

Technical reference

Key points

Key variances between the previous standard, BS 6651, and the IEC/BS EN 62305 - Technical reference table

BS 6651 Standard (withdrawn August 2008)	IEC/BS EN 62305 Standard
Document structure	
118 page document, including 9 pages devoted to risk assessment	Over 470 pages in 4 parts, including over 150 pages devoted to risk assessment (IEC/BS EN 62305-2)
Focus on Protection of Structures against Lightning	Broader focus on Protection against Lightning including the structure and services connected to the structure
Specific tables relating to choice and dimension of LPS components and conductors	Specific tables relating to sizes and types of conductor and earth electrodes LPS components - specifically related to BS EN 50164/IEC 62561 testing regimes
Annex B - guidance on application of BS 6651	IEC/BS EN62305-3 Annex E - extensive guidance given on application of installation techniques complete with illustrations
Annex C - general advice (recommendation) for protection of electronic equipment with separate risk assessment	IEC/BS EN 62305-4 is devoted entirely to protection of electrical and electronic systems within the structure (integral part of standard) and is implemented through single separate risk assessment (IEC/BS EN 62305-2)
Definition of risk	
Risk (of death/injury) level set at 1 in 100,000 (1×10^{-5}) based on comparable exposures (smoking, traffic accidents, drowning etc)	3 primary risk levels defined (IEC/BS EN 62305): – R_1 Loss of human life (including permanent injury) 1 in 100,000 (1×10^{-5}) – R_2 Loss of service to the public 1 in 10,000 (1×10^{-4}) – R_3 Loss of cultural heritage 1 in 10,000 (1×10^{-4})
Protection measures	
Mesh arrangement is promoted as the commonly used means of air termination network	Mesh arrangement, protective angle method, catenary system, extensive use of air finials, all form part of or all of air termination network
2 levels of Lightning Protection mesh design: (20 m x 10 m; 10 m x 5 m)	4 sizes of mesh defined according to structural class of Lightning Protection System: – Class I 5 m x 5 m – Class II 10 m x 10 m – Class III 15 m x 15 m – Class IV 20 m x 20 m
2 levels of down conductor spacing: 20 m & 10 m	4 levels of down conductor spacing dependent on structural class of Lightning Protection System: – Class I 10 m – Class II 10 m – Class III 15 m – Class IV 20 m
Use of bonds promoted to minimize side flashing	Extensive sections/explanations provided on equipotential bonding
10 Ω overall earthing requirement, achieved by 10 x number of down conductors	10 Ω overall earthing requirement achieved either by Type A arrangement (rods) or Type B arrangement (ring conductor)
Requirement to bond all metallic services, (gas, water, electricity etc) to main earth terminal along with external down conductor	Requirement to bond all metallic services to main equipotential bonding bar. 'Live' electrical conductors (e.g. power, data, telecoms) bonded via Surge Protective Devices (SPDs)
Use of bonds promoted to minimize side flashing	Via mounting fixtures
Rolling sphere concept on structures over 20 m tall: 20 m sphere used on highly flammable contents/electronic equipment within building 60 m sphere all other buildings	4 sizes of rolling sphere concept defined according to structural class of Lightning Protection System: – Class I 20 m – Class II 30 m – Class III 45 m – Class IV 60 m

Technical reference

IEC/BS EN 62305-1 - General principles

This opening part of the IEC/BS EN 62305 suite of standards serves as an introduction to the further parts of the standard. It classifies the sources and types of damage to be evaluated and introduces the risks or types of loss to be anticipated as a result of lightning activity.

Furthermore, It defines the relationships between damage and loss that form the basis for the risk assessment calculations in part 2 of the standard.

Lightning current parameters are defined. These are used as the basis for the selection and implementation of the appropriate protection measures detailed in parts 3 and 4 of the standard.

Part 1 of the standard also introduces new concepts for consideration when preparing a lightning protection scheme, such as Lightning Protection Zones (LPZs) and separation distance.

