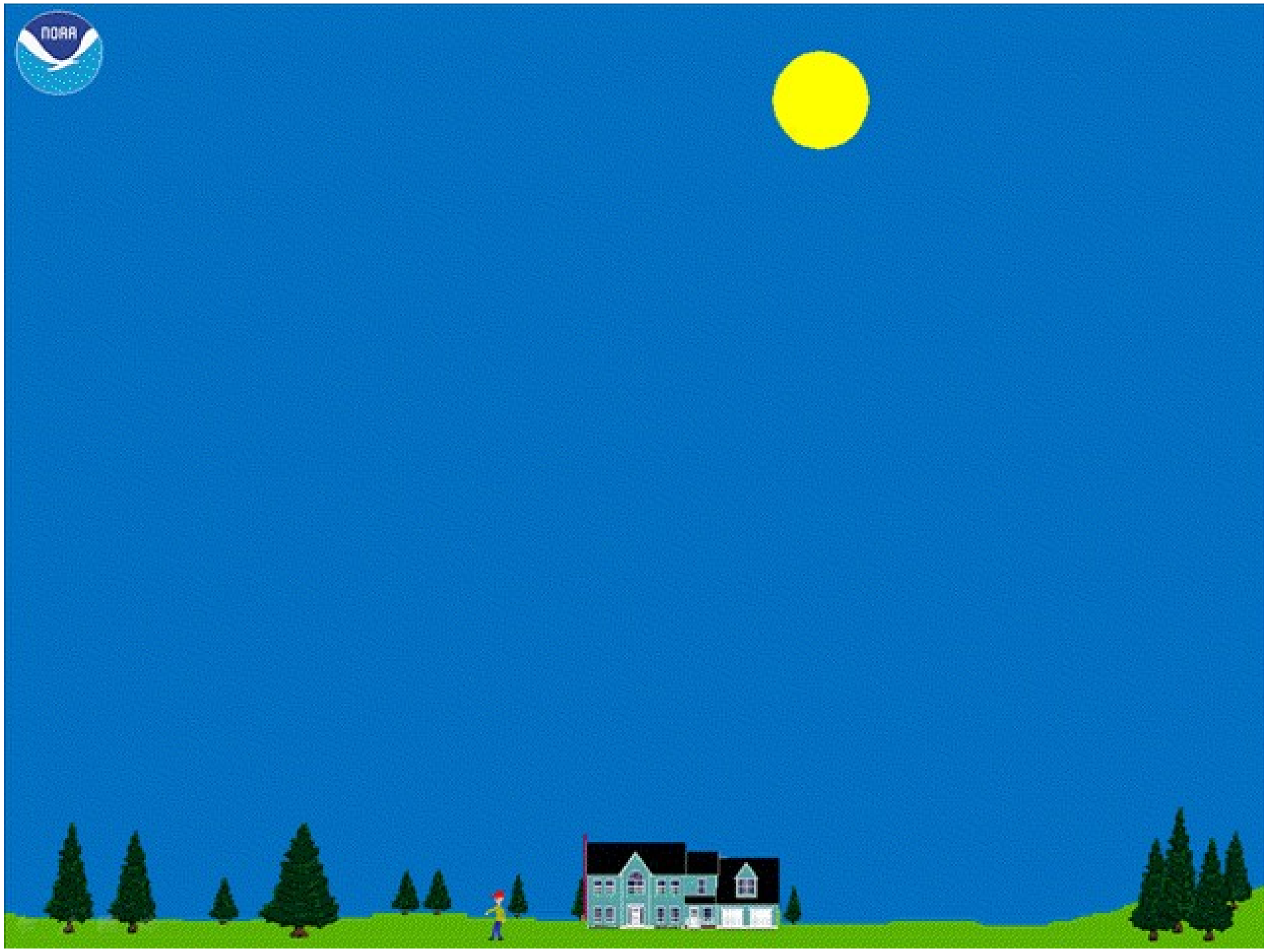
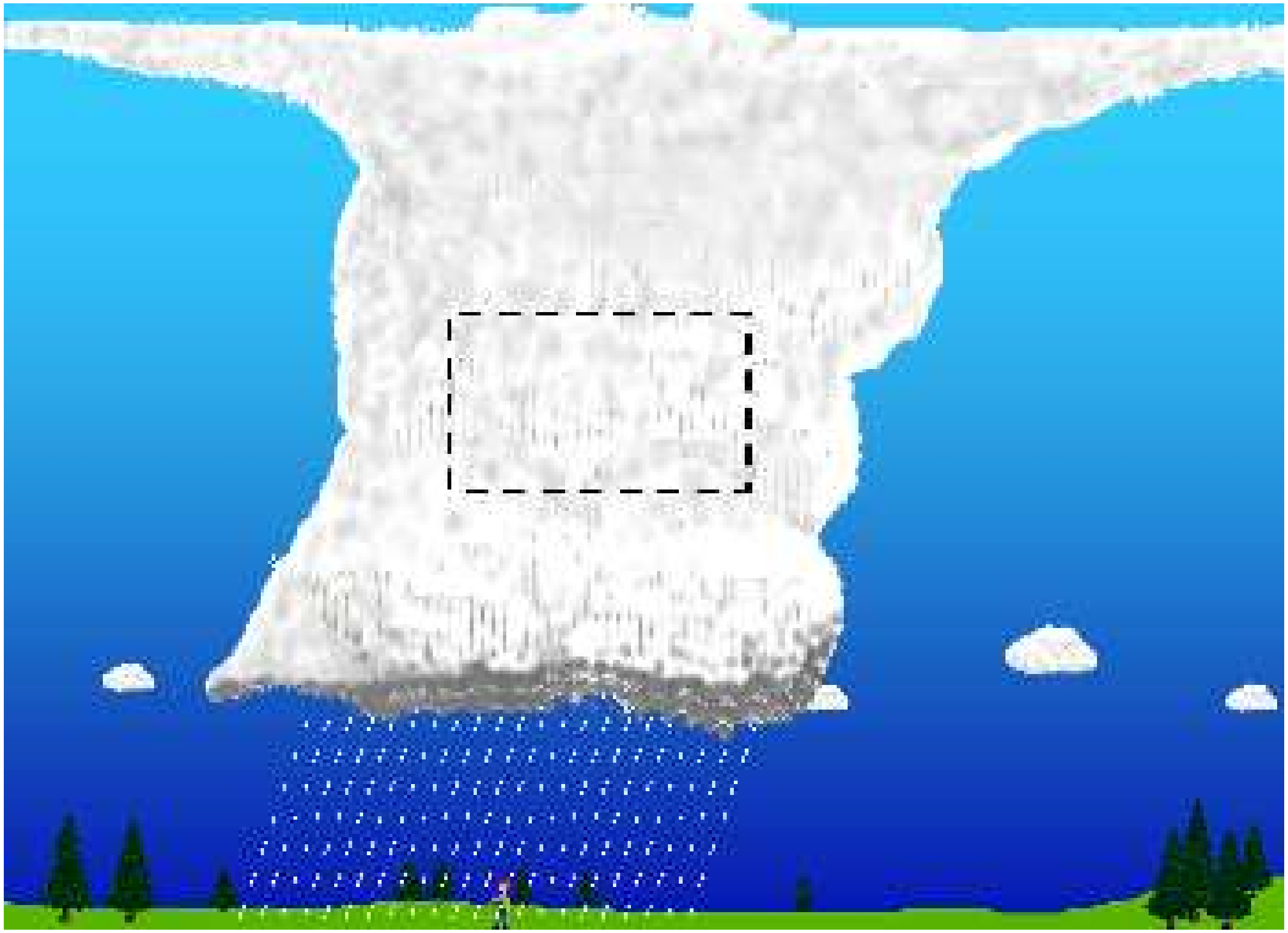
Protection Against Lightning Hazards

Thunderstorm Development



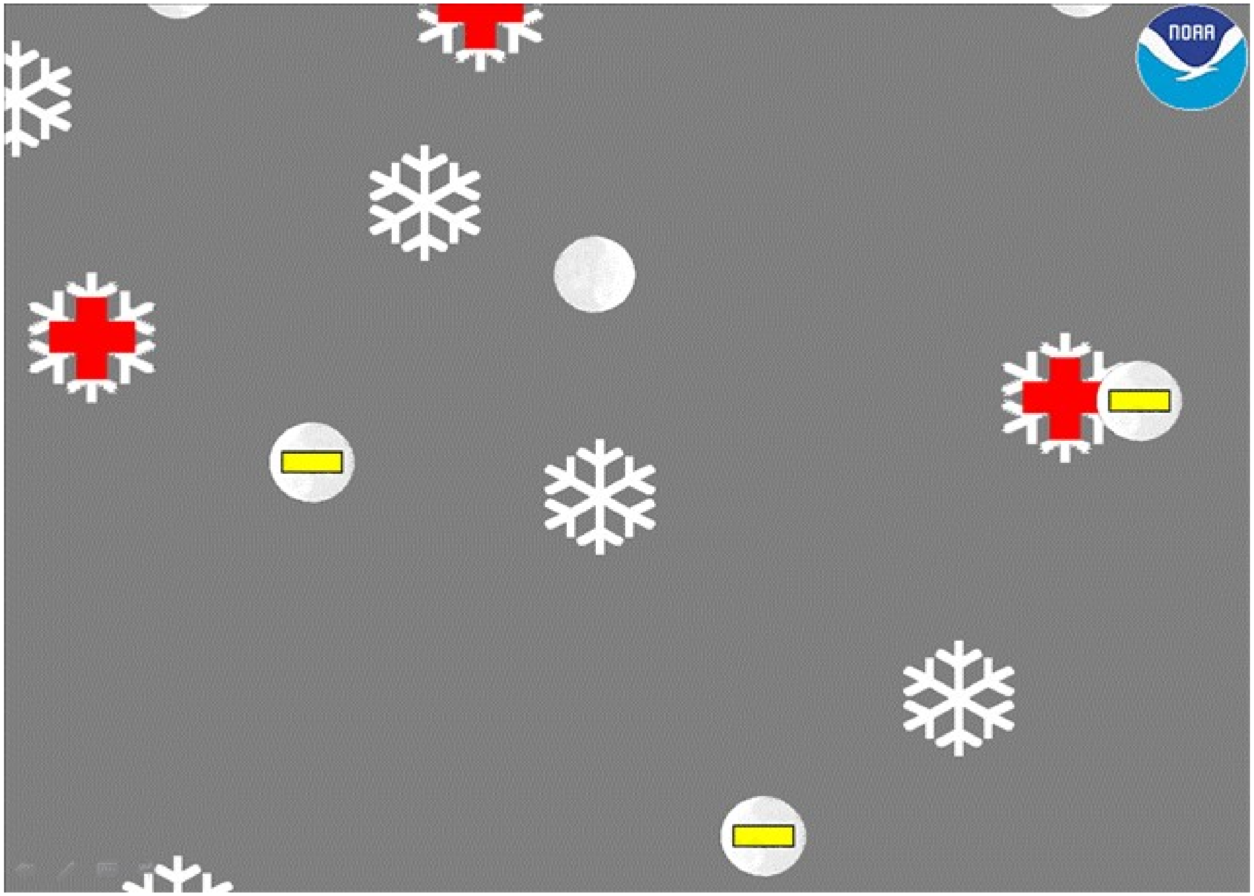
During the day, the sun heats the air near the ground and causes it to rise. When the rising air reaches a certain level in the atmosphere, cumulus clouds start to form. Under certain atmospheric conditions, these cumulus clouds to grow into an anvil-topped thunderstorm cloud (cumulonimbus).

Getting All Charged Up



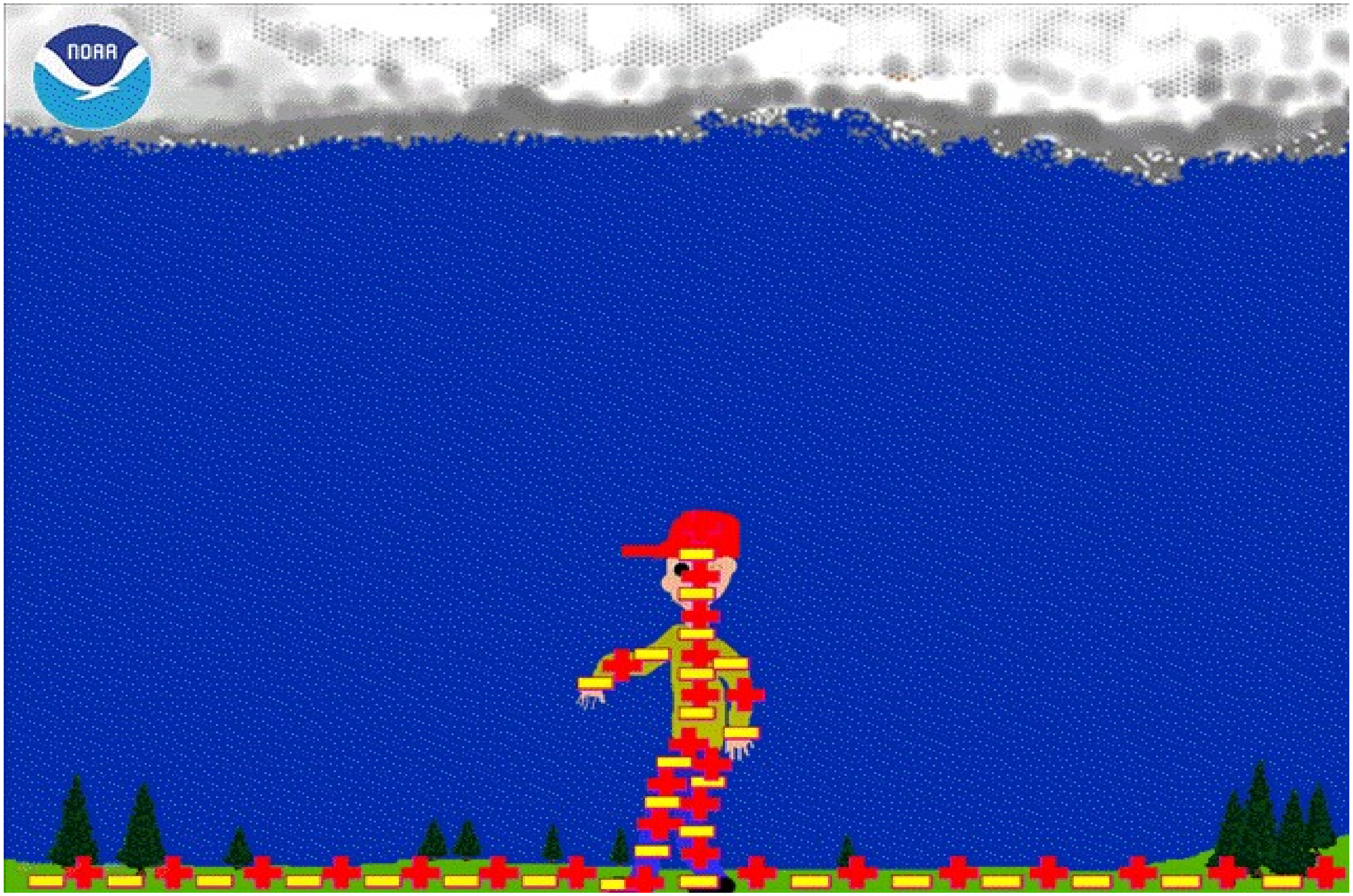
The main charging area of the thunderstorm cloud is in the central part of the storm where temperatures are between -10 and -25 degrees Celsius.

Charging in the Clouds



Here in the central part of the storm, very tiny ice crystals collide with soft pellets of hail in the presence of tiny liquid cloud droplets. After the collisions, where cloud temperatures are between -15ºC and -25ºC, the ice crystals become positively charged and the soft hail becomes negatively charged. Where cloud temperatures are between -10ºC and -15ºC (not shown), the ice crystals become negatively charged and the hail becomes positively charged.

Charging on the ground

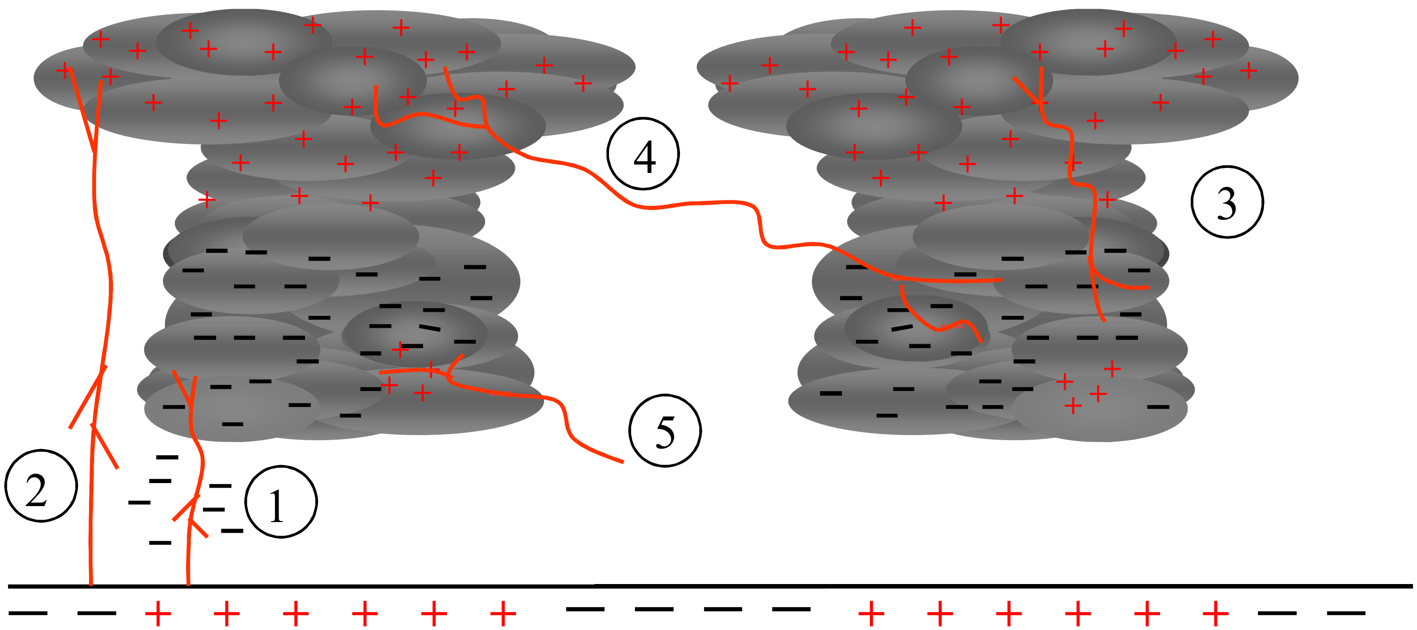


The cloud charges also affect objects on the ground. The negative charges in the cloud not only repel the negative charges in the ground, but, if you're outside, also in you. This could cause you to become positively charged.

