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Risk Control

Protection of buildings against lightning strike

RISCAuthority
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FPA Fire Protection Association

IMPORTANT NOTICE

CONTENTS

SCOPE

This document explains the threat to businesses posed by lightning strikes and outlines the basis of the risk assessment process set out in BS EN 62305: Parts 1 to 4.

Although the principle threat from a lightning strike is to life safety, this publication also provides advice and guidance relating to the threat to property and the potential to paralyse a business, causing considerable disruption, financial loss and damage to electronic systems, computers and communication links.

SYNOPSIS

This document aims to provide an understanding of the phenomenon of lightning and the general requirements for the design, installation, inspection and testing of lightning protection systems for buildings and structures. It does not provide details on the protection of high-risk buildings, such as those used for the manufacture and storage of flammable liquids/gases and explosives, but information has been included for the protection of electronic equipment against electrical disturbances arising from lightning which have been known to cause fires.

The protection of special risks such as complex buildings, air-supported structures, tents/marquees and metal scaffold structures are not covered in detail in this document.

DEFINITIONS

Air termination device:

A system component designed to intercept a lightning discharge.

Bonding:

The means by which components of lightning system and building metalwork are connected together to minimise dangerous potential differences and side flashing.

Collection area:

The total plan area associated with a structure ($m^2 \times 10^{-6}$ ie sq km) which gives an indication of the number of strikes to a structure when multiplied by the local flash density value in flashes/km2/year.

Down conductor:

A conductor connecting air terminations and earth terminations.

Earth termination:

A system component that discharges lightning current to the general mass of the earth.

Electromagnetic compatibility (EMC):

Electromagnetic compatibility is the ability of an electrical device, unit or system to function effectively in its electromagnetic environment without generating unintentional interference to other equipment in the locality.

Surge:

A short duration increase in voltage or current.

Surge protector:

A protective device to limit surge voltages and currents.

Zone of protection:

The volume within which a lightning conductor or lightning conductor system gives protection against a direct lightning strike by capturing the strike to itself.

Note: The style of writing decimals in BS EN 62305 adopts the European notation throughout the four parts of BS EN 62305. Thus, a comma is used instead of a full stop to indicate a decimal point. For example, 21.6 is written as 21,6.

INTRODUCTION

Even though the frequency of lightning activity in the UK is relatively low when compared to some other countries globally, it remains a risk to life, property and electronic systems and needs to be assessed adequately. The assessment of a fire caused by a lightning strike should be considered in the fire risk assessment for the premises undertaken in compliance with the Regulatory Reform (Fire Safety) Order 2005 (or equivalent legislation in Scotland and Northern Ireland) (refs 1-5).

A lightning strike may cause damage to the structure of a building and to electric and electronic equipment housed within it. The latter damage has increased over the years in line with the growing use of high value and high authority electronic equipment in buildings and the increased potential susceptibility of computer systems.

The key function of a lightning protection system is to intercept a lightning strike and provide a path of low impedance to earth along which the discharge can travel to ground. Without this, the lightning would follow paths of high resistance through the building's structure of wood, brick, concrete or similar materials, resulting in the generation of heat and mechanical forces which can cause extensive damage, including fire.

In the case of many structures their inherent form of construction provides the function of a lightning protection system because there is sufficient metal to act as air terminations and down conductors without the need for specially installed lightning protection conductors. Metal framed and metal clad buildings are an example of this.

Lightning damage to electric and electronic equipment is managed by way of strategically placed surge arrestors, suitable location of equipment and appropriate bonding and cable protection.

The need for protection against the effects of lightning should be determined by carrying out a risk assessment as set out in BS EN 62305 (ref 6).

The assessment in the updated standard uses a probability calculator that gives probabilities for direct and indirect strikes separately, recognising that a direct strike does not have secondary effects as the indirect strike is a primary strike on electrical and electronic equipment rather than the building.

This standard consists of four parts:

- Part 1: 2011: General principles;
- Part 2: 2006: Risk management;
- Part 3: 2011: Physical damage to structures and life hazard; and
- Part 4: 2011: Electrical and electronic systems within structures.

The risk assessment process addresses four types of loss:

- L1: loss of human life;
- L2: loss of service to the public;
- L3: loss of cultural heritage; and
- L4: loss of economic value.

The need for lightning protection is evaluated according to risk assessments of social values L1, L2 and L3. If these exceed a tolerable level then protection against lightning is required. (Detailed information regarding the assessment process is set out in Part 2 of the standard.)

