General Advice for Architects and Surveyors

on the Requirements for Lightning Protection

of Parish Churches.

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for the Care of Churches of

Canterbury and Rochester Dioceses

The Diocese of Canterbury

Living faith, building community, transforming lives

Diocese of Rochester

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Contents

1. Introduction.

This guide has been considerably revised since the first edition in 2007. It aims to assist architects, building surveyors and other professionals in drawing up a technical requirement or more detailed specification when inviting contractors to tender for initial installation, subsequent routine maintenance or repair and upgrading of the lightning protection of Anglican parish churches (but not cathedrals) in the dioceses of Canterbury and Rochester and assessing and comparing submitted tenders. This guide is complementary to the general guide 'Diocesan Guide– Church Lightning Protection' and assumes much of the guidance given therein.

The national standards as listed section 11, are the basis of this guide and the requirements for lightning protection of structures. The main Standard is BS EN 62305 *Protection against lightning,* consisting of four parts. The current edition is Edition 2. The international version of edition 3 is due for publication in 2018 and will therefore probably be published as a BS EN Standard in 2018/19. Readers who require more guidance than can be included in this guide but without the full complexity of the four-part standard may find the free manufacturers' guides or the BS Guide, as listed in section 11 meets their needs. These guides may not be based on the latest edition.

It is possible to interpret those standards in such a way that specialist contractors can produce estimates that may not be presenting the information on the same basis, making it difficult to draw a conclusion about to whom to give a contract. There is a danger that decisions may be made solely based on the lowest tender offered on the assumption that the outcome of the project will give a satisfactory long-term life span, and that the estimates are looking at the same quality of installation.

This is an area of technology where there is limited understanding on the part of those who are required to act under ecclesiastical law as inspecting architects and as parish architects. It is not surprising therefore that, with all the other things under their care, they should turn to specialist contractors to seek estimates and to carry out the work. Like so many other areas of contract work, it is not easy to determine that those who are listed as members of ATLAS (Association of Technical Lightning and Access Specialists) are necessarily all playing on a level playing field. ATLAS is only an encouraging and information-disseminating organisation. Whilst there are entry requirements for membership they are not too difficult to obtain. After that the membership is not policed in the same way, as are the members of the ECA or NICEIC in electrical contracting. It is difficult enough for Parochial Church Councils to find financial resources for ministry, let alone to support their legal responsibilities to maintain Listed Buildings. Most churches should be properly protected against the worst effects of a lightning strike. There is evidence from incidents in these dioceses and a neighbouring diocese that this is not always the case.

To employ only steeplejacks without technical supervision, who say that they can carry out lightning protection, is potentially to court disaster. ATLAS run courses on the current BS EN 62305 *Protection against lightning* Standard and issue certificates, one for Part 1 *General principles*, Part 2 - *Risk Management*, and Part 3 - *Design of protection systems* and another for Part 4 – *protection of electrical and electronic systems*. Contractors should be asked to produce relevant copies of these certificates. It is also a problem that some architects, without reference to an expert, will direct changes to a layout without properly understanding the effect of what they have done. There is often too, an issue about visual intrusion; this is addressed in this document.

2. Risk Management

For a church without protection, a risk assessment to determine the need for protection and the required level of protection should be carried out as described in BS EN 62305 – Part 2. The Parochial Church Council or its agent should provide the contractor with all the necessary parameters for satisfactory completion of the assessment, (see Appendix 1).

In Edition 2 of BS 62305 there are four separate risk calculations:

- R_1 - The risk of loss of life or permanent injury of persons,
- R_2 - The risk of loss of a public service, such as electricity, gas, water and communications,
- R_3 - The risk of loss of cultural heritage

R_4 - The risk of economic loss of the structure, its contents and activities.

Of these four risks, normally only R_1 and R_3 are relevant, albeit it may be worthwhile to provide protection for electrical and electronic equipment. For a church, these two risks consider two sources of damage, namely a direct strike to the building and a direct strike to a conducting electrical service, such as mains electricity, telephone and data lines supplying the building. Strikes near the building and electrical services are not normally considered in the risk assessment for churches. Each risk has its own tolerable risk with which the calculated risk is compared. The risk management process is completed by considering the lowest level of protection and the most economic methods of protection to bring all the risks below the relevant tolerable risks. There are four levels of protection (LPL) from Level IV, the lowest level, to Level I, the highest level. In Kent, all but the very largest parish churches would require only the lowest level of protection by a corresponding Class IV Lightning Protection System.

For churches already having some protection and considering upgrading this protection, it will normally be adequate to assume that an LPS Class IV is required.

3. Overall design

3.1 General

The LPS Class determines the positioning of air terminations, the number of down conductors, the separation and bonding requirements and the rating of surge protective devices, as described in succeeding clauses. Many of our churches are listed buildings. It is important that the whole external lightning protection system is designed sympathetically with the architecture of the building, especially if the church is a listed building. Section 3 deals with the general requirements of the lightning protection system. More detailed application is contained in Section 4.

3.2 Air terminations

The positioning of air terminations is determined by rolling an imaginary sphere over and around the building and/or in contact with the ground. Any part of the building which touches the sphere is a point of potential attachment of a lightning strike and should therefore be equipped with an air termination. The radius of the sphere is determined by the LPS Class and is 60 m for LPS Class IV or 45 m for LPS Class III. This radius relates to the probable step length of the lowest lightning peak current in the LPL range of protection, which for LPL IV is 16 kA. The lower current strikes, having shorter step lengths can 'sneak in' to points not open to higher current strikes.

Although an LPS having air terminations solely on a tower and spire will probably deal with all high current strikes and is acceptable to Ecclesiastical Insurance, it often does not give full protection to the whole church for the lower current, but still seriously damaging, strikes. An example taken from an actual church is shown in Figure 1. This is of course only a 2-D view of a 3-D situation but gives a strong indication of the lack of coverage. An air termination system to give full coverage is likely to include roof ridge conductors as air terminations, interconnected with one another and with tower/spire air terminations.

BS EN 62305 specifically states that radioactive air terminals shall not be used. It also strongly recommends that only the real physical dimensions are used in determining the effectiveness and positioning of air termination regardless of the claims of enhanced performance of devices such as early streamer emission (ESE) air terminals.

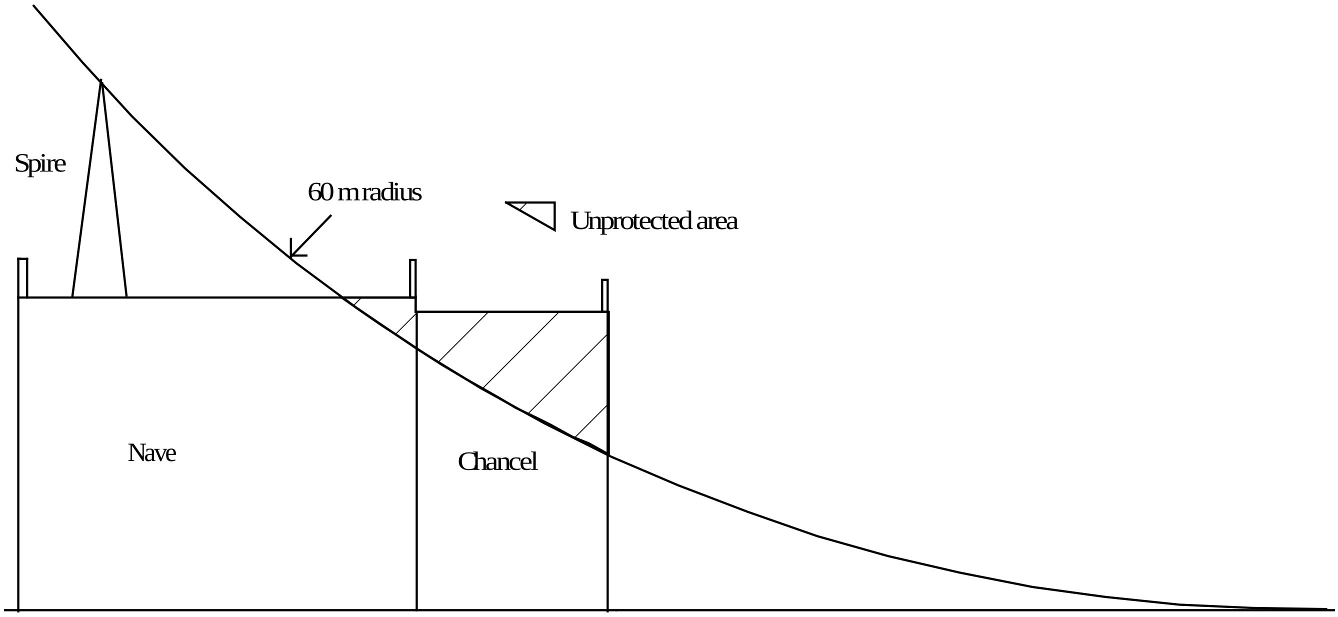


Figure 1 – Unprotected area with spire-only protection

3.3 Down conductors

Down conductors carry the lightning current from the air terminations to ground level. For an LPS Class IV the typical separation should be about 20 m with a total number of down conductors of one for every 20 m or part thereof of the taut string perimeter of the church. For an irregularly shaped building such as a typical older Church with tower and perhaps a spire, it is good practice to install two well-spaced conductors on the tower, and spire if there is one. A tower and spire is likely to receive the more severe strikes and so is more susceptible to flashover from a down conductor to other conducting material. Having two conductors splits any lightning current and reduces the risk of flashover (see section 4.5 on separation). A down conductor should follow a direct route to the ground within the constraints of architectural features. A down conductor should include a test break at or near ground level. From the lower side of the test break, an earth connecting conductor takes the lightning current to the earth point, commonly the top of an earth rod.