Under the charged thunderstorm

If you become "charged up," you could be struck and killed at any moment. Signs that you are becoming "charged" include hair standing on end or a tingling sensation. Don't wait for these signs to happen as it may be too late to avoid getting struck. Seek shelter as soon as there are any signs of a developing or approaching thunderstorm.

Types of lightning discharges



① cloud-to-ground flash (negative)

② cloud-to-ground flash (positive)

③ intracloud discharge

④ intercloud discharge

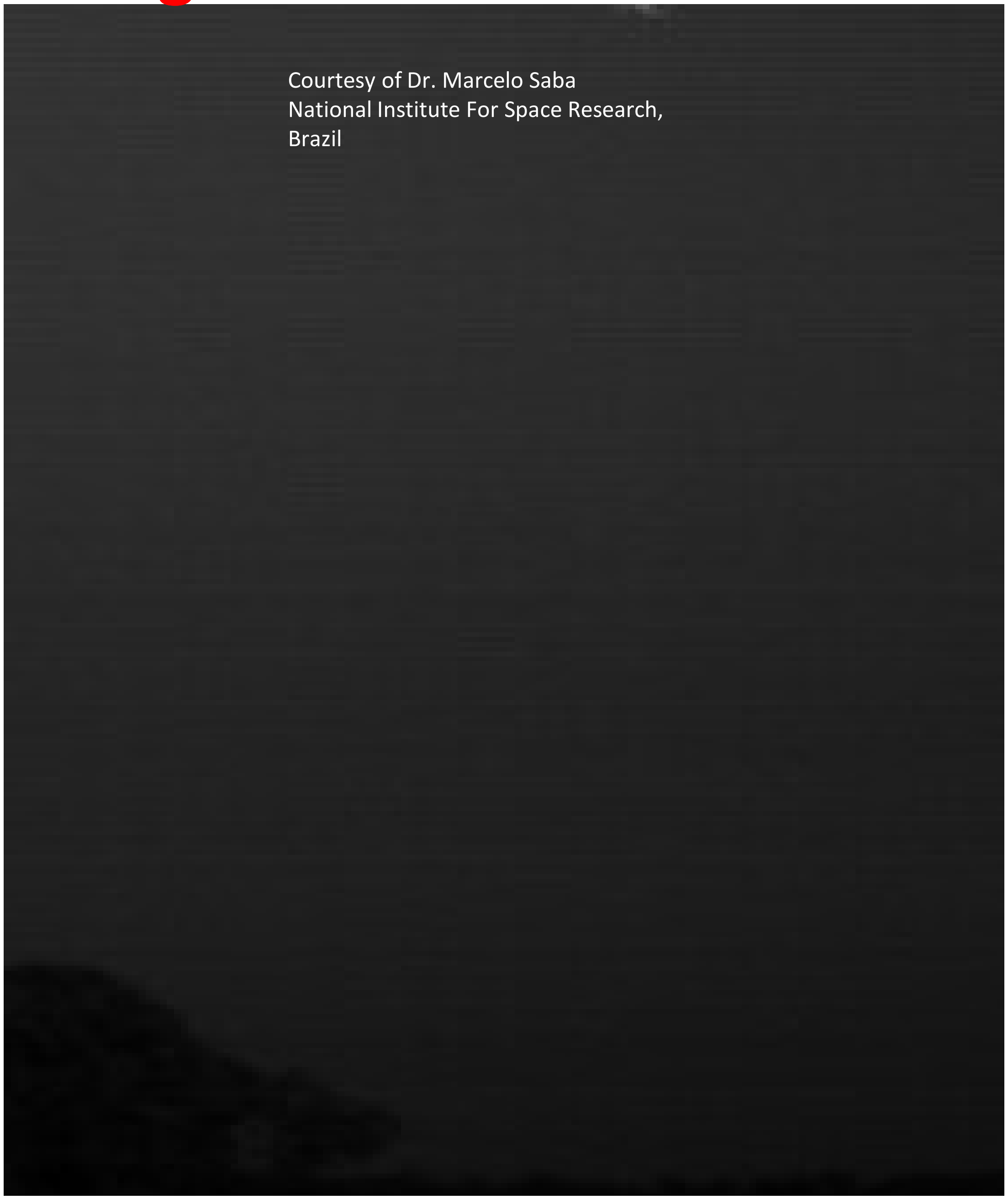
⑤ cloud-to-air discharge

Lightning Flash Video

High speed cameras can be used to capture video of lightning strikes. When played back in slow motion, we can see the stepped leader and return stroke. In this video, the elapsed time between when you see the stepped leader and when you see the return stroke is 1/133rd of a second.

Lightning Flash Video

Here's another video of a lightning flash. In this case, two branches of a stepped leader race to the ground looking for a connection. The first branch to reach the ground, discharges the entire channel. In this video, the elapsed time from when you first see the stepped leader to when you see the return stroke is 1/50th of a second. Note that this stepped leader appears much fainter than the previous. In this case, rather than dart leaders and return strokes, there is a more continuous flow of electricity. We call this continuing current.

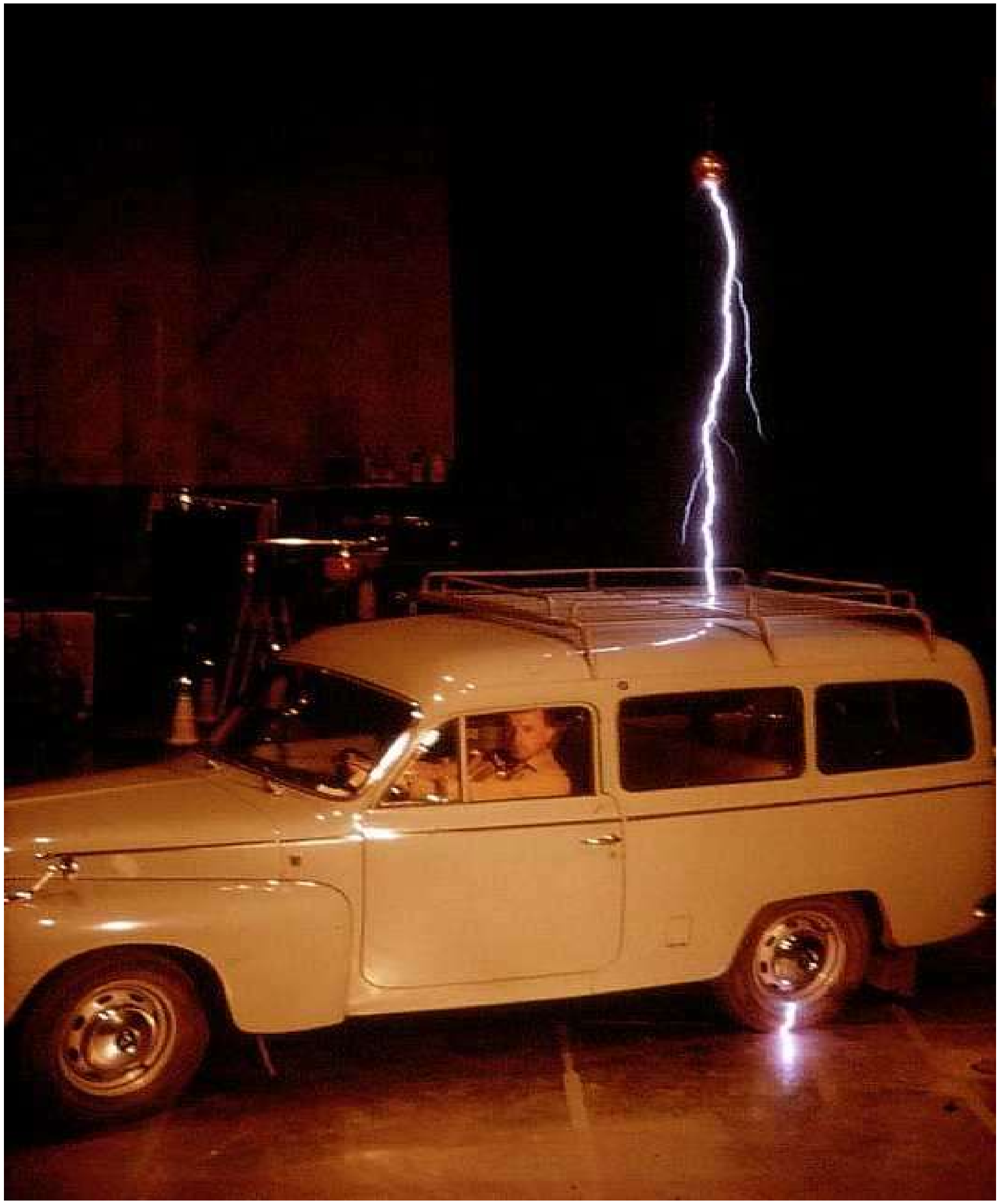


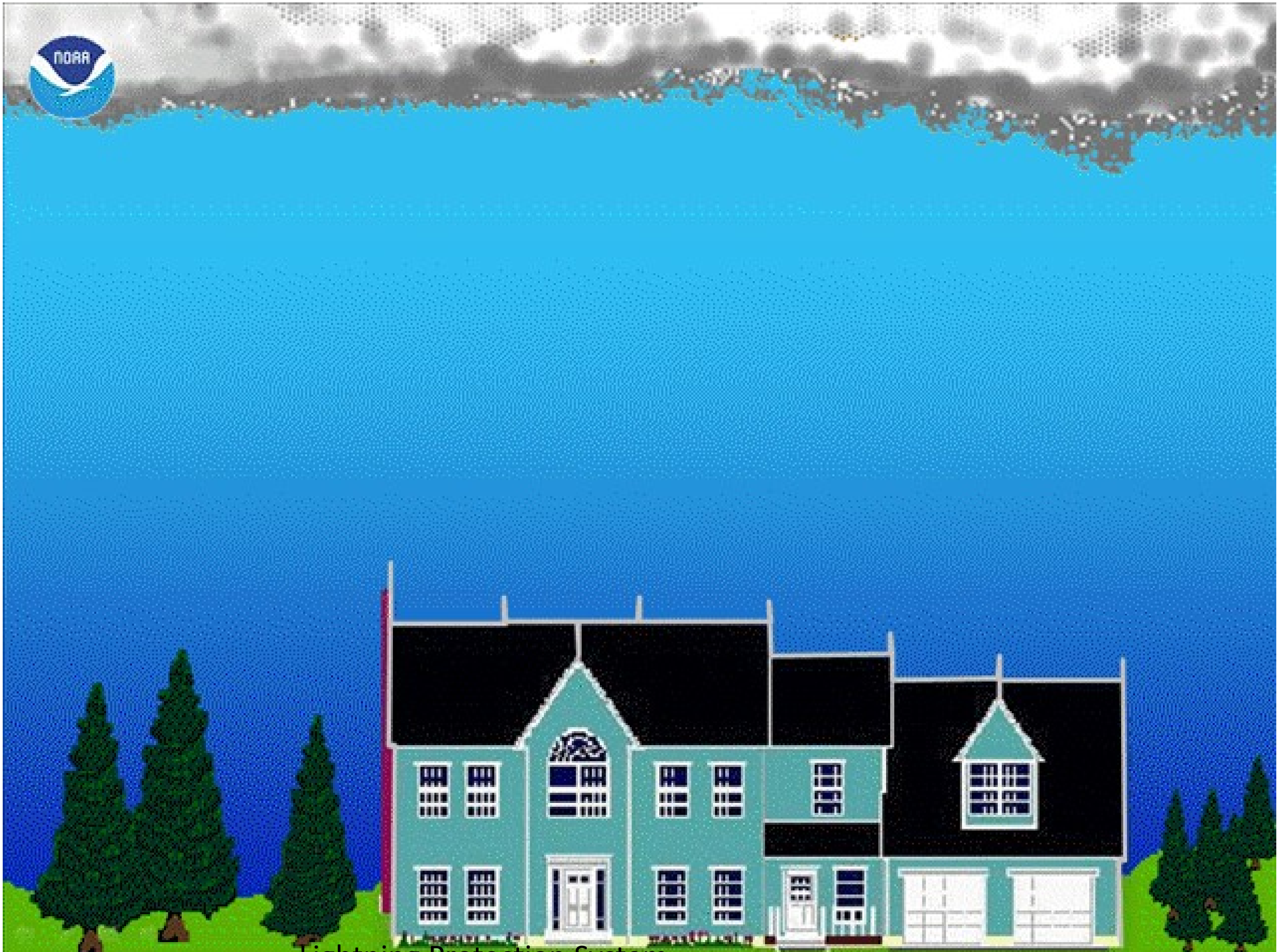

Protection Against **Lightning**

- *In appreciation of the work of a merciful God*

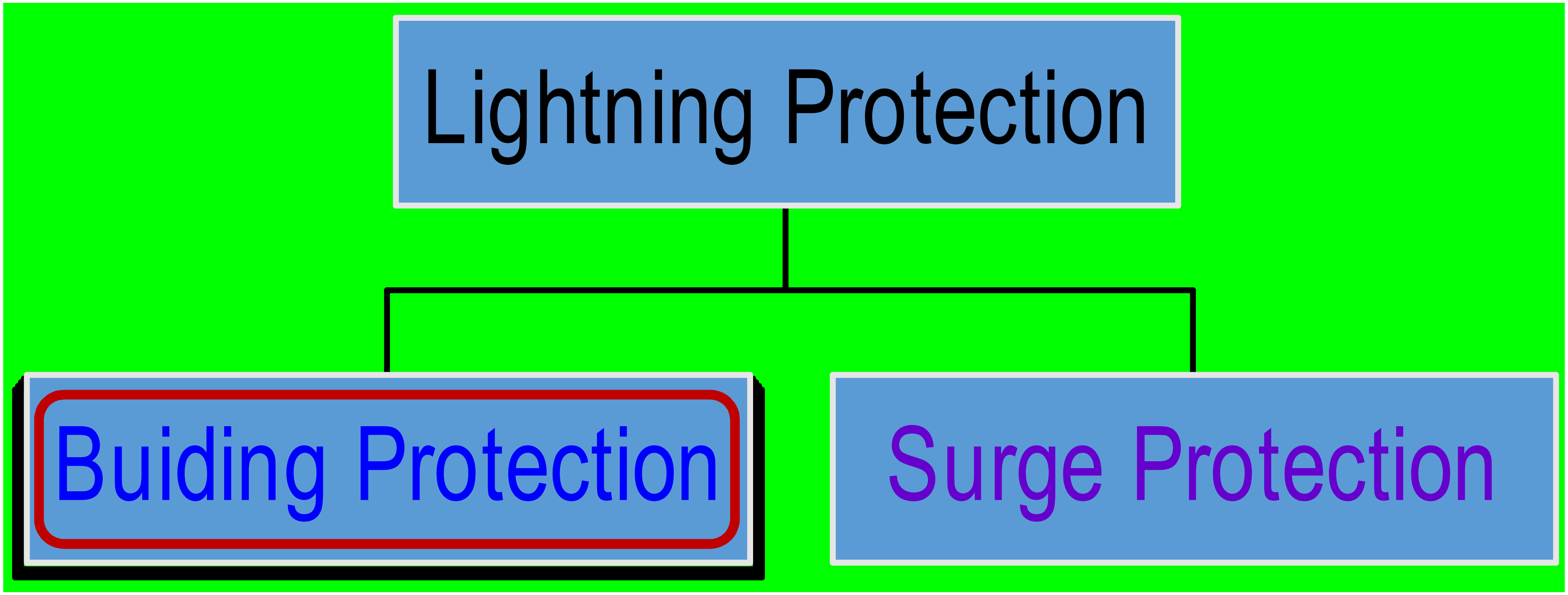
Can we survive a lightning stroke??

Can we survive a lightning stroke??