Damage and loss

IEC/BS EN 62305 identifies four main sources of damage:

- **S1** Flashes to the structure
- **S2** Flashes near to the structure
- **S3** Flashes to the lines connected to the structure
- **S4** Flashes near the lines connected to the structure

Each source of damage may result in one or more of three types of damage:

- **D1** Injury of living beings by electric shock
- **D2** Physical damage (fire, explosion, mechanical destruction, chemical release) due to lightning current effects including sparking
- **D3** Failure of internal systems due to Lightning Electromagnetic Impulse (LEMP)

The following types of loss may result from damage due to lightning:

- **L1** Loss of human life (including permanent injury)
- **L2** Loss of service to the public
- **L3** Loss of cultural heritage
- **L4** Loss of economic value (structure, its content, and loss of activity)

The relationships of all of the above parameters are summarized in Table 5.

Table 5: Damage and loss in a structure according to point of lightning strike (IEC/BS EN 62305-1 Table 2)

Point of strike	Source of damage	Type of damage	Type of loss
Structure	S1	D1	L1, L4**
		D2	L1, L2, L3, L4
		D3	L1*, L2, L4
Near a Structure	S2	D3	L1*, L2, L4
Lines connected to the structure	S3	D1	L1, L4**
		D2	L1, L2, L3, L4
		D3	L1*, L2, L4
Near a Line	S4	D3	L1*, L2, L4

*Only for structures with risk of explosion and for hospitals or other structures where failures of internal systems immediately endangers human life

**Only for properties where animals may be lost

For a more detailed explanation of the general principles forming part 1 of the BS EN 62305 standard, please refer to our full reference guide 'A Guide to IEC/BS EN 62305 Protection Against Lightning'. Although focused on the BS EN standard, this guide may provide supporting information of interest to consultants designing to the IEC equivalent.

Scheme design criteria

The ideal lightning protection for a structure and its connected services would be to enclose the structure within an earthed and perfectly conducting metallic shield (box), and in addition provide adequate bonding of any connected services at the entrance point into the shield.

This in essence would prevent the penetration of the lightning current and the induced electromagnetic field into the structure. However, in practice it is not possible or indeed cost effective to go to such lengths.

This standard thus sets out a defined set of lightning current parameters where protection measures, adopted in accordance with its recommendations, will reduce any damage and consequential loss as a result of a lightning strike. This reduction in damage and consequential loss is valid provided the lightning strike parameters fall within defined limits, established as Lightning Protection Levels (LPL).

Technical reference

IEC/BS EN 62305-1 - Lightning protection levels (LPL)

Lightning Protection Levels (LPL)

Four protection levels have been determined based on parameters obtained from previously published technical papers. Each level has a fixed set of maximum and minimum lightning current parameters. These parameters are shown in Table 6.

The maximum values have been used in the design of products such as lightning protection components and Surge Protective Devices (SPDs).

