



Historic England

Lightning Protection

Design and Installation for Historic Buildings





Summary

Historic England recommends that lightning protection is considered for all churches, and tall or prominent historic buildings. However there is no system that will give absolute protection, and the significance of a building need to be balanced against providing an acceptable level of protection.

Historic England's guidelines are:

- A risk assessment should be carried out.
- Proper consultation with the appropriate authorities or denominational bodies is essential.
- Archaeological supervision of ground-disturbing work may be needed.
- A tower-only system is likely to provide acceptable protection in most cases.
- The aesthetic appearance of the lightning protection system needs to be carefully considered.
- Systems need to be professionally designed, installed and maintained.

This guidance provides advice on the design, installation and maintenance of lightning protection systems for architects, surveyors, engineers and others involved in the care of historic buildings. Lightning protection is specialist work and requires expert design and installation.

Front cover: Lightning strikes are unpredictable. They may not strike the highest point of a building.
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Introduction

The spires and towers of historic churches and other tall buildings are often targets for lightning strikes. Although lightning protection is not a legal requirement, insurance companies may require churches and prominent historic buildings to have lightning and surge protection. This guidance provides advice on the design of new or improved lightning protection and surge protection systems.

Lightning damage

Thunderstorms and lightning most often occur when the weather is hot and humid. In England thunderstorms are more likely in the East Midlands and South East areas.

Climate change studies indicate that the number and power of lightning storms is likely to increase over this century in the British Isles. As a result lightning strikes are likely to become more common in the future (see Further Reading).

Lightning

Lightning is an extremely high current discharge. It can occur between or within highly charged clouds or from a cloud to earth. These discharges can range from about 10 million to 100 million volts.

Lightning strike effects

Lightning strikes to earth usually seek out the path of least resistance. This will be the highest point in a landscape, such as the top of a mountain, a tree, or a spire or tower. Since many historic churches and similar buildings have spires and towers, they can be prone to lightning strikes although it is unpredictable where lightning will hit. If the discharge is uncontrolled or not discharged safely, there is a risk to the structure and its contents.

Direct effects

Most direct damage caused by lightning is usually minor: the weakening of copings, pinnacles and roof tiles, for instance. However, even minor damage can be costly to repair if high-level access is required. Furthermore, masonry damaged by lightning can sometimes fall, posing a serious danger to people below.

There is some evidence that lightning damage is more extensive on towers or spires where the masonry or jointing is in poor condition. The damage is possibly caused by the sonic boom effect created by the rapid vaporisation of the moisture in the air. This stresses the need for regular building maintenance and repair.

The risk of fire from a direct lightning strike is low. Most recorded cases of church fires begun by lightning are from the Victoria era. These fires were usually caused when the strike melted lead pipes and ignited the escaping gas. With the advent of electric lighting, this risk was significantly reduced.



Figures 1, 2: Coping stones blown by a lightning strike to a parapet of Lulworth Castle (Dorset).

Figure 3, 4: Masonry debris from the tower fell through the roof of St Andrew's Church, Ramsbottom (Bury) causing extensive damage.



Indirect effects

Lightning strikes create voltage surges, which in turn can cause an electrical system to shut down, malfunction, or even a complete burn out of wiring and equipment. The more vulnerable items are alarms, boiler controls, sound reproduction systems, computers, telephones and electronic organs and the like.

About 60% of insurance claims for lightning damage to churches are for damage to electrical wiring and equipment. While such damage is more common than structural damage, it is important to note that it is far less costly. Repairing structural damage is on average three times more expensive.

[Section 4](#) provides advice about surge protection equipment to provide protection against voltage surges.



Figure 5, 6: At Easton Maudit church (Northamptonshire) stone blocks were displaced by a sideflash. This may have been due to an ineffective bond or high resistance between the metal vane rod and the lightning conductor.

Sideflash

A sideflash occurs when a bolt of lightning hits a conductor and then leaps to any adjacent metalwork, creating an alternative, low resistance uncontrolled path to earth. It is more likely to occur at the upper levels of the building, where the lightning strike discharge is at its highest voltage. A sideflash current usually travels via electrical wiring and metal service pipes, but may also flow along handrails and through clock mechanisms, lead flashing, drainpipes and other metalwork, often causing damage during its discharge. Where the path is through masonry, some structural damage may also occur. It is worth noting that the insurance statistics indicate that sideflash is not a major cause of lightning damage.

The risk of sideflash can be reduced in the design of lightning protection systems (see [Section 2.8](#)).

1

British standards for lightning protection

For hundreds of years lightning strikes were considered Acts of God, and church owners did not try to prevent damage. Many were slow to take up lightning protection even though by the late 18th century the role of lightning rods was understood. By 1910 up to 30% of churches had lightning protection installed. It is estimated that today 80% of churches and places of worship have a lightning protection system, and it is thought 90% of these are tower-only systems.

Guidance on lightning protection in the UK has a long history and recommendations have been revised and improved over time. For example, there was a Lightning Rod Conference in 1881, 1905 recommendations, and in 1943 a Code of Practice was published. In 1965, the British Standard *BS CP326* was introduced and a new version *BS6651* was published in 1985 and further revised in 1992.

BS 6651 recommended a complex network of conductors, the so-called Faraday cage, rather than tower-only systems (see [Section 2](#)). As the majority of churches had tower-only systems, English Heritage (now Historic England) worked with Ecclesiastical Insurance Group to develop ways that churches could improve lightning protection while protecting the aesthetics of their buildings; and in 2000 English Heritage then published advice on how to apply *BS 6651* to existing protection systems.

In 2006, *BS6651* was superseded by the *British Standard European Norm BS EN 62305*. *BS6651* was withdrawn in 2008 and is no longer current. The *BS EN 62305* updated the standards, and included the protection of electrical systems and equipment such as computers, fire alarms and PA systems. It also defined lightning protection zones (often abbreviated to LPZs).

This guidance looks at the application of the current 2011 edition of *BS EN 62305 Protection against lightning. Physical damage to structures and life hazard* for historic buildings and alternative methods of protecting churches and other historic buildings.

2

Designing a protection system

The design of a lightning protection system should be carried out by an experienced consulting engineer or installer (see [Section 8](#)).

2.1 Risk assessment

Before installing or upgrading a lightning protection system, a qualified consultant or installer should carry out a risk assessment. This is a lengthy calculation and computer software is needed. Owners, custodians or denomination representatives can help by collating as much of the necessary information as possible. This will assist assessors in determining the appropriate level of protection.

The consulting engineer or installer will need information such as:

- Dimensions and use of building
- Types and characteristics of the equipment to be protected
- Construction details such as floor surfaces, roof types and wall materials
- Relative location of the building to its neighbours' building and services such as gas, water and electrical power
- Details and characteristics of all types of incoming services such as gas, water and electrical power
- Types of cable used for power, telecommunications and data
- Earthing systems
- Risk of fire and the current fire protection
- Details of the historic significance of the building and its contents and their value (see 'Loss of Cultural Heritage' below).

The *BS EN 62305* risk assessment is concerned with both possible risks to people, damage to the structure and its contents, and protection against electrical surges which can also cause damage through sparking and causing a fire. The complex calculations are based on the *BS EN62305* three-way matrix of sources of damage, types of damage, and types of risks::

Sources of damage

- strikes to the structure
- strikes near the structure
- strikes to a service
- strikes near a service

Types of damage

- injury to people
- physical damage to structure
- failure of electrical systems

The four types of risks (R) resulting from each source of damage

- R1: Risk of human life
- R2: Loss of public services
- R3: Loss of cultural heritage
- R4: Loss of economic value

The risk assessments take account of the:

- risk of death and injury
- frequency of lightning strikes
- likely location of damage
- possible degree of damage
- cost of installation and maintenance
- need for surge protection

BS EN 62305 defines four classes of protection (I, II, III and IV for minimum and maximum values of lightning currents). These classes are used to determine the parameters in calculating the zone of lightning protection (see [Section 2.3](#)) and components such as Surge Protection Devices (SPDs) (see [Section 4](#)).

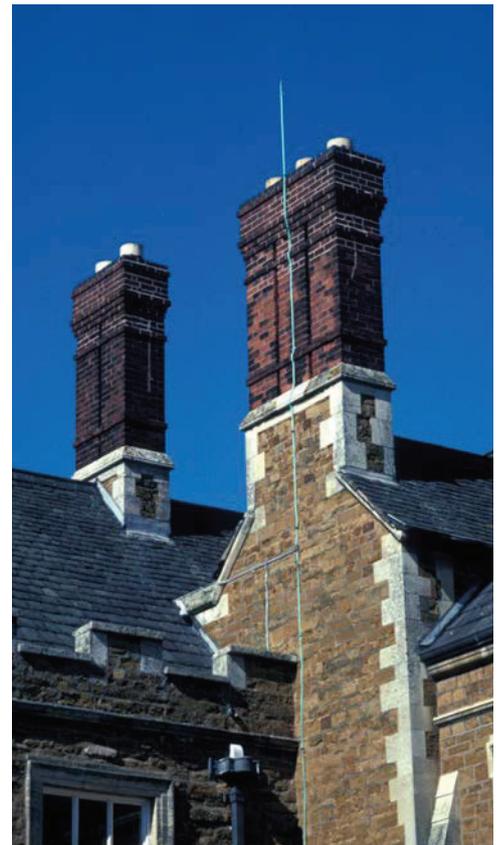
Loss of cultural heritage

An important part of the *BS EN 62305* risk assessment is the loss of cultural heritage.