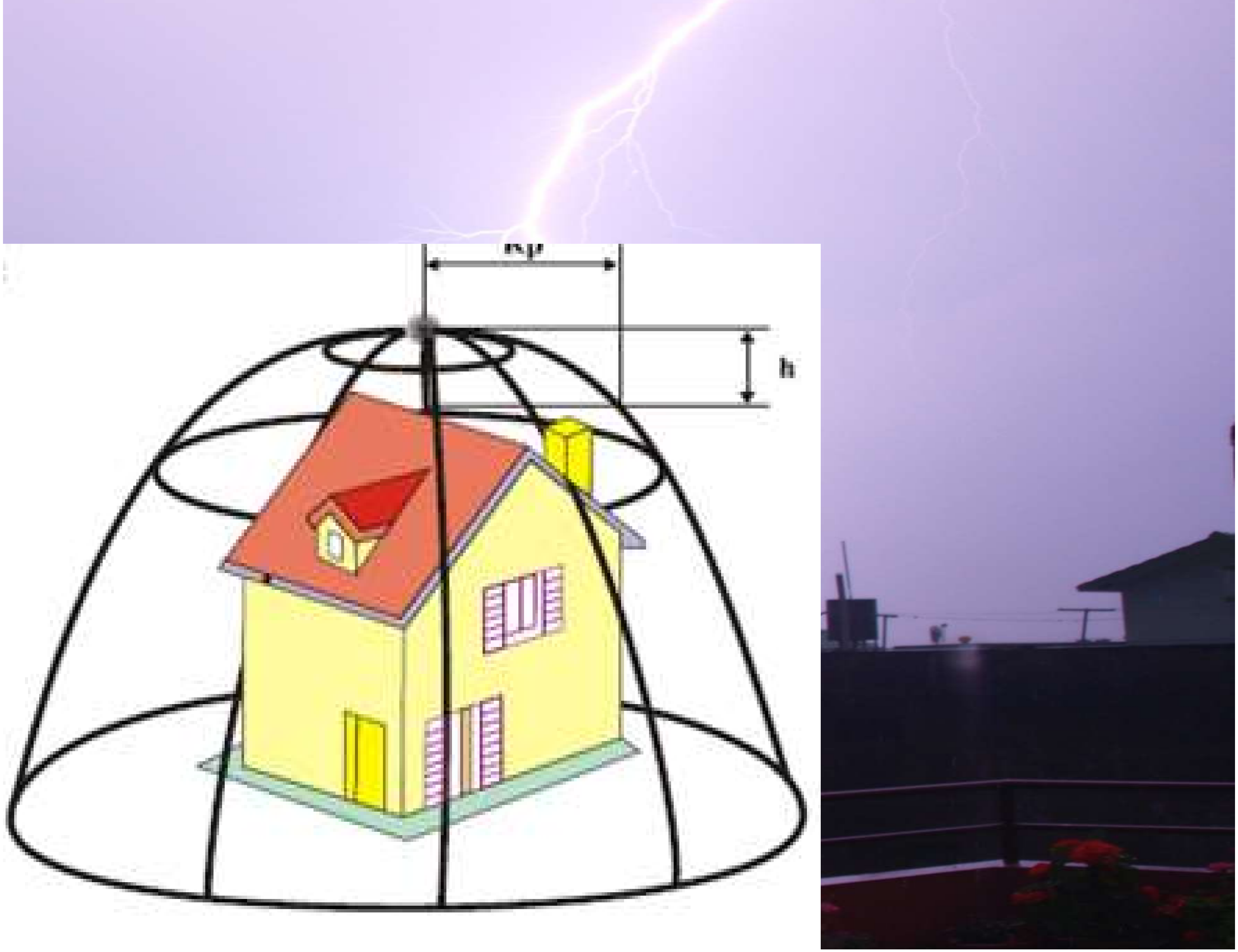


Lightning Protection System



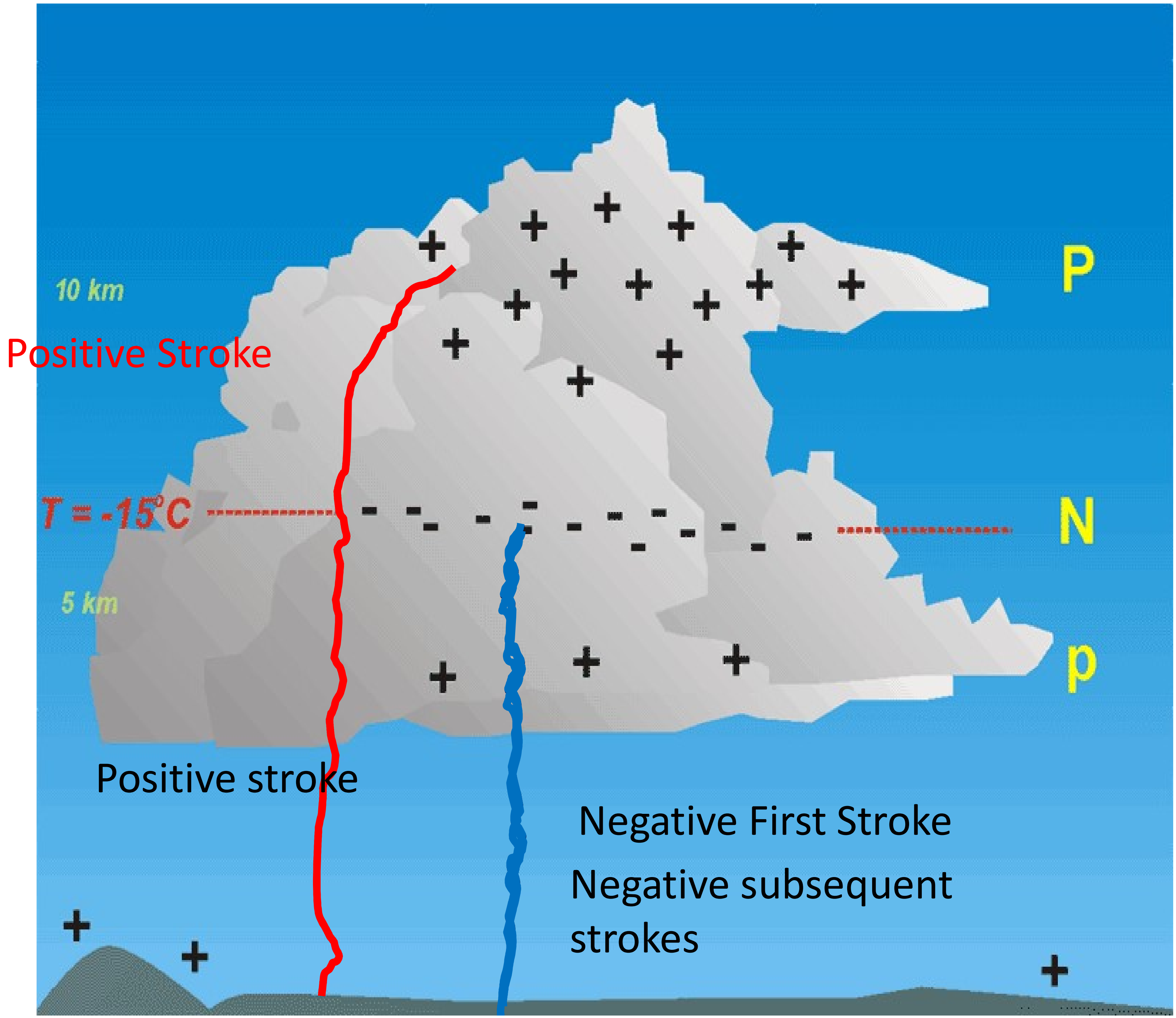
Lightning Protection
Buiding Protection
Surge Protection

BUILDING PROTECTION



Structural Protection

- **A structural protection system consists of two parts**
- **External Protection system**
- a) intercept a direct lightning flash to the structure (with an air-termination system)
- b) conduct the lightning current safely towards earth (using a down-conductor system)
- c) disperse the lightning current into the earth (using an earth-termination system)
- **Internal protection system**
- a) prevents dangerous sparking within the structure using either equipotential bonding or a separation distance (and hence electrical insulation) between the external LPS components and other electrically conducting elements internal to the structure.



10 km
Positive Stroke
T = -15°C
5 km
P
N
p
Positive stroke
Negative First Stroke
Negative subsequent strokes

I_{peak} (kA)

TYPE OF STROKE	95%	50%	5%
Positive	4.6	35	250
Negative first	4.0	20	90
Negative sub.	4.9	11.8	28.6

STANDARDS

IEC 62305-1 (2010): Protection against lightning - General principles (International Electrotechnical Commission)

IEC 62305-2 (2010): Protection against lightning - Risk management

IEC 62305-3 (2010): Protection against lightning - Physical damage and life hazard

IEC 62305-4 (2010): Protection against lightning - Electrical and electronics systems

IEC 62305-5 (2010): Protection against lightning - supply lines

NFPA 780 (2014): Standard for the installation of lightning protection systems (National Fire Protection Association)

AS/NZS 1768 (2007): Lightning protection

SANS 10313 (2010): Protection against lightning — Physical damage to structures and life hazard

NF C 17-102 (1995): Lightning Protection- Protection of structures and open areas against lightning using ESE devices

UNE-21186 (1996): Protección contra el rayo: Pararrayos con dispositivo de cebado

Structural Protection is given under 4 Levels of Protection (Classes of Protection)

Class I or Level I : **Highest level of Protection**

Class II or Level II

Class III or Level III

Class IV or Level IV : **Lowest level of protection**

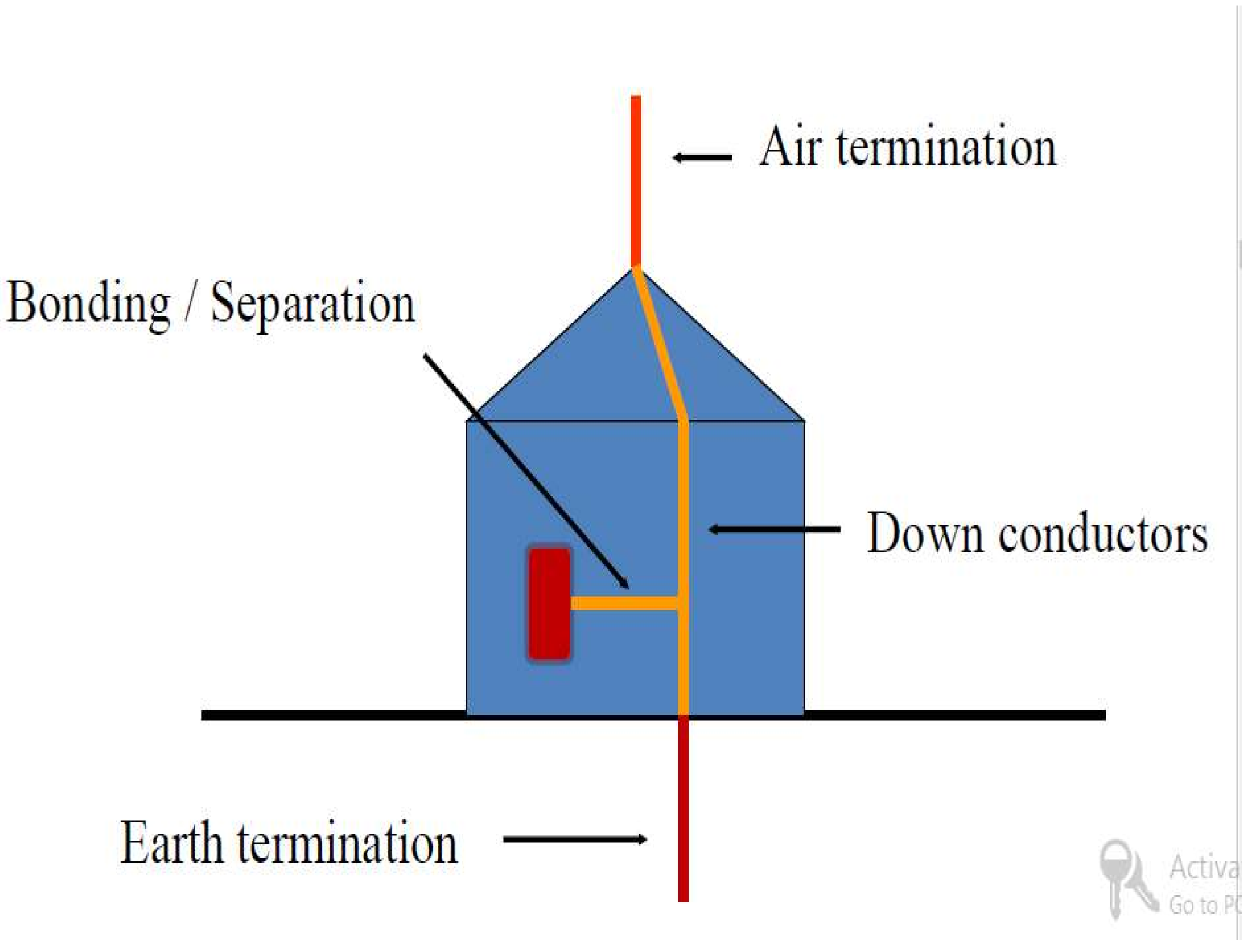
Level of Protection

Limiting Currents (kA)	LPL			
	I	II	III	IV
Maximum	200	150	100	100
Minimum	3	5	10	16

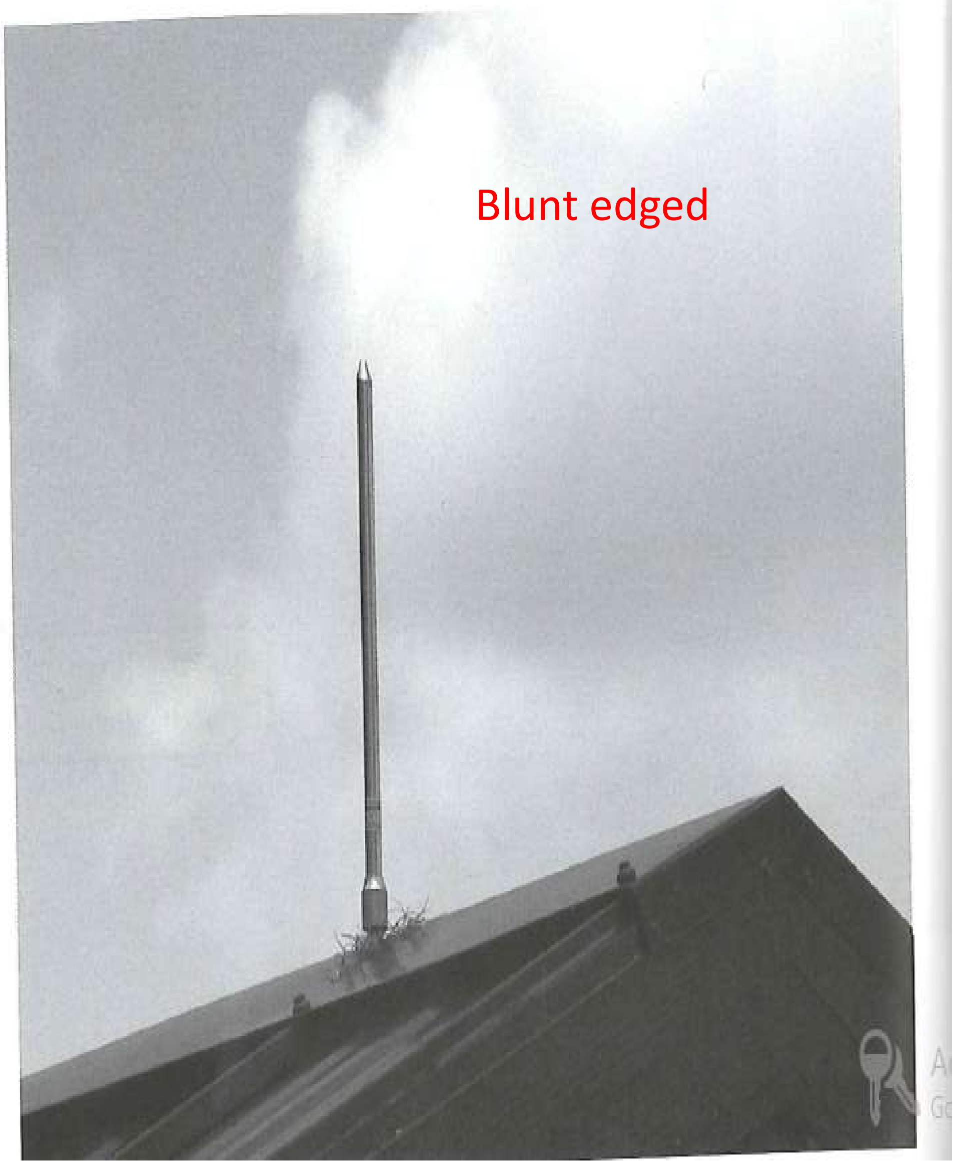
Maximum value of current determines the withstanding capacity of the components of LPS