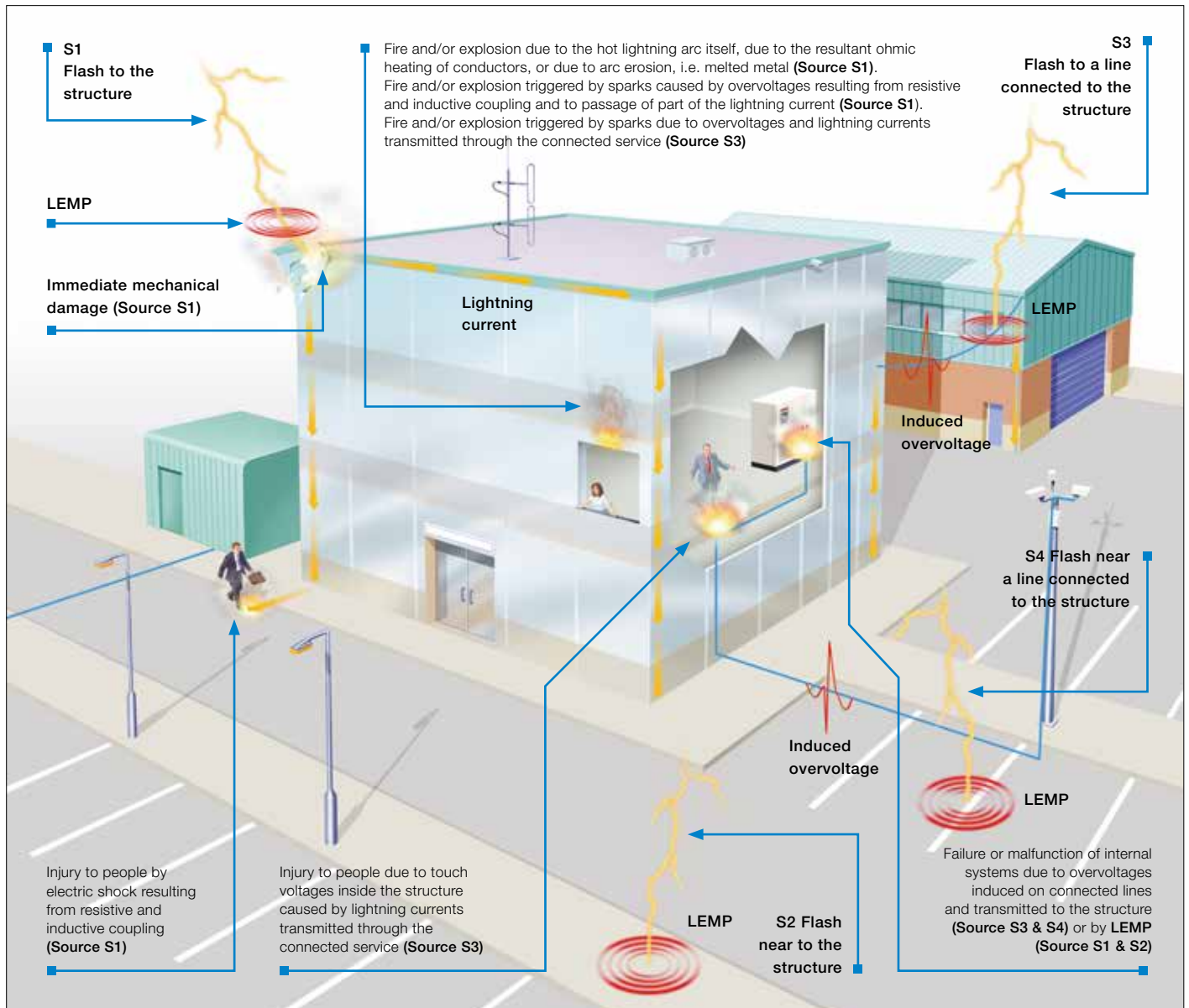
The minimum values of lightning current have been used to derive the rolling sphere radius for each level.

Table 6: Lightning current for each LPL based on 10/350 μ s waveform

LPL	I	II	III	IV
Maximum current (kA)	200	150	100	100
Minimum current (kA)	3	5	10	16

For a more detailed explanation of Lightning Protection Levels and maximum/minimum current parameters please see the Furse Guide to BS EN 62305.

Figure 3. The types of damage and loss resulting from a lightning strike on or near a structure



Technical reference

IEC/BS EN 62305-1 - Lightning protection zones (LPZ)

Lightning protection zones (LPZ)

The concept of the Lightning Protection Zone (LPZ) was introduced within IEC/BS EN 62305 particularly to assist in determining the protection measures required to establish protection measures to counter Lightning Electromagnetic Impulse (LEMP) within a structure.

The general principle is that the equipment requiring protection should be located in an LPZ whose electromagnetic characteristics are compatible with the equipment stress withstand or immunity capability.

