What you may not know about lightning

Abbreviations

IEC – International Electrotechnical Commission
LPL – Lightning Protection Level
LPZ – Lightning Protection Zone
PVC – Polyvinyl Chloride
SPD – Surge Protective Device

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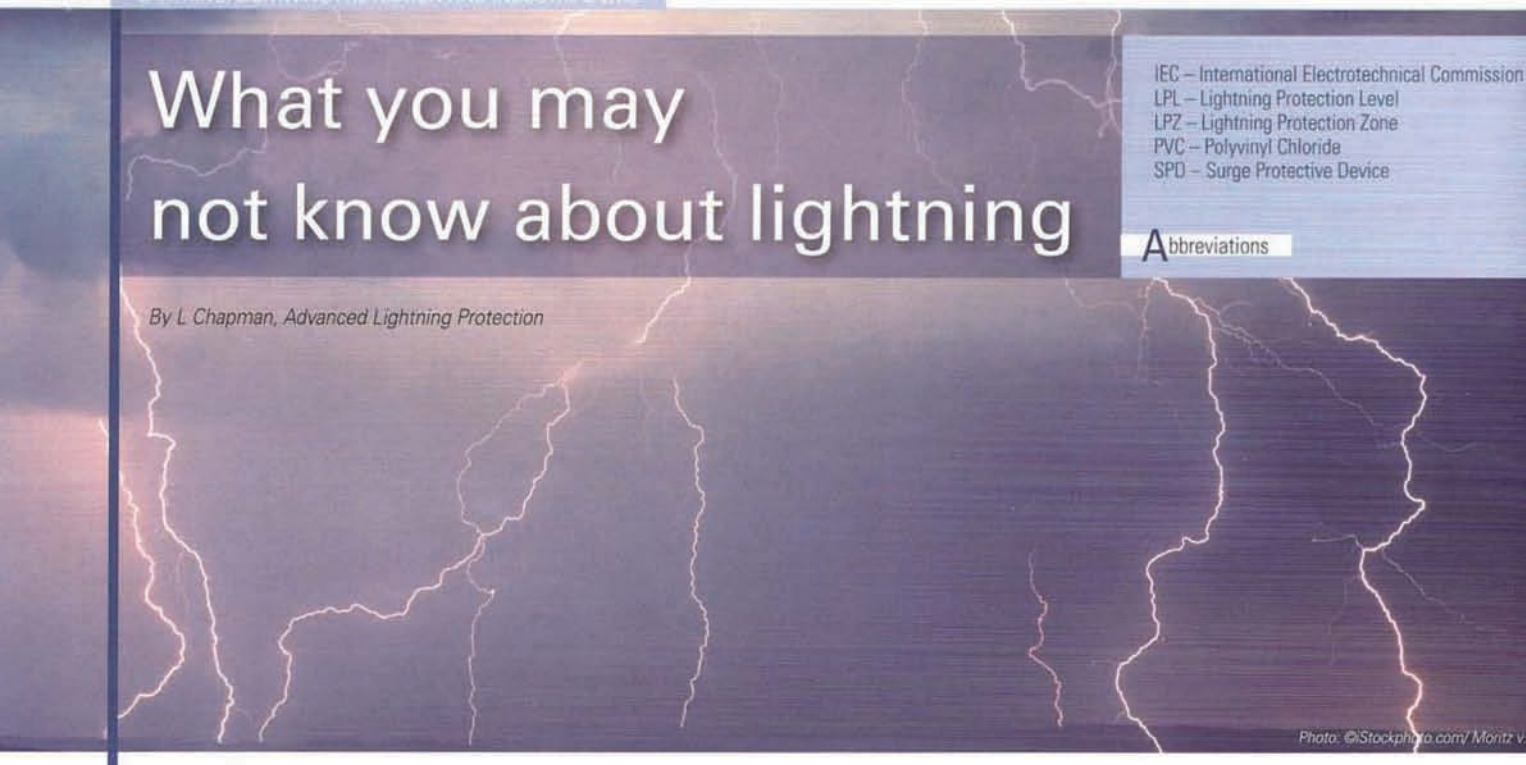

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Lightning can cause catastrophic damage to electrical and electronic equipment as well as structural damage to buildings. The lightning season is upon us and the basic principles of lightning protection must be followed to ensure that your building and equipment are sufficiently protected.