3.4 Earthing

In a Type A earthing system, as appropriate to a Church, each down conductor has its own earth point, consisting of one or more rods or other earth conductors, such as mats or horizontal conductors, to achieve a good connection to the ground. Each interconnection below ground should be provided with an earth inspection pit to enable subsequent testing and if found necessary interconnection to further rods etc., to reduce the earth point resistance. The overall measured network resistance of all the earth points should be below 10 ohms which implies that individual earth points should have on average a resistance of somewhat less than 10 ohms x no. of down conductors. It is also desirable for separation requirements (see 4.4) that the ratio of adjacent earth points should be within the ratio of 2:1. The required earth resistance values are the same for all LPS Classes. Architects should generally specify a resistance significantly lower, say 15 or 20% less than the maximum, to allow for seasonal variation and longer-term deterioration.

3.5 Separation and bonding

As far as possible an LPS should be designed to provide adequate separation between lightning conductors and other extensive conducting material. This is particularly important at height, where high voltages are experienced. The required separation can be reduced by increasing the number of down conductors and by ensuring good earthing. The required separation is also affected by the insulation value of the material between the lightning conductor and other conducting material being considered. It should be noted that stone is a less effective insulator than air. Designing a system to a higher level of protection, LPL I or II, increases the required separation as the higher level of protections are designed to withstand higher currents, leading to higher voltages on a lightning conductor. The actual separation can be increased by moving the designed or actual position of lightning conductors and/or electrical equipment and/or cabling and/or other conducting material. It is necessary therefore to consider whether there is or will be adequate separation between lightning conductors and other extensive metalwork (greater than about 2 m x 1 m) such as bellframes, clockworks, clock faces, lead roofing, rainwater goods, electrical wiring and fittings and communications equipment on tower roofs.

If adequate separation is not achievable, the alternative is electrically to bond the lightning conductor and the critical conducting material. Appropriate sizes and, outside, unobtrusive covering of bonding cables are important. Where live cables are involved, bonding can be achieved only by surge protective devices as described in clause 3.6.

Regardless of separation distances bonding between the nearest lightning conductor and the mains electricity supply's main earth terminal is required in order to bring the LPS and the electrical system to similar voltages at ground level.

3.6 Surge protection

BS EN 62305 regards the fitting of Type 1 Surge protective devices (SPDs) at the intake of electrical services as an integral part of bonding the installation's live cables to an external LPS, in order to minimise fire risk by sparking. Type 1 SPDs are designed to accept the substantial current and energy of a partial lightning current and divert most of this to earth. However, the 'let-through' voltage of the SPDs, as well as the lesser currents induced by strikes near to the service cables and the building, can be damaging to electrical cabling and equipment especially electronic equipment, e.g. organ, fire alarms, CCTV, smoke detectors. Type 2 and 3 SPDs, fitted downstream of, or as combined units with, Type 1 SPDs can give fuller protection. Sound systems and other equipment switched on for limited periods are not so prone to damage. The same principles apply to any other conductive incoming service, such as telephone lines, with conductors not at nominal earth potential. Dehn(UK) provides a free service to advise on surge protection.

4. Design details

4.1 Air Terminations

There may be a metallic weathervane mounted on the spire tip. This should, be utilised as the air termination with the down conductors properly bonded to the base of the fixings of the weathervane. If there is only a tower, then a ring conductor should be fixed to the inside of the wall just below the crenellation, connected to vertical rods, extending to 300 mm above the top of the wall, at the exposed tower corners (i.e. no coverage by a flagpole, stair turret weathervane etc) and to the down conductors. Where there are any pinnacles, a tape or rod should be taken up the back face to avoid visual impact from the ground. Small strike plates should be carefully formed by baring back the PVC serving of the tape or rod by at least 50 mm, and extended by no more than 300 mm above the tip of the pinnacle. These tapes or rods should be joined to the ring conductor. Any metallic flagpole mounted at the top of the tower shall be bonded to the ring tape, and if the flagpole is of non-conducting material but penetrates the cone of protection this may need a specific tape/rod run, preferably up the inside of the flagpole to its top, connecting at its base to the ring conductor.

For all roof ridges, tape or rod shall be used and applied to the surface over which it is run using appropriate fixings set at a maximum of 1 m intervals. It is important to minimise the invasiveness without losing sight of the need to ensure that the air termination tapes or rods are as close to the top of the ridge as is practicable. Where crosses are mounted at the ends of ridges on naves, chancels, transepts and those porches that come within the need for protection elements, small strike points shall be carefully formed by baring back the PVC serving of the extended ridge tape or rod by at least 50 mm, fixed at the back of the cross and extended by no more than 300 mm above the tip.

Most parish churches are unlikely to have spires of much greater than 35 metres overall height and this would give a typical angle of protection of 40^0 from the tip of the spire down to ground level, but a greater angle to the nave ridge. Angles of protection are given in BS EN 62305: 2011, Part 3 (Figure 1 in Ed 2).

Where it is desirable and practicable to run tapes or rods below the tile or shingle surface then it is necessary to connect the tape or rod to outside air terminations by one of three means as shown in Figure 2 and detailed below.

- Strike plates of at least 50 mm x 50 mm x 3 mm thick may be fitted on the tile's upper surface at every 5 m of the run. They are riveted or otherwise firmly fixed to a 25 mm x 3 mm tape which runs under the bottom edge of the tile and then upwards to connect to the ridge tape with a connector conforming to BS EN 62561-1. It is important that the connections of the strike plate to the connecting tape and of the connecting tape to the ridge tape maintain a good electrical connection. The contacting surfaces should be coated with an anti-oxidant paste e.g. Contax. Close liaison with the tiler is necessary to ensure that the strike plate is turned out onto the tile surface, with the top edge no more than 75 mm below the ridge.
- Strike pads which sit on the ridge and are connected with a conductor routed vertically downwards between two ridge tiles to the ridge conductor. Furse of Nottingham make such devices in either copper alloy, part no. PL010 with a copper stem part no.SM010 or aluminium alloy part no. PL005 with a stainless steel stem part no. SM005. These strike pads have a diam. of 112 mm. Strike pads must be placed at a maximum spacing of 5 m.
- A vertical air termination rod extending at least 300 mm above the ridge. Rods must be placed at a maximum spacing of 10 m.

With strike pads and vertical rods, it is important that the entry between the ridge tiles is well sealed to avoid water ingress, allowing for expansion and contraction of the metal.