The architectural and historic importance of the building and its contents needs to be included in the risk assessment. The consultant or installer should be fully briefed and given details, such as the listed building or scheduled monument entry, statement of significance, value and types of contents.

Important buildings such as cathedrals are likely to need higher levels of protection.

Figures 7, 8: Examples of lightning conductors on a water tower and a chimney.



2.2 Applying *BS EN 62305* risk assessments to historic buildings

BS EN 62305-type risk assessments are considered inappropriate and disproportionately costly for parish churches and similar listed buildings that already have tower-only protection systems. For example, if the risk assessment was carried out in full it would require information about many neighbouring buildings which may be impractical to collate.

The *BS EN 62305* is only guidance and does not have any regulatory function. For historic buildings its recommendations need to be applied appropriately and sensitively, and there may be special considerations for some building types like windmills.

2.3 Calculating the Lighting Protection Zone

A specialist installer or consultant can calculate the extent of the building covered by the current or proposed lightning protection system. The two principal methods are the 'rolling sphere' and 'protective angle'.

Rolling sphere method

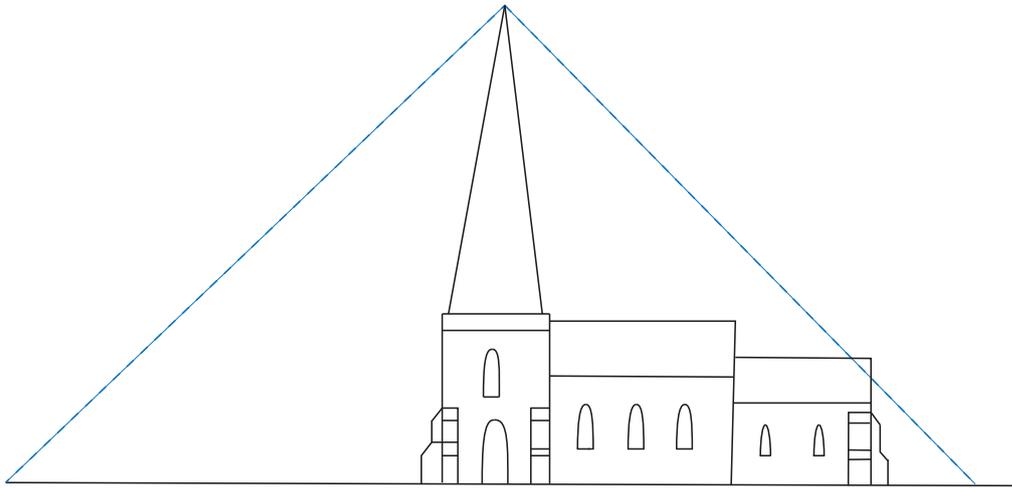
The rolling sphere method is a means of identifying areas of a structure that need lightning protection. An imaginary ball is rolled from the tip of the lightning conductor over the structure. Every place the ball touches is vulnerable to a lightning strike. This is where a lightning conductor will be needed. The size of the ball varies, depending on the level of risk and protection required; the higher the risk, the smaller the ball. Guidance is provided in Annex A, *BS EN62005-3*.

The rolling sphere method is usually the more appropriate method for churches and other historic buildings.

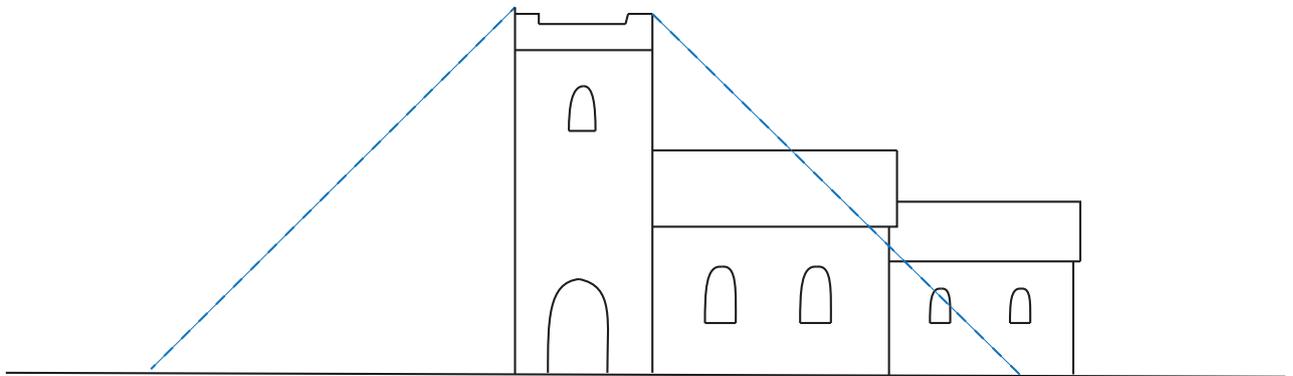
Protective angle method

This is the method used in tower-only systems.

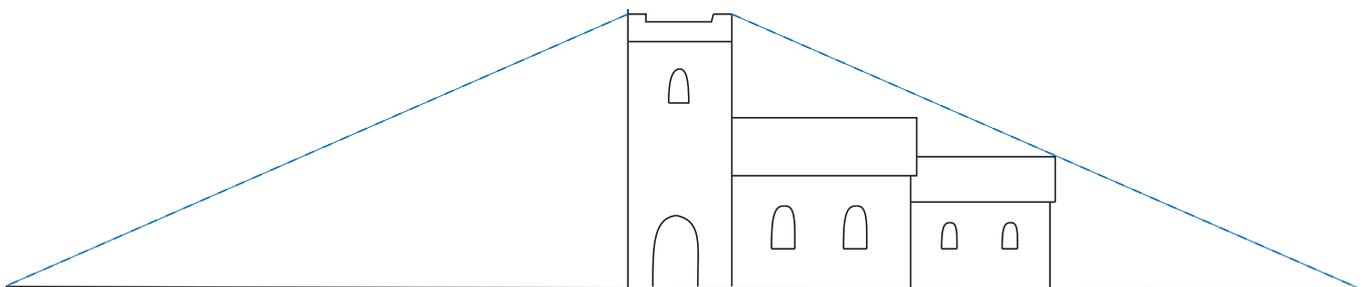
The protective angle method is a mathematically simplified version of the rolling sphere method. In this method, the area from the high point of the lightning conductor's air termination to the ground is modelled as a cone. The angle of the cone varies with the height of the structure and the class of lightning protection system. *BS EN 62305-3* provides guidance on how protective angles can be varied and determined.



A tall spire providing a good zone of protection at 45° to the vertical



The extremities of the nave and chancel are outside the 45° zone of protection although the risk of side strike at these low levels is remote



The effect of increasing the angle to 65° is to bring all of the church within the zone of protection

Figure 9: Sketches showing how varying the angle affects the zone of protection.

2.4 The three elements of a protection system

All lightning protection systems have three separate elements:

- Air termination system
- Down conductors
- Earth electrodes

Generally buildings will need to have several air terminations, down conductors and earth electrodes.

Air termination finials

Where possible, air termination finials are installed on the higher parts of the building, where lightning is most likely to hit. It may take the form of a single point or finial on a spire. When there is no spire, a perimeter tape or horizontal conductor can be used on a parapet, coping or roof of a tower, with small air terminations at the corners remote from significantly higher parts.

Finials can be visually intrusive on the skyline if not carefully positioned. Their use should be limited to the protection of upstands such as pinnacles. A finial can be attached to the upstand by straps or ties or be freestanding. In either case, it should be as close as possible to the upstand, projecting no more than 150 mm above it.

Weathervanes

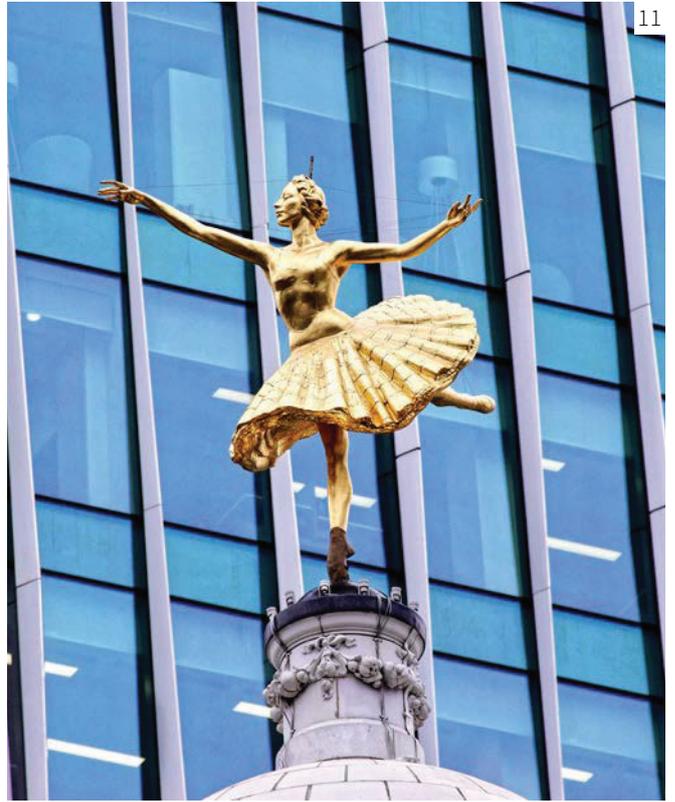
On some buildings, a weathervane or top of a spire can often act as a finial if a good mechanical and electrical connection can be made to the conductor.

