Lightning protection

CFPA-E Guideline No 4:2013 N

CFPA EUROPE

European
Guideline

FOREWORD

The European fire protection associations have decides produce common guidelines in order to achieve similar interpretation in European countries and to give examples how damage from natural hazards can be effectively limited by preventive and defensive measures, normally learnt from experience. CFPA Europe also develops and ratifies guidelines for all aspects of fire prevention, and safety and security related problems.

The objectives of CFPA are to improve safety and security and to prevent the consequent loss of life and destruction of property and business. The market imposes new demands for quality and safety.

The measures of Natural Hazards Guidelines concern not only operators, businesses, specialists and plant officers, but also the population and local administration. This is due to the fact that in contrast to fire, the impacts of natural hazards are often very widespread.

The proposals within this guideline have been produced by Lars Rang, the Swedish Fire Protection Association, and the SFPA has done the final preparation.

The Guideline has been compiled by the Natural Hazards Group in the Guidelines Commission and adopted by all fire protection associations in the Confederation of Fire Protection Associations Europe.

These guidelines reflect best practice developed by the countries of CFPA Europe. Where the guidelines and national requirement conflict, national requirements must apply.

Copenhagen, November 2013
CFPA Europe

Jesper Ditlev
Chairman

Helsinki, November 2013
Guidelines Commission

Matti Orrainen
Chairman

CFPA EUROPE®

Contents

Keywords: lightning, lightning protection, lightning rod

1 Scope

The science of lightning protection was born when Franklin discovered that lightning was a form of electricity.

The conventional protection method is based on the principle of ionization of the air, caused by the electric field which is naturally created in the ground by the storm. Thunderheads are electrically charged bodies suspended in an atmosphere that may be considered, at best, a poor conductor. During a storm, charge separation builds up within the cloud. The charging action (or charge separation) within the storm cell usually leaves the base of the cloud with a negative charge, and the resulting electrostatic field is assumed to be about 10 kV per meter of elevation above earth.

This resulting charge induces a similar charge of opposite polarity on the earth, concentrated at its surface just under the cloud and of about the same size and shape as the cloud. This separation of charges progresses as the storm builds in intensity, until the air is no longer able to act as an insulator.

In those circumstances, the charge is neutralized by the strike, which is caused by the flow of electrons from one body to the other. When there are structures on the ground, they are also charged. Since these structures are above the ground level, they reduce the gap between the earth and the cloud, increasing the possibility to suffer a strike.

This effect can be used to artificially attract the strike to a certain point. For this reason, lightning rods are installed above the structures, acting as a sacrificial termination point, where the lightning stroke is attracted. The electricity is safely dissipated to the ground via conductors. Protection devices must be installed on the electric and electronic equipment of the building.

Recently a different type of rod is being installed: CTS (Charge Transfer System) Lightning Rods, which base their principle in air deionization. Their main objective is to avoid saturation of electrostatic charge between the earth installation and the atmosphere that surrounds us, peacefully compensating the difference of electric potential in the area during the first process of lightning formation.

During the storms, when local ionization increases, the development of the potential field can be avoided by discharging small currents that lead to the installation's grounding and is proportional to the cloud's charge. The charge is driven away from the protected site, leaving it at a lower potential than its surroundings. The final effect is to eliminate the possibility of a lightning strike within the protected area.

The experts, however, cannot agree about the reliability of the CTS technology. In fact, since the 70´s several studies have been carried on this subject, and they have demonstrated that the lightning rods based on the CTS principle do not reduce significantly the probability of a lightning

strike on the protected zone. On the other hand, many authors defend the reliability of the CTS system, which is being widely installed in Russia and Japan.
The concept of protection against lightning as stated in this Guideline is based only on the ionization principle.

2 Why buildings must be protected against lightning

A building that is directly hit by a lightning strike may be damaged or destroyed through fire or material explosions. Fire breaks out through sparking, heating of a conductor or side flashes. If dust is ignited, dust explosions may occur. Material explosions occur if the lightning current passes through very thin conductors or poorly conductive material.