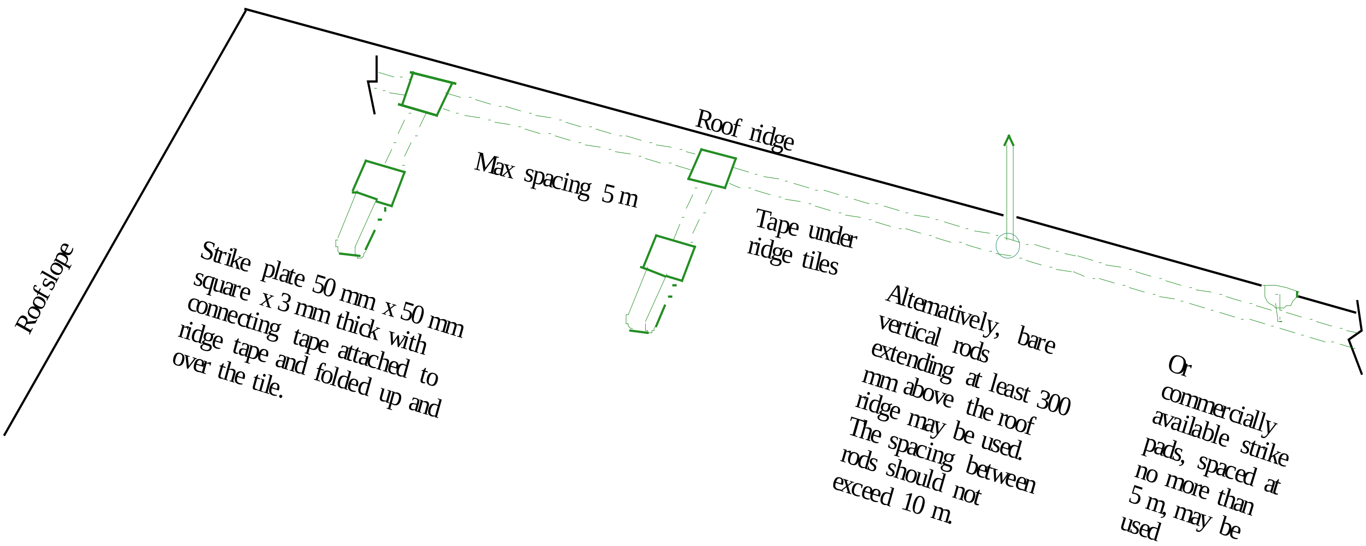


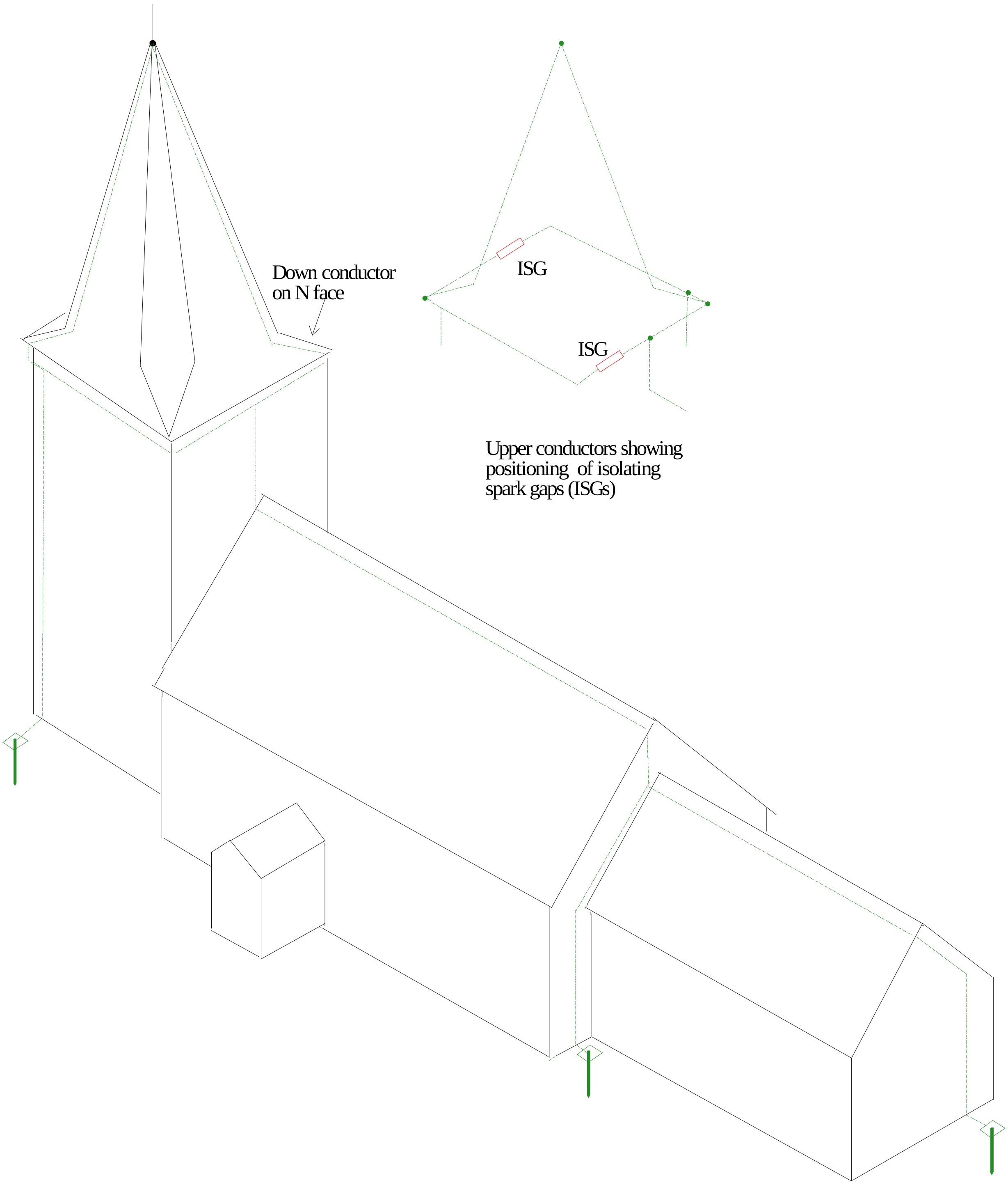
Figure 2 – Air terminations for ridge conductor placed under the ridge tiles

4.2 Down Conductors.

As near as is practicable there should be two down conductors generally set on opposite faces of a spire or tower. These down conductors should be of 8 mm diameter rod or 25 mm x 3 mm tape in PVC-served aluminium or copper. The PVC serving should be coloured to match as near as possible the colour of the cladding of the spire or stonework of the tower. Generally, a slightly darker colour rather than a slightly lighter colour is less obtrusive visually. Also on S facing aspects the colour will fade somewhat over the years. On spires, rods are generally preferable and should be run as close to a break line as possible to ensure that the invasiveness is kept to a minimum.

When a spire is being re-shingled or tiled, it may be possible to run these conductors under the surface and this should be considered. If this approach is used, care must be exercised to see that the tape is laid in a routed slot in the boarding to which the shingles may be fixed, at not greater than 50 mm depth below the shingle surfaces, and that the tape is free to move to take up any expansion and contraction.

Where a spire is set on a tower it is generally advisable to include a ring conductor at the spire-tower broach, both to help equalise the current in the conductors and also to provide convenient and unobtrusive connections between the down conductors themselves and to ridge tapes. Where this is the case, isolating spark gaps should be inserted in the ring to allow for proper continuity testing of the two down conductors that connect at the tip or metallic weathervane of the spire (see Fig 3 and Appendix 2).



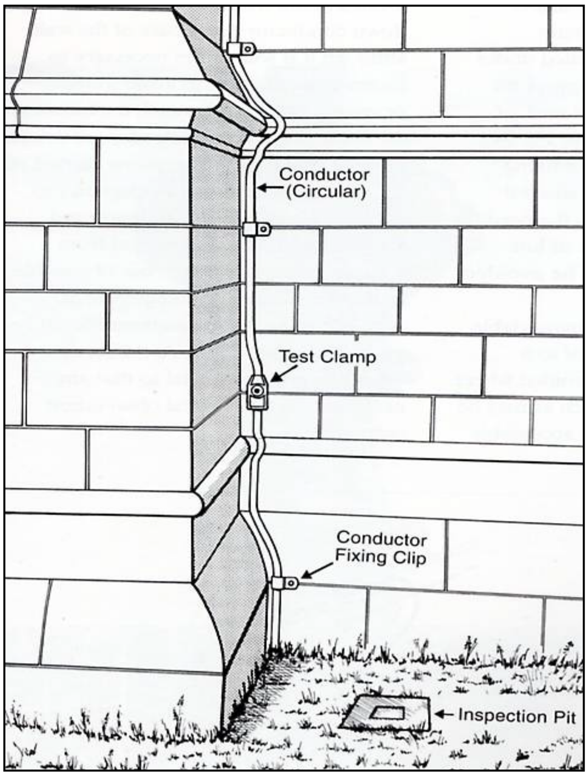
Note: The system layout, including bonding connections, which are not shown here, should facilitate testing as described in 8.2

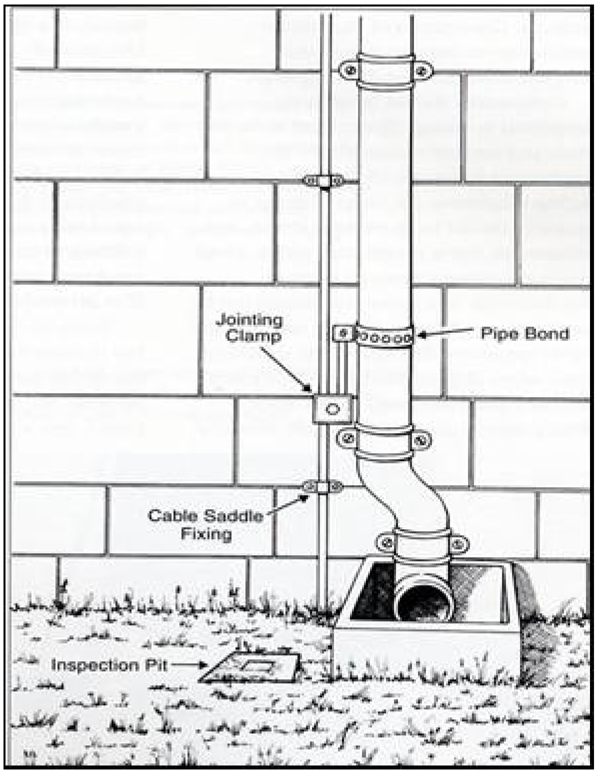
Figure 3 – Layout of a typical smaller parish church installation

Lightning conductors must not be routed through water spouts and should were possible avoid being routed in any water carrying channel. Down conductors should terminate at about 500 mm above ground level at a test break which must be a bi-metallic joint if aluminium has been used on the upper network. The test break transfers connection to a copper conductor of the same cross-section to continue down to the earth connection (see Fig.3).

Down conductors should be fixed using clips of the same colour as the coating of the conductors, if convenient, following the lines of any nearby rain water down pipe etc. (see Fig.4). The clips should be fitted at a maximum spacing of 1 m and where possible screwed into mortar joints and not into stonework.