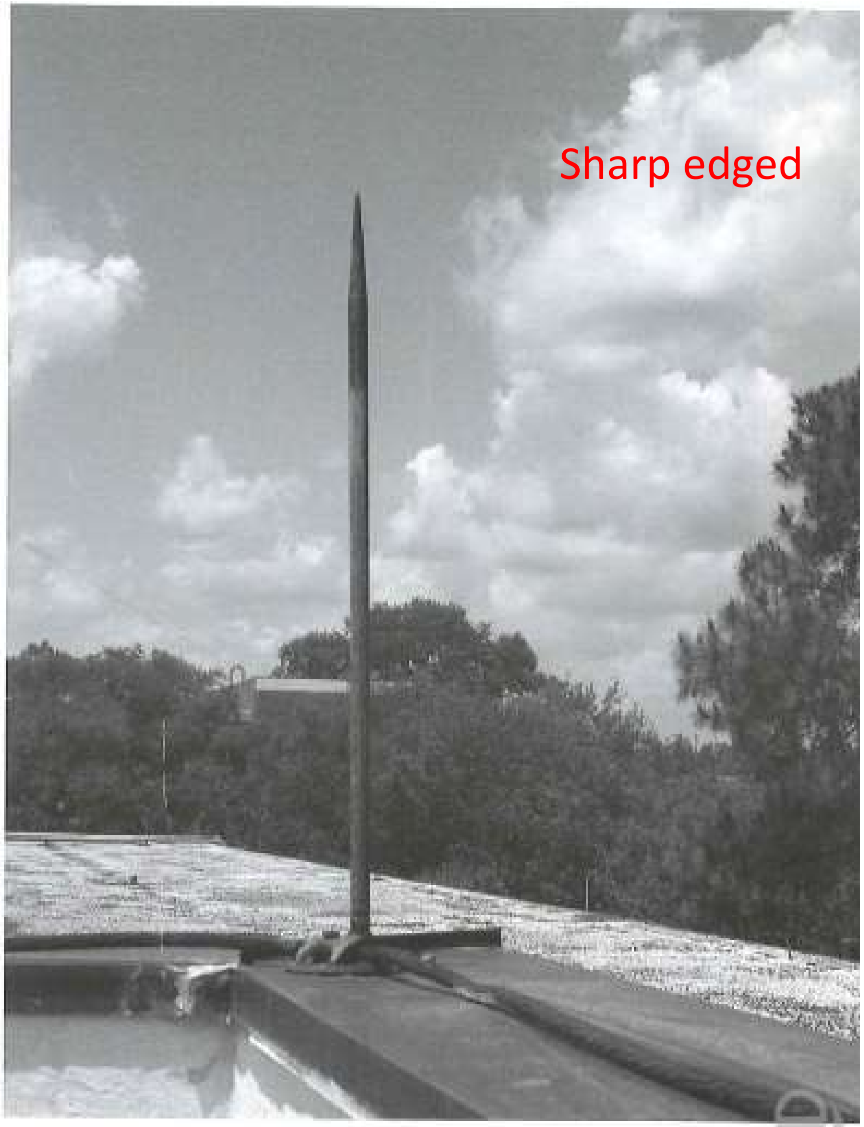
Minimum value of current determines the probability of lightning stepped leader bypassing the LPS

Main components of a Lightning Protection System (LPS)



Air Terminals





Dimensions and materials of air terminals

Material	Configuration	Cross-sectional area in [mm²]
Copper, tin-plated copper	Solid tape	50
	Solid round [b)]	50
	Stranded [b)]	50
	Solid round [c)]	176
Aluminium	Solid tape	70
	Solid round	50
	Stranded	50
Aluminium alloy	Solid tape	50
	Solid round	50
	Stranded	50
	Solid round	176
Copper coated aluminium alloy	Solid round	50
Hot-dipped galvanised steel	Solid tape	50
	Solid round	50
	Stranded	50
	Solid round [c)]	176
Copper-coated steel	Solid round	50
	Solid tape	50
Stainless steel	Solid tape [d)]	50
	Solid round [d)]	50
	Stranded	50

a) Mechanical and electrical properties as well as corrosion resistance properties must meet the requirements of the future IEC 62561 series.

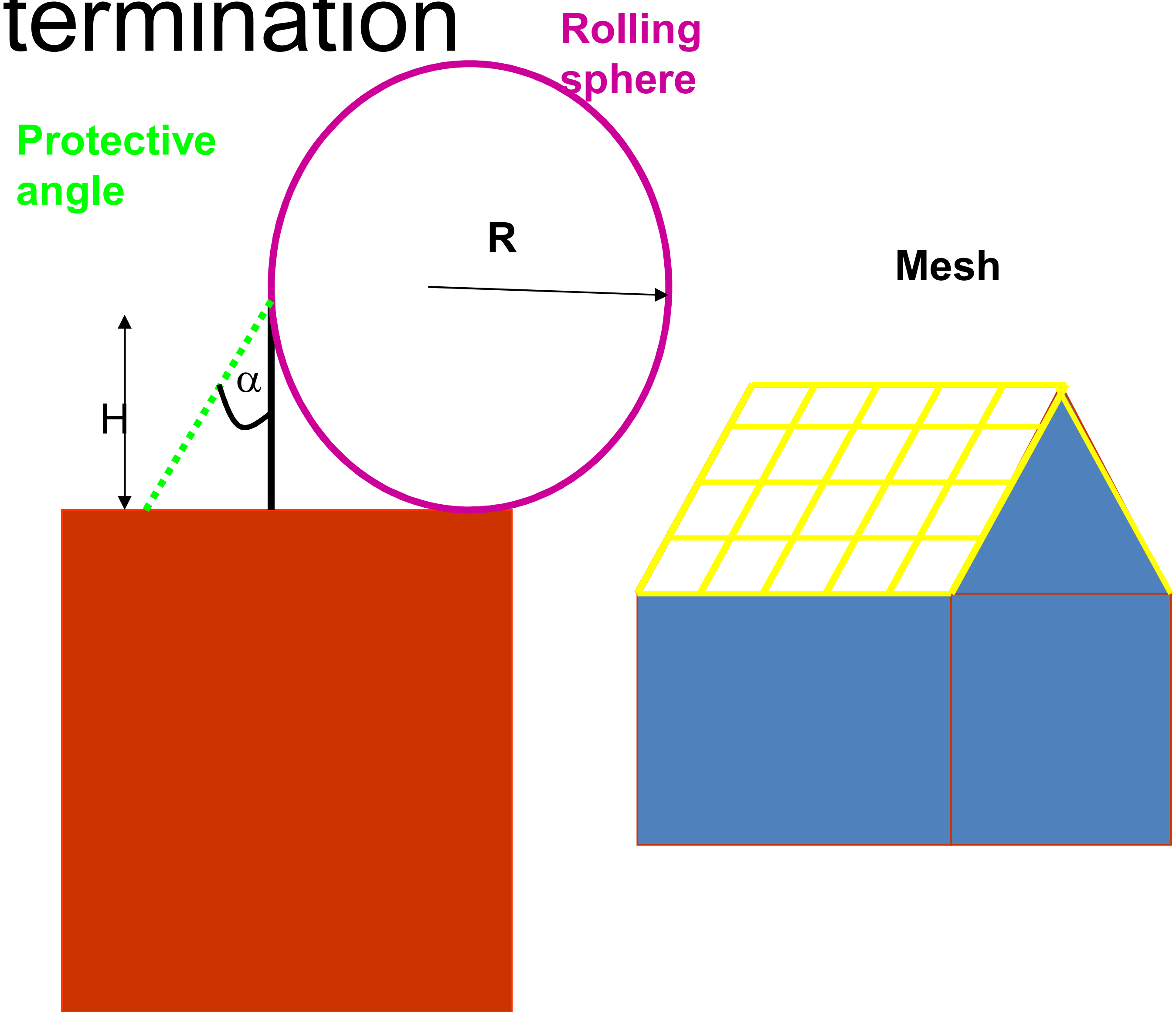
b) 50 mm² (diameter of 8 mm) may be reduced to 25 mm² in certain applications where the mechanical strength is not an essential requirement. In this case, consideration should be given to reduce the spacing between the fasteners.

c) Applicable for air-termination rods and earth entry rods. For air-termination rods where mechanical stress such as wind load is not critical, an at least 1 m long rod with a diameter of 9.5 mm may be used.

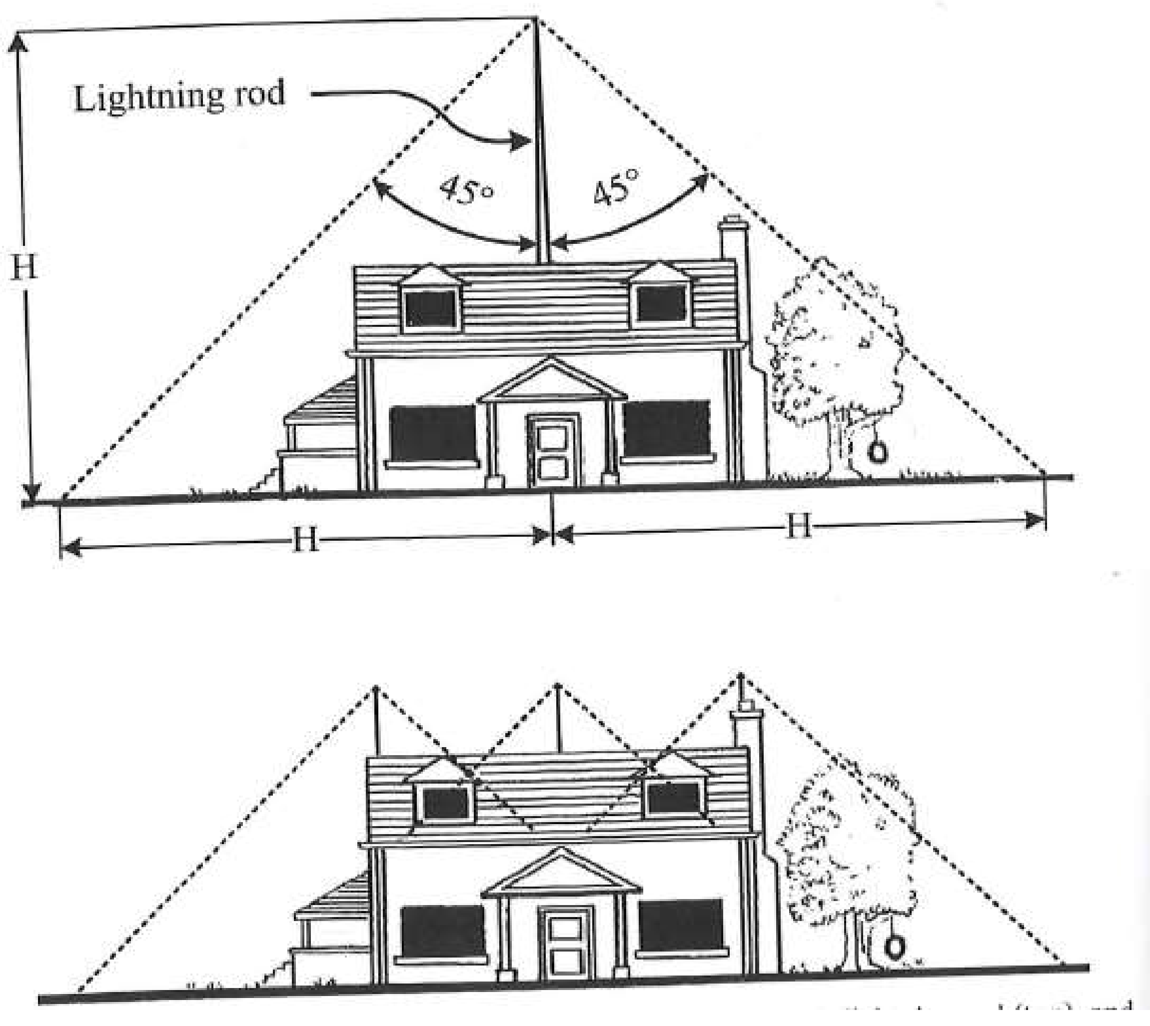
d) If thermal and mechanical considerations are important, these values should be increased to 75 mm².

Material, configuration and minimum cross-sectional area of air-termination according to Table 6 of IEC 62305-3

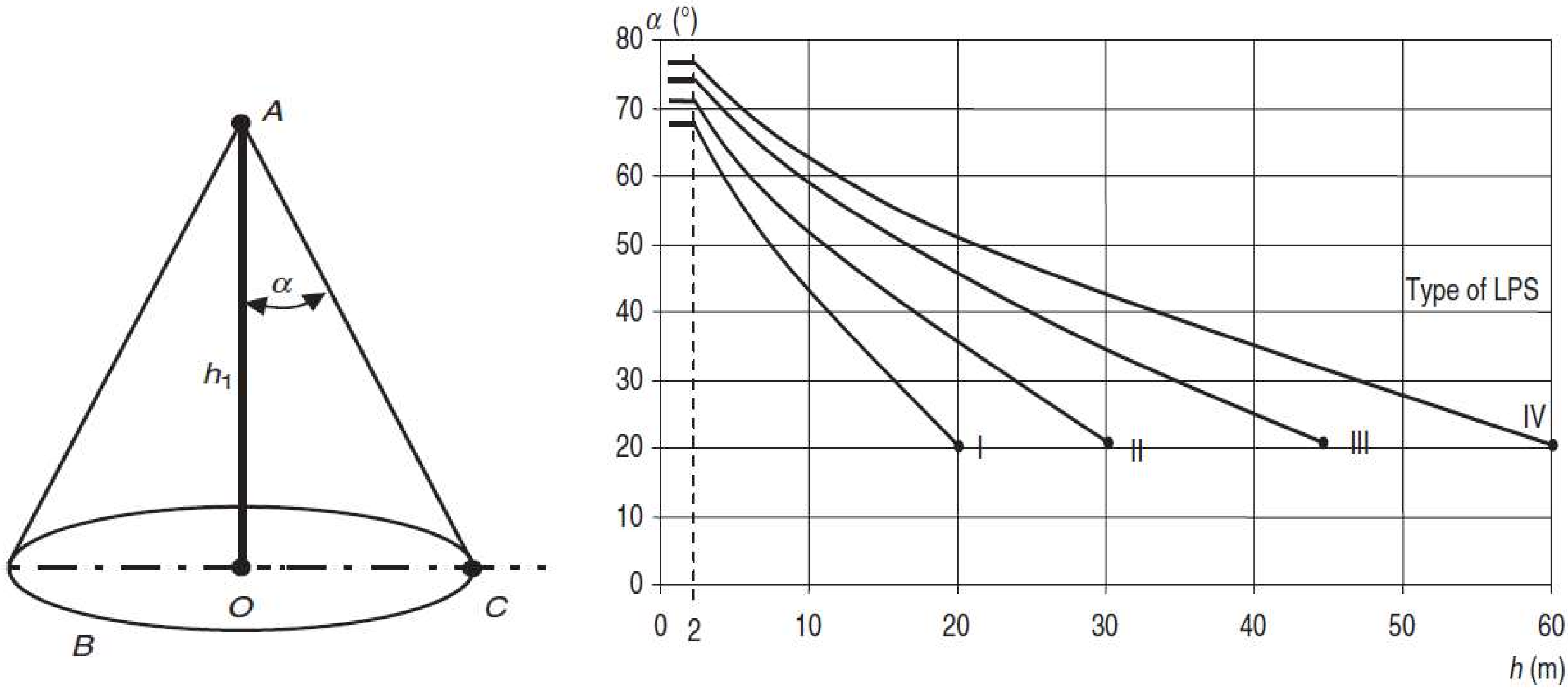
Three Methods to install the air termination



Protection Angle Method

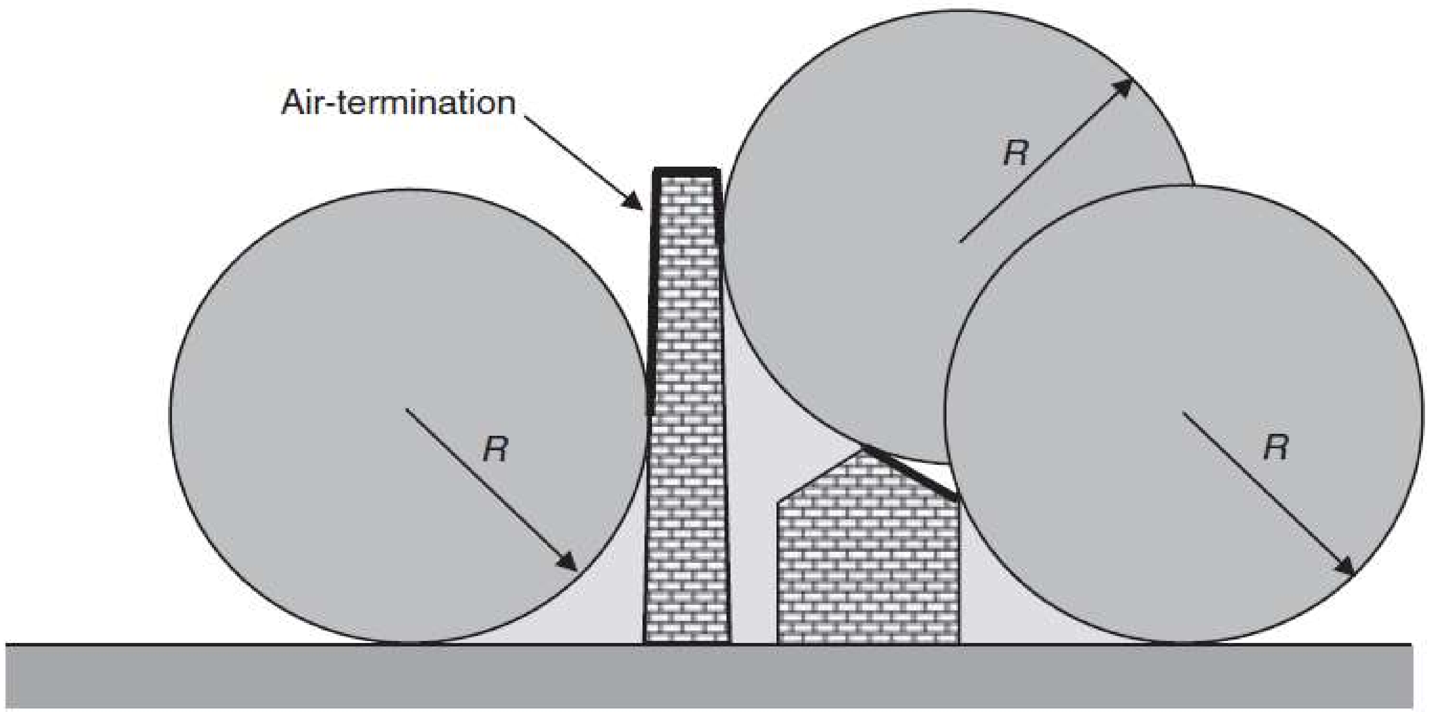


Level of Protection (Angle of Protection)