A lightning strike can destroy sensitive electronics if electrical apparatus is exposed to higher voltages than it can withstand. This may occur by the lightning current entering the building through an electrical conductor, telecommunications wiring or other metallic conductor. If the lightning current is spread in the building via e.g. an electrical conductor, this conductor can be damaged and can at a later time cause fire. These fires are classified as electrical fires, but may be caused by an earlier lightning strike near the building.

A lightning strike may also give rise to a strong electromagnetic pulse which can damage unprotected electrical or electronic equipment in the vicinity. A building need not therefore be exposed to a direct strike by the lightning for damage to occur because of the electromagnetic pulse.

Lightning is formed when a charged cloud is discharged. Such discharge may occur inside the cloud, to another cloud, or to the ground.

A discharge to the ground starts with preliminary strike that gradually moves downwards from the lightning cloud. When this preliminary strike makes contact with the ground, an electrically conductive channel is formed between the cloud and the ground. In this channel there is a main discharge and large currents are carried in the channel. In most cases several main discharges occur in the same channel, i.e. there are several current pulses through the channel. The temperature in the lightning channel may be as high as 30 000 ° C. The mean value of current pulses in Sweden is about 5 000 – 30 000 Amps (the main fuse in an ordinary private house is 25 Amps).

Lightning can also develop from the ground up to the cloud from e.g. tall masts.

3 Different types of lightning protection

Lightning protection for buildings and installations may be divided into three principal types

- Protection against overvoltage on incoming conductors and conductor systems
- Protection on direct strike by lightning
- Protection against the electromagnetic pulse of the lightning

A lightning protector can never fully guarantee that buildings or installations will not be damaged by lightning, but a well-designed, installed and maintained lightning protector considerably reduces the probability that damage will be caused by lightning.

It is important that consultants and installers of special competence in this area are engaged for the design, installation and maintenance. The applicable national standards and/or international IEC Standards shall be observed.

3.1 Protection against overvoltages on incoming conductors and conductor systems

3.1.1 General

It is more usual for damage in a building to occur because the lightning current is conducted into the building than because the building is directly hit. The lightning strike can have effects several kilometres from the point of impact, and the damage caused need not be manifested directly. For example, damage to the insulation of electrical conductors may cause fires at a later date.

In order that protection of the building and its installations shall be effective, all incoming and outgoing metallic conductors must be protected against overvoltages by being connected to earth directly or via a surge diverter. For electrical, telecommunications and signal wiring, the protection is provided with the help of components that have the duty to remove the high current to earth. Other metallic conductors are to be connected directly to earth, with the exception of gas pipes that are normally connected via a spark gap (see subsection 5.1.5).

3.1.2 Protection of electrical conductors

Spark gap

A spark gap is a component comprising two electrodes with a gas, or insulating material, between them. If the voltage between the electrodes becomes too high, there is a flashover and the gas begins to conduct current, whereupon the overvoltage is limited. Generally, the faster the lightning current increases, the higher the voltage peak that the spark gap allows to pass.

Varistor

A varistor is a voltage dependent resistor. It has high resistance when the voltage across it is normal. If the voltage rises, however, its conductivity markedly increases and the overvoltage is curtailed.

Valve type diverter

The valve type diverter comprises either only a varistor or combination of a spark gap and a varistor. The spark gap and the varistor may be coupled in parallel or in series.

A valve type diverter is preferably placed in the service centre after the service fuses, between the phases of the incoming conductor and the PEN conductor. In a TN-S system the valve type diverter is connected between the phases and the N conductor and the PE conductor. To facilitate installation, it is recommended that a potential equalisation bar (PUS, main earthing bar) is mounted. The potential equalisation bar shall be connected with the incoming PEN conductor (PE conductor in a TN-S system). If the incoming PEN conductor (PE conductor in TN-S system) is connected to a separate earth electrode system, large overvoltages can be reduced.

A valve type diverter shall be installed in a non-flammable place or in an airtight metal container that prevents ignition in the surroundings. The installation of protection on electrical conductors shall be carried out only by a qualified electrician.