Two examples of conductor runs using 8 mm round section conductors, including bonding to rainwater goods are shown in Figure 4. Where it is felt appropriate to fit anti vandal protection to down conductor positions at ground level this should not be of metallic construction for reasons of electrical safety and visual obtrusiveness. UPVC guards designed to fit both 25 mm x 3 mm tape and 8 mm rods are available in 3 m lengths from Furse of Nottingham in the same colours as conductor coverings. The casing should be aesthetically matched to the surface to which it is to be attached. Hardwood guards may also be used. Adequate access should be provided to test breaks and joints to allow testing and inspection of joints.





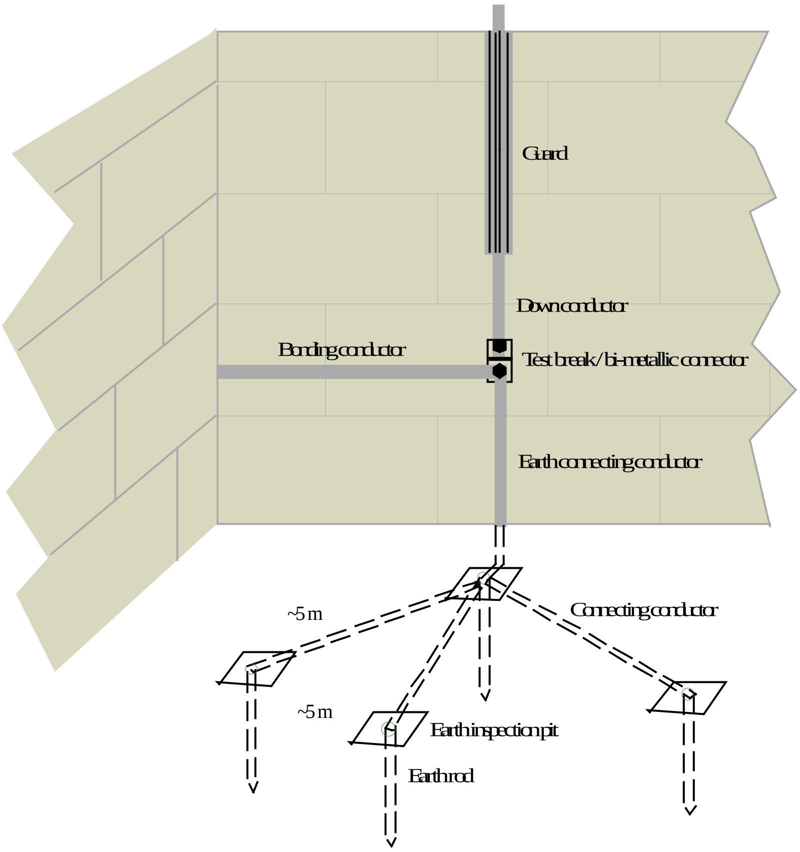
Note: In (b) there normally would be a test break/bi-metallic joint below the jointing clamp

(a) **(b)**

Figure 4 – Examples of down conductor runs and bonding to rainwater goods

4.3 Earthing

Often contractors will quote that the earthing will meet the requirements of BS EN 62305. The requirements BS EN 62305 are more relaxed than those of its predecessor, BS 6651. As noted in section 3.6 and detailed in 4.4 Table 1, it is desirable for earth point resistances of adjacent earth points to differ by a factor less than 2:1, as this helps to equalise the lightning current in down conductors and reduce the separation distances. However, where a system is being upgraded from a single earth point of less than 10 ohms to several earth points it may uneconomical to install all other earth points to a resistance of less than 20 ohms. There is however no requirement comparable to that of BS 6651 that stated each earth point must have a resistance of no more than 10 ohms x the number of down conductors. What is important is to **specify** a maximum measured network resistance of no more than about 8.5 ohms to ensure than upgrading of earth points is unlikely to be needed for several years. To this end it may also be good to specify a maximum earth point resistance of no more than 8.5 ohms x number of down conductors. The general Diocesan leaflet allows then, in subsequent routine testing, that the measured earth network resistance must not exceed 10 ohms and the measured resistance of individual earth points must not exceed 12 ohms x the number of down conductors.



Where an earth point consists of two or more earth rods or other earthing conductors, then the connecting conductors should retain their plastic sheath. Bare connecting conductors, being at a shallow depth of say 200 mm to 300 mm, are in soil of very variable resistivity through rain and drying out and can give rise to misleading measurement of earth point resistance and generally are in the effective volume of the earth rod so do not assist in earthing. Each earth rod should be fitted with an earth inspection pit. Figure 5 shows a possible layout.

But, on very rocky ground, this approach may not be practicable and the use of ring tapes around the building should be considered. These shall be of not less than 25 mm x 3 mm cross section and of bare copper, and, dependent on archaeological constraints, laid as deeply as is practicable starting at least 1 metre away from the building perimeter.

Figure 5 – A possible layout of conductors earthing conductors

Soil resistivity surveys enable one to predict the depth of rod required to achieve a particular value of earth resistance. However, such surveys cannot predict whether it is possible to drive rods to the required depth because hardness of rock or obstructions such as large flints may make further driving impossible. In difficult situations, it is possible to use a crow's foot arrangement with 3 or 4 rods at points separated from one another by a distance of about the depth of the deepest rod (see Figure 5). Closer spacing reduces the efficacy of the rods as the volumes of 'influence' overlap.

There should be one or more earth rods connected to each down conductor. Only driven earth rods should be used unless soil resistivity tests have proved that other measures may be necessary. Each rod shall be not less than 16 mm nominal diameter and be driven to a depth of not less than 2.4 m. The nearest rod should be driven as close to its connecting down conductor as is practicable but clear of building foundations, say 1 m from the wall. Other rods should be spaced horizontally from one another and the nearest rod by a distance equal to the depth of the deepest rod in accordance with guidance given in BS 7430. If the depth of an original rod is unknown, then there should be a minimum horizontal separation of 5 m. Although it is generally preferable to have a single vertical rod at each earth point it is sometimes necessary in conditions of hard rock and/or high soil resistivity to insert rods at more than one position.

The connection from the down conductor to the earth rod should be of either 25 mm x 3 mm PVC-served copper tape or 8 mm diameter PVC-served copper rod. The reason for the PVC serving is that the earth connecting tape being trenched at a fairly shallow depth can contribute to a varying and misleading earth rod resistance. A typical arrangement is shown in Figure 4.

Note: ***Other measures include the pre-drilling of boreholes into which a slurry of Marconite (or similar material) is poured after the rods have been suspended in the borehole that will usually be not less than 100 mm diameter. Where lattice mats are proposed, these should be set flat on a pre-laid Marconite bed of 200 mm depth at least 1.5 metre below ground level and then overlaid with a further 200 mm of the same material, allowing this to set before backfilling with soil. Lattice mats should be avoided if possible in churchyards with burials.***

4.4 Separation

Very large voltages develop at height on lightning conductors during a lightning strike. Part of the strike current may therefore seek alternative paths to earth through other conducting material by sparking across flammable material to that conducting material.

The separation requirements, which depend on several factors, are given in clause 6.3 of BS EN 62305-3:2011. Table 1 below gives separation distances, using the simplified method, for typical installations.

Table 1 – Separation distances

Required separation for lightning protection system Class IV			
Height above bonding point or earth	**Number of down conductors**		
	1	2	3 or more
	Reducing factor		
	1	0.66	0.44
20 m	1.6 m	1.1 m	0.7 m
10 m	0.8 m	0.6 m	0.4 m
1 m	0.1 m	0.1 m	0.1 m

Notes
1. The separation distances are those required over or through stonework. Distances through air should be halved.
2. Distances have been rounded up to the nearest 0.1 m.
3. The separation distances above assume that the earth resistances of (adjacent) earth points differ by a factor of no more than 2:1. If this is not so the distances are those in the first column, i e. with a factor of 1.

If possible, the separation should be increased to an adequate distance by appropriate siting of new down conductors and/or moving conducting material such as cables and electrical fittings. Where the required separation distance cannot be met, the conducting material should be bonded to the nearest lightning conductor (see section 4.5 below).

4.5 Joints and Bonds

Where there is inadequate separation between the LPS components and other conducting material it will be necessary to bond them together electrically in accordance with clause 6.2 of BS EN 62305-3:2011. The bond must have sufficient cross-sectional area to conduct that part of the lightning current expected to flow through the bond. Typically, this will be met using at least the minimum dimension specified in the Standard for an internal bond; 6 mm^2 if in copper. Reliance on metallic rainwater goods to take the place of a tape or circular conductor must not be considered valid since electrical continuity between components of metallic rainwater goods cannot be guaranteed.