The concept caters for external zones, with risk of direct lightning strike, or partial lightning current occurring (LPZ 0) and levels of protection within internal zones (LPZ 1 & LPZ 2).

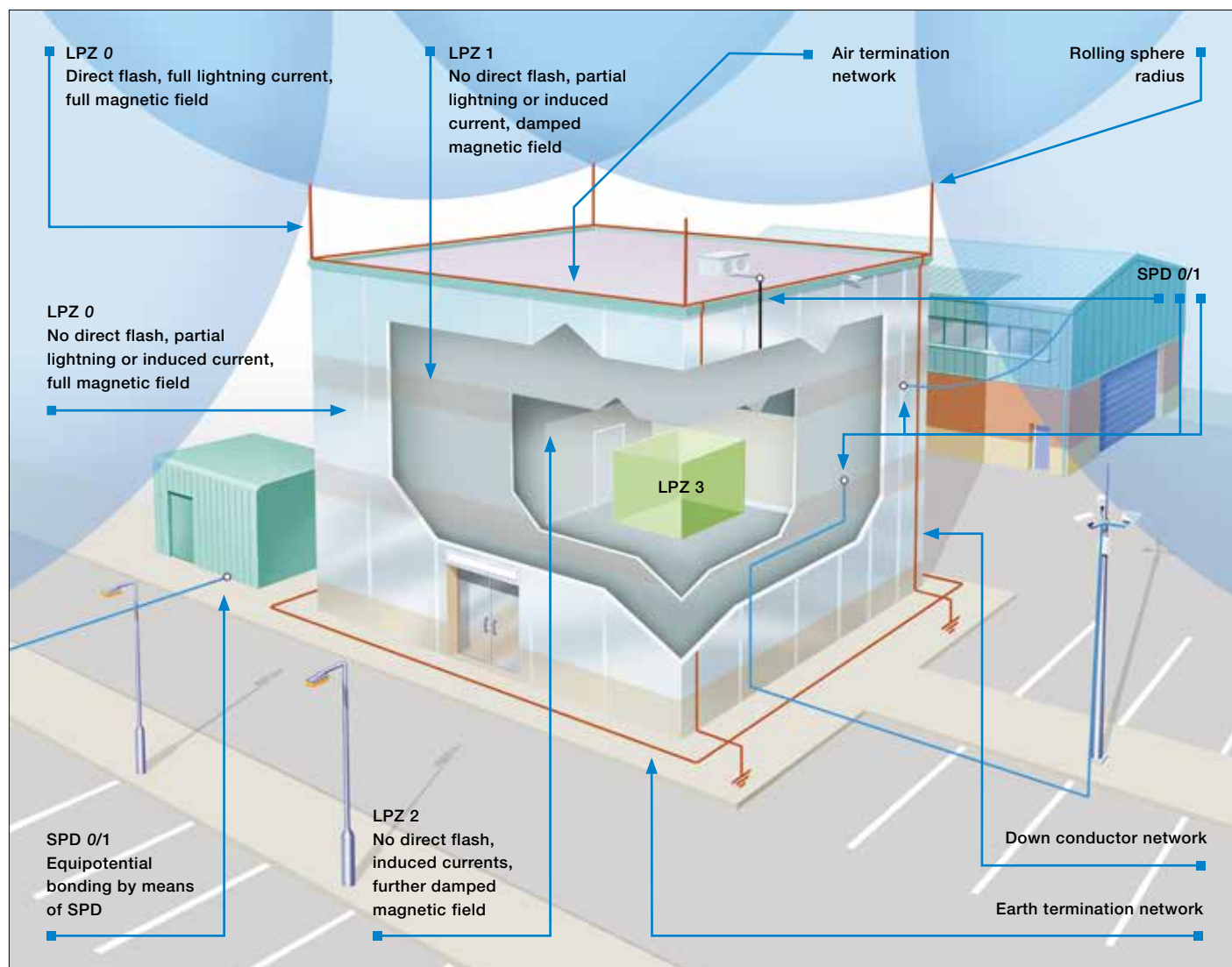
In general the higher the number of the zone (LPZ 2; LPZ 3 etc) the lower the electromagnetic effects expected. Typically, any sensitive electronic equipment should be located in higher numbered LPZs and be protected against LEMP by relevant Surge Protection Measures (SPM as defined in BS EN 62305).