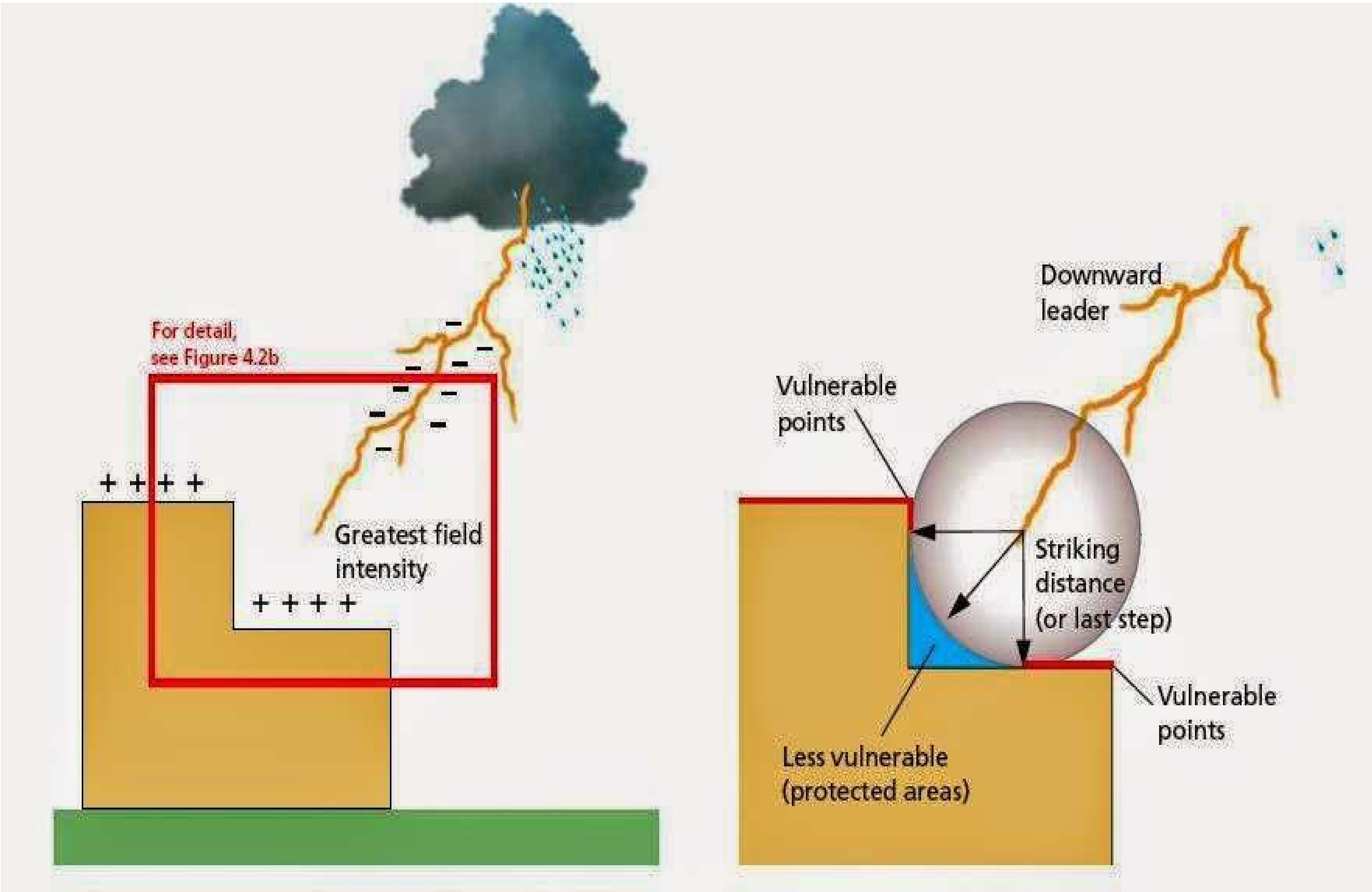


Volume protected by a vertical air-termination rod. A *is the tip of the air-termination rod,* B *is the reference plane,* OC *is the radius of the protected area, and* h_1 *is the height of the air-termination rod above the reference plane of protection.*

Rolling Sphere Method

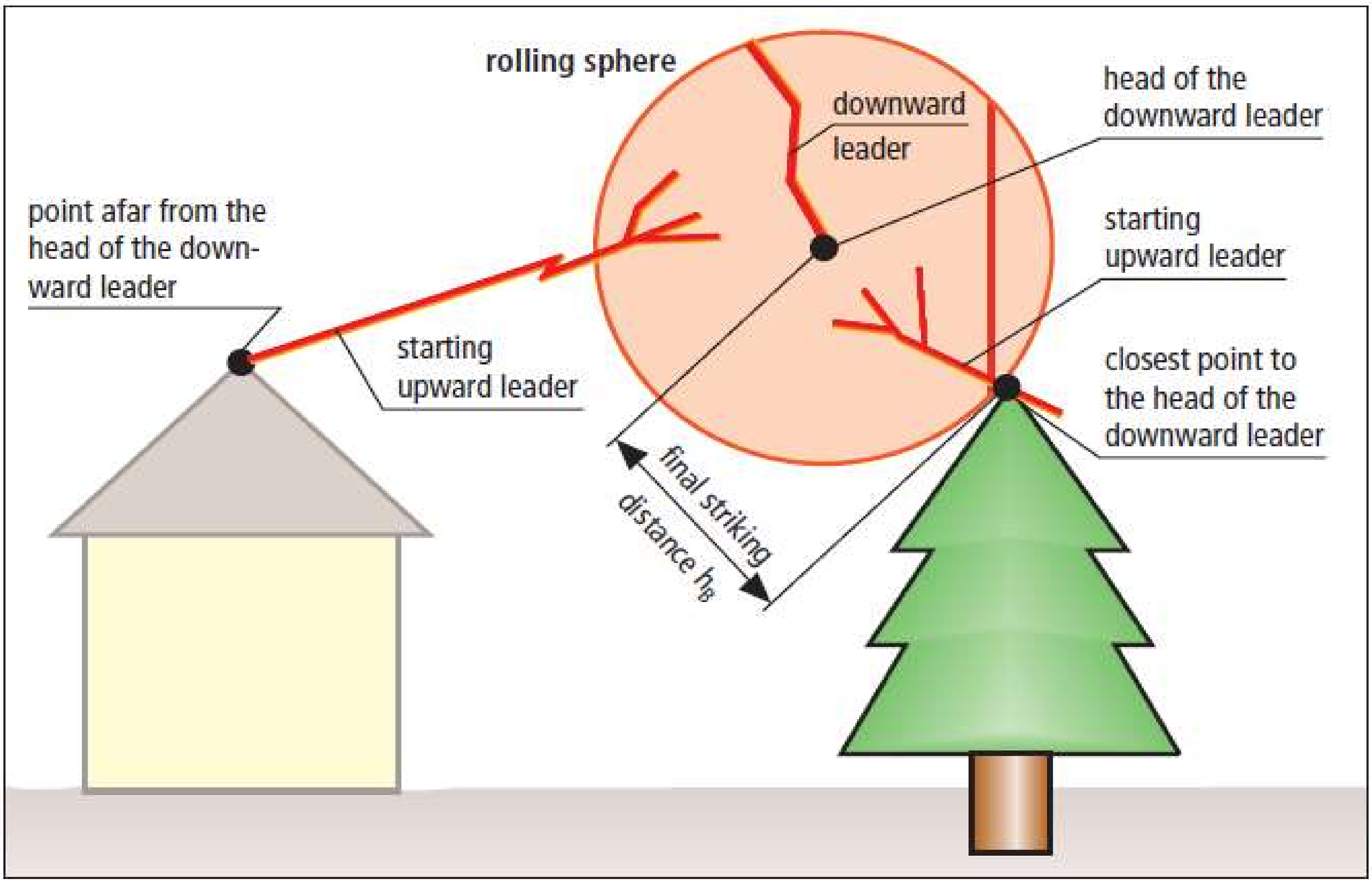


Striking Distance on a house

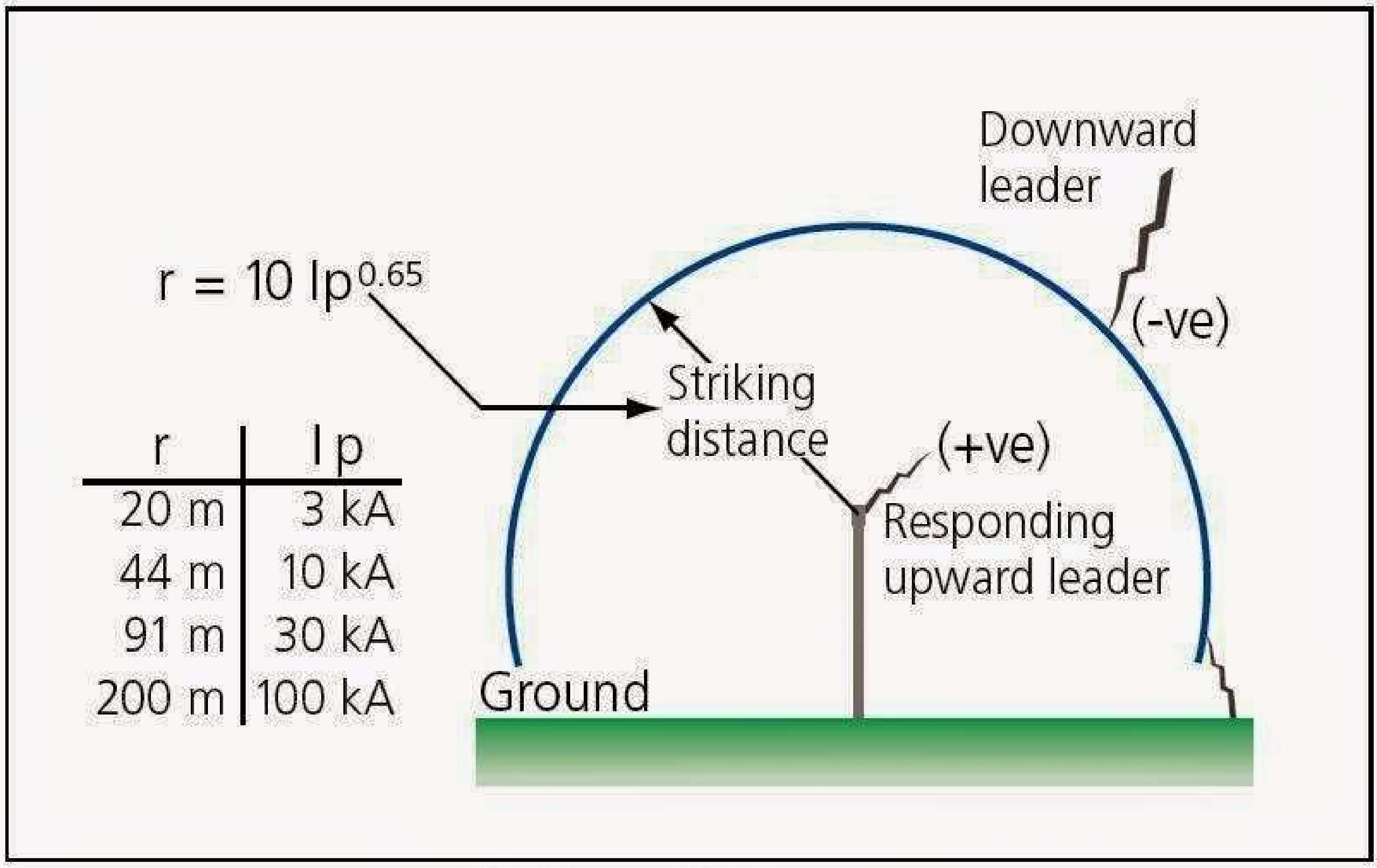


Development of downward leader/striking distance

Striking Distance, radius of the sphere

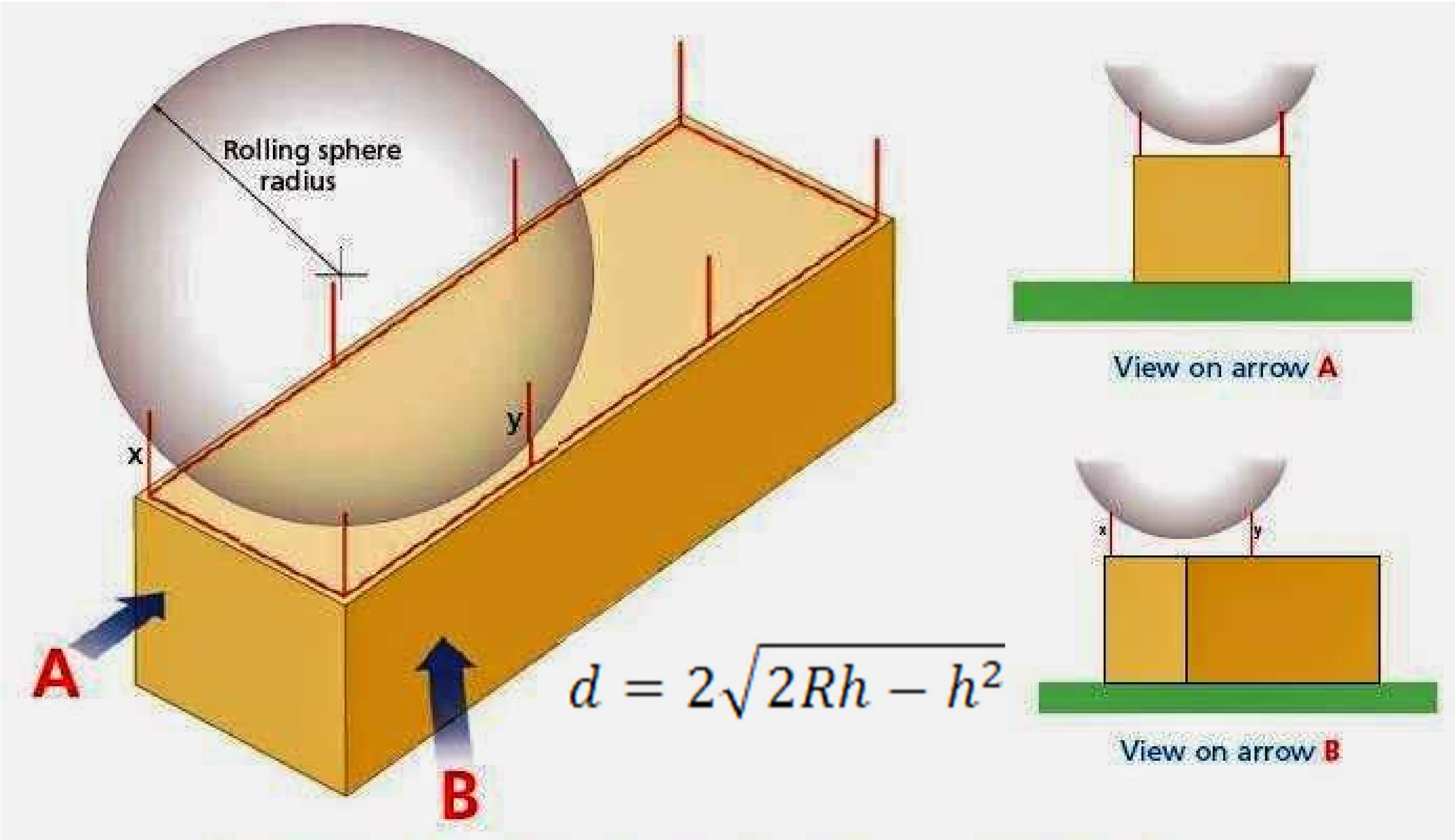


Striking Distance and radius of the sphere



Striking Distance.

Separation of Air terminals



Application of the rolling sphere to air rods in a non-isolated system

Calculating Distance between air terminals

$$d = 2\sqrt{2Rh - h^2}$$

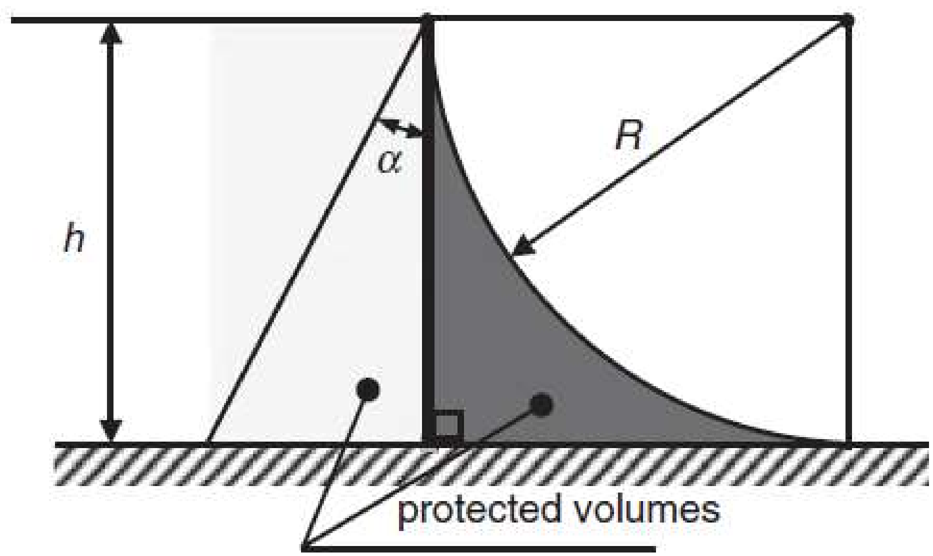
Height of rod (m)	Distance between air-terminations (m)			
	LPL I r = 20 m	LPL II r = 30 m	LPL III r = 45 m	LPL IV r = 60 m
0.5	8.8 (6.2)	10.9 (7.7)	13.3 (9.4)	15.4 (10.9)
1	12.4 (8.8)	15.3 (10.8)	18.8 (13.3)	21.8 (15.4)
1.5	15.2 (10.7)	18.7 (13.2)	23.0 (16.2)	26.6 (18.8)
2	17.4 (12.3)	21.5 (15.2)	26.5 (18.7)	30.7 (21.7)

Note: *Distances in brackets provide grid distances.*

rolling sphere protection distance.