In addition to assessing the need for the structure to be protected, the economic benefits of providing protection measures should also be evaluated in order to reduce the economic loss, L4. In this case, lightning protection is effective if the loss in the presence of protection measures plus the cost of the measures is assessed to be lower than the total loss without the protection measures.

Although in most cases life safety criteria are likely to be the most important aspect of the assessment process, there may be cases where the need for protection will be necessary irrespective of the results of the economic assessment. This could be the case, for example, when considering the protection of heritage properties.

Although lightning protection is not a legal requirement for all buildings and structures, the requirements of the Electricity at Work Regulations 1989 (ref 7) will apply to most businesses. Regulation 6 requires electrical installations to be protected from the harmful effects of natural hazards, which include lightning.

Lightning protection systems, to be effective, should be designed, installed, inspected and maintained in accordance with BS EN 62305 using high quality, tested and approved components and preferably by a member of the Association of Technical Lightning and Access Specialists (ATLAS).

As is the case with all British Standards, BS EN 62305: Parts 1 to 4 are not retrospective and thus existing lightning protection systems designed to the previous standard, BS 6651 (ref 8) need not be altered unless significant changes have been made to the structure or a new electrical system has been installed. However, if there has been a refurbishment of the building or a new electrical installation, surge protection should be installed if the building had an existing lightning protection system. All newly installed electrical mains systems require surge protection for indirect lightning strikes.

RECOMMENDATIONS

1. Understanding lightning

Lightning is the result of the discharge from a region of high electrical potential in a cloud to a point of low potential during a thunderstorm. Although there appears to be some debate as to exactly how the polarisation of a cloud occurs, there is general consensus that clouds are negatively charged at the base and positively charged at the top.

Thunderclouds, which are electrically charged bodies suspended in air, induce a positive charge on the surface of the earth below. As the intensity of the storm increases, the build-up of potential in the cloud continues until the electrical energy is released in the form of a flash of lightning. The lightning process consists of a very fast and dim stepped leader which is invisible to the naked eye and which normally travels from the cloud to the ground. The visible flash, however, is the main stroke (or 'return stroke') which travels back from the earth to the cloud.

The average duration of a lightning flash is 0.25 seconds. Most lightning strikes to earth are negative and travel from the base of the thundercloud to the ground. Positive strikes, where the discharge is from the earth upwards to a cloud, can occur under certain specialised conditions, such as from very tall buildings, masts and mountain tops. Strikes to ground will normally go to elevated objects (trees, buildings etc) but on flat ground will go straight to the ground.

Areas that have large numbers of thunderstorm days per year experience the highest rate of lightning flashes to ground.

Lightning activity varies across the UK; BS EN 62305-2, page 151, indicates that there is more activity in the east than the west and more in the south than the north, with central England being the highest, at about 1 flash/km^2/yr. It is important to understand that the values on the map are very long term averages, so that in any particular area a strike might occur tomorrow, or next week but then possibly not for several years.

This may change, however, as the pattern of lightning activity is changing from year to year in line with trends in the global climate.

2. Principles of lightning protection

The first successful attempt to prevent lightning damage to buildings was in the middle of the eighteenth century when Benjamin Franklin fitted, on his house, the first lightning conductor (or Franklin Rod, as it became known, particularly in the USA).

Lightning protection systems provide a path of low impedance by which a lightning discharge can go from the strike point on the building to earth without causing damage. Without an adequate conducting path, a lightning discharge could follow a path of high resistance through the brick, concrete or wooden structure of a building resulting in damage caused by the arcing which gives high temperatures and large mechanical forces. All metallic parts of a building might be able to serve as lightning protection components if they are electrically conducting from the top of the building to earth (for example steel stanchions and beams, the reinforcing bars of concrete, or metallic roofs and outside wall skins) as long as there is sufficient metal. Safe skin thicknesses are given in Part 3 of BS EN 62305.

Lightning protection is described in BS EN 62305: Parts 1 to 4; protection is based on the 'Faraday cage' principle. An understanding of the principles of the Faraday cage is central to understanding the function of conventional lightning protection systems. A Faraday cage, named after the famous British scientist Michael Faraday, is an assembly of vertical and horizontal conductors forming an interconnected 'cage' which when used on a building for lightning protection, considerably reduces the currents, and magnetic and electric fields inside the building, owing to the 'shielding' effect of the numerous conductors. It does not form a complete shield to the whole spectrum of electromagnetic interference, but is particularly useful for lightning.

In addition to the effects of lightning on the structure, surges along electrical and electronic services entering and leaving premises may also need to be eliminated by way of strategically placed surge arrestors.