Flagpoles

An adapted flagpole, with a conductor running up a hollow centre to a metal termination, can be used to disguise air termination.

Down conductor

The down conductor (a metal tape or rod) connects the air termination system to the earth electrodes to carry the lightning current from the roof to the ground. Each conductor is normally connected to its earth electrode via a test clamp on the wall at a low level or a fully connected ring conductor around the building. Its route to the ground should be as direct and as unobtrusive as possible.



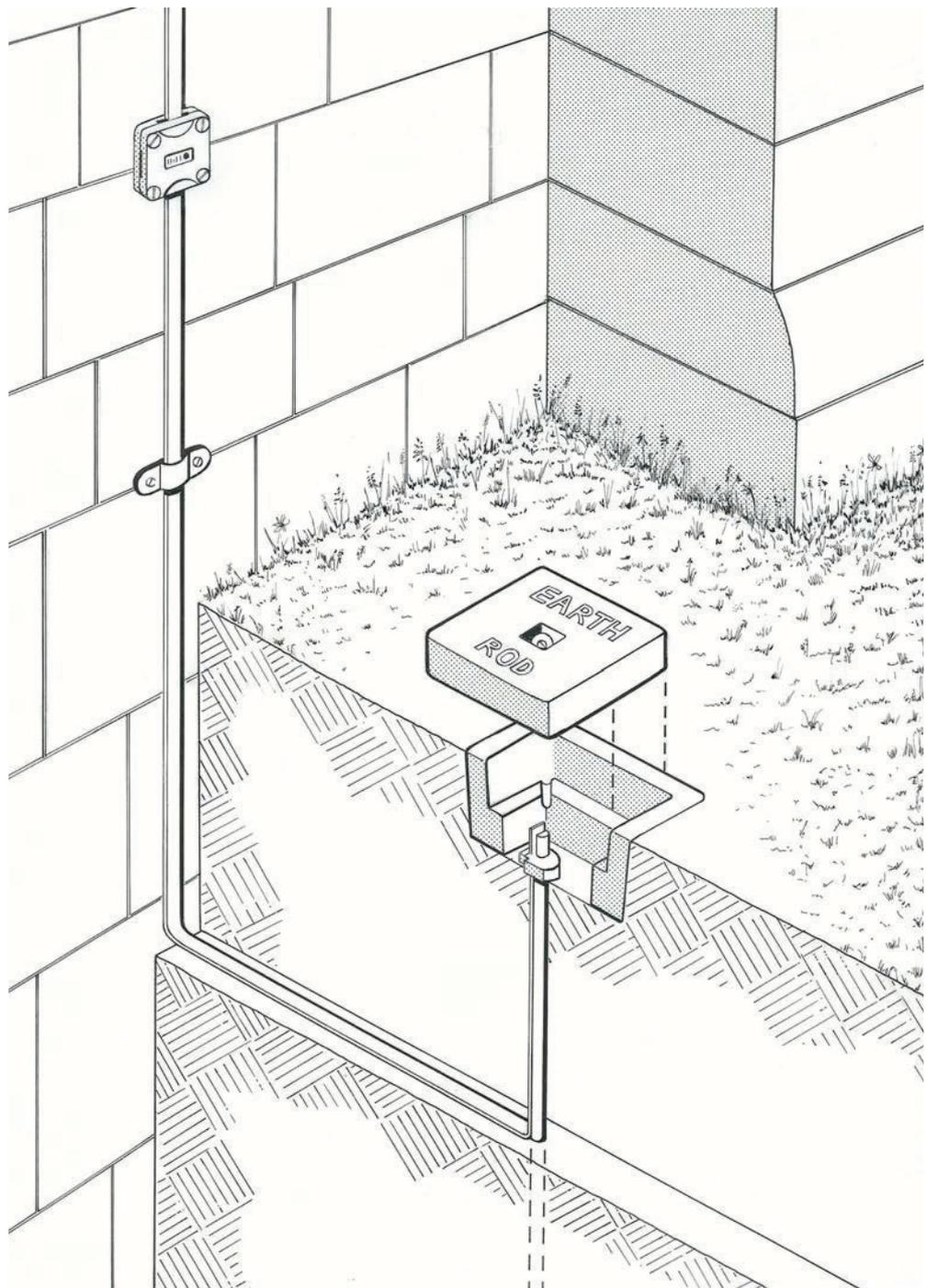
Figures 10–13 : Examples of air termination finials including a weathervane and a flagpole.

Earth electrodes

Earth electrodes are metal rods driven into the ground and connected via the down tape system to the conductors and air terminators at the top of the building. They can also be horizontal tapes or a lattice earth mat, or a combination of these three methods. When lightning strikes, the current travels via the conductors to discharge into the ground.

More information on the individual lightning protection system components is given in [Section 3](#).

Figure 14: Cross-section through an inspection pit showing the method of clamping the down conductor to the earth electrode. Note the use of flat strip conductor with saddle-type fixing clips and test clamp fixed into jointing rather than masonry blocks.



2.5 Design considerations for historic buildings

Every lightning conductor system is a visual and material intrusion to some extent. In the case of an historic building, the consulting engineer should work with the architect or building surveyor to minimise impacts. This can be done by:

- treating each building individually
- understanding the building and its characteristics
- creating an installation that respects the building

In order to produce a lightning conductor system which is as unobtrusive as possible, a site visit will enable all involved to:

- select the most appropriate cross section and PVC sheath colour of conductor for the building
- decide how to position the conductors inconspicuously on a reasonably direct route, bends should be avoided wherever possible
- find ways to avoid important or interesting architectural features such as windows and carvings, as well as places where conductors may be more obtrusive, such as plain façades
- make use of architectural features such as rainwater downpipes, the corners between buttresses and walls to conceal conductors and reduce visual impact
- select the most appropriate type of fixing to be installed in mortar joints or similar locations where they can be hidden
- consider the risk of metal theft: It may be appropriate to protect the lower section of lightning down conductor – think about whether the protection system can be removed without damaging the fabric

Where the listed building is a more modern structure the steelwork or reinforcement bars may be designed to act as a Faraday cage-type lightning protection system.

Figure 15: The down conductor has been carefully fixed not to damage the brickwork at Fazeley Mills (Staffordshire); however, the rainwater downpipe could have been used to conceal it.



2.6 Permissions and consents

Before designing a new or upgraded lightning protection system, it is important to check whether any consents are required:

- [Planning permission](#)
- [Listed building consent](#)
- [Scheduled monument consent](#)
- Authorisation from a [denominational body](#) (for places of worship)

Usually, Church of England Diocesan Advisory Committees require all proposals for repair and upgrading lightning protection to be submitted for consideration before applying for a Faculty. Some dioceses have published their own guidance on lightning protection for parish churches (see [Section 7](#)). [ChurchCare](#) also provides advice about lightning protection and permissions. For Roman Catholic churches, see the [Catholic Historic Churches](#) website for more information.

Generally the building insurer will require to be informed of lightning protection system repairs, upgrading or a new installation.

Even if formal permission is not deemed necessary, the consultation can open a helpful discussion about design considerations.

2.7 Types of protection systems

Tower-only systems

Traditional tower-only systems (also called protective angle systems) usually consist of one air termination and down conductor attached to earth electrodes. While a single conductor can be used, two down conductors (on opposite sides of the tower) are now preferred because they:

- lower system voltages and reduce the risk of sideflash to earthed metal components such as electrical circuits
- increase the likelihood of discharging a lightning strike to the earth, where soil resistance is high
- facilitate continuity testing of the conductors
- provide security against physical failure, damage or vandalism

It is Historic England's view that tower-only systems with two down conductors provide an acceptable level of protection with minimal visual impact for most historic churches and similar buildings. Tower-only systems and protective angle methods for assessing lightning protection are valid interpretations of the *BS EN 62305* standard (see *BS EN 62305-3 Annex A*). However, it should be noted that some older tower-only systems might be in poor condition and earthing inadequate. Maintenance and regular inspection is addressed in [Section 5](#).

Figure 16: A very old and unusual iron conductor made of screwed sections at St Lawrence's Church, Hougham (Kent). Note the lack of support of the roof section.