SPM were previously referred to as a LEMP Protection Measures System (LPMS) in IEC/BS EN 62305:2006.

Figure 4 highlights the LPZ concept as applied to the structure and to SPM. The concept is expanded upon in IEC/BS EN 62305-3 and IEC/BS EN 62305-4.

Selection of the most suitable SPM is made using the risk assessment in accordance with IEC/BS EN 62305-2.

Figure 4. The LPZ concept



Technical reference

IEC/BS EN 62305-2 - Risk management

IEC/BS EN 62305-2 is key to the correct implementation of IEC/BS EN 62305-3 and IEC/BS EN 62305-4. The assessment and management of risk is now significantly more in depth and extensive than the approach of BS 6651.

IEC/BS EN 62305-2 specifically deals with making a risk assessment, the results of which define the level of Lightning Protection System (LPS) required. While BS 6651 devoted 9 pages (including figures) to the subject of risk assessment, IEC/BS EN 62305-2 currently contains over 140 pages.

The first stage of the risk assessment is to identify which of the four types of loss (as identified in IEC/BS EN 62305-1) the structure and its contents can incur. The ultimate aim of the risk assessment is to quantify and if necessary reduce the relevant primary risks i.e.:

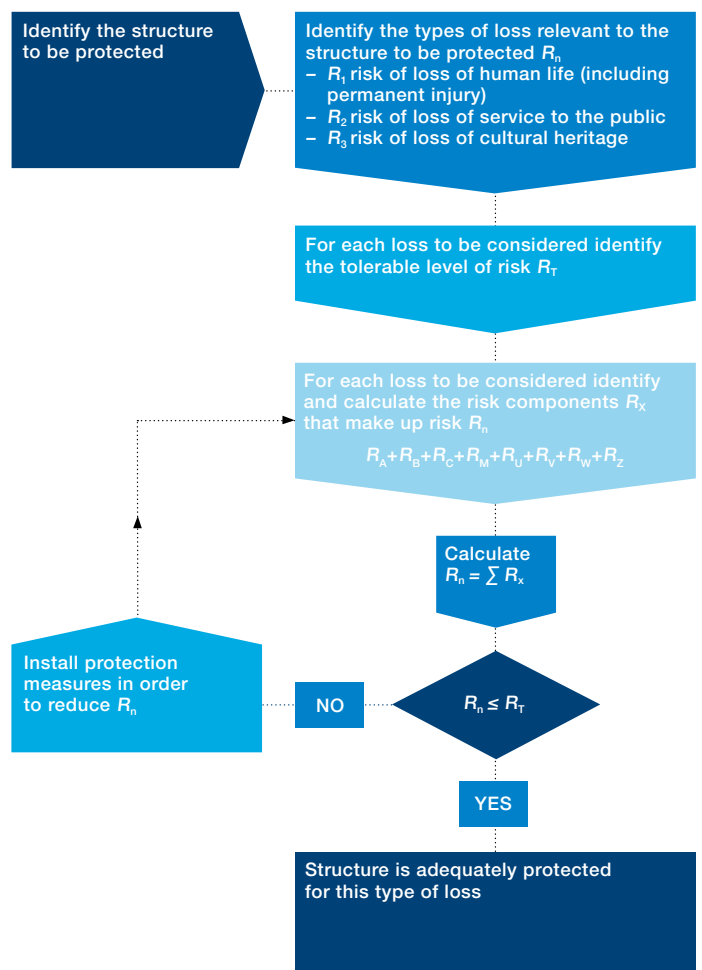
- R_1 risk of loss of human life (including permanent injury)
- R_2 risk of loss of service to the public
- R_3 risk of loss of cultural heritage
- R_4 risk of loss of economic value

For each of the first three primary risks, a tolerable risk (R_T) is set. This data can be sourced in Table 7 of IEC 62305-2 or Table NF.1 of the National Annex of BS EN 62305-2.