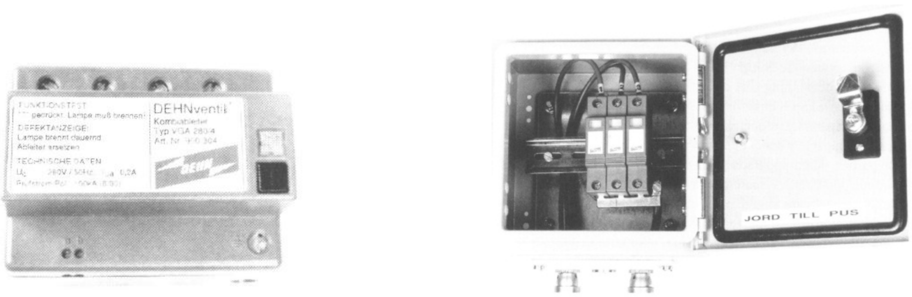

Fig. 1 Different types of valve type diverter

Complementary protection

Lightning current deflecting components have a time delay from the instant they are exposed to overvoltage until they are activated. Because of this time delay, the components can allow a voltage peak of a few kV to pass for a short period. This voltage peak can damage electrical equipment. Assessment of whether apparatus need protection to reduce the voltage peak depends on how tolerant the apparatus is to overvoltages and what voltage peak the valve type diverter allows passing.

If further protection of apparatus is needed, such protection may consist of a surge diverter or some other type of protection that filters off the voltage peak. In the following, such protection is referred to as complementary protection.

There are many different complementary protectors on the market intended for different types of apparatus. If complementary protection is installed, this may interfere with the apparatus unless the correct protection is chosen.

The complementary protection can with advantage be placed near the apparatus it is to protect, or on the distribution board. However, if the protection is placed on the distribution board, it provides inferior protection against the electromagnetic pulse of the lightning.

A complementary surge diverter may be damaged if excessive current is conducted through it. The choice of complementary protection must therefore be coordinated with the protection preceding it.

There are also types of protection other than surge diverters for reducing the voltage peak. Examples of such protection are filters, magnetic stabilisers and UPS (uninterruptible power supplies). In normal operation also, these may cause the protected apparatus to be exposed to less interference. They may however themselves have to be protected by a surge diverter to prevent damage to them by excessive incoming voltages.

3.1.3 Protection of telecommunications wiring

For the protection of incoming telecommunications wiring, a *surge arrester tube* is normally used, connected at the same place as the valve type diverter according to 5.1.2. The surge arrester tube shall be placed in a non-combustible place or into an airtight metal container that prevents ignition in the surroundings. The installation of protection before the origin of electrical installation requires the permission of the service provider. Installation of protection on telecommunications wiring to an incoming PEN conductor (PE conductor in TN-S system) may only be carried out by the service provider.

Electrical and telecommunications wiring should be drawn into the building at the same place. The potential equalising conductor from the protection for telecommunications wiring for the incoming PEN conductor (PE conductor in TN-S system) should be shorter than 10 metres, and the protection will be better, the shorter the conductor is. The potential equalising conductor should be laid at least 2 metres from equipment sensitive to interference.

Damage to apparatus may arise if the potential difference between electricity and telecommunications is excessive, and also by the voltage peak that passes the surge arrester tube. If necessary, *complementary protection* can be installed. See Subsection 5.1.2. regarding complementary protection.

If the telecommunications cable is an optic cable without a metallic mantle, it cannot bring in overvoltages which ma y damage connected apparatus. It is however a condition that there is an optic cable “the whole way” to the apparatus.

3.1.4 Reduction of voltages caused by the electro-magnetic pulse of the lightning

The lightning gives rise to a varying electromagnetic field that induces voltage in the electrical conductors. The voltage is the higher, the longer the conductors are. If the conductors, e.g. electrical and telecommunications wiring, supply the same apparatus, dangerous potential differences may arise. Several measures can be taken to reduce the effects of the lightning’s electromagnetic pulse:

- After the first protection, the conductors are to be drawn (to the same apparatus) as small distance as possible without interference occurring between the conductors.
- The conductors are to be drawn so far into the building as possible if it has conductive external walls and roof, e.g. of reinforced concrete. The electromagnetic pulse of the lightning is least at the centre of the building because the walls and roof screen off some of the pulse.
- The use of screened cables.
- Installation of complementary protection before the apparatus.
- Screening of the apparatus to be protected, see Section 5.3.