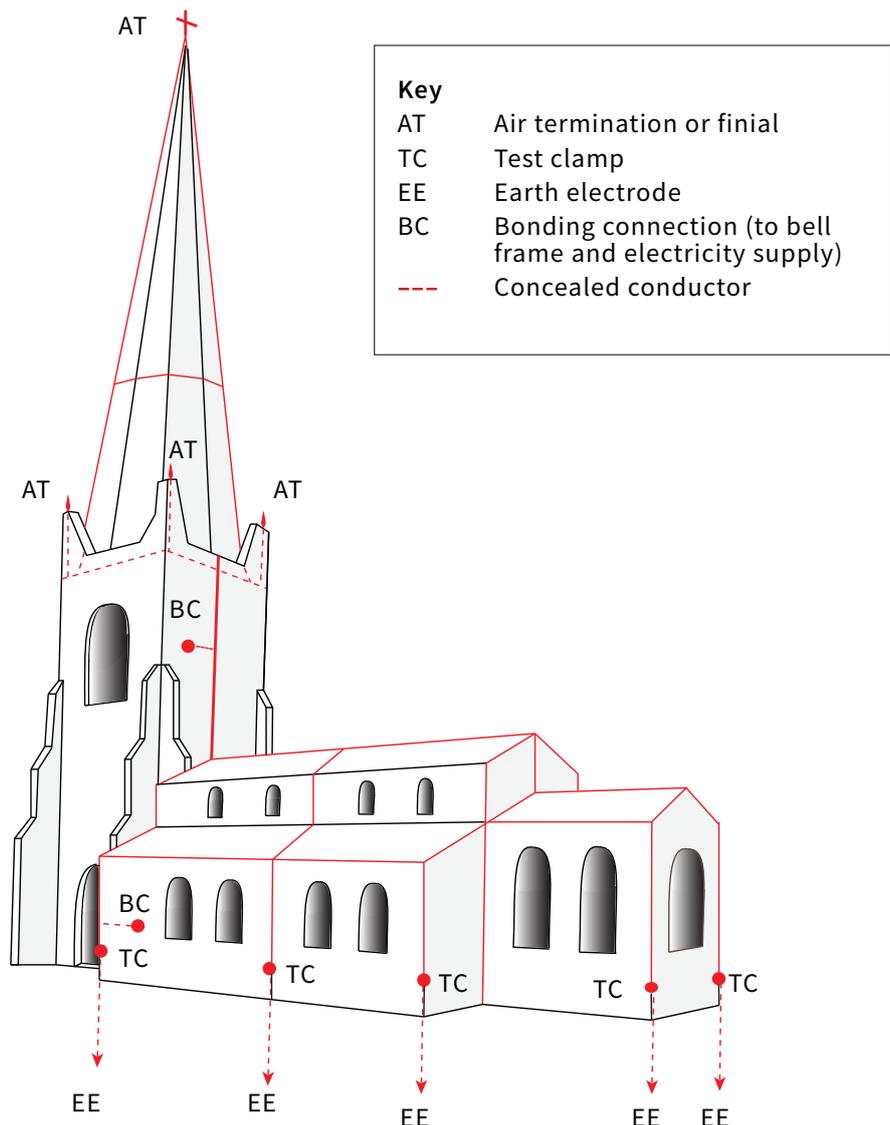


Faraday cages

A Faraday cage (or mesh system) is a network of air terminations and down conductors over all facades of a building. When lightning strikes, it discharges the current around the building, and stops it from penetrating the interior. These cages have air termination conductors close to the edges of the roof. The *BS EN 62305* defines different configurations for the four lightning protection levels.

The Faraday cage system is commonly used to protect buildings that have large plane surfaces such as an office block. Although these systems provide greater protection than tower-only systems, they are visually intrusive. Careful attention needs to be paid to the siting and colour of the conductors on historic buildings. They are also far more expensive to install than a tower-only system. However, when a building like a cathedral or stately home in an area of high lightning flash density has major historical value and important contents, the extra protection afforded by a Faraday cage may be needed.

Figure 17: A typical Faraday cage system of lightning protection. This system is symmetrical and has nine electrodes, including three not seen on the nave and one on the left-hand side of the tower. The bonding connections to gutters and drainpipes are not shown.

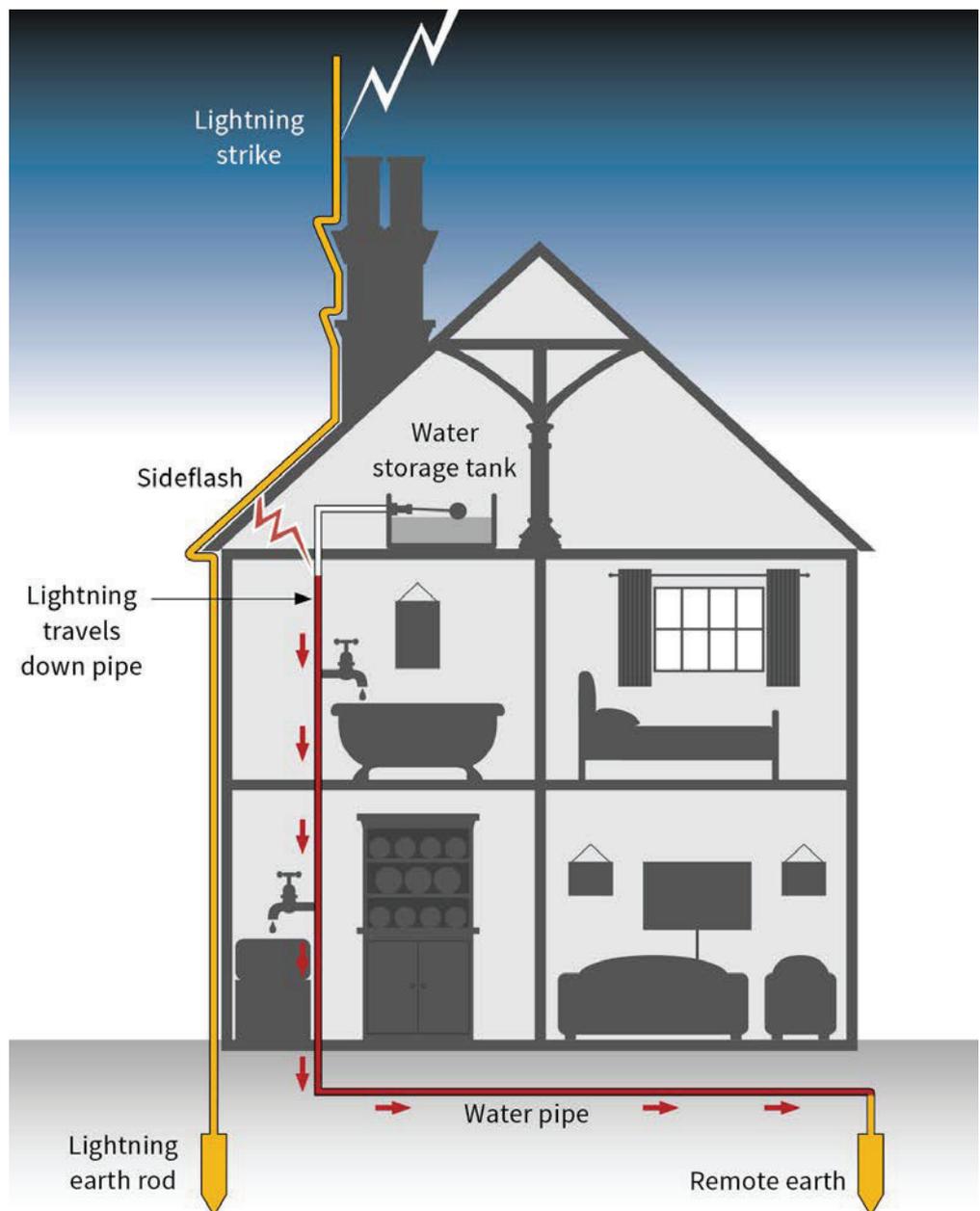


2.8 Reducing sideflash risks through separation or isolation

Putting a gap between conductors and metalwork is the simplest way to lower the risk of sideflash. This is called 'separation' or 'isolation'. It is not always possible to create enough of a separation in a tower only system which would need to be in the region of 1.6 metres for a typical tower roof level of 20 metres from ground level. In these cases, bonding the lightning conductor to all adjacent metalwork within the separation distance will perform the same function. It is important to note, though, that bonding can introduce high voltages into a building. These voltages can be hazardous. The consulting engineer will advise on the risks involved, and design solutions.

If possible, conductors should be kept separate from adjacent metalwork. This will reduce the risk of sideflash.

Figure 18: Even with a lightning conductor installed, sideflashing can occur if metalwork is not bonded.



2.9 Bonding

Bonding the lightning conductor to all metalwork can eliminate the risk of sideflash. Conductors should follow the shortest practical route when bonding external and relatively accessible metalwork, such as lead flashings, gutters, drainpipes, bell frames, clocks and handrails, though surface horizontal runs at a low level should be avoided. The bonding should be unobtrusive and colour-matched with the building. Non-standard colour bonding, rather than green and yellow, is acceptable but both ends must be labelled, for example 'Lightning earth – Disconnect for testing only'.

Internal earthed building services such as gas, water, electricity and other wired services should be bonded at the point of intake. If the pipes are non-metallic, conductors can be bonded to the internal piped metallic services. The cable used to bond incoming building services should be buried or inserted into a conduit in order to conceal it. Some towers have aerial systems that act as lightning conductors; they too should be bonded to the lightning protection system along with metal bell frames.