Each primary risk (R_n) is determined through a long series of calculations as defined within the standard. If the actual risk (R_n) is less than or equal to the tolerable risk (R_T), then no protection measures are needed. If the actual risk (R_n) is greater than its corresponding tolerable risk (R_T), then protection measures must be instigated. The above process is repeated (using new values that relate to the chosen protection measures) until R_n is less than or equal to its corresponding R_T .

It is this iterative process as shown in Figure 5 that decides the choice or indeed Lightning Protection Level (LPL) of Lightning Protection System (LPS) and Surge Protective Measures (SPM) to counter Lightning Electromagnetic impulse (LEMP).

Figure 5. Procedure for deciding the need for protection (IEC/BS EN 62305-1 Figure 1)



StrikeRisk risk management software

An invaluable tool for those involved in undertaking the complex risk assessment calculations required by IEC/BS EN 62305-2, StrikeRisk facilitates the assessment of risk of loss due to lightning strikes and transient overvoltages caused by lightning.

Quick and easy to use, with full reporting capability, StrikeRisk automates risk assessment calculations and delivers results in minutes, rather than the hours or days it would take to do the same calculations by hand. Contact Furse for more details about StrikeRisk.

Technical reference

IEC/BS EN 62305-3 - Physical damage to structures & life hazard

IEC/BS EN 62305-3. This part of the suite of standards deals with protection measures in and around a structure.

The main body of this part of the standard gives guidance on the design of an external Lightning Protection System (LPS), internal LPS and maintenance and inspection programmes.

Lightning Protection System (LPS)

IEC/BS EN 62305-1 has defined four Lightning Protection Levels (LPLs) based on probable minimum and maximum lightning currents. These LPLs equate directly to classes of Lightning Protection System (LPS).

The correlation between the four levels of LPL and LPS is identified in Table 7. In essence, the greater the LPL, the higher class of LPS is required.

External LPS design considerations

The lightning protection designer must initially consider the thermal and explosive effects caused at the point of a lightning strike and the consequences to the structure under consideration. Depending upon the consequences the designer may choose either of the following types of external LPS:

- Isolated
- Non-isolated

External LPS design considerations

An Isolated LPS is typically chosen when the structure is constructed of combustible materials or presents a risk of explosion.

Conversely a non-isolated system may be fitted where no such danger exists.

An external LPS consists of:

- Air termination system
- Down conductor system
- Earth termination system

These individual elements of an LPS should be connected together using appropriate lightning protection components (LPC) complying (in the case of BS EN 62305) with IEC/BS EN 62561 series. This will ensure that in the event of a lightning current discharge to the structure, the correct design and choice of components will minimize any potential damage.

Table 7: Relation between Lightning Protection Level (LPL) and Class of LPS (IEC/BS EN 62305-3 Table 1)

LPL	Class of LPS
I	I
II	II
III	III
IV	IV

Air termination system

The role of an air termination system is to capture the lightning discharge current and dissipate it harmlessly to earth via the down conductor and earth termination system. Therefore it is important to use a correctly designed air termination system.

IEC/BS EN 62305-3 advocates the following, in any combination, for the design of the air termination:

- Air rods (or finials) whether they are free-standing masts or linked with conductors to form a mesh on the roof
- Catenary (or suspended) conductors, whether they are supported by free-standing masts or linked with conductors to form a mesh on the roof
- Meshed conductor network that may lie in direct contact with the roof or be suspended above it (in the event that it is of paramount importance that the roof is not exposed to a direct lightning discharge)

The standard makes it quite clear that all types of air termination systems that are used shall meet the positioning requirements laid down in the body of the standard. It highlights that the air termination components should be installed on corners, exposed points and edges of the structure.

