

FIRE SAFETY AWARENESS MONTH CAMPAIGN - EXPERT PERSPECTIVE

LIGHTNING PHENOMENON, DESIGNING ASPECT AND LATEST TECHNOLOGICAL DEVELOPMENT FOR SYSTEM PROTECTION

SIBAJI PATTANAİK

Corporate Technical & Energy Services, Aditya Birla Management Corpn. Pvt. Ltd., Raigad
E-mail: sibaji.pattanaik@adityabirla.com**1. Introduction**

Lightning is one of the most widely studied and documented natural phenomena. Lightning is the result of the development of



cells of high potential in cloud systems because of charge accumulation and the consequent discharge between cells carrying opposite charges or to ground.

It is one of the leading causes of transient over-voltages in electrical systems. A proper understanding of lightning is essential for planning protection against lightning strikes so that no untoward damage is caused to control rooms, office buildings, and electrical installations.

A lot of research has been done over a number of years worldwide, and several publications, as well as national and international standards, have evolved which give us a good insight into this phenomenon.

An indicative list is given below.

- AS 1768: 2007 Australia/ New Zealand standard for lightning protection
- ANSI/NFPA 780 Standard for the installation of Lightning Protection Systems
- IEEE 142: 1991 IEEE green book (Chapter 3)
- IEC 1024:1993 Protection of structures against lightning
- IS/IEC 62305-1 to 4
- UL 96 & 96A, and LPI 175

Nature's beauty is pleasant to human race over the generations. At the same time, its savagery is uncontrollable. Unfortunately, lightning is a daily phenomenon in many parts of the World, unlike the Mother Nature's fury. Lightning activity is on the higher scale over the period of years as per the historical reports collected by Metrological departments across the world. There are two significant problems due to lightning. 1) Loss of Human life and 2) the other is a loss of property (like fires, damage to electrical / electronic gadgets).

There are **five elements** that need to be in place to provide an effective lightning protection system.

- **Strike termination devices** must be suitable to accept direct lightning before they reach insulated building materials.
- **Cable conductors** that route the lightning current over and through the construction, without causing any

damage to the structure, between strike terminations at the top and the grounding electrode system at the bottom.

- The **grounding electrode system** must efficiently move the lightning to its final destination away from the structure and its contents.
- **Bonding** or the interconnection of the lightning protection system to other internal grounded metallic systems must be accommodated to eliminate the opportunity for lightning to side flash internally. Lightning protection components are made from materials that resistant to corrosion, and they must be protected from accelerated deterioration.
- Finally, **surge protection devices (SPDs)** must be installed at every service entrance to stop the intrusion of lightning from utility lines, and further equalize potential between grounded systems during lightning events.

When these elements are identified and integrated correctly during the design stage with a suitably designed earthing grid, incorporated into a neat skillful installation, and no changes to the building occur, the system will protect the structure against lightning damage.

When these elements are identified and integrated correctly during the design stage with a suitably designed earthing grid, incorporated into a neat skillful installation, and no changes to the building occur, the system will protect the structure against lightning damage.

Typical Problems in the current Installations:

1. Non-standard Air termination systems are used widely. Short Circuit current tested air terminals are used, where the testing is in no way connected to lightning current. The so-called special rods available in the market increase the cost of installation & just do the job of a simple metal rod (Franklin rod). Incredible stories and calculations of most of the air termination rods available in the market reduce the psychological fear of people only but make the installation complicated.
2. Lightning Protection is often believed as Air terminal, down conductor and a connection to the earth, which unfortunately fulfills only a part of a protection system, suitable for small and simple building.
3. Bends and loose contact in the lightning protection system lead to flashover, which may result in a fire. The risk is higher if down conductors are routed through electrical or other shafts.
4. Protection measures for sensitive electronic equipment are not considered.