While bonding is usually a straightforward process, it can be more problematic where electricity is supplied to a building by overhead cable or a combined neutral earth system. Before bonding is carried out it is important to understand the building's earthing arrangement. Usually the electrical supply company will have provided a separate protective conductor (or a combined neutral and protective conductor). A circuit protective conductor (cpc) joins together all exposed conductive parts and connects them to the main earthing terminal. However, where the supply company has not supplied a protective conductor, it is the responsibility of the building owner or custodian to provide a protective conductor to a separate earth electrode in the ground. The utility supply companies and aerial operators should always be contacted before bonding, and a qualified electrician used for all work on the electrical system (see [Section 5](#)).

Building services should be relocated from parts of a building that are vulnerable to sideflash, such as the underside of a roof.

Historic England offers other guidance on other external equipment such as [photovoltaic arrays](#). The principles covered in sections 3.8 and 3.9 still apply and Surge Protection Devices (SPDs) should be considered (see [Section 4](#)).

2.10 Design considerations for sheet metal roofing

A sheet metal roof can be a conductor, eliminating the need for additional conductors. However, there must be a good electrical continuity connection between sheets to ensure low resistance to current flow. Over time, the integrity of the contact surface may deteriorate. Connecting the sheets mechanically, by clamps, or by welded (preferably flexible) joints can overcome this. Where the metal sheeting is utilised and there is a direct strike, the metal may get damaged although the likelihood of this is low.

In cases where sheet metal provides inadequate protection, other solutions can be found. A tower roof, for example, can be bonded to the perimeter system. If a small metal roof such as a porch is located away from any down conductors, it can remain isolated from the lightning protection system. In the case of a large lead roof, a tower-only system might prove problematic. One solution would be to extend the tower-only system into a partial Faraday cage by means of a ridge conductor and an additional down conductor at the end farthest from the tower or spire. The lead roof could be bonded to the conductors at appropriate points.

3

Installing a protection system

Only specialist contractors such as members of the Association of Technical Lightning & Access Specialists (ATLAS) or those that have undergone training with the Steeplejack and Lightning Protection Training Group, and with relevant experience should be employed to install and maintain a lightning protection system. They will be able to follow all safety procedures while also employing all the special care necessary for work on historic buildings.

3.1 Health and safety

Installing a protection system involves working at heights which can be dangerous work. Health-and-safety legislation places a duty of care on contractors and their employees for the benefit of themselves and the public. Contractors must be aware of these statutory duties and the special care required when working on historic buildings. All other parties, including the client, church authority, architects, building surveyors and other advisers involved in the design and installation of a lightning protection system must also comply with health-and-safety legislation and ensure that both access and working conditions are safe.

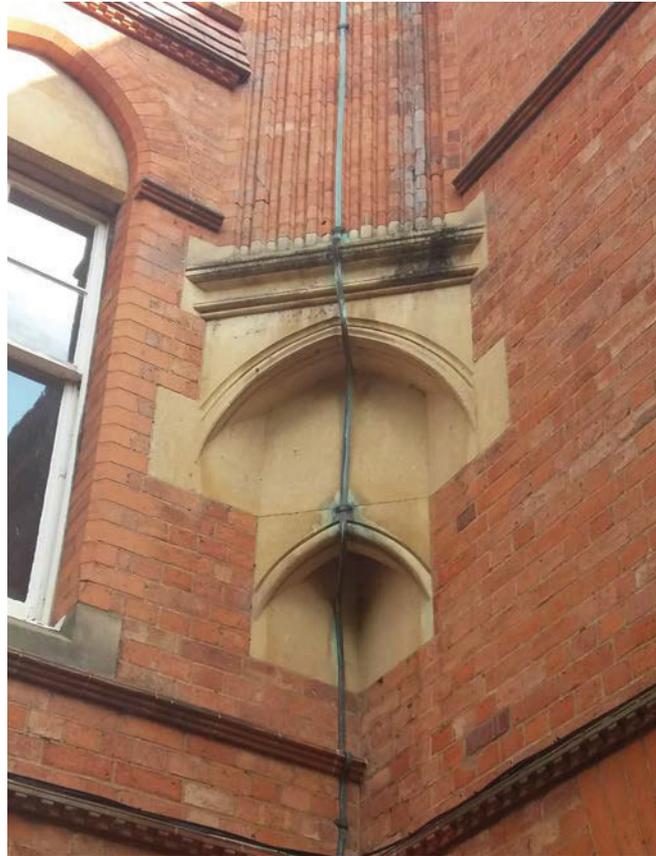
3.2 Lightning system components

Conductors

Aluminium or copper

The above-ground part of conductors may be made of aluminium or copper, though only copper or copper-clad materials should be used below ground. Aluminium is cheaper, lighter, and easier to handle than copper. However, it is more likely to corrode, as it is vulnerable to the lime content in pointing. Copper, the more traditional material, is less likely to deteriorate, and thus has a longer life, though it can be vulnerable to theft. Any anti-vandal or theft deterrent such as guards must not be visually intrusive or by installing them lead to more damage to the building. Historic England's [Metal Theft from Historic Buildings: Prevention, Response and Recovery](#) provides further advice.

Figure 19: Copper conductors can cause staining as seen at Highbury Hall, Birmingham.



Flat strips or rods

The conductor may be either a flat strip or a rod. The flat strip is usually 25 x 3mm (although 20 x 2.5mm is the acceptable minimum for copper). The equivalent rod is 8mm in diameter for copper and aluminium. The rod conductor is often easier to install, as it can be bent in all directions. It is also less obtrusive. A flat strip conductor can only be bent neatly in one direction. However, it can follow profiled elements such as stringcourses more closely than a rod can.

Colours

On new installations, conductors with UV stabilised PVC sheathing are usually used, although bare conductors are still available. PVC sheathed conductors are preferred as they blend in with the surroundings and do not corrode, therefore preventing staining of masonry. They are available in a range of colours, including white, black, brown, grey and stone. Other colours may be available to special order.

Jointing

Joints in conductors should be kept to a minimum wherever possible. The down conductor should be installed in one continuous length to guarantee conductivity. Connections to a down conductor for bonding should be made in non-ferrous, clamp-like joints. A range of different joints, clamps and other fittings is available.

It is usual to apply a thin film of conducting anti-corrosion grease to all jointed surfaces. Connection of aluminium conductors to copper should use purpose-made bimetallic couplings.

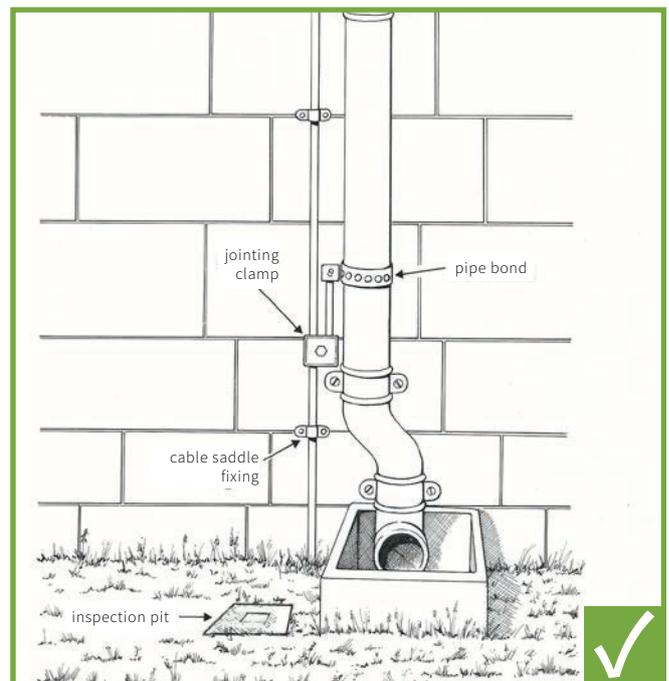
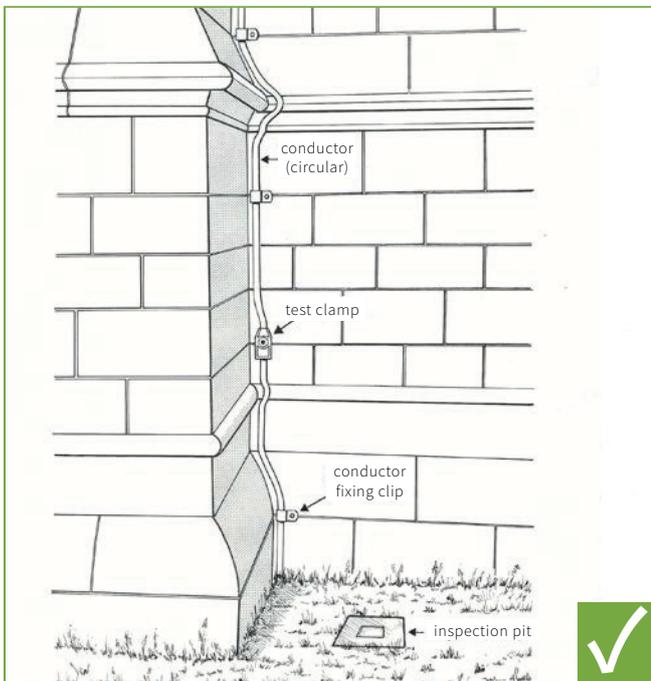
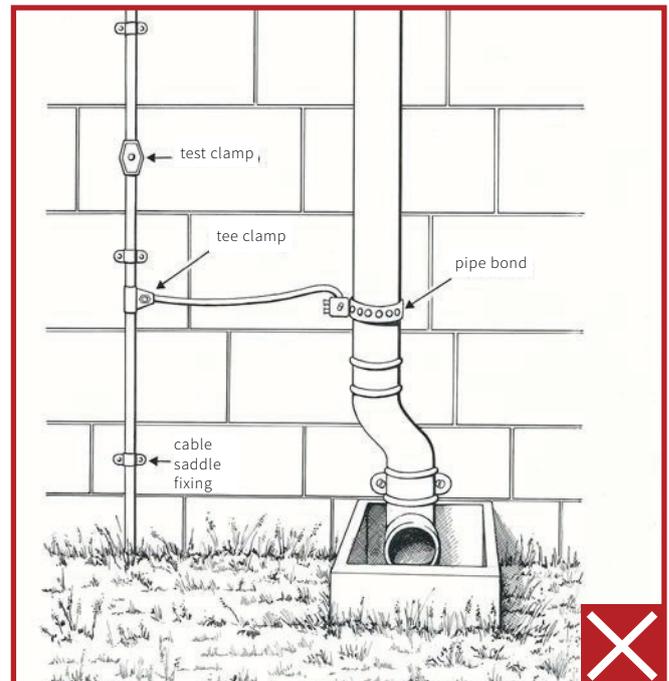
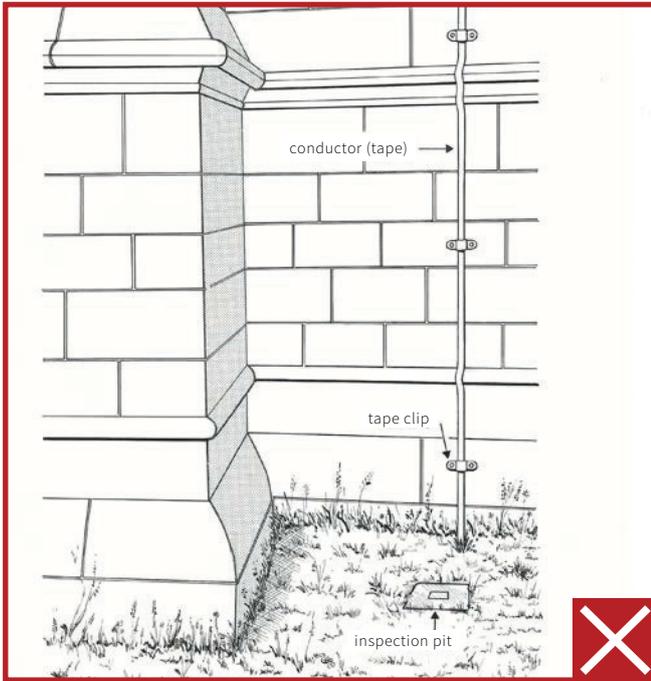