3.1.5 Connection of non-live incoming and outgoing metallic pipes

Metallic pipes that are not live, e.g. gas and water pipes, are to be connected to the incoming PEN conductor (PE conductor in TN-S system). The connection is to be made to the main earthing bar (potential equalising bar, PUS). All incoming conductors, both electrical and non-electrical, should be brought into the building at the same place.

A gas pipe is to be connected via a spark gap in order to prevent galvanic corrosion. Other conductors are to be directly connected to the main earthing bar.

3.1.6 Potential equalisation

Wide metallic conductors and objects, e.g. ventilation ducts, water pipes and heating pipes, as well as conductive building components such as reinforcement and steel girders, should undergo potential equalisation in order to prevent dangerous sparking. For the connection of the potential equalising conductor a main earthing rail (potential equalisation rail, PUS) should be installed in the service centre or main switchboard of the building. The potential equalising conductor is to be drawn from the main earthing rail to the different building components and objects which are to be subject to potential equalisation.

Apparatus provided with protective earthing need not be connected to the separate potential equalising conductor since they are connected with the incoming PEN conductor (PE conductor in TN-S system) via the earth conductor.

3.1.7 Earthing electrode

The earthing electrode can be arranged with one or several earthing rods or a ring main. A ring main is a conductor that is dug down into the earth around the building; see Fig. 5. If the earthing electrode is provided as a ring main, the building is also protected against voltages spread in the ground.

European Guideline

3.2 Protection on direct strike by lightning

3.2.1 General

A lightning conductor protects the building from damage by direct strike by lightning, but does not prevent the lightning striking the building. The lightning conductor has the function to lead the lightning current down to earth in a controlled manner. The protection comprises an external and an internal lightning conductor. The duty of the external lightning conductor is to capture the lightning discharge and lead it down into earth without the occurrence of side flashes and other danger. Side flashes occur when the voltages between a lightning current conductor and other conductive objects become so high that a flashover occurs. Side flashes can cause fires or destroy building components.

An external lightning conductor comprises a roof conductor system, downlead system and an earth conductor system. An internal lightning conductor mainly comprises overvoltage protection for electricity and telecommunications and a potential equalisation system. A protection on direct strike by lightning also reduces the magnetic field in the building caused by the lightning currents in the lightning conductor and by the lightning's electromagnetic pulse in the external lightning conductor. Fig. 4 shows a sketch of how protection against a direct strike by lightning can be constructed.

3.2.2 Roof conductor

The roof conductor has the duty to capture the lightning current and lead it, uniformly distributed, to the downlead system. It is essential that the lightning current should be as uniformly distributed as possible in the downleads, since the lightning current gives rise to a varying magnetic field around these. The magnetic field causes current to begin to flow in conductive objects in the building. The more downleads there are, the smaller the current will be in them, which makes the magnetic field weaker around each downlead.

The roof conductor system shall be at such distance from conductive objects that side flashes do not occur. Side flashes may ignite objects in the building and cause fire.

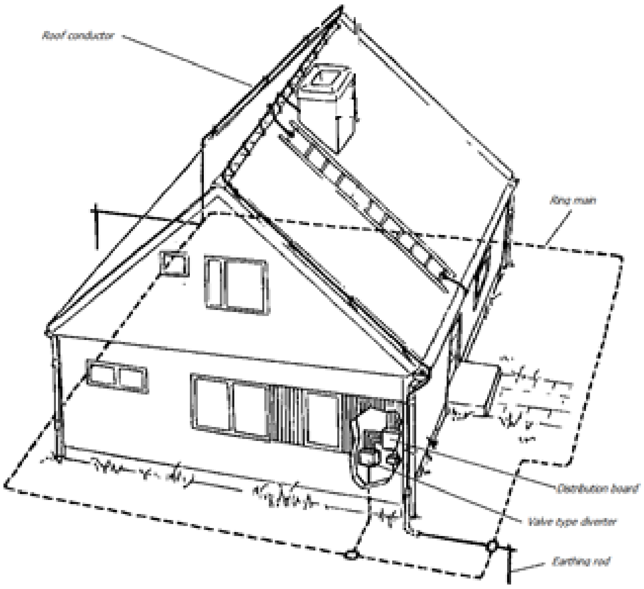

Fig. 2
Building with lightning conductor installation, with ring main and additional earth conductor

3.2.3 Downlead system

The main function of the downlead system is to conduct the lightning current down into the earthing electrode system. The downlead system must also provide protection against lightning strike from the side of the building if the building is taller than about 20 metres. It is important that the downlead system should be at such distance from conductive objects inside the building (which are not connected in a proper way to the lightning protection) that there is little likelihood of side flashes between the downlead and conductive objects.