Steel bellframes, clock mechanisms, incoming metallic services and any other isolated metal work having inadequate separation must be bonded by a short route to the nearest down conductor. Where bonding to lead work is required, special care must be taken to ensure not only that the bond is good, but also that corrosion inhibitors have been carefully applied to the joint to ensure that there shall be no galvanic action at the joint. Where metallic roofing covering is bonded, care must be exercised to see that weatherproofing is not compromised. Down pipes of 20 m height or greater, which are close to the down conductor must be bonded at top and bottom of the pipe to the down conductor, the bottom connection being at or just above the test break, due regard being paid to avoid direct copper to aluminium contact. Other downpipes require a single bond only. Where it is necessary to run an internal bond inside the building care shall be taken to see that such bonds are adequately separated from electrical items unless the electrical protective earth conductor is adequately sized to deal with a portion of the lightning current, e.g. electrical clock drives may need to have larger cross section equipotential bond than that called for in BS7671. Also, if say a bellframe is bonded to the lightning conductor then it is necessary to review the separation between the bellframe and other conducting material, such as clockworks, and apply further supplementary bonding where there is inadequate separation. Generally, joints in tape runs shall be made with an appropriate junction clamp with a full 25 mm overlap.

The main equipotential bond from the nearest down conductor to the electrical main intake shall be of not less than 16 mm^2 cross section PVC served copper or 22 mm^2 cross section PVC served aluminium, and shall be as short and as direct as is possible. If the bond is in lightning conductor material, it must have a suitable blending PVC coating. If the bond uses a cable, the PVC serving shall NOT be green/yellow anywhere on the external faces of the building. An unobtrusive colour e. g. black, grey or brown may be used at low level.

The connection at the down conductor shall be at or above the test break and fixed in such a way that the connection can be easily disconnected for testing purposes. This bond must go by a short route from the nearest down conductor to the incoming electrical supply's main earth terminal (MET) and must not be in series with any other bond. Both ends of the conductor must be clearly labelled as to its function (See section 7).

Often it is necessary to drill through a considerable thickness of difficult wall construction to achieve the shortest run. If the conductor is a PVC-covered aluminium rod it should be passed through a sleeve inserted after drilling, to ensure that the PVC covering is not scuffed whilst pulling the rod through. Making good shall be carried out using only lime mortar of grade NHL (Natural Hydraulic Lime) 3.5 or as otherwise directed by the architect.

Care must be taken to check that other incoming utilities e.g. gas, water, telecommunications, oil lines etc., have been equipotentially bonded in accordance with BS7671 or as required by the supplier of the utility, and if not, this shall be considered as being required and discussed with the supplier to determine whether or not suitable Surge Protection Devices (SPDs), should be fitted between the LPS and the incoming service at the entry point to the building of the service concerned (see 4.6 below).

At any form of connection, allowance must be made to ensure that the current transfer interface is between the material being connected and ***not*** via a screwed thread. The method of connection for all joints should be either by a factory-made clamp connecter, brazing, welding, crimping, seaming or bolting***. In no circumstances should self-tapping screws be allowed, particularly where connecting to other metal work for bonding purposes.*** Additionally, when bolting flat strip, the minimum requirement is two M8 bolts or one M10 bolt. For riveted joints, at least four rivets of 5 mm diameter should be used. Bolted connections of flat strip to sheet metal of less than 2 mm thickness should be shimmed for an area of not less than 10 cm^{2,} and not less than two M8 bolts should be used.

4.6 Surge protection

Type 1 surge protection is a requirement on all incoming conducting services with live cables, e. g. electrical power, including PV solar panels, telephone and data services. Not all Association of Technical and Lightning Access Specialists (ATLAS) members can themselves deal with the technical aspects of surge protection.

4.6.1 Surge protection of electrical power circuits and equipment.

Appendix 3 indicates the different types of electrical power supply that may be encountered. All phases supplied even if not in use must be protected. The SPDs to be fitted must be not less than 10/350 µs impulse rated and must be sited as close as is practicable to the main switch for the whole system, within an enclosure of appropriate IP (ingress protection) rating. All cabling must be as short as possible and suitably rated for this proximity to the service fuse. Where the current rating of the supply is higher than that of the SPD, then the SPD should be protected by fuses related to the SPD's rating.
In may be convenient to install an isolator upstream of the SPD so that the SPD can be replaced without disconnection of the supply, e. g. by the supply company's fuses.
For the mains electrical intake, it is necessary to specify the number of phases and the phase rating (shown on the supplier's fuses), typically 3-phase 100 amp. It is possible to fit a combined Type 1 and 2 SPD at a similar price to a Type 1 SPD. A list of some suitable SPDs is given in Appendix 4.

For individual final circuits feeding installed sound systems, an organ or other equipment, except telephones, an in-line unit of 8/20 µs impulse rating (Type 3 SPD) should be fitted. It may also be practicable to have stand-alone plug-in surge units, and where this applies the contractor should be so instructed.

4.6.2 Surge protection of equipment connected to telephone lines.

A BT-approved in-line SPD should be fitted at the master socket or similar position close to the cable intake. It is arranged for the incoming side of the unit to accept the “dirty” line and the outgoing side is used for the telephone, computer modem, Wi-Fi hub, data line for remote monitoring of intruder or fire alarm and any other equipment connections. This unit needs to be fitted as close as possible to an available low impedance earth connection. As far as possible all cable pairs, whether in use or not, should be provided with surge protection. Details of some suitable SPDs are given in Appendix 4 and methods of connection are given in Appendix 5.

5. Requirements for other equipments

The need for adequate separation of the LPS from other conducting material or if this cannot be met then the need for bonding has already been referred to in 3.5 and 4.5. However, there is another important situation arises when external equipment is fitted to a church already having an LPS fitted. Installers of equipment, such as communications equipment on tower roofs, PV solar panels on other roofs and external CCTV cameras, are often unaware of the requirements of BS EN 62305. It is therefore important to specify that any new equipment should be installed with due attention to integration with the existing lightning protection system, particularly the siting of equipment within the protected area of the LPS, adequate separation from the LPS and conducting material already bonded to the LPS, e.g. lead roofing, or bonding to the LPS and the installation of Type 1 SPDs where any equipment is either outside the protected area or is bonded to the LPS, such as antennae active elements and coax cables.

6. Materials

All materials used must conform to the appropriate British Standard. BS EN 62561 *Lightning protection components* series covers most components; see section 9 for relevant parts of the Standard. It is recommended that all components for the external LPS should be of either Thomas & Betts (Furse), A N Wallis Ltd or Dehn manufacture. Surge protection devices are also available from Mersen and Phoenix Contact. See Appendix 4 for details.

All tapes used on the open surface of the building should be of 25 mm x 3 mm cross section or 8 mm diameter round section, in aluminium or copper, PVC served with a colour to match as close as is practicable to the surface over which they are installed. Where applicable, any conductors below tiles or shingles should be of bare copper. Strike plates will be needed for under-tile or shingle applications and these are specified in Fig 2. Commercially available strike plates are unsightly and generally not appropriate for church work.
All joint clamps must be suitable for the metals to be joined. Particularly, where a copper to aluminium joint is required it must be of bi-metallic or stainless steel construction. All joints that are not for testing purposes shall be coated with a universal electrical jointing (anti oxidant) paste on all surfaces and the whole then bound with Denso tape or sprayed with a rubber compound. Joints at the junction between the tapes and circular section material and the test clamp should be treated with universal electrical paste.

Where it is necessary to drill into the fabric to create a fixing for a component such as a tape or circular section conductor, wall plugs should be of nylon and at least 45 mm depth to accommodate a minimum size no.10 stainless steel screw of sufficient length to ensure that at least 40 mm of the thread engages with the wall plug.

Earth rods must have a minimum diameter of 16 mm (nominal size) and be made of copper-bonded steel, solid copper or stainless steel construction, conforming to BS EN 62561-2, generally available in 1.2 m and 2.4 m lengths. The copper-bonded rods are the more commonly used rods. Copper rods are more resistant to corrosion but not so strong for driving into hard soil conditions. Stainless steel rods are also highly corrosion resistant but more expensive.

Rods should be terminated in an inspection pit conforming to BS EN 62561-5 either in concrete or a high-performance polymer; the latter has a lockable lid. If earth mats or plates are necessary they should consist of a lattice construction in copper tape with an overall minimum size of 900 mm x 900 mm x 3 mm. The connecting tape should be of 25 mm x 3 mm copper, PVC served, and the fixing to the lattice should be of sufficient overlap to allow at least three M8 bolts to be spaced in line.

Where it is necessary to treat the soil for lowering resistance at an earth rod or mat, only materials conforming to BS EN 62561-7 shall be used. Marconite is recommended. Conducrete has promising properties and is also currently used, albeit its long-term reliability is as yet unassessed.

7. Labels.

A label, engraved to give black lettering on a white background, using a suitably robust material other than dymo or other system labelling, e.g. traffolyte, must be affixed at the origin of the electrical service, worded as follows: -

**This structure is provided with a Lightning Protection System.
The bonding to other services and the main equipotential bonding should be maintained accordingly.**

Where the main equipotential bond is terminated at the down conductor a permanent, durable label in accordance with BS 951 shall be affixed in a visible position, as below: -

Lightning safety electrical connection – remove for testing only

8. Inspection and Testing.

8.1 Inspection

Inspection of the finished new or upgraded system should be carefully carried out in the presence of the client or the appointed agent. The contractor will be required to show pictures taken during installation of any above ground works which may be concealed from view at ground level, to indicate that all weather and corrosion protection methods called for have in fact been carried out.