Figure 20: Positioning down conductors

Top: Bad practice

Left: This example, with fixings into stone, has caused irreversible damage. Note the absence of a test clamp to isolate the earth electrode for testing.

Right: In this example, note absence of earth pit for access to inspect earth clamp connecting conductor to earth rod.

Bottom: Good practice

Left: This example makes use of natural features to minimise visual effects, with fixings installed in mortar joints to avoid damage to stonework. Note the unobtrusive test clamp and the use of P clips to allow the conductor to be fixed close to the corner.

Right: This circular down conductor with saddle clips makes use of a drainpipe to minimise visual effects. Note the bonding connection to the drainpipe and the connection clamp which also serves as the test clamp.

Bends in conductors

Bends in conductors should be kept to a minimum, and sharp bends avoided where possible.

If down conductors end up cantilevered such as over a parapet wall, a lightning strike could flash to anyone standing beneath. Such re-entrant loops are best avoided. In most cases, it should be possible to route the conductor through a hole in the parapet wall. Where conductors pass through architectural features, suitable precautions should be taken to prevent the trapping and freezing of water.

Bonding conductors

Bonding conductors are usually the same size, colour, and type as the lightning conductor. *BS EN 62305-3* Tables 8 and 9 set out the sizes of bonding conductors in copper, aluminium and steel. Bonding conductors to incoming building services must be insulated but do not need to be green/yellow cable if labelled at both ends as recommended by *BS 7671 Requirements for Electrical Installations. IET Wiring Regulations (2018)*.

The bonding connection should be made of non-ferrous materials. Proprietary clamps are available for this purpose.

Where a flexible connection is required, a short length of braided copper or equivalent cross sectional area to the conductor can be used.

Fixings

Fixing clips

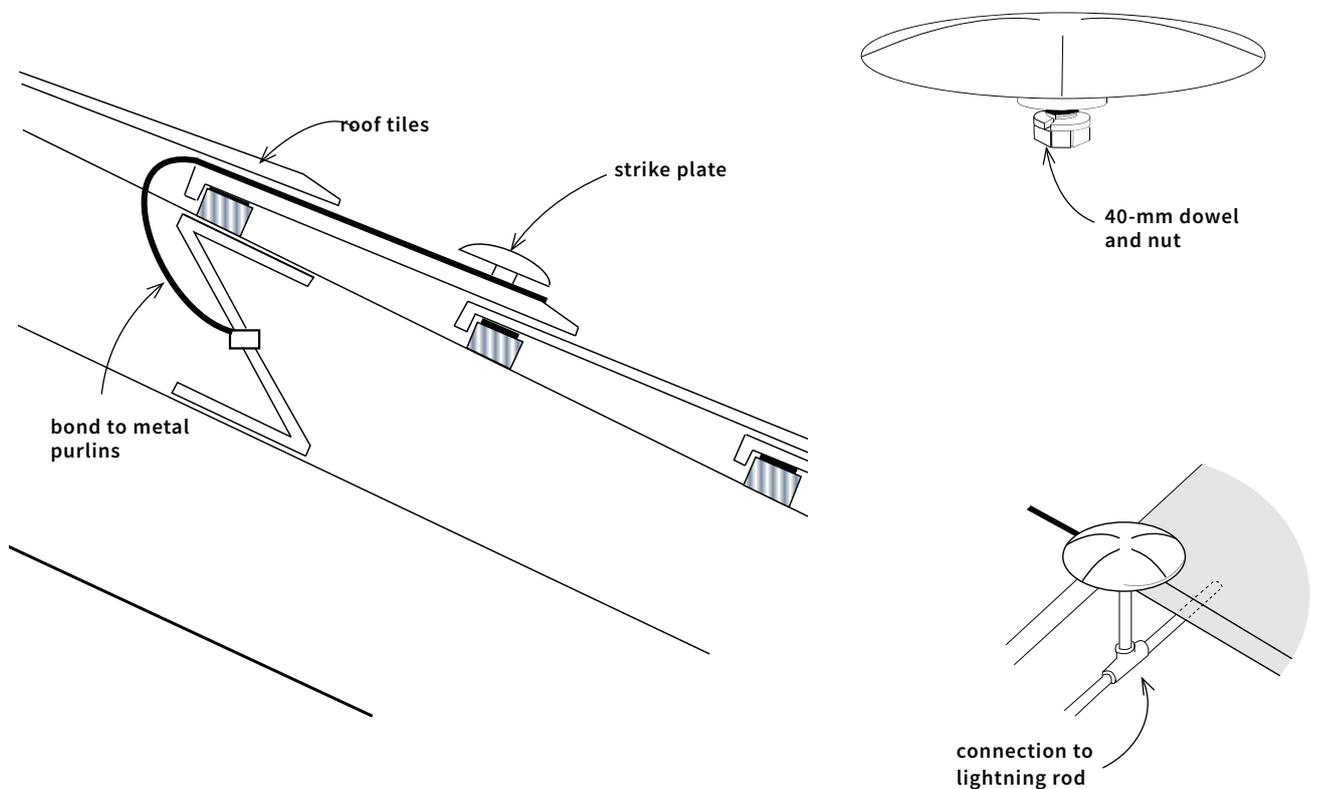
Fixing clips keep conductors firmly in place and prevent movement during a lightning discharge. Plastic and non-ferrous metal clips (both bare and PVC covered) are available for supporting both circular and flat conductors. Metal clips are more robust and longer lasting than plastic clips. Wrap-around or P clips (with a single screw fixing) and saddle clips (with a fixing screw either side of the conductor) are more secure than push fit designs, some of which are of the 'stand off' type which does not allow the conductor to fit closely to the wall.

Fixing to tile or slate roofs

A special fixing known as a slate holdfast is available for tile or slate roofs. Occasionally, usually for aesthetic reasons, strike plate conductors are installed under roof tiles or slates but this is usually only feasible if the roof is being stripped for re-roofing. The plates, if employed, will need to be connected at prescribed intervals.

Adhesive clips are available for fixing conductors to lead and other sheeted metal surfaces; this eliminates the need for welding of lead tags. When working with these fixings, **hot working techniques** should be avoided if at all possible.

Figure 21: An external metal strike plate (made of gunmetal or aluminium), showing how it is fitted under the roof tiles. Details of the strike plate, and how it is connected to the lightning rod, are shown on the right.