Recommendations:

1. Air Terminal is not only a vertical rod but consists of interconnected steel installations in the roof in the form of a mesh. A vertical air terminal only provides a specific angle of protection.
2. Down conductor in a modern building is nothing but the interconnected steel reinforcement in the columns, which will additionally do the job of protecting electronics in the building acting a Faraday Cage Lightning Electromagnetic Pulse (LEMP). This method avoids the routing of down conductors external to the structure and has no influence on the aesthetics of the building. All metal installations including metal frames of facades need to have interconnection with down conductor / steel reinforcement.
3. Earthing is not just one or more vertical rods in the soil, but a foundation earthing using the steel reinforcement in the foundation. Additional ring earthing outside the building, which is connected to steel reinforcement, is required in some cases.
4. Buildings with electronic installations need additional measures such as meshed air terminal, shielding, screening, bonding, and SPDs.
5. Additional interconnected ring conductors for protection of people outside the building against step potential is necessary.

2. Lightning Protection by Design:

It is crucial to integrate lightning protection during the design stage. Lightning protection is an integrated part of any structural protection and needs to be provided at design stage with proper coordination between architect, civil and electrical engineers as well as a lightning design expert. Implementing the protection measures from foundation onwards is cost-effective, efficient and do not influence the aesthetics of the building.

This also avoids frequent inspection of installation and problems due to corrosion and theft.

3. What is a Surge? How it is caused and importance of surge protection:

Industries want faster, more productive, more efficient machinery. Interestingly, the equipment installed to

increase the productivity is also often the equipment that suffers the most from frequent power disruptions. When entire processes are automated, the efficient operation of machines and their controls become increasingly dependent on quality power.

Put in simple terms; surge is an abnormal increase in current and voltage for a very short period (duration of 10/350 microsecond). There are various sources of the surge. The two major classifications are surges generated by direct lightning hit and manmade transients (sag due to capacitor switching, frequent switching on/off of heavy equipment, welding, etc.)

However, many organisations ignore the most significant threat to their systems - voltage surges caused by lightning and electrical switching events.

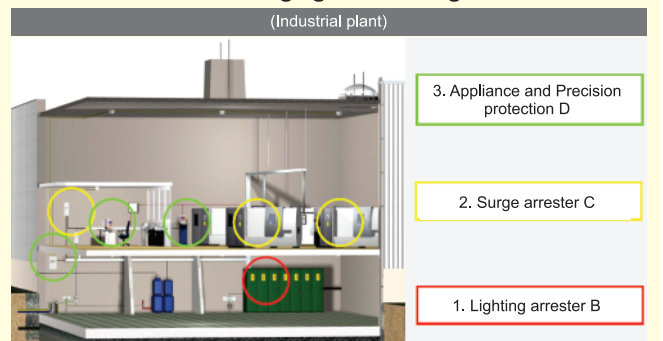
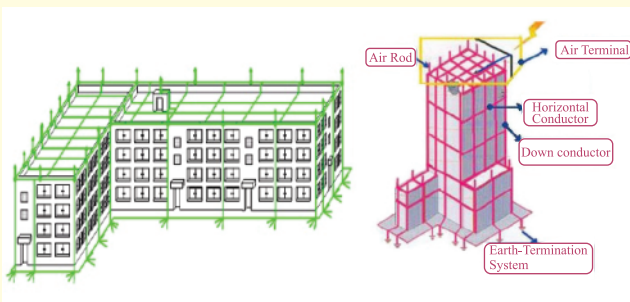
Apart from the enormous cost involved in replacing damaged equipment, consider other expenses that are difficult to quantify: severe disruption to your operations - data loss, the breakdown of weighbridge, downtime, loss of communication system, inconvenience to your staff and your customers.

Lightning activity near a building can cause voltage surges (transient overvoltage). These brief but significant increases in voltage on mains power supplies or data communication lines can be conducted into the electronic circuitry of computers and other sensitive electronic equipment.

This results in data loss, loss of communication, system disruption, physical damage to equipment (either immediate or later through component degradation) and costly downtime. Electrical switching events can cause the same problems although chiefly affecting mains power supply.

Example of Installations in use of SPDs and Lightning arresters.

Unfortunately, the application of all these equipment is for a different purpose altogether and not for protecting equipment from surges. Air terminals provide the safe path for the lightning current to reach the ground through down conductor without damaging the building. MCB -Miniature



Generally, we feel that SPDs are not required as we have a number of other existing arrangements / gadgets to protect viz. External lightning Arrester, MCB/MCCB, proper earthing, shielding, UPS, Isolation transformer, etc.