The inspection details should be recorded and handed to the client on completion of the works.

8.2 Testing

Prior to the submission of any tender to carry out the work, it is recommended that the contractor carry out soil resistivity tests at the site involved, so that any problems about the correct earth resistance readings being obtained can be financially assessed from the commencement. Caveats in a tender to avoid this approach are not encouraged.

On completion of the works the individual earth points should be assigned a number and located on a record drawing. Each point should be tested and the value of its earth resistance and the depth of the driven rod recorded. The values should not exceed those specified in a contract based on the guidance given in clause 4.3 above.

The system should be checked for continuity between all adjacent pairs of down conductors, with the earth rods and equipotential bonds disconnected. The continuity resistance shall be recorded.

The system shall then be coupled together, excluding for a measurement of the lightning protection earth network resistance, the equipotential bond to the electrical mains service main earth terminal and other bonds providing parallel paths to earth, such as the bellframe to clockworks to the main earth terminal, and the overall resistance of the system measured and recorded. The value should not exceed that specified in a contract based on the guidance given in clause 4.3 above.

The main equipotential bond and other bonds shall then be connected and the whole system resistance measured again and recorded.   The tester must ensure that it is safe to carry out this latter test.

9. Records.

The following records should be prepared by the contractor and handed to the client on completion of the works:

- Scale drawings, showing the nature of the works, appropriate dimensions, materials used and position of all component parts of the LPS including joints. should be specified in the contract.
- The nature of the soil and any special earthing arrangements used.
- The type and location of all earth electrodes.
- The test results and conditions of test (weather at the time of test and ground condition e.g. dry etc.).
- A Certificate of Assurance that all lightning protection components are in compliance with BS EN 62561 Parts 1 to 8 inclusive.
- The name of the person(s) responsible for the installation, inspection and testing.

10. Notes to contract

10.1 Damage to tiles.

It is not always obvious that there is a need to check before the start of works the condition of the existing tiling, which may be in poor condition, such that a workperson, whilst being careful, may crack or break the occasional tile during their work. It is therefore recommended that the following clause be inserted within a contract to ensure that the cost of repairs is covered should there be a dispute between the parties after the works have been completed: -

> ***The architect and the contractor shall meet on site prior to the commencement of roof works to agree the existing condition of the tiling. Particular attention shall be given to ensuring minimum damage to any tiling. If such damage occurs, the contractor shall immediately inform the architect in order to make arrangements for an approved repair. Such repair shall be at the contractor's expense and must be agreed by both parties prior to the contractor leaving the site. As far as is practicable, all such damage shall be repaired to match existing tiling.***

10.2 Safety with Bells.

It should be remembered that where there is work on a steeple or tower containing a set of bells, it may be necessary for workpersons to enter the tower, for example to install bonding to a bellframe or fix internally ladders to be run up the outside of the spire/tower for access. Bell Captains should be advised of this so that all bells are left down during such work.

11. Standards, Regulations and Guides.

BS EN 62305-1: 2011: Protection against lightning Part 1: General principles

BS EN 62305-2: 2012: Protection against lightning Part 2: Risk Management

PD 62305-2:2014 Flash density map 2014 – Supplement to BS EN 62305-2:2012

BS EN 62305-3: 2011: Protection against lightning Part 3: Physical damage to structures and life hazards

BS EN 62305-4: 2011: Protection against lightning Part 4: Electrical and electronic systems within structures

BS EN 62561-1 - Lightning Protection Components (LPC) – Part 1 – Requirements for connection components

BS EN 62561-2 - Lightning Protection Components (LPC) – Part 2 – Requirements for conductors and earth electrodes

BS EN 62561-3 - Lightning Protection Components (LPC) – Part 3 – Requirements for isolating spark gaps

BS EN 62561-4 - Lightning Protection Components (LPC) – Part 4 – Requirements for conductor fasteners

BS EN 62561-5 - Lightning Protection Components (LPC) – Part 5 – Requirements for earth electrode inspection houses and earth electrode seals

BS EN 62561-6 - Lightning Protection Components (LPC) – Part 6 – Requirements for lightning strike counters

BS EN 62561-7 - Lightning Protection Components (LPC) – Part 7 – Requirements for earth enhancing compounds

IEC TS 62561-8 - Lightning Protection Components (LPC) – Part 8 – Requirements for components for isolated lightning protection systems *(not yet published)*

BSI PD CLC/TR 50469 – 2005 Lightning Protection Systems - Symbols

BS IEC 62793:2016 Protection against lightning — Thunderstorm warning systems

ITU-T Recommendation K.46: 2012 Protection of Telecommunication Lines using metallic symmetric conductors against Lightning induced surges

ITU-T Recommendation K.47: 2012 Protection of Telecommunication Lines using metallic conductors against Direct Lightning discharges

BS 7671: 2008 Wiring Regulations (IEE 17th Edition)

BS 7430: 2011 Code of Practice for Earthing

DD CLC/TS 50539-12:2010 Low-voltage surge protective devices — Surge protective devices for specific application including d.c. Part 12: Selection and application principles — SPDs connected to photovoltaic installations, (expected to become BS EN 61643-32).

Electricity at Work Regulations 1989

The Faculty Jurisdiction Rules: 2016

CDM Regulations 2015

BIP 2118 Protection Against Lightning – A UK Guide to the practical application of BS EN 62305 Michael Henshaw. Published by BSI in 2007

Lightning Protection Guide published by Dehn and Söhne

A Guide to BS EN 62305:2006 – *Protection Against Lightning* published by Furse, a subsidiary company of Thomas & Betts

12. Drawings and Photographs.

The architect should provide at tender stage a set of outline drawings to include the roof plan and all four elevations to a suitable scale (say 1:200) at A3 size. It would also be advantageous to include a set of pictures taken all round the building to include any obviously difficult areas so that there is no doubt about where it should be possible to run conductors, and to indicate the point of entry of all services and utilities.

13. Acknowledgement.

This, first, revision of the document has been prepared by The Rev'd Christopher Miles MA, MSc, C Eng, FIET, Lightning Protection Consultant for the Dioceses of Canterbury & Rochester and Church Buildings Council representative on the British Standards Institution Lightning Protection Committee.

Appendix 1

Data

Data Required for a Risk Assessment

To establish if there is a need for Lightning Protection it is necessary to carry out a detailed Risk Assessment as described in BS EN 62305 – Part 2. The church council, its architect or surveyor should ascertain before any contract is considered if a contractor being chosen to tender has the ability to carry out this risk assessment. If that is established then the following information will need to be provided to the contractor to allow satisfactory completion of the assessment.

The data that needs to be collected to carry out the assessment is: -

- Scaled elevations and roof plan of the church.
- Construction materials of walls, roof coverings, (e.g., tiles clay/slate, shingles, or metal and type of metal), internal flooring material and whether carpeted.
- Isolation of the church. Is it within 60 metres of other property, surrounded by trees within 60 metres that are taller than the tower/spire, built on a mound or sited in hilly or flat country?
- Local footpaths close to the church.
- Metal guttering, steel bell frame, metal flagpole.
- Historic Monument Listing of building if appropriate.
- Full occupancy details (see below).
- Detail of incoming electrical service and type of service (see Appendix 2), number of phases in use at the intake position, voltage, frequency, service fuse size. Where the intake is located and whether the incoming cables are underground or overhead. If possible, the distance to the nearest supply transformer.
- List all electronic equipment, e.g., organ, computers, fire alarms, security systems, sound systems.
- Telephone service, whether overhead or underground service, its entry point to the building, and the location of the master socket.
- Gas, oil and water services and where they enter the building. Whether the oil storage tank is metallic, where located in relation to the building and the route of any metallic filler pipe.
- What type of fire precaution equipment exists, if any?
- Any specially valuable contents, especially if likely to be damaged by fire.
- Opening times of the church and typical occupation figures as below.

Risk to People

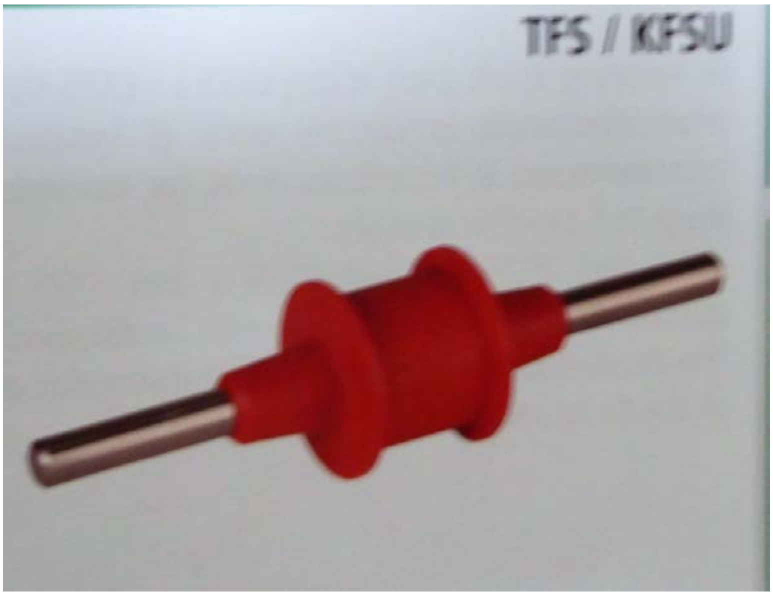
Activity	No. of People[1] (P)	Hours per occasion (H)	Times per year (T)	Hours per year (T x H)
Sunday Services:-				
Early morning service				
Mid morning service 1				
Mid morning service 2				
Evening service				
Mid-week service				
Separate baptisms				
Weddings				
Funerals				
Special Services				
Vestry(s)				
Church office				
Flower arrangers				
Cleaning teams				
Maintenance				
Visitors (winter)				
Visitors (summer)				
Bell ringing				
Bell ringing practice				
Organist's practice				
Choir practice				
Other Activity:-				
Schools Services				
Concerts				
Other social events				
			Total[2]	

Notes

1. The number of people is relevant only when it is necessary to zone a building, for example where there is an upper room which presents particular evacuation difficulty in the event of a fire, such as a bellringing chamber with a difficult exit.
2. The total of (T x H) divided by 8760 (the number of hours in a year) gives the proportion of time for which the building is occupied. A typical figure is 0.08; this may be used in risk calculations where detailed figures as above are not available.