Generally, the parts of a structure most likely to be struck by lightning are those that project above the surrounding structure. These include:

- flagpoles;
- chimneys;
- towers;
- elevated water tanks;
- roof structures;
- steeples; and

- radio, television, mobile phone and microwave masts.

(Other structures may require lightning protection. These include tents, bridges and trees near to heritage buildings, but these are outside the scope of this document.

Modern lightning protection systems consist of:

- air termination devices on the roof and elevated parts of a structure;
- earth termination devices;
- down conductors connecting the air termination devices to the earth termination devices;
- devices to isolate or electrically bond metal building components in close proximity to the components of the lightning protection system to prevent side flashing; and
- electronic system protection.

3. Determining the need for lightning protection

Buildings should be subjected to a lightning risk assessment; BS EN 62305-2: **Protection against lightning: Risk management** (ref 6) describes risk assessment methods.

In some cases, the need for protection will be obvious, (for example, in the cases of large public assembly occupancies and tall structures. However, for less obvious cases, the following section describes the BS EN 62305-2 approach.

3.1 Risk assessment

Risk analysis advocates first determining the risk of a structure being hit by lightning. The current standard uses a 72° angle down from the top of the building (that is, a slope of 1 vertical to 3 horizontal). (See Figure 1.)

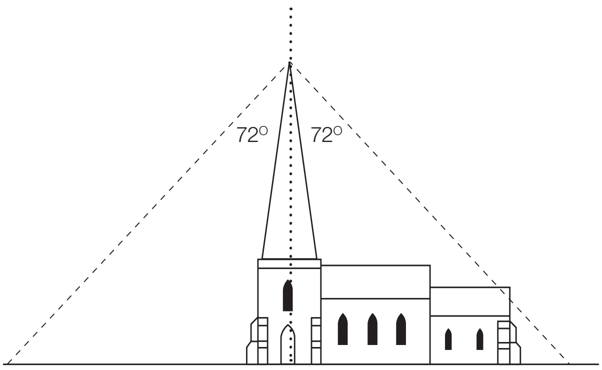


Figure 1: The area of protection (see 3.1)

Having calculated the collection area, a risk of strike is deduced by applying a 'location factor', to account for the proximity of buildings, trees etc and their height, followed by several other factors as detailed in Table 1.

The factors set out in Table 1 are multiplied together to give the overall risk. Although the scoring system in BS EN 62305 has been modified from that in the earlier standard, BS 6651, a risk of 10^{-5} or above is still considered the point at which protection would normally be needed. Thus, if the resulting risk is 1 in 100,000 or higher (for example, 1 in 10,000) good reasons would need to be formulated to support a decision not to install suitable protection.

Table 1: Risk analysis factors. (All references refer to BS EN62305-2)

Symbol	Definition	Reference in BS 62305-2
Ad	the collection area in $m^2 \times 10^{-6}$	see paragraph A.2.1
N_g	flashes/km^2/year	see page 151 for UK
C_d	the location factor	see table A.2
P_B	the protection factor (=1 for no lightning protection system as is normally the case for an initial risk assessment)	see table B.2
h_z	a factor depending on special hazard	see table C.5
r_p	a fire protection factor (normally 1)	see table C.3
r_f	a further fire factor (=10^{-2} for most buildings)	see table C.2
L_f	a factor concerning physical loss	see table C.7

3.2 Assessing the risk to electrical and electronic equipment

The purpose of this assessment is to determine the risk to all electrical and electronic equipment (such as CCTV, communications and data processing equipment) from direct discharges and induced currents.

The probability is determined by taking into consideration the lightning flash density and the effective collection area. The effective collection area is dependent on:

- the plan area of the structure;
- the localised area over which an increase in ground electrical potential due to a strike could affect the building;
- the collection area of any adjacent structure that has electrical or electronic connections to the structure;
- the collection area of any incoming mains services; and
- the collection area of data lines taking into consideration the type of cable used.

The vulnerability of the equipment to damage will depend on the probability of a strike and the following weighting factors:

- the type of structure. Buildings with lightning protection in accordance with BS EN 62305 will be allocated the lowest weighting value; and
- the type of shielding arrangements.

(In the case of high risk buildings the weighting factors will also include the risk of fire and the risk of explosion.)