Fixing to masonry

Fixings to masonry should be in mortar joints, not stonework. Particular care should be taken when drilling into the narrow joints normally associated with ashlar blocks. Screws should be of non-rusting material such as brass or stainless steel, inserted into proprietary plastic plugs. Where mortar is particularly soft, chemical (epoxy resin) fixings may be beneficial, although repointing with a mortar matching the existing mortar (but not cement) would be preferable.

Fixings drilled into horizontal surfaces such as parapets should be sealed to prevent the ingress of water into the stonework. This can be achieved by means of a suitable sealant (mastic or silicon) placed under the base of the fixing clip before tightening. When fixing to the course below a coping stone, care should be taken not to break the joint and lift the stone.

Earth electrodes

Earth electrodes are usually steel-cored rods with bonded copper sheaths, although other materials such as solid copper and stainless steel are available. The rods are typically 14.5mm in diameter, and available in lengths between 1.2m and 1.8m. They can be screwed together and driven by hand or power hammer to a considerable depth, usually in a purpose-made ground level inspection pit that will enable future maintenance access. It is usually located about a metre or less away from the wall, although sometimes it will be necessary to increase the distance in order to avoid foundations or voids such as crypts. The earth connecting conductor is then clamped to the top of the electrode.

The *BS EN 62305* sets out three arrangements for earth electrodes:

- Type A: a horizontal or vertical electrode. This is probably the most appropriate for historic buildings (as explained above)
- Type B: a fully connected ring earth electrode in contact with the soil for a minimum 80 per cent of its length
- Foundation earth electrodes: like Type B, but the electrodes are installed in concrete. This type is usually only used for new buildings.

BS EN 62305 recommends an overall earth termination system electrical resistance of 10 ohms or less. If the earth electrical resistance is high (above 10 ohms), additional earth electrodes may be needed to meet *BS EN 62305* earthing standards.

Sites with high electrical resistance

There are considerable regional variations in soil resistance. Soils with high electrical resistance do not discharge lightning strikes as effectively as low resistant soils. The risk assessment (which may include a soil resistance test) will determine how many earth electrodes are necessary. Installing more electrodes and carrying out soil tests can be expensive, and potentially disturb archaeology. In some cases, where the soil resistance is especially high, it might not be feasible to install a conventional earth electrode arrangement, instead it may be necessary to employ a Type B earthing arrangement and ignore the 10 ohm requirement.

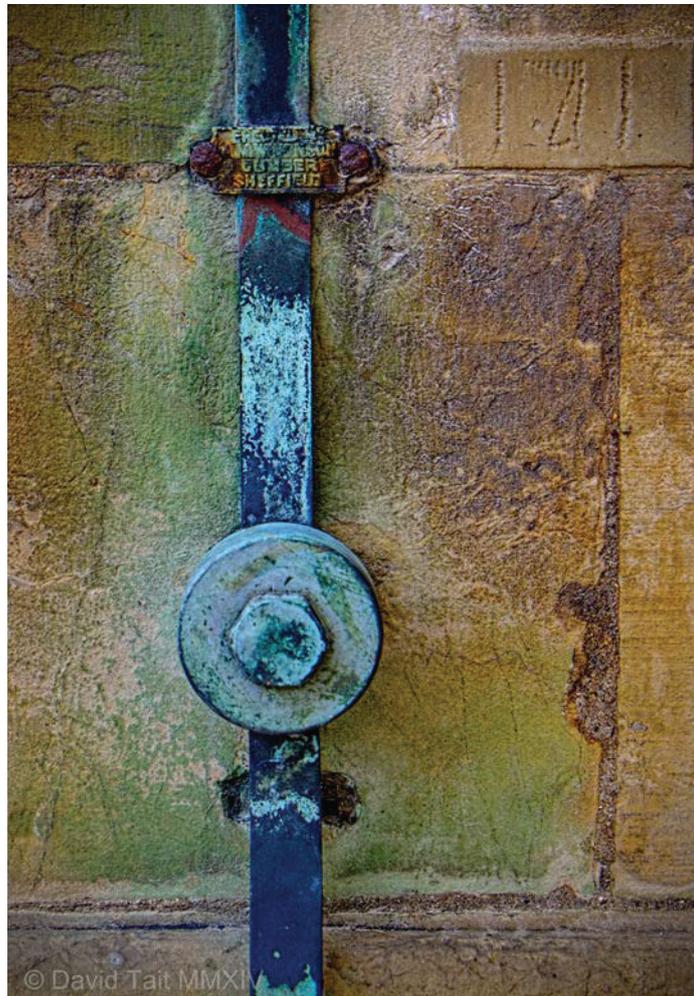
Test clamps

A non-ferrous test clamp is inserted in the down conductor at a low level on the outside wall where it is easy to access (see Figure 20 on good and bad practice).

Precautions

The location of underground building services such as gas, water or electrical power should be determined from existing records or by using suitable buried-services location equipment before any earth electrodes are driven into the ground or excavations carried out. Archaeological advice may be needed, and the work overseen by an archaeologist working with the architect or building surveyor (see [Section 8](#)).

Figure 22: An example of an old test clamp.



4

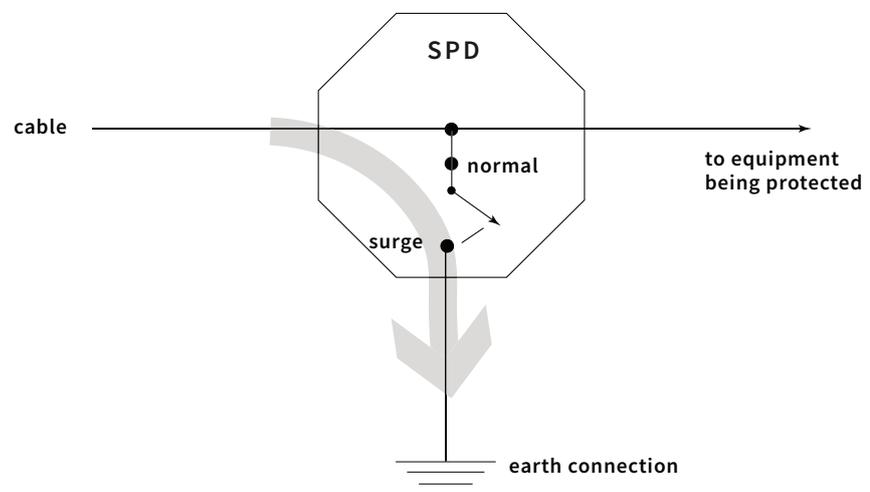
Surge protection devices (SPDs)

Voltage surges can damage electronic components such as printed circuit boards and result in the loss of a facility such as boiler controls, fire alarms, lighting controls, computers, telephone and public address systems. Installing a surge protection device (SPD), which can be thought of as a simple switch that detects and diverts unwanted voltages, will protect equipment and cable networks from damage. A SPD is an integral part of a lightning protection system. Even if buildings do not have a lightning protection system installed, a SPD will limit or help prevent damage if lightning hits. Surge protection should be installed and maintained in all historic buildings.

SPD equipment needs to be fixed carefully so it does not damage the building fabric. This type of equipment is usually installed at the main incoming service location, the distribution board location(s) or adjacent to the equipment via a plug-in unit. The choice of an SPD device depends upon the:

- risk of lightning strikes
- equipment that requires protection
- type of equipment, and whether it could generate electrical flashes
- proposed location for the SPDs

Figure 23: Surge protection device (SPD) acting as an earth connection.



BS 7671 Requirements for Electrical Installations. IET Wiring Regulations (2018) sets out the requirements for the correct selection of SPDs against electrical surges. There are three types of SPDs:

- **Type 1** protects against direct lightning strikes
- **Type 2** is the main protection for low voltage installations and is normally installed in each distribution board
- **Type 3** supplements type 2 and is installed near sensitive loads

Specialist advice should be sought about selecting SPDs and their installation from a qualified electrical contractor and a member of ATLAS, or a chartered electrical engineer (see Section 6 for qualifications).

The installation of SPDs must be undertaken by a qualified electrical contractor.

5

Testing, recording and maintenance

Maintenance is an important part of lightning protection. A poorly maintained installation will be unable to discharge voltage safely, and puts a building at greater risk than if it had no protection at all. However, lightning protection systems are fairly robust. They need only basic routine maintenance involving periodic visual checks and testing of the conductor continuity and resistance to earth.

Inspectors should follow the procedures set out in BS EN 62305 and the Electricity At Work Regulations 1989 and should be:

- A specialist lightning protection contractor, such as a member of the Association of Technical Lightning & Access Specialists (ATLAS)
- An electrical contractor, preferably a member of the Electrical Contractors Association (ECA) or the National Inspection Council for Electrical Installation Contracting (NICEIC), or National Association of Inspectors and Testers (NAPIT)
- A chartered electrical engineer (a member of the Institution of Engineering and Technology (IET) or the Institution of Building Services Engineers (CIBSE).

If the structure has been hit by lightning, the lightning protection system should be inspected to ascertain if there has been some damage or ground conditions have changed. A full inspection and test should be carried out after initial installation, repairs, and modifications.