Isolating spark gaps

Where it is necessary to apply a ring tape at the eaves level of the spire at the tower/spire broach it is recommended that isolating spark gaps are fitted in the ring as shown in Fig. 3 to allow continuity testing to be carried out properly from ground level. A suitable spark gap, the Dehn TFS/KFSU is shown below on its own and as fitted (in a different application). The TFS item is a high capacity isolating spark gap rated at 100 kA and is the appropriate one for lightning protection applications such as is shown in Figure 3. Dehn should be consulted on the appropriate sleeve or other connector.



Appendix 3

Electrical Services and Mains Surge Protection

Electrical Services.

Churches are supplied at 230 volts 50 Hz single phase, having a single supplier's fuse rated at 63 or 100 amp or three-phase with 100-amp fuses in each phase. In the latter case, all three phases may not have been put to use and only two of them may be involved, in giving effectively a two-wire system with a neutral, each leg having an effective 230 volts 50 Hz 100 ampere capacity. It is necessary to give the contractor enough information to be able to determine how the supply is connected to allow proper selection of any necessary surge protection equipment. It may well be relevant to determine the type of tariff to which the supply is applied. Some churches may be electrically heated or have separately owned communications equipment; this could result in separated metering, requiring additional surge protection equipment.

It is also necessary to supply information about the basic system connection type, and these are known as, TN-S, TN-C-S, and TT. Type IT and TN-C are rarely used in the UK and are therefore not shown. The other connections are shown diagrammatically on the following pages of this Appendix. Some churches are supplied from an overhead line and in a rural parish this is maybe a TT supply, which needs localised earthing arrangements at the church, near to the intake position.

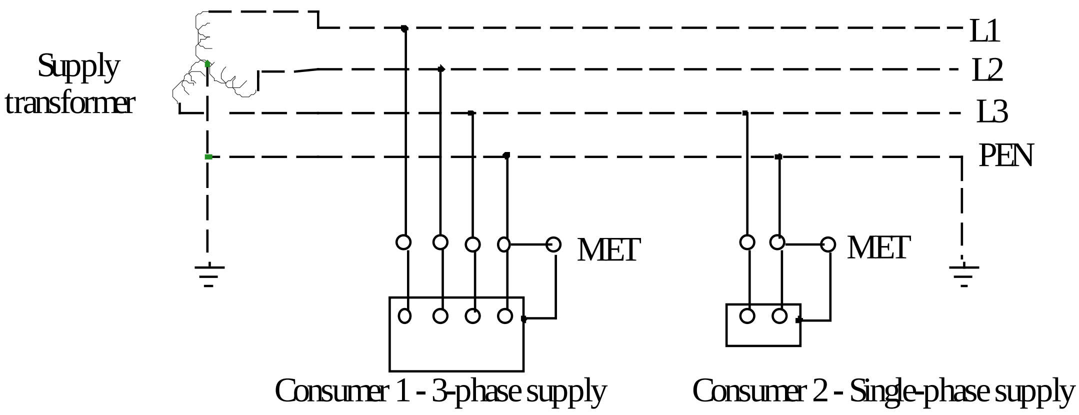
The type of surge protection fitted is dependant on the position in the system where it is to be fitted. At most mains intake positions (for lightning protection level IV) the types shown below are advised.

Typical Mains Surge Protection Units

Electrical Service Connection Types
(Based on BS 7671: 2008 Appendix 9)

1. TN-C-S system.

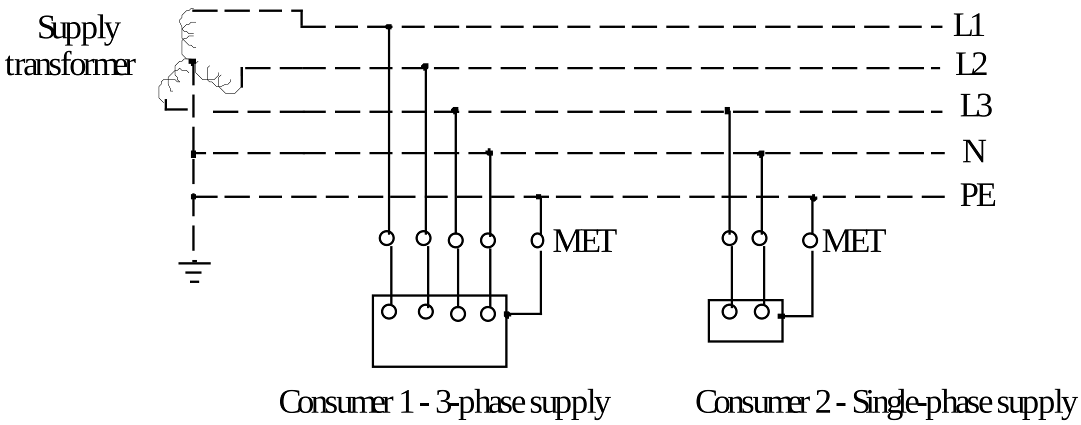
TN-C-S system (also known as PME supply)



In a TN-C-S system the neutral and protective functions are combined (C) in a single protective earth and neutral (PEN) conductor in supplier's distribution. The system is also known as a protective multiply earthed (PME) system, as additional earthing, say at every third pole of an overhead supply, guards against a hazard arising from the unlikely event of a broken neutral.
In the consumer's installation, there is a single connection of the PEN conductor to the consumer's main earth terminal (MET) and thereafter the neutral and PE conductors are quite separate (S). It is unlikely that the consumer would need to supplement the earthing with his own earth.

2. TN-S system.

TN-S system

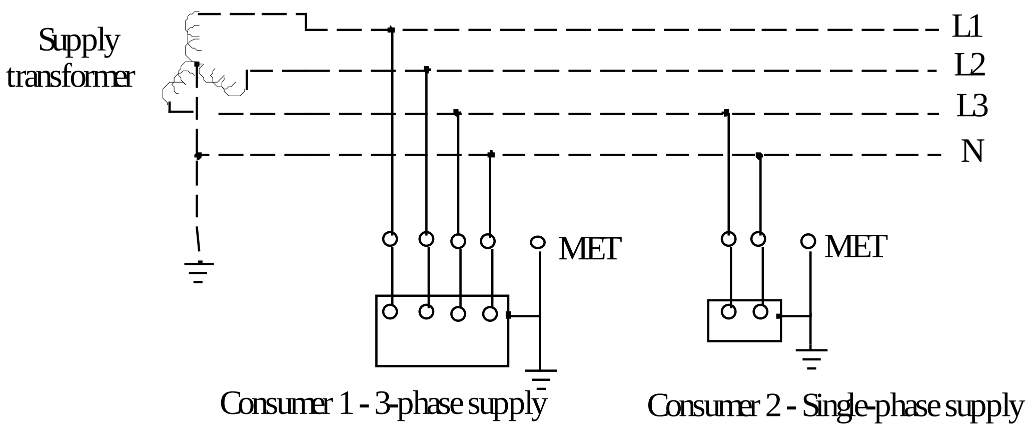


In a TN-S system there are separate neutral and protective earth conductors throughout, i. e. in both the supplier's distribution in which the metallic sheath of the cable is earthed and in the consumer's installation. The consumer is therefore able to use the supply PE conductor via a connection to the MET.

3. T-T system.

In a T-T system the supply is earthed remotely at say the supply transformer. The supplier provides no earth to the consumer. The consumer must therefore provide his own earth. This is a separate earth from the lightning protection system's earthing, albeit the two are bonded together by a bonding conductor from the nearest lightning down conductor to the MET.

T-T system



Notes on types of supply

The *first* letter indicates the type of *supply earthing*
T indicates that one or more points of the supply are directly earthed (for example the earthed neutral at the transformer). T = Terre, the French for earth.

The *second* letter indicates the type of *earthing arrangement in the installation*
T all exposed conductive metalwork is connected directly to earth.
N all exposed conductive metalwork is connected directly to an earthed supply conductor, typically the combined earth/**N**eutral conductor.