3.2.4 Earthing electrode system

The earthing electrode system shall transmit the lightning current to earth in such a way that other installations in the earth are not damaged by a lightning strike. The way the earthing electrode system is to be constructed depends on the frost penetration depth, the composition and water content of the soil. The risk of corrosion shall be borne in mind in choosing metal in the earth. The earthing electrode system can be laid as a ring main with or without earthing rods. If the contact resistance is low, separate earthing rods may be provided for each downlead.

3.2.5 Natural components

The building may also contain conductive components that can form part of the lightning protection if they otherwise satisfy the requirements for lightning conductors. Examples of components that can satisfy requirements are reinforcement, sheeting roofs, lift guides, etc. When conductive building components are connected, it is important to ensure that the points where these are jointed conduct current well, otherwise there is a risk of sparking, and combustible material in the vicinity may be ignited. If the sheeting roof of a building is used and it is laid on combustible material, the risk of ignition of the base material must be considered.

3.2.6 Important to bear in mind

Connection of conductive components to the lightning protection

If a conductive component (apparatus, conductor, building component, etc.) is situated too near a lightning conductor, a flashover may occur. The safe distance of the lightning protector is the distance where there is little likelihood of flashover to a conducting component.

In order to decrease the risk of side flashes to a conductive component at a distance smaller than the safe distance, the conductive components shall be connected to the lightning protection. A conductive component longer than two metres, or one earthed and placed inside the safe distance, shall be connected to the lightning protection. For smaller objects and unearthed objects the risk of side flashes is stated to be small.

If the objects are connected in a correct way, the voltage between the lightning conductor and the conductive object decreases and the risk of a side flash is reduced. It may however mean that dangerous voltages arise between the object and other conductive objects in the building, which increases the risk of side flashes to these. In such a case there must be a safe distance to these objects, or they must also be connected to the lightning protection.

The risk of corrosion

When a lightning protection system is installed, the risk of corrosion when different metals are joined must be taken into consideration.

Conductor dimensions

When a conductor is sized, consideration must be given to the heat generated in the conductors when lightning current flows through them. A conductor with insufficient conductivity may be heated so much that it is blown up or its insulation is destroyed.

Strength

A lightning conductor shall have such strength that it is not destroyed by the mechanical forces of the lightning current and by external mechanical forces such as ice and snow.

Future installations

When a lightning protection is installed, it is important to ensure that future installations are constructed in such a way that they do not reduce the efficacy of the lightning protection. The calculated safe distances must be observed so that the risk of side flashes is not increased. Conductive objects, longer than two metres, or objects that are earthed and placed within the safe distance, shall be connected to the lightning protection as above.

3.3 Protection against the electromagnetic pulse of the lightning

If the building contains very sensitive electronics, protection against the lightning's electromagnetic pulse needs to be arranged. Screening is one method of solving this problem.

Screening is the provision of an electrically conducting sleeve around the object to be protected. If a screen is exposed to an electrical field, there will be voltage differences in then. However, these voltage differences are equalised, the better the conductivity of the screen, and if it has no openings in it.

The screen also provides protection against magnetic fields. The effectiveness of the screen against electromagnetic radiation is determined by its thickness, conductivity and openings. A thick screen without openings, made of a material of good electrical conductivity, is a good screen.

When screening of a building is planned, it should be divided into zones depending on how much electromagnetic radiation can be permitted. At every zone boundary a screen which can consist of e.g. reinforcement, a conductive floor and walls, or a conductive apparatus sleeve, is to be provided. Metallic conductors shall be subjected to potential equalisation both when they enter the building and at each zone boundary. Overvoltage protection and filter are to be installed as needed at each zone boundary.

All openings in the screen will let through more or less radiation. It is therefore important not to make openings at a later date.