The final decision to provide protection is made after taking into consideration all the possible consequential effects of damage to critical electrical and electronic equipment. Depending on the severity of the risk, protection, consisting of screening and a coordinated set of surge protection devices may be required. The following are examples where surge protection may be appropriate:

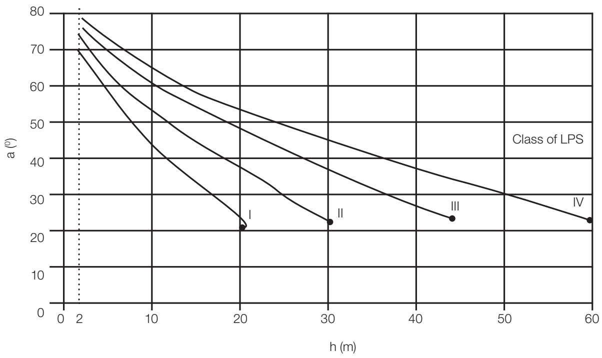
- electrical panels and switchgear that bring supplies into the building from the mains supply;
- electrical panels and switchgear that take the supply to other buildings and facilities;

- power distribution systems within buildings between the incoming mains distribution panel and the supply side of a socket outlet or fused connection;
- inside the cabinets of equipment not served by a socket or fused outlet;
- the load side of sockets or fused connections; and
- telecommunication lines entering (or leaving) a building.

It is particularly important that special attention is given to parts of the building where a number of services are in the same 'service tunnel' (for example, electricity cables, plumbing, telecommunications and computer network cabling). A lightning strike in this area of a building can paralyse a business, causing considerable disruption and financial loss.

Table 2: Maximum values of rolling sphere radius, mesh size and protection angle corresponding to the class of lightning protection system. (From BS EN 62305-3).

Protection method			
Class of LPS	Rolling sphere radius	Mesh size w_m	Protection angle
I	20	5x5	See figure 1 below
II	30	10x10	
III	45	15x15	
IV	60	20x20	



Note 1 Not applicable beyond the values marked with • only rolling sphere and mesh methods apply in these cases.

Note 2 h is the height of air-termination above the reference plane of the area to be protected.

Note 3 The angle will not change for values of h below 2 m.

4. System design guidelines

4.1 Zone of protection

The zone of protection represents the extent that a lightning conductor, or assembly of conductors protects against a direct strike. Principally, BS EN 62305 specifies four different protection levels, I to IV, of which for general purpose buildings (that is, not having significant fire or explosion risk etc), level III would be appropriate for most structures. (See pages 18-19 of BS EN 62305-3.)

High buildings are at risk from a strike to the side. For level III protection for buildings over 45m high and complex structures of any height, the zone of protection is determined using a rolling sphere method, for which the rolling sphere radius is 45m. This method of assessing the protected volume takes into account the risk of strikes to the side of a building.

The rolling sphere method is based on the likely behaviour of lightning flashes. Flashes are preceded by a downward leader that deposits charge along its route. As this leader progresses, a charge of opposite sign is induced on the surface of the earth and on trees, buildings and other structures, until the electric field is sufficiently high on an uppermost extremity for an upward leader to be launched to meet the downward leader. Because the upward leader is launched from the point of greatest electric field intensity, and is not constrained to go vertically upwards, it can travel in any direction before making the final jump to meet the downward leader.

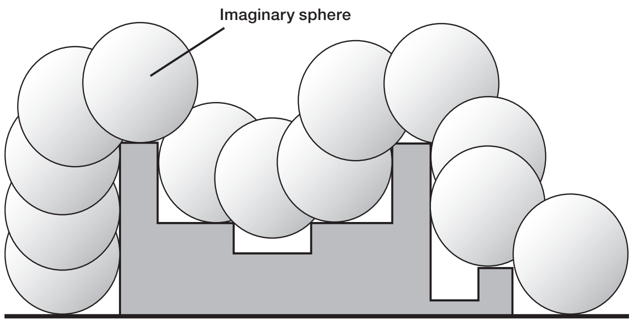
The points equidistant from the ends of the leaders before the final jump are assumed to be equally likely to receive a lightning strike and therefore the surface of a sphere centred on the position of the leader before the last step defines the positions to which the leader could jump.

The possible positions for the leader to approach may be simulated by rolling an imaginary sphere, of radius equal to the last step length (45m), over the building down to ground level.

(Note: The rolling sphere method should not be applied to high risk structures such as buildings housing flammable liquids or explosives as they may need a higher level of protection as set out in other parts of BS 62305).