Otherwise, a visual inspection at ground level to check the integrity of the installation should be carried out regularly by the property staff and a record kept. Some ATLAS members advise an interval of 11 months, which allows for seasonal variations to be noted and recorded and some church dioceses advise that annual inspections should be carried out. However, if the lightning protection system is simple, and changes have not been recorded, it may be possible to perform testing and maintenance less frequently. If the interval is two and a half years, alternate inspections could become part of more general five-yearly (sometimes called quinquennial) building inspections. In the case of a church, its' appointed architect or surveyor would be responsible for arranging the inspection and tests and any necessary remedial measures. Insurers may also ask for a copy of the test report.

Details of the installation, including any available 'as installed' drawings and records of all tests, should be kept on the site for future use, and a duplicate archive set kept in an agreed location.

It is also vital that buildings are maintained to reduce risks of damage. As highlighted previously, lightning damage is more extensive if masonry or jointing is in poor condition.

Figure 24: Engineer testing an installation.



6

Glossary

Air termination The upper part of the external lightning protection system intended to intercept lightning flashes. It may consist of a single finial or a number of interconnected finials and horizontal conductors.

Bond A metallic connection between the lightning conductor and adjacent metalwork.

Earth A reference point, conventionally taken as zero, for all other voltages on the system.

Earth electrode A metal rod of low resistance driven into the ground. This is part of the earth termination system provides direct electrical contact with the earth and disperses the lightning current in the ground

Earth mat A lattice of copper tapes. Typically, mats are one to two metres square, buried in the ground, often in an earth enhancing compound.

Faraday cage A network of conductors laid over the roof and down the walls at intervals, connected to the earth by earth electrodes.

Finial A metal rod or part connected to the lightning conductor at the highest point which will carry the lightning current into the down conductors .

Impedance A property of a conductor, measured in ohms, which determines how easily electricity flows.

Inspection pit A purpose-made ground level pit at an earth electrode to enable maintenance access.

Ohm A measure of impedance of a conductor to the flow of electricity.

Quinquennial inspection An inspection of the fabric of a building carried out every five years. Quinquennial inspections are a policy of Anglican and Roman Catholic churches.

Ring conductor A conductor buried around the outside of a building, connected to all down conductors and earth electrodes.

Sideflash A discharge of energy from the conductor to adjacent metalwork, following the ionisation of air or breakdown of the insulation separating material.

SPD A Surge Protection Device which is a normally open switch but which closes when the voltage across it exceeds a threshold level diverting surge energy to earth. There are three types (see [Section 4](#)).

Strike

Direct strike When a lightning bolt makes contact at the highest point.

Indirect strike The surge of electricity and the effect on equipment and structure when a lightning bolt makes contact.

Side strike A lightning strike that makes contact below the highest point.

Surge A sudden increase of voltage, always of short but intense duration.

Tower-only system A church lightning protection system where the tower or spire is used to protect all or most of the remainder of the church via the cone of protection method. It involves two conductor down tapes on opposite sides of the tower connected to earth pits and an air finial or finials at roof level.

Voltage A measure of the potential difference (in volts) between a conductor and earth during a strike.

Zone of lightning protection The area that a lightning conductor protects.

7

Further reading

Historic England publications

Practical Building Conservation series

This series of fully illustrated books published by Routledge provide detailed guidance on understanding, deterioration, assessment and care and repair. More information is available on [HistoricEngland.org.uk/abc](https://www.historicengland.org.uk/abc).

Building Environment (2014)

Concrete (2013)

Conservation Basics (2013)

Earth, Brick & Terracotta (2015)

Glass & Glazing (2012)

Metals (2012)

Mortars, Renders & Plasters (2012)

Roofing (2013)

Stone (2012)

Timber (2012)

Historic England 2017 *Metal Theft from Historic Buildings: Prevention, Response and Recovery*

Historic England 2018 *Energy Efficiency and Historic Buildings: Solar Electric (Photovoltaics)*

Historic England 2018 *Fire Safety: Hot Work and Historic Buildings* advice note available for download on [Historic England.org.uk](https://www.historicengland.org.uk)

Historic England 2018 *Insuring Historic Buildings and other Heritage Assets*

Other publications

Allen, N L 1988 *The protection of churches against lightning*. London: Council for the Care of Churches

Allen, N L 1988 *Sideflash in lightning protection: a report on tests with masonry*. Manchester: University of Manchester, Institution of Science and Technology

Anderson, R 1879 *Lighting conductors, their history, nature and mode of application*. London and New York: E and FN Spon

British Standards Institution 2011 [BS EN 62305-3:2011](#). *Protection against lightning: Physical damage to structures and life hazard*

British Standards Institution 2018 [BS 7671:2018](#) *Requirements for Electrical Installations. IET Wiring Regulations*

Cooray, Vernon 2009 *Lightning Protection* London: Institution of Engineering and Technology (IET)

Ecclesiastical Insurance 2018 [Lightning Protection for Churches](#), advice note available for download on www.ecclesiastical.com

Gertler, Charles G and O’Gorman, Paul A 2019 '[Changing available energy for extratropical cyclones and associated convection in Northern Hemisphere summer](#)' *Proceedings of the National Academy of Sciences of the United States of America* Vol 116 (10) 4105–4110

Health and Safety Executive (HSE) 1974 [Health and Safety at Work etc. Act 1974](#)

Health and Safety Executive (HSE) 2015 (3rd edn) [The Electricity at Work Regulations. Guidance on the Regulations](#)

Henshaw, Michael L 2007 [Protection against lightning, A UK guide to the practical application of BS EN 62305](#) BSI Business Group

National Meteorological Library and Archive 2011 [Fact sheet 2: Thunderstorms](#). v01, 11/0434

Webpages and online advice

ChurchCare (Church of England)

www.churchofengland.org/more/church-resources/churchcare

- [Lightning Protection Systems](#)
- [The Faculty Jurisdiction Rules 2018](#)

Examples of online diocesan advice:

- [London](#)
- [Rochester](#)
- [Chichester](#)

Ecclesiastical Insurance 2018 Risk management and guidance. [Lightning advice for churches](#)

Health and Safety Executive (HSE) [Workers' health and safety](#)

Institution of Engineering and Technology (IET) [BS 7671](#)

National Meteorological Library and Archive [Thunder and lightning](#)

8

Where to get advice

8.1 Useful organisations

Association of Technical Lightning & Access Specialists
6-8 Bonhill Street
London EC2A 4BX
Tel: 0844 249 0026
Fax: 0844 249 0027
Email: info@atlas.org.uk
www.atlas.org.uk/

Chartered Institute for Archaeologists (CIfA)
Power Steele Building
Wessex Hall
Whiteknights Road
Earley
Reading
Berks RG6 6DE
Tel: 0118 966 2841
www.archaeologists.net

ChurchCare
Cathedral and Church Buildings Division
Church House
27 Great Smith Street
London SW1P 3AZ
www.churchofengland.org/more/church-resources/churchcare

Ecclesiastical Insurance
Beaufort House
Brunswick Road
Gloucester
Glos GL1 1JZ
Tel: 0345 600 7531
Email: risk.advice@ecclesiastical.com
www.ecclesiastical.com

Electrical Contractors Association (ECA)
Rotherwick House
3 Thomas More St,
London
E1W 1YZ
Tel: 020 7313 4800
www.eca.co.uk

Institution of Engineering and Technology (IET)
Michael Faraday House
Six Hills Way
Stevenage
Herts SG1 2AY
Tel: 01438 313 311
Email: postmaster@theiet.org
www.theiet.org

Institute of Historic Building Conservation (IHBC)
Jubilee House
High Street
Tisbury
Wilts SP3 6HA
Email: support@ihbc.org.uk
www.ihbc.org.uk

National Association of Inspectors and Testers (NAPIT)
4th floor Mill 3
Pleasley Business Park
Mansfield
Notts NG19 8RL
Tel: 0345 543 0330
Email: info@napit.org.uk
www.napit.org.uk

National Inspection Council for Electrical Installation Contracting (NICEIC)
NICEIC Customer Services
Tel: 0333 015 6625
Email: enquiries@niceic.com
www.niceic.com

The Listed Property Owner's' Club
Lower Dane
Hartlip
Kent ME9 7TE
Tel: 01795 844939
Email: info@lpoc.co.uk
www.lpoc.co.uk

Steeplejack and Lightning Protection Training Group
6-8 Bonhill Street
London EC2A 4BX
Tel: 0844 249 0023
Email: info@slptraininggroup.org.uk
www.slptraininggroup.org.uk

The Society for the Protection of Ancient Buildings (SPAB) including the SPAB
Mills Section
The SPAB
37 Spital Square
London E1 6DY
Tel: 020 7377 1644
Email: info@spab.org.uk
www.spab.org.uk

8.2 Contact Historic England

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Brooklands
24 Brooklands Avenue
Cambridge CB2 8BU
Tel: 01223 582749
Email: eastofengland@HistoricEngland.org.uk

Fort Cumberland
Fort Cumberland Road
Eastney
Portsmouth PO4 9LD
Tel: 023 9285 6704
Email: fort.cumberland@HistoricEngland.org.uk

London and South East
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Bristol BS1 4ND
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Email: [southwest@
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Fire Fly Avenue
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Email: [swindon@
HistoricEngland.org.uk](mailto:swindon@HistoricEngland.org.uk)

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Tel: 01904 601948
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HistoricEngland.org.uk](mailto:yorkshire@HistoricEngland.org.uk)

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