4 The need for lightning protection

In order to investigate the need for lightning protection, the following factors should be taken into consideration

- The design of the building
- The environment around the building
- The material in the building
- The number of lightning strikes to earth in the area
- The value of the building and its contents
- Sensitive electronics in the building
- Loss of revenue in the event of breakdown
- Escape facilities and number of staff in the building
- Fire protection in the building
- The historical and cultural value of the building
- The social function of the building
- Cable laying up to the building
- Conductivity of the ground
- The risk to the surroundings

The design of the building
A building that is tall and has a large footprint has a greater likelihood of being struck by lightning. IEC Technical Report No 61662 "Assessment of the Risk of Damage due to Lightning" contains a method for calculating how often a building may be expected to be struck by lightning.

The environment around the building
The environment affects the probability that the building will be struck by lightning. If there are nearby buildings or if the building is situated in a hollow, the risk of the building being struck is reduced.

The method in IEC Technical Report No 61661 "Assessment of the Risk of Damage due to Lightning" can take into consideration these factors and the way they influence the likelihood of the building being struck by lightning.

The material in the building
The material used in the building has an effect on the seriousness of the consequences of a lightning strike. If the material on the outside is electrically conductive, e.g. sheeting or reinforced concrete, there is a certain natural lightning protection. These buildings tolerate a lightning strike better than buildings comprising non-conductive material such as timber or brick. A non-conductive material can be blown apart by the lightning strike.

The number of lightning strikes to earth in the area
Certain areas have a larger mean number of lightning strikes to earth annually than others. The probability that the building will be exposed to a lightning strike is larger in areas with a larger mean number of strikes.

The value of the building and its contents
If lightning protection is to be installed merely to protect property, the cost of the lightning protection must be compared with the value of the building's contents. Consideration must also be given to how unique these are.

Sensitive electronics in the building
Sensitive electronics in the building may be destroyed or cease to function as a result of a direct strike, overvoltages that are conducted into the building, or by voltage induced into the building by the lightning's electromagnetic pulse.

Here it is important to investigate how important the electronics are for continued function of the activity in the building, and how serious the consequences of a failure of the electronics would be. The cost of repairs to the electronics also affects the need for lightning protection.

Loss of revenue in the event of breakdown
If the effect of lightning on the building would cause a breakdown in operations, it is important to investigate how long and how expensive such a breakdown would be. Such an investigation should also consider whether such breakdown could also entail loss of market shares.

Escape facilities and the number of persons in the building
For the safety of persons it is important to consider how many persons are regularly present in the building and if they have limited freedom of movement or reduced physical mobility. Statistically speaking, it is relatively improbable to be killed by lightning. This does not, however, mean that lightning cannot strike a place of assembly, in which case the consequences can be very serious.

Fire protection in the building
Good fire protection in the building is important because it can alleviate the consequences of a fire started by a lightning strike.

A lightning strike can destroy or disrupt fire alarm installations and in this way negatively affect fire protection.

Lightning often triggers an automatic fire alarm without the outbreak of fire. A correctly installed lightning protection considerably reduces the risk of this happening.

The historic and cultural value of the building
For a building where lightning protection is being considered only because of the high historic and cultural value of the building, the probability of the building being affected by lightning should be investigated.

The social function of the building
If the building has an important social function, e.g. hospital, nuclear plant, water, gas or electricity installation, major telecommunications installation and radio stations, alarm and surveillance centres, important installations for the police, military, rescue services and traffic control, a lightning protection may be needed.

An assessment should be made of the consequences for the public if the installation is knocked out by lightning. It should also be assessed whether the function which these buildings have are especially important during thundery weather or whether a breakdown then can be accepted.

Cable laying up to the building
If electric and telecommunications cables are completely laid in the ground, the risk that lightning current will be led into the building is less than if the cables are placed wholly or partly above ground. "Assessment of the Risk of Damage due to Lightning" contains a method for calculating how often a building will be exposed to over-voltages.

Conductivity of the ground
If the ground has good conductivity, the voltage due to the lightning decreases over some tens of metres from the site of the strike. If the conductivity of the ground is low, large voltages may arise along the ground surface over up to several kilometres from the site of strike. Voltages can then

enter the building via the ground, electric or telecommunications networks or some other metallic conductor.