Lightning is an atmospheric emission of electricity, which characteristically occurs during thunderstorms. A bolt of lightning can reach temperatures of nearly 30 000° C, which is sufficient heat to fuse soil and sand into glass tubes called Fulgurites. Ice inside a cloud is thought to be a key constituent in lightning development, and may cause a forcible separation of positive and negative charges within the cloud, thus assisting in the formation of lightning. As a thundercloud rises, expanding ice crystals collide with falling hailstones. The hail strips electrons from the ice. The top of the cloud becomes primarily positive and the bottom mostly negative with scattered positive areas at its base. Negative charges in the lower cloud stimulate a positive region on the earth. Static electricity builds and a negative leader is instigated from the lower cloud. The downward leader creates serrated, branched channels; upward leaders shoot out from the ground. Where the upward and downward leaders meet, determines the lightning strike point. Immediately a massive, luminous return stroke wave front rises up the ionise path. As the return stroke wave front moves upwards, heavy currents flow to ground. An average bolt of lightning conducts a negative electric current of 40 kA, although magnitudes of up to 250 kA have been documented. The voltage developed depends on many factors.

Storm detectors

Lightning Detection Systems are storm detectors that supply information to warn of the risk of lightning activity, recording lightning after the occurrence of a lightning strike within a certain area of the installation. These systems can be national (like the Southern African Lightning Detection Network) or local, and monitor storm activity. The Lightning Detection Systems can provide warning of a possible lightning strike as well as actual lightning strikes. Lightning Detection Systems measure the electrical activity of the storm cloud and the resulting lightning discharge and 'output' the processed information into a warning format when the levels may be dangerous. This unit is based on the electromagnetic field reception, generated by a lightning discharge.

Chance of being struck

The actual chance of a normal house in South Africa being struck directly by lightning is less than once in 25 years. However, that house will be exposed to the effects of a lightning strike up to ten times a year. A lightning strike one kilometre away can cause damage to sensitive electrical and electronic equipment. In the South African context and the high rate of crime, the continuous effective functioning of security systems such as access control and alarm systems is of vital importance. Modern electronics such as telecommunications, computer systems, and security systems are prone to damage from lightning, surges and other transient pulses. The cost of lightning and surge damage can be considerable; however the biggest danger is fire as a result of electrical short circuits caused by such surges. To greatly reduce the risk of damage caused by lightning and other surges it is necessary to have a properly designed and correctly installed lightning protection system.

What is lightning protection?

A lightning protection system is made up of five elements:

- Air-termination system.
- Down-conductors system.
- Earth-termination system.
- Separating distances.
- Lightning equipotential bonding.

The above five protection elements are further divided into main two categories of protection, namely - external lightning protection and internal lightning protection.

Take note

- The average lightning strike does not exceed 40 kA.
- Lightning protection systems are there to reduce the risk of failure to acceptable levels.
- The initial cost of an LPS is quickly recovered by the reduction in the cost of losses.

External lightning protection

The lightning strike must be confined to a designed air termination system, which will conduct the energy to the ground via the down conductors installed. The energy will then be dispersed into the ground via the earthing system. The earth potential differences will be removed by bonding the various earths together.

Internal lightning protection

Internal lightning protection is a means to prevent hazardous sparking from occurring inside the structure. This is achieved by equipotential bonding or maintaining safe separation distances between components of the lightning protection system and other conductive elements inside the structure. The lightning equipotential bonding reduces the potential voltage differences caused by the lightning current. This is accomplished by bonding all separate conductive parts of the installation directly by means of bonding conductors or indirectly by means of surge protective devices (SPDs).

Lightning protection standards

South Africa, like most countries in the world, has adopted the International Electrotechnical Commission's (IEC) 62305:2007 series 1 to 4 standard on Lightning Protection [1]. In South Africa this series is incorporated into SANS 10313:2008 [2].

Before any lightning protection system is considered, a Lightning Risk Management analysis should be conducted in accordance with SANS 62305-2:2007. This will determine whether lightning protection is required and what level of lightning protection (level of risk efficiency) must be used in the design to limit the risk of damage accordingly.

Parameters	Lightning Protection Level		
	I	II	III-IV
I (kA)	200	150	100
W/R (MJ/Ω)	10	5.6	2.5
Q_s (As)	100	75	50
Q_{long} (As)	200	150	100
Effectivity	98%	95%	80-90%

Figure 1: Lightning parameters for the various lightning protection levels [1].

If the lightning protection system is designed and installed according to SANS 10313:2008 [2], then it would have a protection efficiency ranging from 80 - 98% depending on the risk level. It must be remembered that lightning is an Act of God and lightning protection is a means of reducing the risk to acceptable levels – it cannot be eliminated.

Surge protection

Surge protection is an essential element of the overall protection system, not only in areas prone to lightning but in every environment where electrical and electronic equipment is used. Electrical short circuits, switching surges as well as surges generated by the supply authority could result in severe damage to equipment with possible fire risk, loss of revenue due to lost man hours as well as loss of irreplaceable data.