Circuit breaker or MCCB - Moulded Case Circuit Breaker is for protecting equipment from the short circuit which is operated due to fault current flow. MCB or MCCB operate in milliseconds. Surges are of microsecond duration which means MCB or MCCB cannot detect a surge; it passes through them and damages the equipment.

4. Developing and implementing a lightning protection strategy

There should be a decent idea of the impact of the lightning threat on business. The next step is to analyse what you know and put a simple but effective strategy into place in order to deal with the threat. Such a strategy is proposed below.

A study carried out for an Existing lightning System Design: Earthing System Design Review

Get a reputed and qualified consultant to check the earthing system of your premises. The earthing system is vital to both general electrical safety and the correct operation of lightning surge protectors.

Risk Management (lightning): It evaluates the risk of loss of life, service, cultural heritage and economic values for a given structure after knowing the permissible upper tolerable limit. Accordingly, the selection of appropriate protection measures – LPS would be made to reduce the risk below the tolerable limit by using risk software in compliance IS/IEC 62305-2.

Lightning Protection System Design (LPS): Design engineering to be carried out for the

1. Protection of a structural (industrial plant, high-rise building) against physical damage (fire) by means of an external lightning protection system
2. Engineering design for protection of personnel against injury due to touch and step voltages by means of the internal lightning protection system

Lightning Protection Measure Systems (LPMS): Design engineering for the protection of electrical and electronics systems within a structure (industrial plant, high-rise building) to be able to reduce the risk of permanent failures due to lightning electromagnetic impulse.

Finally, a maintenance strategy should be put in place to check that the earthing system and surge protection devices remain in good working order. Earthing systems degrade with time due to corrosion, theft (as they mostly comprise of copper) and accidental disconnection during site activities other than electrical work. They should be checked on regular basis. Surge protection devices degrade with use like any other physical product and should be maintained and replaced accordingly.

Different Installation Methodology applied

The installation of a lightning protection system using rods and meshed conductors must follow the standards IEC

62305 Lightning Protection:

There are five methodologies, i.e., 1) Rolling sphere Method, 2) Protection angle method 3) Collection volume method 4) Mesh Method 5) Erection Electro -Geometrical Method.

Pictorial representation of commonly used Methods is shown overleaf.

CASE STUDY

This is a problem of repeated TV set failures whenever a thunderstorm hit the area. The TV had a cable connection. No SPDs were provided either on the power supply wires or the TV cable.

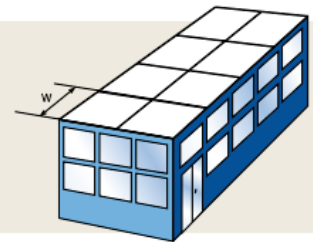
Analysis

It was found that two separate grounds were provided in the house at opposite ends. One was by the power supply

Mesh method

According to this method, conductors forming a mesh should be placed on the structure. The separation depends on the protection level:

- Protection Level I: w = 5m
- Protection Level II: w = 10m
- Protection Level III: w = 15m
- Protection Level IV: w = 20m



The mesh should initially be applied to the cover perimeter, especially edges and overhangs.

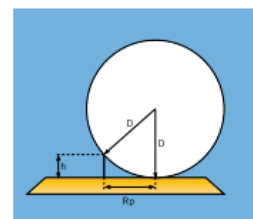
For buildings higher than 60m, a mesh with the same size should also cover the upper 20% of the outer walls.

Rolling sphere method

The rolling sphere method is based on an electrogeometrical model, where it is assumed that the downward leader that will strike the structure to be protected has the shape of a sphere with a radius D (space where the last step of the downward leader can stay). The points where this sphere can touch the structure should be provided with air terminals.