In some areas the soil layer is relatively thin, and at times of powerful storms high voltages can therefore arise over a distance of several kilometres from the site of strike.

Clay-like materials have good conductivity, while sand, fine sand and stone have lower conductivity.

The risk to the surroundings
The risk to the surroundings should be considered if lightning protection is to be installed. This mainly applies to industries. For installations which must conduct a hazard analysis, lightning and also the effect of lightning on the security system must be included as a hazard.

5 Inspection

When lightning protection has been installed, it must be inspected on completion so that any faults and errors in the choice of materials and execution may be discovered. Continuous and periodic inspection of the lightning protection is just as important. Damage may occur, especially in the event of lightning strike when the protection performs its purpose, but also through some other external action. The protection may further be impaired or completely put out of action, owing to alterations to the building or its different installations.

5.1 Inspection of lightning protection installations

The following must be observed on inspection of lightning protection installations

- It is the owner of the lightning protection installation who is responsible for ensuring that periodic inspection of the lightning protection installation is performed.
- On completion of the installation and after every alteration of the lightning protection, construction of the installation in accordance with the Standard shall be checked. This shall be done by a person who possesses adequate theoretical and practical knowledge of lightning protection.
- Visual inspection should be made annually. At the same time, the mechanical and electrical connections of the installation must be checked. A check shall also be made whether any alterations have been made which may affect the function of the lightning protection.
- The electrical state of concealed parts of the lightning protection must be checked every six years for normal residential buildings and every three years for other buildings. The lightning conductor shall be made in such a way that electrical inspection is possible.
- The earth return path resistance of the earthing electrode shall be measured at the time of installation and during periodic inspection to the extent this is possible
- The symmetry and joints of the earth electrode are to be inspected at the time of installation and should also be inspected if the properties of the electrode may have been changed
- At the time of each inspection, records shall be drawn up and placed in a suitable place.

- The owner of the lightning protection installation should ensure that the function of the lightning protection installation is not impaired by e.g. new installations.

5.2 Inspection of lightning protection installation according to proposed IEC Standard

The lightning protection shall be inspected by a person with expert knowledge of lightning protection. This shall be done during installation and on completion. When regular inspection of the electrical installation is prescribed, the lightning protection installation shall also be inspected. A visual inspection shall be made annually. Total inspection and testing of the lightning protection installation shall be carried out every second to every sixth year depending on the degree of protection. Inspection of critical components of the lightning protection installation shall be made at intervals of one to four years depending on the surroundings and the activity in the building. An inspection of the lightning protection installation shall occur when alterations or repairs have been made to the building. An inspection shall also be made if there has been a lightning strike in the installation. In most areas, the resistance of the earthing electrode shall be measured at different times of the year. The inspection of the lightning protection shall be documented.

6 Definitions

PEN (Protecting Earth and Neutral conductor) = Common protective conductors and the neutral conductor. Works like "re-wire" to the transformer neutral / ground point in TN-C systems (TN-C = 4-conductor system: three phase (line conductor) and PEN).

TN-S = 5-wire system, comprising 3 phases (line conductors), the neutral conductor N (neutral conductor) and a protective conductor PE (Protective conductor).

PUS = Potential equalization. (Equipotential Bonding System). The aim is to achieve the same ground potential as possible (have near the same Earth equipotential between different kind off metal parts as) between conductive material, ie. between the exposed parts (exposed-conductive-parts) = eg ugnstomme (like oven) and extraneous conductive parts (and extraneous-conductive-parts) = eg metal (like pipe), by connecting all conductive parts to a common main earthing terminal in the building (and connect them all to a main Earthing terminal in the building).

Flashover ⟨electro-technical⟩

Electrical discharge that occurs over the surface of a solid dielectric in a gaseous or liquid medium