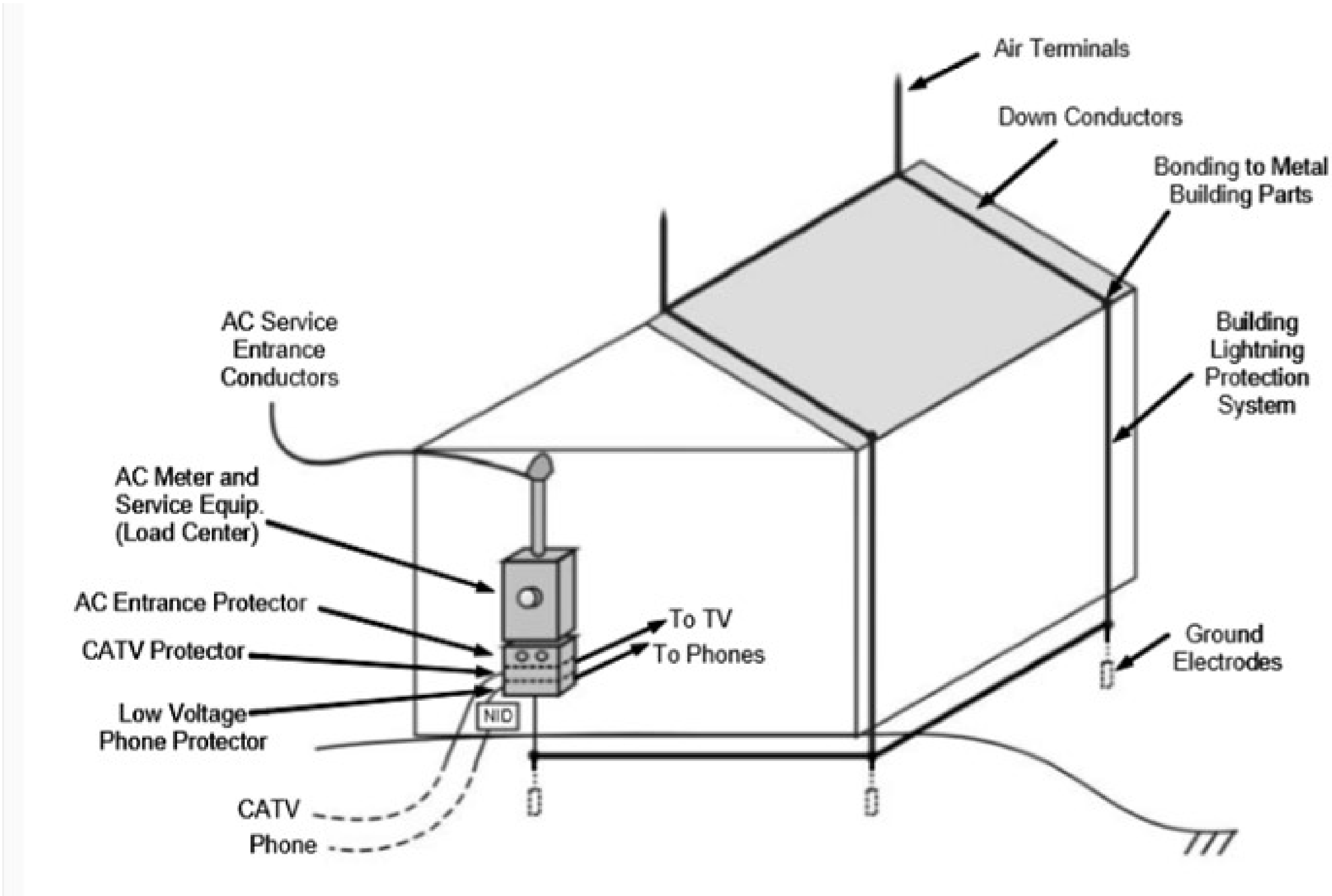
Mesh Method

Level of Protection

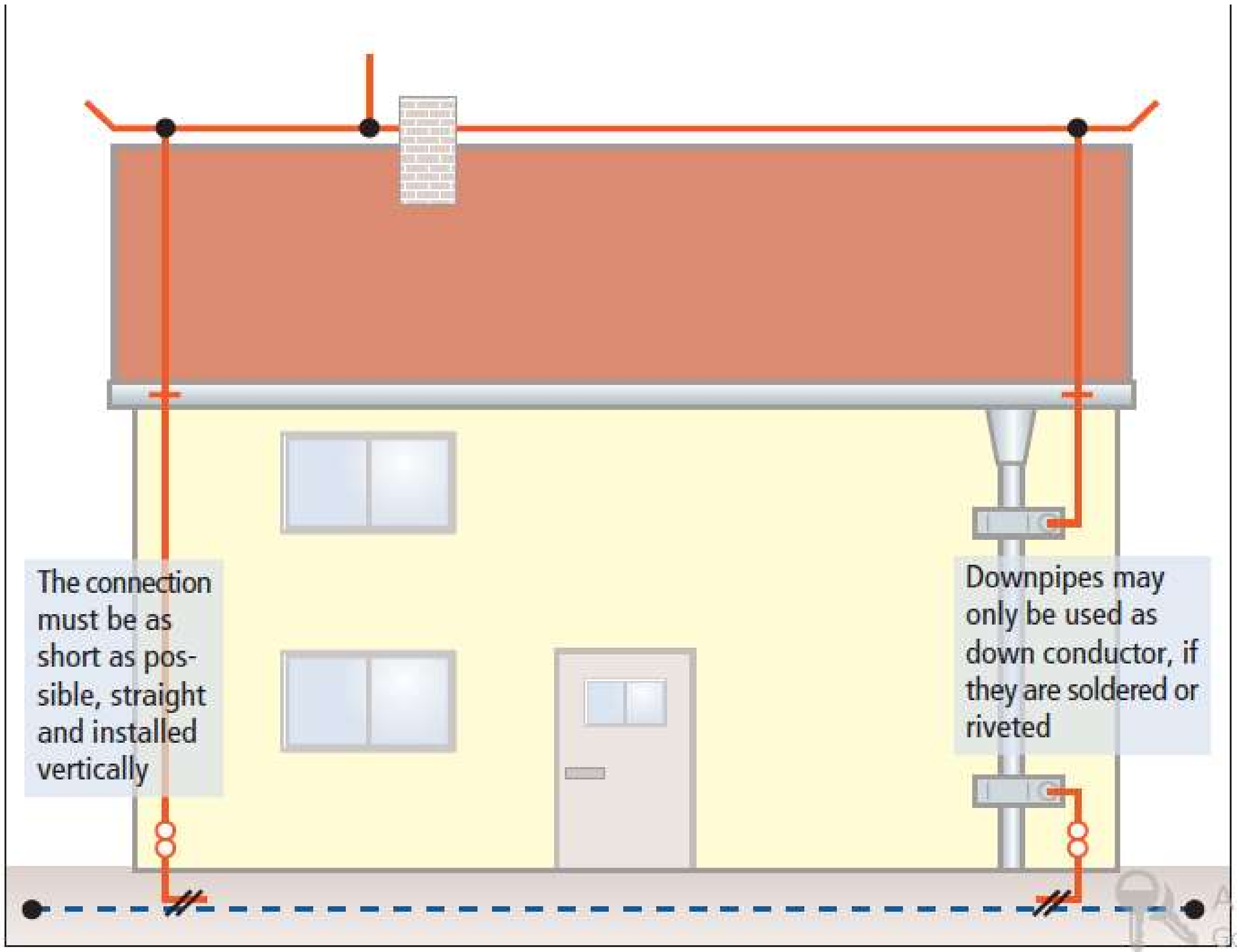


	Protection method	
Class of LPS	Rolling sphere radius R (m)	Mesh size W (m)
I	20	5 × 5
II	30	10 × 10
III	45	15 × 15
IV	60	20 × 20

LPS Down conductor on a simple of house



Down conductor system



Typical values of the distance between down-conductors and between ring conductors according to the class of LPS

Class of LPS	Typical distances m
I	10
II	10
III	15
IV	20

Material, configuration and min. cross sections of air-termination conductors, air-termination rods and down conductors according to IEC 62305-3

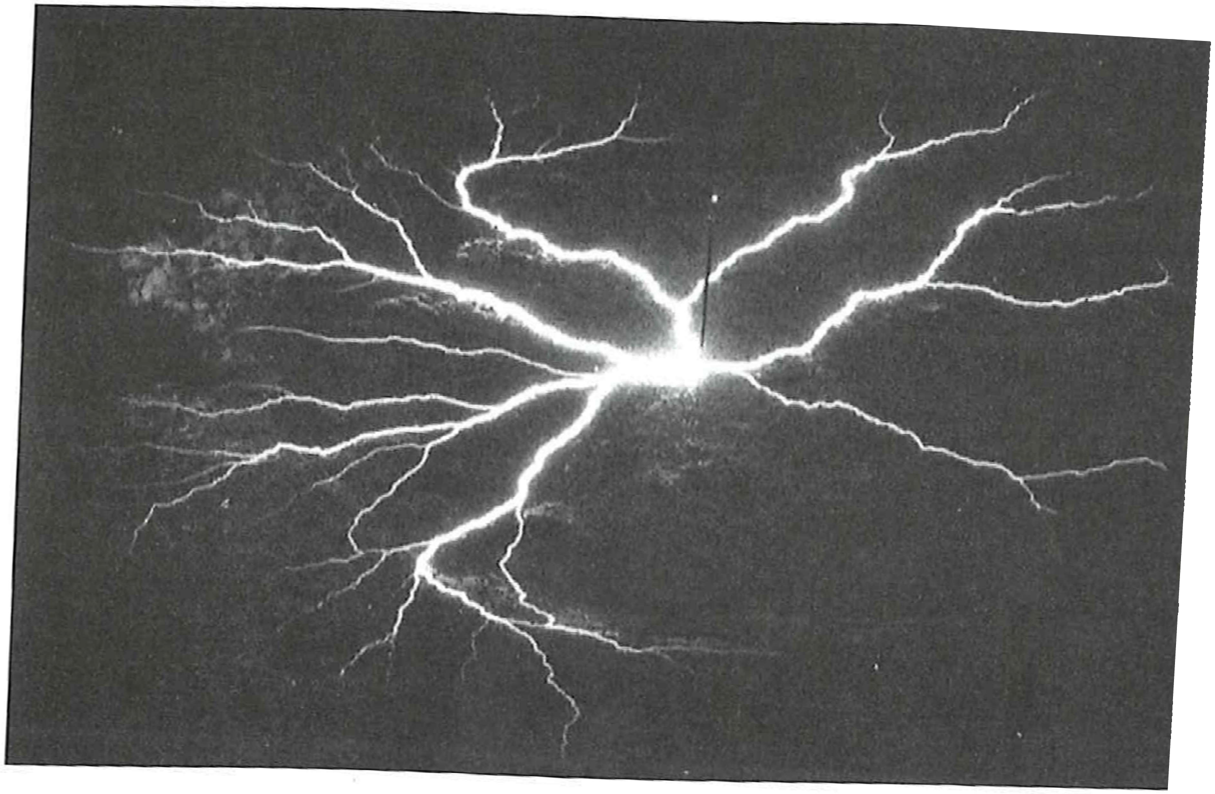
Material	Configuration	Min. cross-section mm²	Remarks[10]
Copper	solid flat material solid round material[7] cable solid round material[3), 4]	50[8] 50[8] 50[8] 200[8]	min. thickness 2 mm diameter 8 mm min. diameter each wire 1.7 mm diameter 16 mm
Tin plated copper[1]	solid flat material solid round material[7] cable	50[8] 50[8] 50[8]	min. thickness 2 mm diameter 8 mm min. diameter each wire 1.7 mm
Aluminium	solid flat material solid round material cable	70 50[8] 50[8]	min. thickness 3 mm diameter 8 mm min. diameter each wire 1.7 mm
Aluminium alloy	solid flat material solid round material cable solid round material[3]	50[8] 50 50[8] 200[8]	min. thickness 2.5 mm diameter 8 mm min. diameter each wire 1.7 mm diameter 16 mm
Hot dipped galvanised steel[2]	solid flat material solid round material[9] cable solid round material[3), 4), 9]	50[8] 50 50[8] 200[8]	min. thickness 2.5 mm diameter 8 mm min. diameter each wire 1.7 mm diameter 16 mm
Stainless steel[5]	solid flat material[6] solid round material[6] cable solid round material[3), 4]	50[8] 50 70[8] 200[8]	min. thickness 2 mm min. thickness 8 mm min. diameter each wire 1.7 mm diameter 16 mm

Earth Termination System

- The earth-termination system is the third part of an external LPS that is intended to conduct and disperse the lightning current into the earth, without causing any danger to people or damage to installations inside the structure to be protected.
- In general, a low earthing resistance, if possible, lower than 10 Ohm when measured at low frequency, is recommended

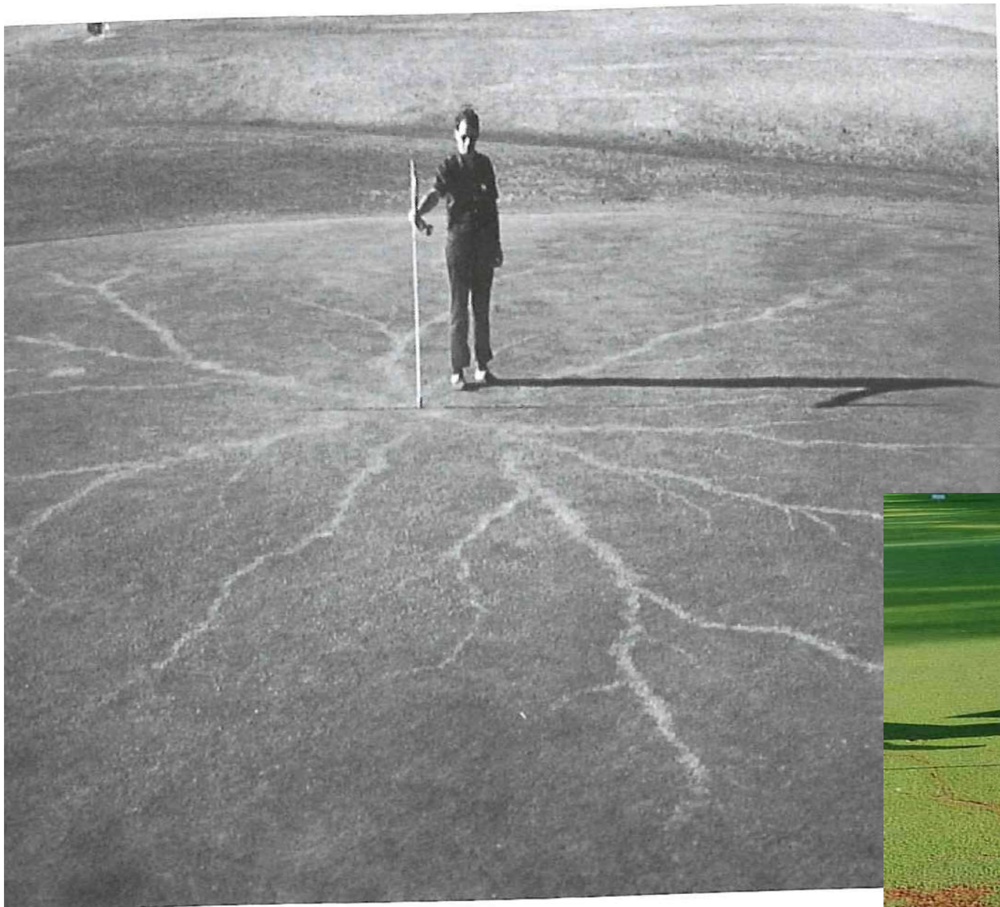
Earthing/Grounding

Surface arcing



Photograph of surface arcing of about 4 m radius from the point of current injection via a ground rod into soil in a laboratory experiment (Wang *et al*. 2005). Courtesy of Liew Ah Choy.