According to the Standard IEC 62305-3, the rolling sphere radius depends on the protection level:

- Protection Level I: D = 20m
- Protection Level II: D = 30m
- Protection Level III: D = 45m
- Protection Level IV: D = 60m

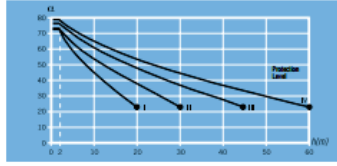
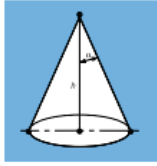


Once these air terminals are installed, the protection radius (Rp) on a flat surface can be defined as shown in the figure and the formula:

$$R_p = \sqrt{2 \cdot D \cdot h - h^2}$$

Angle method

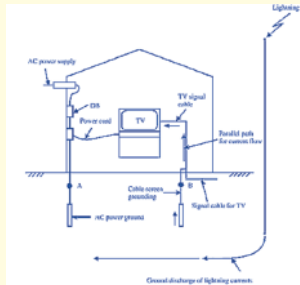
According to this method the protection volume is given by a line which origin is at the air terminal, and which angle depends on the height and the protection level, according to the following chart and graphic:



PROTECTION LEVEL	h (m)	20	30	45	60
D (m)	α	α	α	α	α
I	20	25	*	*	*
II	30	35	25	*	*
III	45	45	35	25	*
IV	60	55	45	35	25

* For structures higher than 60m, this method cannot be applied.

company, and the other was by the cable operator. These were not bonded to each other. The power ground had a connection to the TV through the power cord and the other through the cable screen. Any lightning discharge in the vicinity of the house caused the flow of current in the ground, some of which tended to flow through the TV set's components, which provided a parallel path in the absence of bonding between the two grounds.



Rectification: Approved surge protection devices were provided for both power and cable TV circuits. The ground electrodes were bonded together by an adequately sized copper wire. The problem of TV failure during thunderstorms ceased thereafter.

5. Conclusions

The adverse effects of direct and indirect 'lightning strikes' to a business can be minimised. In fact, a lightning strike is one of the only forms of natural disaster in which any damage to person or property can be mitigated by providing the right technology and strategy that are employed beforehand. At the end of the day, the risk of damage must be weighed up against the cost of installing and maintaining a lightning protection system and each business requires a unique strategy to fight this threat.

The implementation of a Lightning protection system includes some art, science, craftsmanship, and technological intuition. This is a specialized industry with its own Standards designed purpose - specific of dealing with nature's grand random destroyer.

Some additional Information

Common mistakes:

The most common mistake made in lightning and surge protection is to believe that if a building has external protection or a mast, the equipment inside the building is safe. This is not true. The external lightning protection is only there to protect the building and to provide a convenient path for the lightning current to be dissipated into the earth.

It has been well documented that direct lightning strikes are responsible for a small percentage of damage to electronic equipment. In excess of 90% of the damage occurs due to indirect effects.

Myth 1 – Lightning Only Strikes the Tallest Objects Fact: Lightning is indiscriminate, and it can find you anywhere. Lightning hits the ground instead of trees, cars instead of nearly telephone poles and parking lots instead of buildings.

Myth 2- A House will always keep you safe from Lightning Fact: While a house is the safest place you can be during a storm, just going inside is not enough. You must avoid any conducting path leading outside, such as corded telephones, electrical appliances, wires, TV cables, plumbing, metal doors or window frames, etc. Don't stand near a window to watch the lightning. An inside room is generally safe, but a home equipped with a professionally installed lightning protection system is the safety shelter available.

Myth 3 – Surge Suppressors can protect a home against Lightning.

Fact: Surge arresters and suppressors are essential components of a complete lightning protection system, but can do nothing to protect a structure against a direct lightning strike. These items must be installed in conjunction with a lightning protection system to provide whole house protection.

Warming will increase lightning by 50%, Times of India.

The Times of India, Chennai Saturday, November 15, 2014;
Kounteya.Sinha@timesgroup.com

New climate models have predicted a 50% increase in lightning strikes across the world during this century because of warming temperatures linked with climate change. The University of California, Berkeley's climate scientist David Romps, and his colleagues looked at predictions of precipitation and cloud buoyancy in 11 different climate models and concluded that their combined effect would generate more frequent electrical discharges to the ground). "Lightning is caused by charge separation within clouds, and to maximize charge separation, you have to loft more water vapour and heavy particles into the atmosphere," he said, "we already know that the faster the updrafts, the more lightning and the more precipitation, the more lightning.").