7 Standards etc. regarding lightning protection

IEC 62305-1	**Protection against lightning - Part 1**: General principles, Provides general principles to be followed for protection of structures against lightning, including their installations and contents, as well as persons.
IEC 62305-2	**Protection against lightning - Part 2**: Risk management, Applicable to risk assessment for a structure or for a service due to lightning flashes to earth. Its purpose is to provide a procedure for the evaluation of such a risk. Once an upper tolerable limit for the risk has been selected, this procedure allows the selection of appropriate protection measures to be adopted to reduce the risk to or below the tolerance.
IEC 62305-3	**Protection against lightning - Part 3**: Physical damage to structures and life hazard Provides the requirements for protection of a structure against physical damage by means of a lightning protection system (LPS), and for protection against injury to living beings due to touch and step voltages in the vicinity of an LPS (see IEC 62305-1). This standard is applicable to: a) design, installation, inspection and maintenance of an LPS for structure.
IEC 62305-4	**Protection against lightning - Part 4**: Electrical and electronic systems within structures. Provides information for the design, installation, inspection, maintenance and testing of electrical and electronic system protection (LPM) to reduce the risk of permanent failures due to lightning electromagnetic impulse (LEMP) within a structure.

8 Literature for further reading

In addition to the above standards, etc. that includes both background information design attributes suggest the following books:

P Hasse J Wiesinger	EMV Blitz-Schutzzonen-Konzept ISBN 3-7905-0670-2 Pflaum Verlag ISBN 3-8007-1982-7 VDE Verlag
P Hasse J Wiesinger	Handbuch für Blitzschutz und Erdung, 1989. ISBN 3-7905-0559-5 VDE Verlag
Ronald B Standler	Protection of electronic circuits from overvoltages, 1989 ISBN 0-471-61121-2 John Wiley & Sons
Electrosuisse	Leitsätze des SEV 4022:2008 "Blitzschutzsystem"

European Guideline

9 European guidelines

Fire

Guideline No	1:2002 F	-	Internal fire protection control
Guideline No	2:2013 F	-	Panic & emergency exit devices
Guideline No	3:2011 F	-	Certification of thermographers
Guideline No	4:2010 F	-	Introduction to qualitative fire risk assessment
Guideline No	5:2003 F	-	Guidance signs, emergency lighting and general lighting
Guideline No	6:2011 F	-	Fire safety in care homes for the elderly
Guideline No	7:2011 F	-	Safety distance between waste containers and buildings
Guideline No	8:2004 F	-	Preventing arson – information to young people
Guideline No	9:2012 F	-	Fire safety in restaurants
Guideline No	10:2008 F	-	Smoke alarms in the home
Guideline No	11:2005 F	-	Recommended numbers of fire protection trained staff
Guideline No	12:2012 F	-	Fire safety basics for hot work operatives
Guideline No	13:2006 F	-	Fire protection documentation
Guideline No	14:2007 F	-	Fire protection in information technology facilities
Guideline No	15:2012 F	-	Fire safety in guest harbours and marinas
Guideline No	16:2008 F	-	Fire protection in offices
Guideline No	17:2008 F	-	Fire safety in farm buildings
Guideline No	18:2013 F	-	Fire protection on chemical manufacturing sites
Guideline No	19:2009 F	-	Fire safety engineering concerning evacuation from buildings
Guideline No	20:2012 F	-	Fire safety in camping sites
Guideline No	21:2012 F	-	Fire prevention on construction sites
Guideline No	22:2012 F	-	Wind turbines – Fire protection guideline
Guideline No	23:2010 F	-	Securing the operational readiness of fire control system
Guideline No	24:2010 F	-	Fire safe homes
Guideline No	25:2010 F	-	Emergency plan
Guideline No	26:2010 F	-	Fire protection of temporary buildings on construction sites
Guideline No	27:2011 F	-	Fire safety in apartment buildings
Guideline No	28:2012 F	-	Fire safety in laboratories
Guideline No	29:2013 F	-	Protection of paintings: Transport, exhibition and storage
Guideline No	30:2013 F	-	Managing fire safety in historical buildings
Guideline No	31:2013 F	-	Protection against self-ignition and explosions in handling and storage of silage and fodder in farms

Natural hazards

Guideline No	1:2012 N	-	Protection against flood
Guideline No	2:2013 N	-	Business Resilience – An introduction to protecting your business
Guideline No	3:2013 N	-	Protection of buildings against wind damage
Guideline No	4:2013 N	-	Lightning protection

Security

Guideline No	1:2010 S	-	Arson document
Guideline No	2:2010 S	-	Protection of empty buildings
Guideline No	3:2010 S	-	Security system for empty buildings
Guideline No	4:2010 S	-	Guidance on key holder selections and duties