Figure 2: Factory building over 20m high; the areas touched by the rolling sphere need protection

4.2 Design process



4.2.1 Lightning protection, in common with other forms of fire protection, should be considered at the building design stage. This will help to ensure cost-effective installation (for example by utilising structural steel) and an aesthetically acceptable design. It is also important that there is effective protection in place from the earliest opportunity as new building works are as vulnerable to structural damage as completed ones.

4.2.2 The design of lightning protection systems should only be undertaken by a suitably experienced engineer. Consultation with and approval of the system should also be sought from the insurers of the premises.

4.2.3 No part of a structure should be protected in isolation.

5. System components and installation

5.1 Air termination devices

Air termination devices consist of a series of vertical and/or horizontal conductors to intercept the lightning discharge immediately above the vulnerable part of the building. When installing air termination devices, measures for level III protection should:

5.1.1 Ensure that no part of the roof is more than 7.5m from the nearest horizontal conductor.

5.1.2 Use a grid network of mesh size no greater than 15m by 15m on large, flat roofs.

5.1.3 Provide additional conductors on multiple ridge roofs where the distance between the ridges renders them necessary.

5.1.4 Aluminium, copper or galvanised steel strips or rods (20mm x 2.5mm strips or 8mm diameter rods are acceptable, or stranded conductors as specified in BS EN 62305-3 tables 6 and 7).

5.1.5 Fixing centres: BS EN 62305-3 specifies on page 102 Table E 1 that for solid round conductors such as air terminations, both horizontal and vertical, fixing centres of 1m are used. For tape and stranded conductors 0.5m is specified for all horizontal and vertical conductors, except vertical ones up to 20m above ground, but 0.5m thereafter.

5.2 Down conductors

The down conductors provide paths of low impedance from the air termination devices to the earth terminations. When installing down conductors, measures should include:

5.2.1 Installing conductors symmetrically around the outside walls of the structure, starting from the corners.

5.2.2 Following the most direct path that avoids sharp bends or narrow loops.

5.2.3 Providing an average down conductor spacing of 15m or less around the perimeter. The perimeter of the building here is measured at roof or ground level, whichever is greater.

5.2.4 Providing at least two down conductors for tall buildings where testing and inspection may be difficult (for example for tall chimneys).

5.2.5 Joining the conductors to form the Faraday Cage. This reduces the impedance and increases the number of paths for a discharge to follow, and so improves the protection of the interior of the building.

5.2.6 Use of natural conductors. Using metal parts of the structure such as steel frames, reinforcing bars, steel roofs and exterior walls in certain cases as part of the lightning protection system provided that their electrical continuity can be assured. It may be necessary to connect these parts to the air terminations and/or earth terminations.

5.2.7 The greater the number of interconnected down conductors provided, the lower the risk of side flashing occurring.

5.2.8 Using suitable materials, as in 5.1.4 above.

5.2.9 Fixing centres: BS EN 62305-3 specifies on page 102 Table E 1 that for solid round conductors, both horizontal and vertical fixing centres of 1m are used. For tape and stranded conductors, 0.5m is specified for all horizontal and vertical conductors, except vertical ones up to 20m above ground where 1m is used, but 0.5m thereafter.

(Note: BS EN 62305-3 gives recommendations for conductor types and sizes in tables 6 and 7. The values in these tables are different in a few details in the 2011 edition compared to the earlier 2006 version.)

5.3 Earth termination networks

Properly made earth terminations are critical to the safe and effective dispersal of a lightning strike into the ground. The type of earth termination provisions will be influenced by the ability of the ground to conduct the lightning current. This will depend on factors such as moisture content and type, for example clay or stone. BS 7430 (ref 9) gives recommendations on earthing.

Guidelines for earth terminals include:

5.3.1 Achieving a combined resistance to earth of 10Ω or less for the whole of the earth termination network (excluding bonding to other services) but see BS EN 62305-3 page 28 Figure 3, where minimum lengths of earth electrodes are specified.

5.3.2 Providing each down conductor with an earth terminal.

5.3.3 Providing a common earth termination network for the lightning protection system and all other services.

Figures 3 and 4: Each down conductor should be provided with an earth terminal (5.3.2)

5.3.4 Fitting suitable provisions to isolate earth terminals for testing purposes.

5.3.5 Earth electrodes and conductors. The recommended sizes of conductors are generally similar to BS 6651, and the BS EN values are given in 62305-3, page 34 Table 7, and comprise copper, galvanised steel, or stainless steel rods of 15mm diameter, 14mm diameter and 15mm diameter respectively. Aluminium is not suitable for earth rods.