Lightning current distribution

The lightning impulse current combines two key factors. The first is the fast rise time which is useful for determining the voltage value due to inductive effects. The second is the long duration which essentially refers to the energy in the stroke. High-frequency effects are not present in this latter period, allowing ohmic resistance to be used for calculation of current distribution.

Type and class of SPDs

SPDs are divided into three - Class I, II and III. Class I type SPDs are referred to as lightning current arresters and have to be able to withstand substantial parts of the lightning impulse current from a direct lightning strike. Class II and III are referred to as overvoltage arresters and are mostly subjected to partial lightning currents and induced surges. If a structure requires lighting protection in terms of the Risk Management assessment then Class I lightning current arresters must be installed at the entry point to the structure which is normally the main incoming distribution board.

Many people assume that if they install surge protection plugs they will be sufficiently protected. These protectors are normally classified as Class III arresters and are actually designed to offer protection against spikes and surges induced into the cabling within the building. An item to be noted is that SANS 10142-1:2008 [3] states that Class III arresters can only be used in conjunction with upstream Class II arresters.

Earthing systems

Earthing systems are designed to safely dissipate any fault current that may occur. Fault currents can be caused by lightning or electrical faults and a low impedance earth must be present for the safe dissipation of the fault current. It is important that an adequate earthing system be properly designed and installed specifically to the unique requirement of the structure, such as hazardous areas, electronic process control, local lightning conditions, corrosiveness of ground etc, as well as aesthetics. These applications are:

- Lightning protection earthing systems, designed to dissipate the lightning energy into the ground.
- Electrical mains or earthing systems designed for the dissipation of electrical fault currents.
- Dedicated earthing systems designed to protect dedicated electrical systems, such as computer systems and telecommunications systems.

The special earthing requirements for the protection of hazardous or explosive locations can also be regarded as a dedicated earthing system. It is recommended that all earthing systems be inspected or audited annually.

Soil resistivity

A soil resistivity survey is conducted prior to design of the earthing system to determine the soil resistivity of the site. The installation will be designed according to the results obtained. Depending on the soil resistivity values, some earthing systems may require the combination of both types of earth electrodes or the use of conductive cement. All installations as well as material used must comply with relevant codes of practice as well as strict quality control. Earth electrodes are installed to improve dissipation of surge energy into the ground. The earth electrodes must comply with SANS 1063:2008 [4] and be installed in accordance with SANS 10199:2004 [5].

Underground connections are often the vulnerable section of an earthing system, especially if they are exposed to corrosion and high current. Therefore it is important that the underground connections are exothermically welded as they form molecular bonds which do not oxidise with age and they can endure repeat fault currents. The size and type of earthing conductors depend once again on the application. For below ground earthing systems usually stranded copper, stainless steel conductors, flat copper and PVC (Polyvinyl Chloride) insulated copper, are utilised. Continuity tests must be conducted throughout the installation. There must be continuity between the different earthing systems and the lightning protection system. This results in the creation of an equipotential earth. Once the installation is complete the earth resistance is tested. The resistance and layout of the earthing system determines the efficiency of the protection system installed.

Lightning protection systems for thatch roofs

Lightning protection performed on thatch roofs requires the installation of a free standing mast, with at least a lightning protection level II as required by SANS 10313:2008 [2]. The installation of galvanised masts is recommended. The height and design is determined by numerous factors such as proximity of other structures, the building structure, and location. The combustible properties of thatch grass in areas where there is high lightning density poses fire hazards. The aim of the lightning mast is that a preferential point of discharge is provided for the lighting to strike. Note that by installing a mast or external lightning protection on any building will not be sufficient to prevent damage to equipment inside the building as the electromagnetic effects and induction will still cause damage to equipment within the building. In fact, if you install external lightning protection or a lightning mast, you will actually require Class I type lightning current arresters suitable to use for transition between lightning protection zone (LPZ) 0A and LPZ 1. The external lightning protection is there only to offer protection to the building itself (structural protection) and therefore does not protect the equipment within the building.

The proper protection principles must be applied using international and local standards in the design, supply and installation of a lightning protection system. It is the combination of the earthing systems, the structural protection system and the surge protection system that creates the entire lightning protection system.

Conclusion

In order to protect electrical and electronic equipment as well as buildings from lightning and surges, it is necessary to install the correctly designed LPS, in accordance with the relevant codes of practice, as previously described. Although the initial installation may seem costly, in the long term, the resultant protection of electrical and electronic equipment as well as buildings greatly compensates for the initial cost.

References

[1] IEC 62305:2007. Lightning protection system for structures.
[2] SANS 10313:2008.The protection of structures against lightning.
[3] SANS 10142-1: 2008: Code of Practice for the wiring of premises.
[4] SANS 1063:2008: Earth rods, couplers and connections.
[5] SANS 10199:2004. The design and installation of an earth electrode.

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