Surface arcing



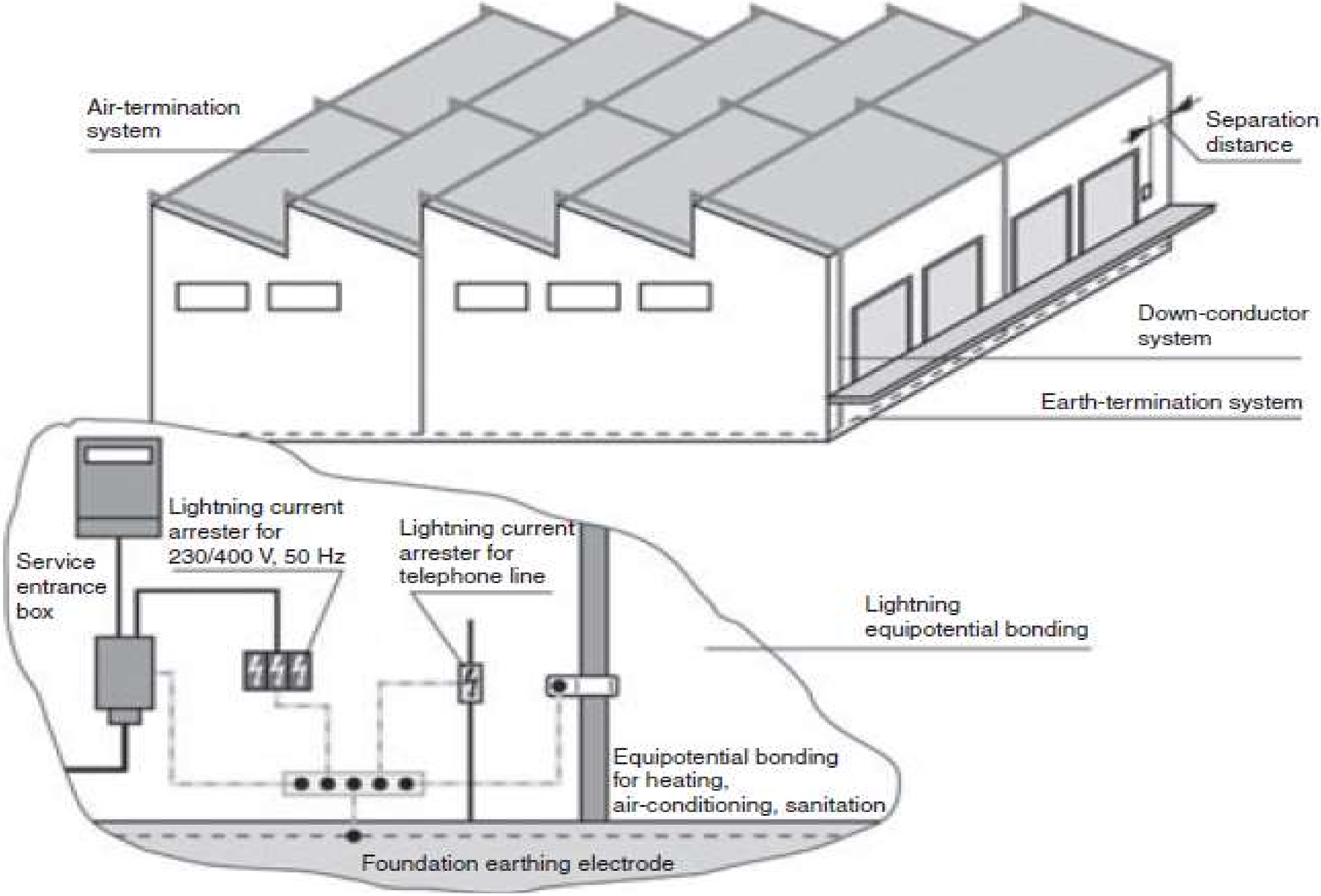
ograph showing evidence of electrical breakdown across the Earth's surface
urrent of natural lightning injected into a grounding electrode, in this case t
f course green. Courtesy of E. Philip Krider.

Internal Protection and Bonding

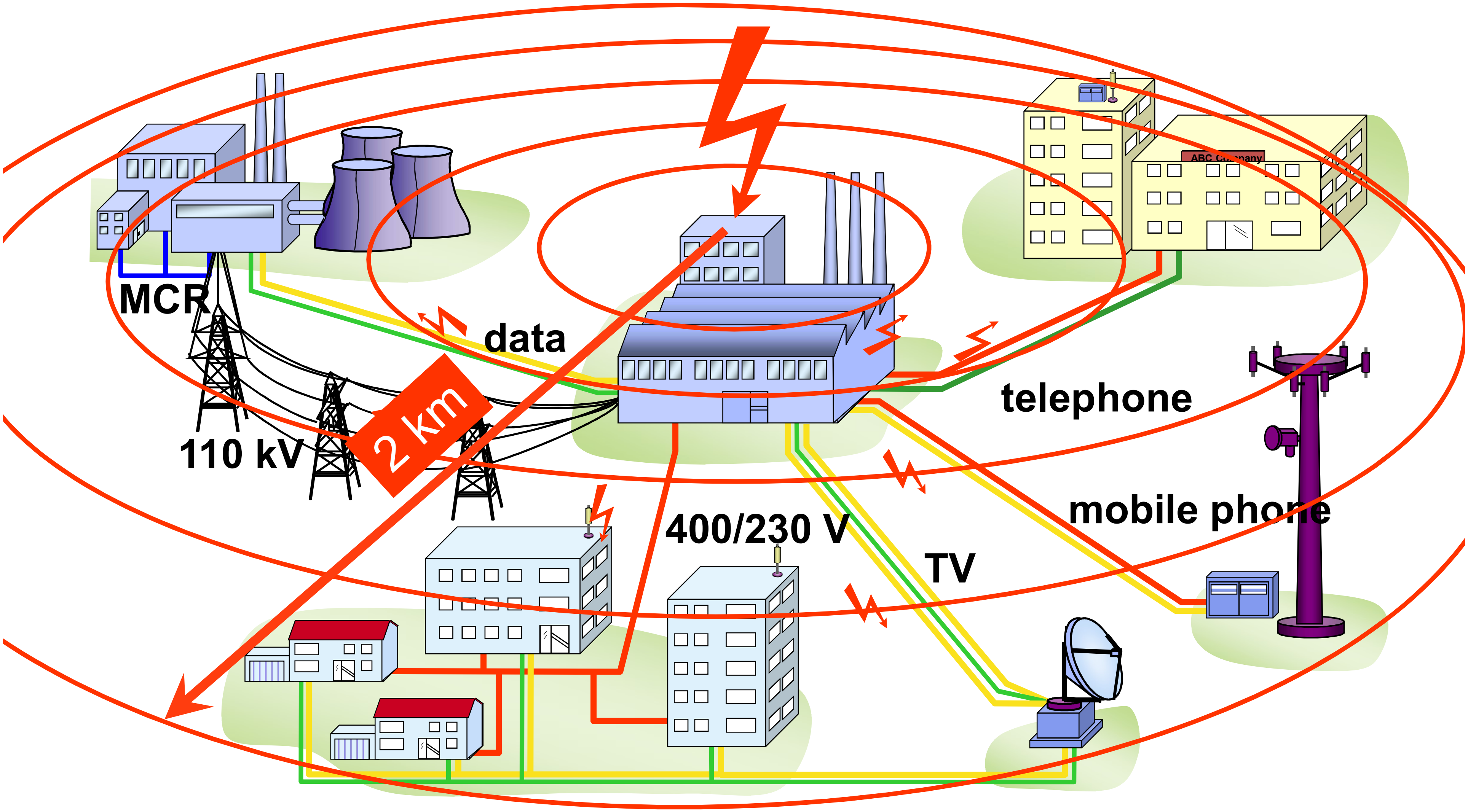
This is achieved by means of equipotential bonding or a safety distance between

- components of the LPS and other conductive elements inside the building or structure.
- The protection equipotential bonding reduces the potential drops caused by the lightning current.
- This is achieved by connecting all separate, conductive parts of the installation directly by means of conductors or SPDs (SPDs)

Internal Protection and Bonding

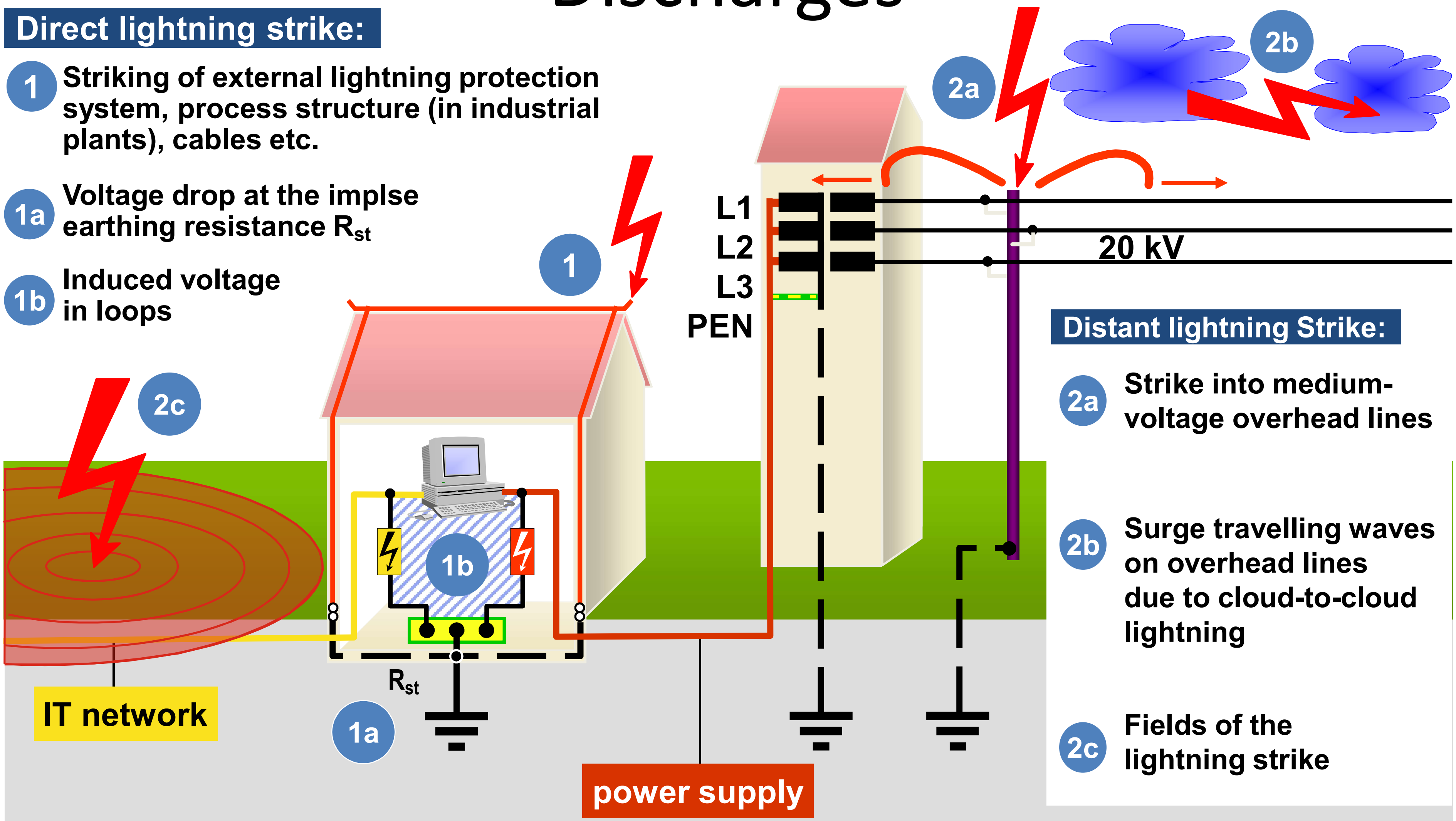


Danger due to Lightning Strokes



Lightning threat within a range of 2 km

Causes of Surges due to Lightning Discharges



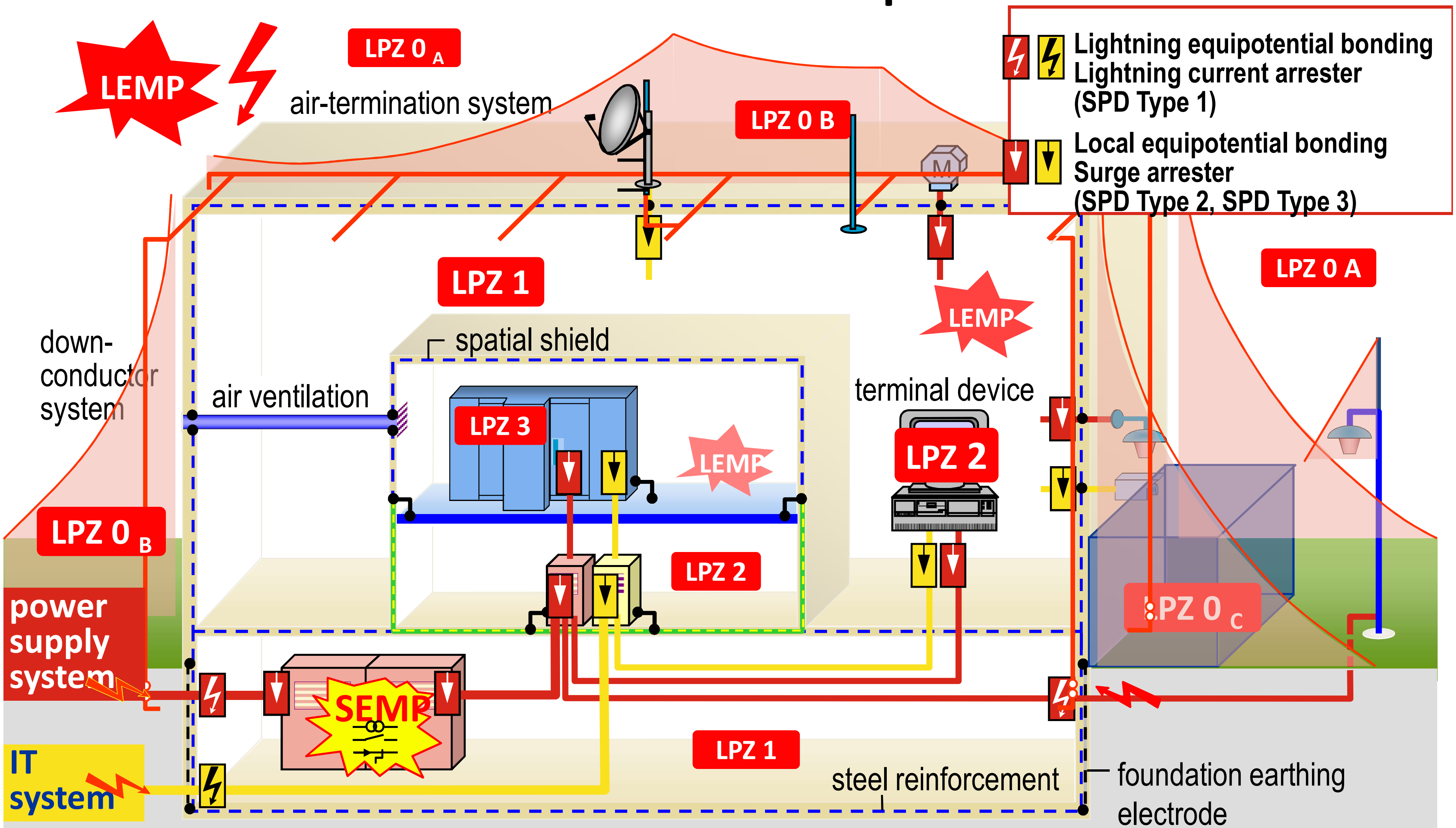
Standardisation of Surge Protective Devices

IEC 61643-1

Performance Requirements of Surge Protective Devices for Low-Voltage Power Supply Systems

Class I	Class II	Class III
Protection Against Direct Lightning Currents (Lightning Current Arrester)	Protection Against Indirect Lightning Effects (Surge Arrester)	Protection Against Switching Overvoltages (Surge Arrester)
(10/350 µs)	(8/20 µs)	(1.2/50 µs; 8/20 µs)

EMC-Orientated Lightning Protection Zones Concept

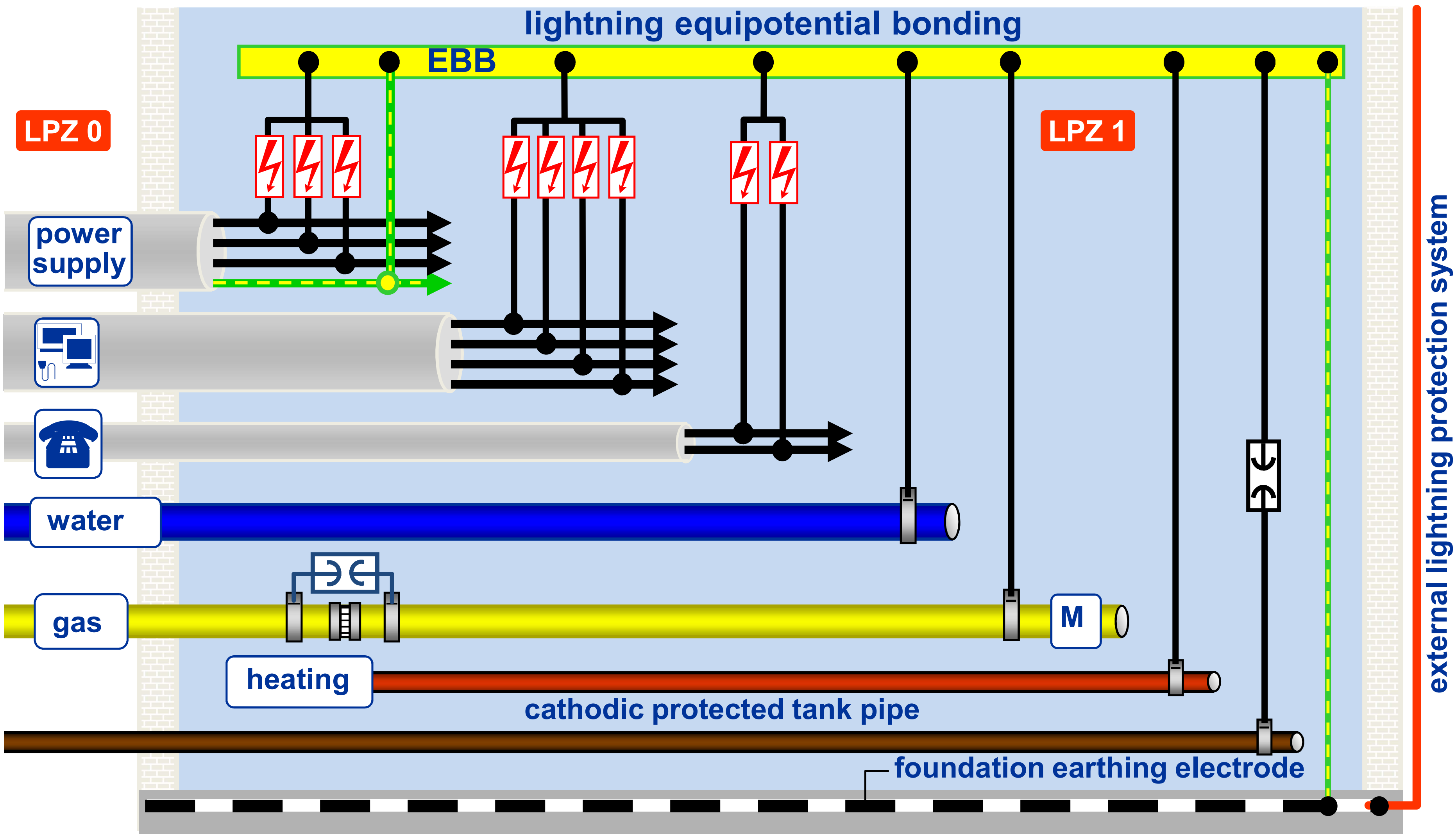


Internal Lightning Protection System

Based on IEC 62305-4

- **Equipotential Bonding at the Boundary of LPZ**
- **Equipotential bonding for all metal parts and supply lines (e.g. metal pipes, electrical power or data lines) which are entering at the boundary of an internal LPZ shall be carried out at equipotential bonding bars which are installed as closely as possible to the point of entry.**
- **SPDs with suitable power carrying capacity for electrical power and data lines at the point of entry into the LPZ have always to be installed.**

Lightning Equipotential Bonding for incoming Lines



Internal Lightning Protection
Surge Protective Devices

Based on IEC 62305-4

Surge protective devices for lightning equipotential bonding must be capable of safely controlling the partial lightning currents to be expected to flow through them.
For this purpose, surge protective devices are chosen according to the requirements on site and installed in accordance with IEC 60364-5-53
The residual voltage at the surge protective device installed into the building, has to be coordinated with the impulse withstand capability of the installation.