5.4 Bonding

Side flashing occurs when metal parts of the structure and components of the lightning protection system are in close proximity and have a large potential difference during the strike. Side flashing can be prevented by providing clearance distances between the components, sufficient to give electrical isolation, or by bonding the components to equalise the differences in electrical potential. As isolation is difficult to achieve, bonding is more common, and more easily achievable.

When considering bonding:

5.4.1 Bond all metal forming parts of the building including utility services in contact with the ground.

5.4.2 Bond exposed metal attached to the outside surface of the building or protruding through walls regardless of any earth connection.

5.4.3 Use materials for bonding that are essentially similar to those used for air terminals and down conductors.

6. Inspection and maintenance

6.1 Visual inspection

6.1.1 Visual inspection should be carried out by a suitably qualified and experienced person to confirm conformance with the standard used for the design:

- during installation;
- on completion;
- after any alterations or extensions to the system or building including the installation of equipment on rooftops and facades of tall buildings;
- after a known lightning flash to the buildings; and
- at regular intervals, on an 11 month schedule to check the mechanical condition of all conductors, bonds, joints, electrodes and to ensure that all recently added services have been bonded as required.

Although BS 62305-3 calls for periodic testing at such intervals as determined with regard to the nature of the structure to be protected, it is best practice that the installation be inspected and tested at least every 11 months so that over a period of time testing occurs during different periods of ground conditions.

6.1.2 The results of the visual inspections should be recorded, together with a note of any parts of the installation that it may not have been possible to inspect.

6.2 Testing

6.2.1 Testing should be carried out in accordance with acceptable standards, for example BS 7430 (ref 9), by a suitably qualified person.

6.2.2 The resistance to earth of each earth electrode, the resistance of the complete earth termination system and the measurement of electrical continuity of bonds and joints where necessary should be tested:

- on completion of the installation;
- after alterations, extension or modification;
- after a known discharge; and
- on a regular basis (such as every 11 months) so that seasonal variations in conditions are observed.

6.2.3 Full details of all tests should be recorded.

7. Electrical and electronic systems protection

An increasing number of electrical and electronic information systems are being installed in buildings, and if these are not adequately protected, two principal problems may arise:

- fire risk as described above for other aspects of lightning problems, and
- effects on electronic systems, which, owing to the extensive use of relatively vulnerable electronic components, may cause damage or upset, resulting in loss of the use of the systems.

The On-site Guide (ref 11) states in section 3.7.2.2:

Where surge protection devices (SPD) are required:

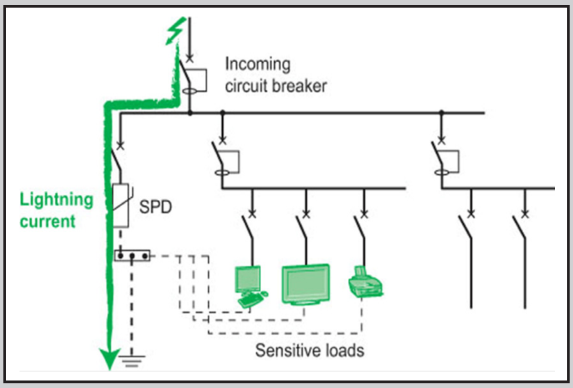
Surge protection devices should be considered in the following circumstances:

- The low voltage supply to the installation, at some point, is provided by bare overhead conductors at risk of direct lightning strike;
- The building requires, or already has, a lightning protection system; and
- The risk of loss of any part of the installation or equipment due to damage caused by any transient overvoltages (including switching transients) is not acceptable.

If there is a risk of direct strikes, including if there are overhead supply lines, then Type 1 or Type 1+2 SPDs should be installed at the distribution board/consumer unit to prevent flashovers.

If there is a higher risk of overvoltages causing damage (typically for server rooms or other sensitive electronic equipment) Type 2 or Type 2+3 SPDs should be added to distribution boards connected to that sensitive equipment and/or in UPS systems.

Principle of protection system in parallel (Fig J17 from the On-site Guide)



Electronic systems have a wide range of applications, including those controlling:

- fire detection and warning;
- building environment control;
- security, CCTV, audio warning and intruder alarms;
- computers controlling a wide range of business and industrial operations; and
- communications, both digital and audio.

In fact, almost any modern business system uses up-to-date electronic technology in its operation and some industries are economically dependent on the extensive use of electronic systems.

Unless specifically protected, modern electronic systems can be vulnerable because of the use of semiconductor technology which operates at very low voltages (typically in the range of 2-24 volts) and can be damaged or upset by surge voltages of little more than twice the normal operating voltage.