The *third and fourth* letters indicate the arrangements of the earth supply conductor.
S neutral and earth conductor systems are quite **S**eparate
C neutral and earth are **C**ombined in a single conductor

This Appendix gives possible sources of surge protection devices. The Table should be used as a guide only, with a careful check that physical dimensions, including connections are appropriate as well as checking on the need for enclosures. All work on the Church's electrical system must be undertaken by an NICEIC (National Inspection Council of Electrical Installation Contractors), ECA (Electrical Contractors' Association) registered contractor or NAPIT (The National Association of Professional Inspectors and Testers) electrician with full scope membership.

Table – Surge protective devices

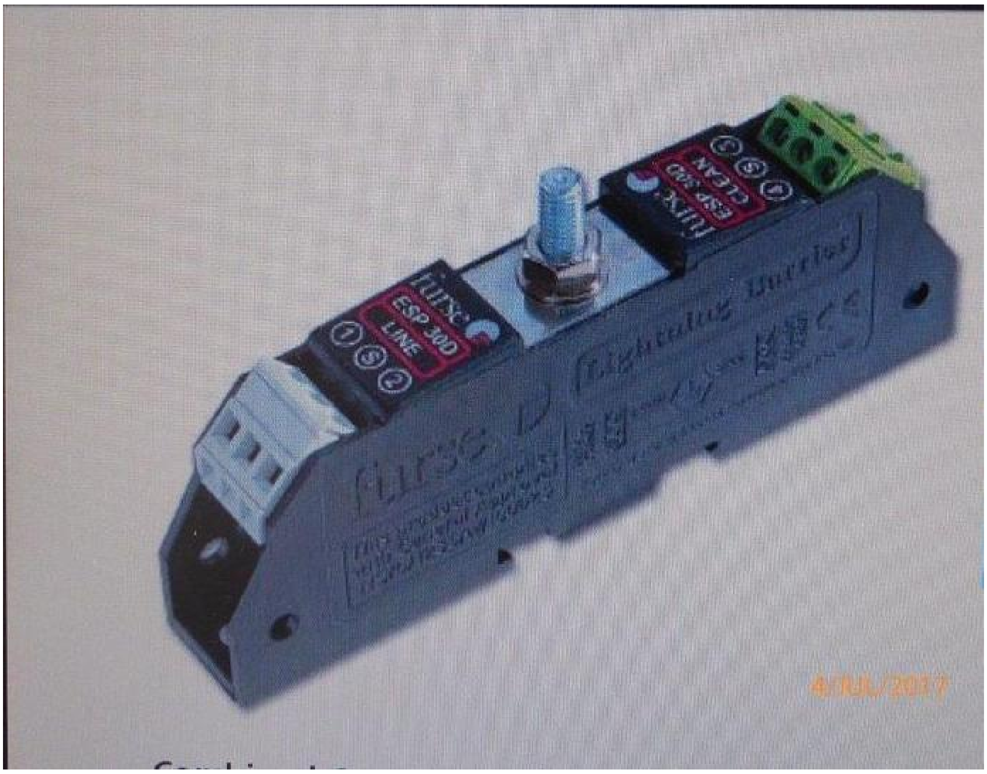
Manufacturer	Application	Product Code or part number
ABB Furse, Wilford Road, Nottingham NG2 1EB Web www.furse.com Tel 0115 964 3700 E mail: enquiry@furse.com	Single phase 100 amp rated mains	ESP 240 M1 - Type 1, 2 and 3
	3-phase 100 amp per phase mains	ESP 415 M1 - Type 1, 2 and 3
	Telephone and data	ESP 50D or 110D - Type 1 single pair. CME series mount and earthing kits WBX series weatherproof enclosures
Dehn (UK), Unit N8b, Meltham Mills Industrial Estate, Meltham, Holmfirth HD9 4DS Web www.dehn.co.uk Tel 01484 859 111 E mail: info@dehn.co.uk	Single phase 100 amp rated mains TN supply	Dehnshield 941 200 -Types 1 and 2
	Single phase 100 amp rated mains TT and TN supply	Dehnshield 941 110 -Types 1 and 2
	3-phase 100 amp per phase mains TN-S supply	Dehnshield 941 400 -Types 1 and 2
	3-phase 100 amp per phase mains TT and TN-S supply	Dehnshield 941 310 -Types 1 and 2
	Telephone and data	DBX U4 KT BD S 0 180 for 2 pairs Type 1, IP 65 protected DBX U2 KT BD S 0 180 for 1 pair, Type 1, IP 65 protected DLC TC BT – 929 026 Type 2
Mersen UK Unit 12, Tungsten Building, George Street Portslade, BN41 1RA Web: www.mersen.com Tel: 01273 425119 (Sales Office) 01273 415701 (General) E mail: ?	3-phase 100 amp per phase mains	STM T1 - Type 1
	3-phase 100 amp per phase mains	STM T12 - Types 1 & 2
	Single pair telephone line screw connection	Cirprotec DIN series - Type 2 only
	Plug in device for telephone lines with separate earth lead.	Cirprotec MCH series – Type 2 only
Phoenix Contact Ltd Halesfield 13 Telford Shropshire TF7 4PG Web: www.phoenixcontact.com Telephone: 0845 881 2222 e-mail: info@phoenixcontact.co.uk	3-phase 100 amp per phase mains for TN-C supply	FLT-SEC-T1+T2-3C-350/25-FM-2905469 Combined Type 1 and 2. Plug in.
	3-phase 100 amp per phase mains for TN-S supply	FLT-SEC-T1+T2-3C-350/25-FM-2905470 Combined Type 1 and 2. Plug in.
	2-phase 100 amp per phase mains for TN-S supply	FLT-SEC-T1+T2-2S-350/25-FM-2905468 Combined Type 1 and 2. Plug in
	2-phase 100 amp per phase mains for TN-C supply	FLT-SEC-T1+T2-2C-350/25-FM-2905467 Combined Type 1 and 2. Plug in.
	1-phase 100 amp per phase mains for TN-S supply	FLT-SEC-T1+T2-2C-350/25-FM-2905466 Combined Type 1 and 2. Plug in.
	1-phase 100 amp per phase mains for TN-C supply	FLT-SEC-T1+T2-1C-350/25-FM-2905465 Combined Type 1 and 2. Plug in.

Notes

1. Where the current rating of the supply is higher than that of the SPD, then the SPD should be protected by fuses related to the SPD's rating. In may be convenient to install an isolator upstream of the SPD so that the SPD can be replaced without disconnection of the supply, e. g. by the supply company's fuses.
2. A telephone line may have more than one cable pair; all pairs require surge protection.

Installation of surge protection unit for a BT Line

1. Furse Type 1 SPD. The picture below shows a Furse Type ESP 30D surge protector, identical in outward form to the ESP 50D and 100D recommended in Appendix 4. There are 3 screwed connections on the white connector block at the left-hand end for the incoming line (dirty side) and 3 screwed connections on the green block for the line to telephones and/or other communications equipment (clean side). The centre connection, marked S, is for the connection of the cable screen if one is present. Both screen connections link internally with the centre earthing stud. The M6 stud is designed to take an earthing cable with a lug terminal. The earth cable of 4 mm^2 copper should go either to the main earth terminal (MET) of the electricity supply or to a separate earth. Either way the length of the earth cable should be no more than about 15 m. A separate earth point should have a resistance of no more than about 25 ohms. If there is more than one pair in the incoming cable then each pair, even if not in use, should have its own SPD. This ensures that surges from a direct lightning strike on all lines are diverted to earth, thus minimising the fire risk. In the case of unused pairs there will be no connections to the green connector. The SPDs may be mounted in an existing cabinet or in a Furse enclosure using a Combined Mounting and Earthing kit, such as a CME 4, capable of accepting up to four ESP 50D or 100D units.



1. Furse Type 2 SPD. Where it is desired to provide protection for equipment connected to the telephone line, for example, a computer modem, then it is necessary to fit a Type 2 downstream of the Type 1 SPD. A suitable Furse device is the ESP TN/JP shown in the photograph below as installed. The JP in the designation indicates that it is fitted BT type jack plug, which can be plugged into the BT master socket The earth stud at the left-hand end can be connected to the protective earth of any nearby 13 A socket using a minimum cable size of 1 mm^2. The line to the equipment is plugged into the socket at the right-hand end of the photograph.

3. Dehn Type 1
The Dehn Type 1 unit shown, as installed, in the photo can be either a DBX–U4-KT-BD-S-O 180 for 2 pairs (4 wire) as designated U4 or DBX–U2-KT-BD-S-O 180 for 1 pair (2 wire) as designated U2. If the incoming cable has more than 2 pairs then an additional unit would be required. If pairs are unused then they should still be fitted with surge protection with an earth connect but there would be no cable to a master socket.

4. Dehn Type 2. As listed in Appendix 4, Dehn Surge protector DLI TC BT part number 929 026 is a generally suitable Type 2 plug-in device for a single BT in-use line to deal with the let–through surges from a Type 1 device.

5. Approval.
All the above units shown or referred to in this appendix are BT-approved.