Surge protective devices Class I to be installed at the entry of the building, keep a significant part of the power of lightning currents away from the inside of the building.

What is a Lightning Current Arrester installed into a Power Supply System supposed to perform?

- **Discharging of lightning currents several times without desctruction of the equipment.**
  = Discharge capacity 100 kA (10/350 µs)

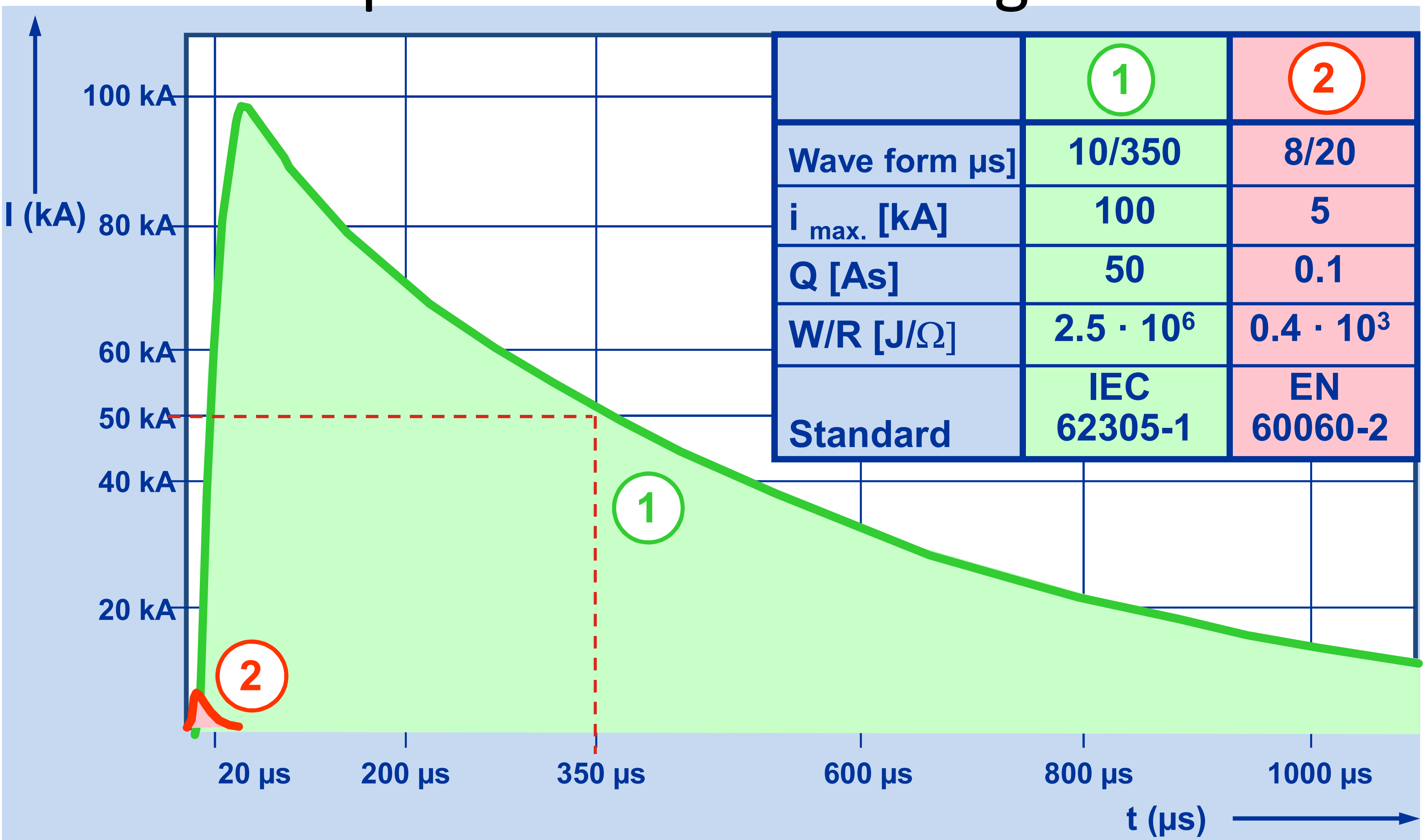
- **Providing of a lower voltage protection level than the voltage strength of the downstream installation.**

- **Extinguishing or limiting of mains follow currents.**

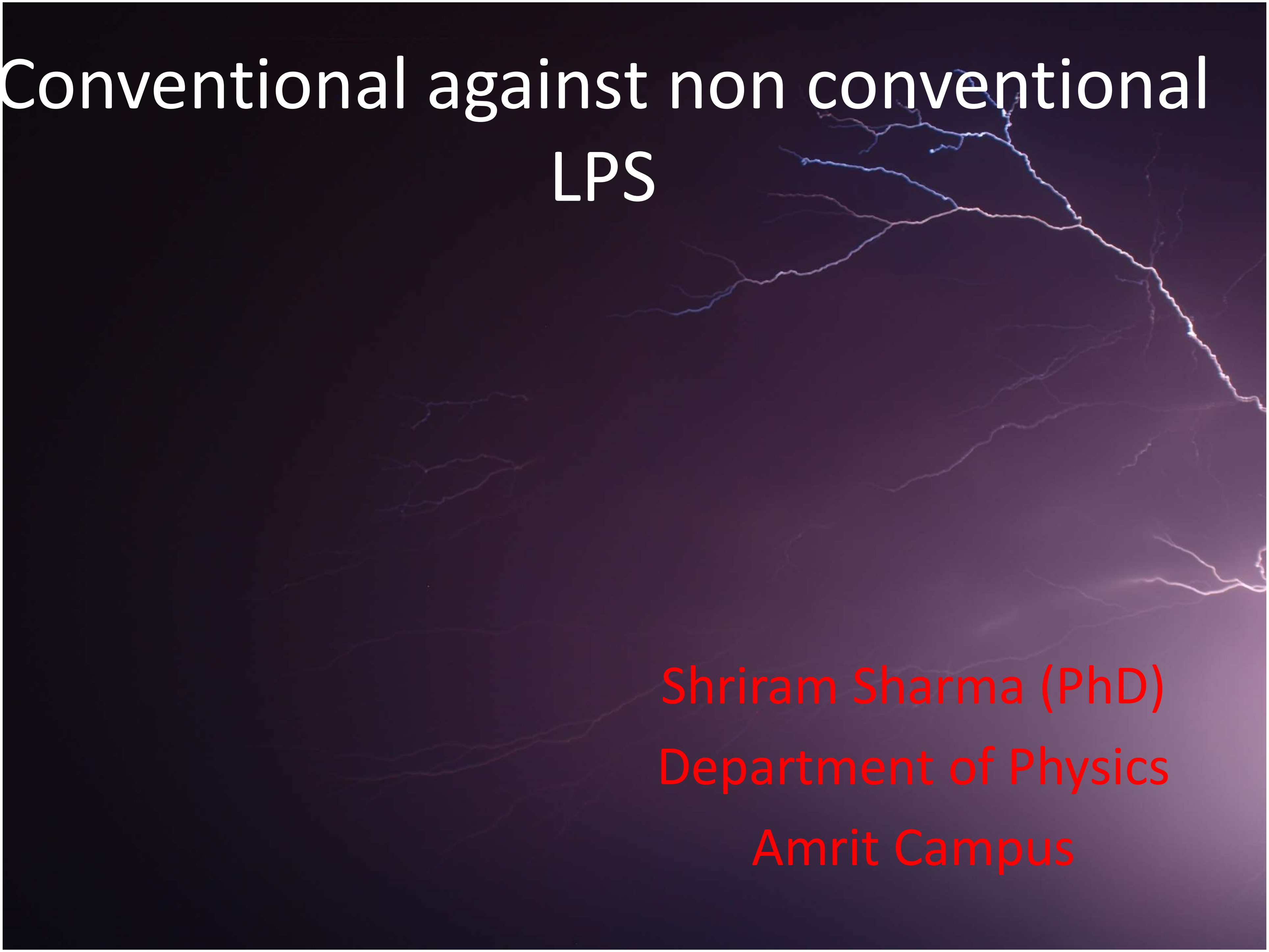
- **Ensuring of the energy coordination to downstream surge protective devices and/or terminal equipment.**

1 Test Impulse Curent for Lightning Current Arresters

2 Test Impulse Current for Surge Arresters



	1	2
Wave form µs]	10/350	8/20
$i_{max.}$ [kA]	100	5
Q [As]	50	0.1
W/R [J/Ω]	$2.5 \cdot 10^6$	$0.4 \cdot 10^3$
Standard	IEC 62305-1	EN 60060-2



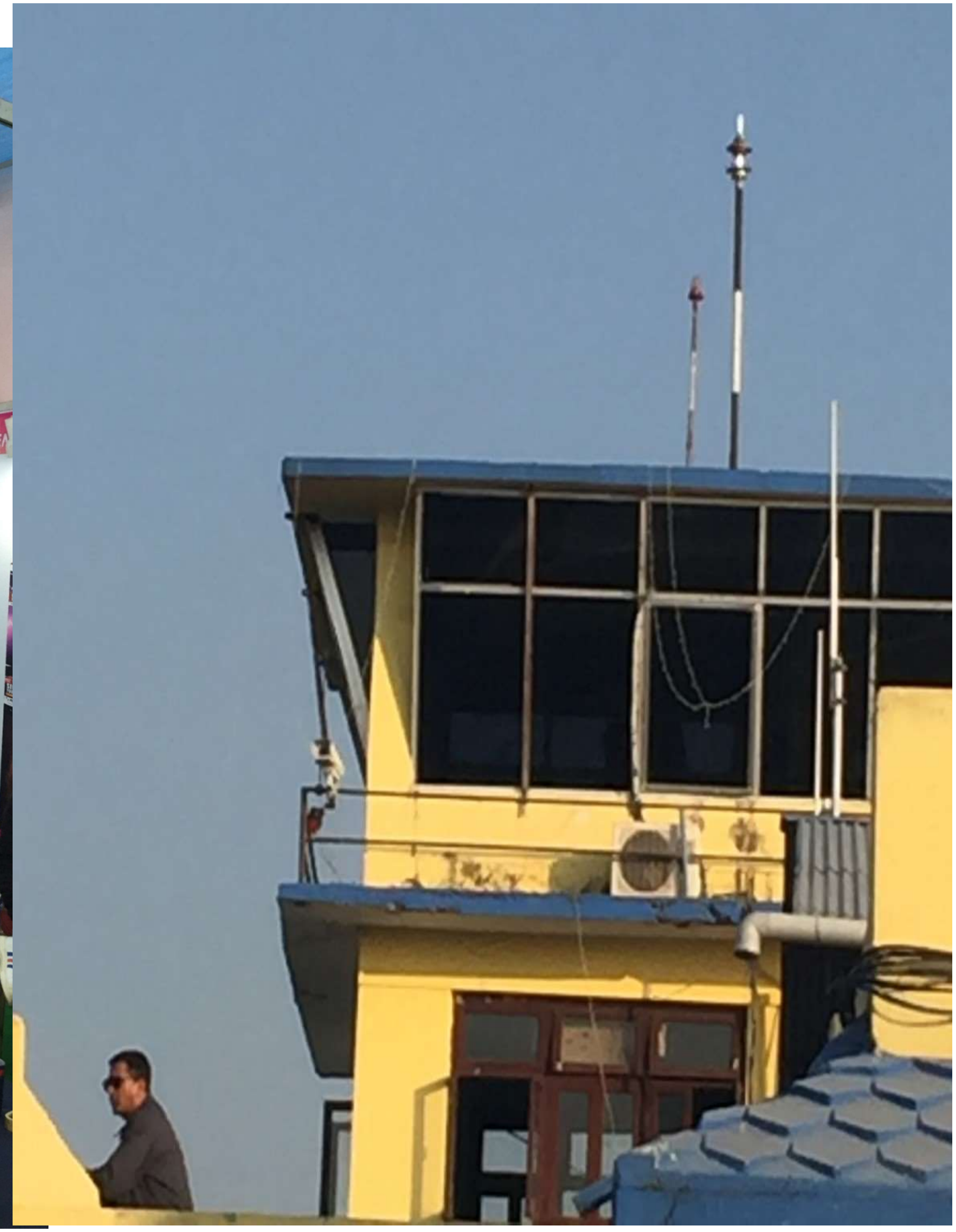
Conventional against non conventional LPS

Shriram Sharma (PhD)
Department of Physics
Amrit Campus

Conventional air terminals

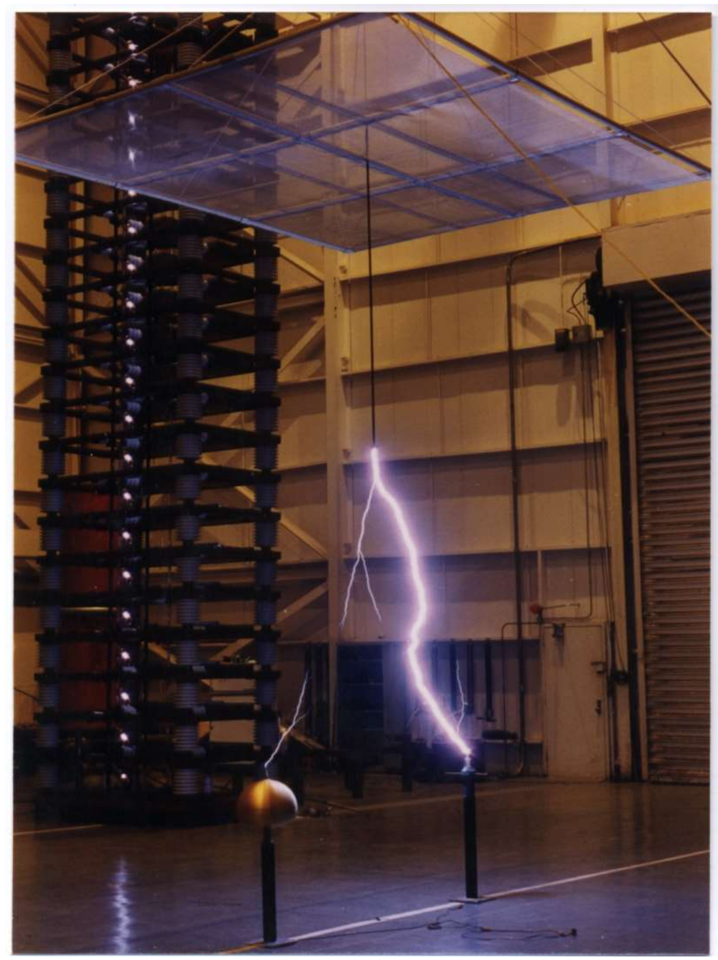
Non conventional Air Terminal


G21 - G2
REMEDIES
Earthing Systems Pvt. Ltd.
SECURING YOUR ASSETS
EARTHING | LIGHTNING | BOND
AWARDS & CERTIFICATIONS
INDIA'S LEADING CHE
ENGINEERING



Testing of ESE devices

Some lab evidence of non-superiority of ESE



Lightning struck within few meters from ESE….!

Other ESE failures -

ESE fails itself


ESE fails itself

What the standards warn

Radioactive air-terminals shall not be allowed. Any other kind of air-terminal like dissipation system/ESE air-terminal/CSE air-terminal shall not be acceptable

----**NATIONAL BUILDING CODE OF INDIA 2016 Vol B Page 88**

Some wrong Practices in Kathmandu

Some wrong Practices in Kathmandu

Conventional Vs Non conventional

Some wrong Practices in Kathmandu