In this context, the term 'upset' is used to describe an interruption of the function of an electronic system when the system can no longer fulfil its intended operation for a short or long period, but where no actual damage has occurred. Normally human intervention will have to be made to reset the system to function correctly again and the resulting period of disruption to the business may cause considerable financial losses.

7.1 There are several approaches to the protection of electronic and electrical systems that should be considered, but these fall into two main areas:

7.1.1 Where appropriate, use should be made of surge protection devices such a gas discharge tubes, Zener type transient voltage protectors and various other non linear devices for current diversion and voltage clipping.

7.1.2 Measures such as careful design of wiring and cable layouts, use of metallic cable trays and screened (shielded) and armoured cables should also be taken. Adherence to the principles of earthing and bonding of cable screens, cable trays, computer room earthing and bonding layout, is vital for preventing lightning currents from entering the electronic equipment building.

7.2 Full integration of the lightning protection system and building earth system into one integrated whole is particularly useful for distributed electronic systems with cables between the interconnected parts of the system.

7.3 In many instances, specialised types of surge protection might be required for minimising transients into equipment arriving along data lines.

The principal sources of guidance for surge protection devices (SPD) are the BS 7671:2008 + A1 2011 (IET wiring regulations) (ref 10) and the IET 'On-site Guide' (ref 11)

Since the major cause of fires from lightning is associated with damage to the electrical power system, owing to the problem of 'power follow-on' after a lightning strike has damaged insulation, these two publications give excellent guidance on the use of surge protection devices to protect the electrical power systems, and so prevent fires.

7.4 Good cable installation practices for EMC must be achieved in the first instance by the equipment and cabling installers, and this must be subject to the supervision of an experienced installer who can use best practice in the installation.

7.5 Protection of electronic cabling and wiring layout for minimal interference is described in BS EN 62305-4 (Part 4 of reference 6), and also IEC 61000-5-2: Electromagnetic Compatibility (EMC)) (ref 12) and these provide very good practical recommendations for EMC, of which lightning is a sub-division.

8. Developments in lightning protection

Existing reference information indicates that, over recent years, most of the development regarding lightning protection has centered around improved standards and codes of practice. In regard to developments in lightning protection technology, BS 6651: 1999 (ref 8) made the following statement:

'The principle applying to all the provisions of this British Standard (BS) is that of the 'Faraday Cage' form of lightning protection. The (BS) Technical Committee is aware of development and research on other technologies in the field of lightning protection that has been taking place in recent years, but it is the (BS) Committee's considered opinion that the materials, extent and dimensions of the air terminations, down conductors, earth terminations, bonding, components etc as laid down in this code of practice be adhered to in full, irrespective of any devices or systems employed which are claimed to provide enhanced protection.'

This view has not changed and applies equally well to BS EN 62305: Parts 1-4.

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   - Part 2: 2006: **Risk management**.
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FURTHER READING

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- **Guidance notes: Church – fire**, V2, 2010, Ecclesiastical Insurance.

9. Checklist

		Yes	No	N/A	Action required	Due date	Sign on completion
9.1	**Determining the need for lightning protection (Section 3)**						
9.1.1	Have the buildings been subjected to a lightning risk assessment as set out in BS EN 62305-2: **Protection against lightning: Risk management?** (3.0)						
9.1.2	Has risk analysis been used to determine the risk of a structure being hit by lightning? (3.1)						
9.1.3	Has an assessment been undertaken to determine the risk to all electrical and electronic equipment (such as CCTV, communications and data processing equipment) from direct discharges and induced currents? (3.2)						
9.2	**System design guidelines (Section 4)**						
9.2.1	Has the zone of protection representing the extent that a lightning conductor, or assembly of conductors protects against a direct strike been determined? (4.1)						
9.2.2	Has the appropriate protection level been determined using BS EN 62305? (4.1)						
9.2.3	In the case of new build projects, has lightning protection been considered at the building design stage? (4.2.1)						
9.2.4	Has the design of the lightning protection system been undertaken by a suitably experienced engineer? (4.2.2)						
9.2.5	Is the whole of the structure protected? (4.2.3)						
9.3	**System components and installation (Section 5)**						
9.3.1	Do measures for level III protection ensure that no part of the roof is more than 7.5m from the nearest horizontal conductor? (5.1.1)						
9.3.2	Do measures for level III protection use a grid network of mesh size no greater than 15m by 15m on large, flat roofs? (5.1.2)						
9.3.3	Do measures for level III protection provide additional conductors on multiple ridge roofs where the distance between the ridges renders them necessary? (5.1.3)						
9.3.4	Do measures for level III protection utilise aluminium, copper or galvanised steel strips or rods of suitable size, or stranded conductors as specified in BS EN 62305-3 tables 6 and 7? (5.1.4)						

9.3.5	Do measures for level III protection specify horizontal and vertical, fixing centres of 1m for solid round conductors as air terminations? (5.1.5)						
9.3.6	Are conductors installed symmetrically around the outside walls of the structure, starting from the corners? (5.2.1)						
9.3.7	Do conductors follow the most direct path that avoids sharp bends or narrow loops? (5.2.2)						
9.3.8	Are down conductors spaced an average of 15m or less apart around the perimeter? (5.2.3)						
9.3.9	Are at least two down conductors provided for tall buildings where testing and inspection may be difficult (for example for tall chimneys)? (5.2.4)						
9.3.10	Are conductors joined to form a Faraday Cage to reduce the impedance and increases the number of paths for a discharge to follow? (5.2.5)						
9.3.11	Are natural conductors used where applicable? (5.2.6)						
9.3.12	Has consideration been given to the fact that the greater the number of interconnected down conductors provided, the lower the risk of side flashing occurring? (5.2.7)						
9.3.13	Do the measures include the use of suitable materials? (5.2.8)						
9.3.14	Are the fixing centres as specified in BS EN 62305-3? (5.2.9)						
9.3.15	Has a combined resistance to earth of 10Ω or less been achieved for the whole of the earth termination network? (5.3.1)						
9.3.16	Is each down conductor provided with an earth terminal? (5.3.2)						
9.3.17	Is a common earth termination network provided for the lightning protection system and all other services? (5.3.3)						
9.3.18	Have suitable provisions been fitted to isolate earth terminals for testing purposes? (5.3.4)						
9.3.19	Are earth electrodes and conductors of the recommended sizes and materials? (5.3.5)						

9.3.20	Are all metal parts of the building including utility services in contact with the ground suitably bonded? (5.4.1)						
9.3.21	Is all exposed metal attached to the outside surface of the building or protruding through walls regardless of any earth connection bonded? (5.4.2)						
9.3.22	Are materials used for bonding essentially similar to those used for air terminals and down conductors? (5.4.3)						
9.4	**Inspection and maintenance (Section 6)**						
9.4.1	Are visual inspections carried out by a suitably qualified and experienced person to confirm conformance with the standard used for the design: • during installation? • on completion? • after any alterations or extensions to the system or building including the installation of equipment on rooftops and facades of tall buildings? • after a known lightning flash to the buildings? • at regular intervals, on an 11 month schedule to check the mechanical condition of all conductors, bonds, joints, electrodes and to ensure that all recently added services have been bonded as required? (6.1.1)						
9.4.2	Are the results of the visual inspections recorded, together with a note of any parts of the installation that it may not have been possible to inspect? (6.1.2)						
9.4.3	Is testing carried out in accordance with acceptable standards, for example BS 7430, by a suitably qualified person? (6.2.1)						
9.4.4	Is the resistance to earth of each earth electrode, the resistance of the complete earth termination system and the measurement of electrical continuity of bonds and joints where necessary tested: • on completion of the installation? • after alterations, extension or modification? • after a known discharge? • on a regular schedule (such as every 11 months) so that seasonal variance in conditions are observed? (6.2.3)						
9.4.5	Are full details of all tests recorded? (6.2.3)						
9.5	**Electrical and electronic systems protection (Section 7)**						
9.5.1	Where appropriate, is use made of surge protection devices such as gas discharge tubes, Zener type transient voltage protectors and various other non linear devices for current diversion and voltage clipping? (7.1.1)						

9.5.2	Are measures such as careful design of wiring and cable layouts, use of metallic cable trays and screened (shielded) and armoured cables also taken? (7.1.2)						
9.5.3	Are the lightning protection and building earth systems fully integrated where there are distributed electronic systems with cables between the interconnected parts of the system? (7.2)						
9.5.4	Has consideration been given to specialised types of surge protection for minimising transients into equipment arriving along data lines?(7.3)						
9.5.5	Have good cable installation practices for EMC been achieved by the equipment and cabling installers, who have been subject to the supervision of an experienced installer who can use best practice in the installation? (7.4)						
9.5.6	Have the recommendations for the protection of electronic cabling and wiring layout for minimal interference which is described in BS EN 62305-4 and also IEC 61000-5-2 been observed? (7.5)						

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