The three basic methods recommended for determining the position of the air termination systems are:

- The rolling sphere method
- The protective angle method
- The mesh method

These methods are detailed over the following pages.

Technical reference

IEC/BS EN 62305-3 - Physical damage to structures & life hazard

The rolling sphere method

The rolling sphere method is a simple means of identifying areas of a structure that need protection, taking into account the possibility of side strikes to the structure. The basic concept of applying the rolling sphere to a structure is illustrated in Figure 6.

The rolling sphere method was used in BS 6651, the only difference being that in IEC/BS EN 62305 there are different radii of the rolling sphere that correspond to the relevant class of LPS (see Table 8). This method is suitable for defining zones of protection for all types of structures, particularly those of complex geometry.

The protective angle method

The protective angle method is a mathematical simplification of the rolling sphere method. The protective angle (α) is the angle created between the tip (A) of the vertical rod and a line projected down to the surface on which the rod sits (see Figure 7).

The protective angle afforded by an air rod is clearly a three dimensional concept whereby the rod is assigned a cone of protection by sweeping the line AC at the angle of protection a full 360° around the air rod.

The protective angle differs with varying height of the air rod and class of LPS. The protective angle afforded by an air rod is determined from Table 2 of IEC/BS EN 62305-3 (see Figure 9).

Table 8: Max. values of rolling sphere radius corresponding to the Class of LPS

Class of LPS	Rolling sphere radius
I	20 m
II	30 m
III	45 m
IV	60 m

Table 9: Max. values of mesh size corresponding to the Class of LPS

Class of LPS	Mesh size
I	5 x 5 m
II	10 x 10 m
III	15 x 15 m
IV	20 x 20 m

Varying the protection angle is a change to the simple 45° zone of protection afforded in most cases in BS 6651. Furthermore the new standard uses the height of the air termination system above the reference plane, whether that be ground or roof level (See Figure 8).

The protective angle method is better suited for simple shaped buildings. However this method is only valid up to a height equal to the rolling sphere radius of the appropriate LPL.

Figure 6. Application of the rolling sphere method

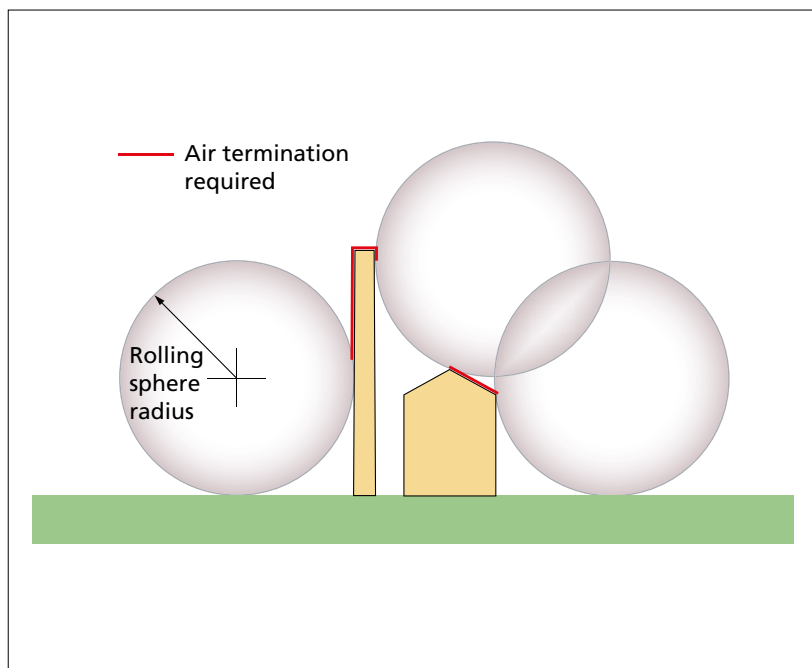
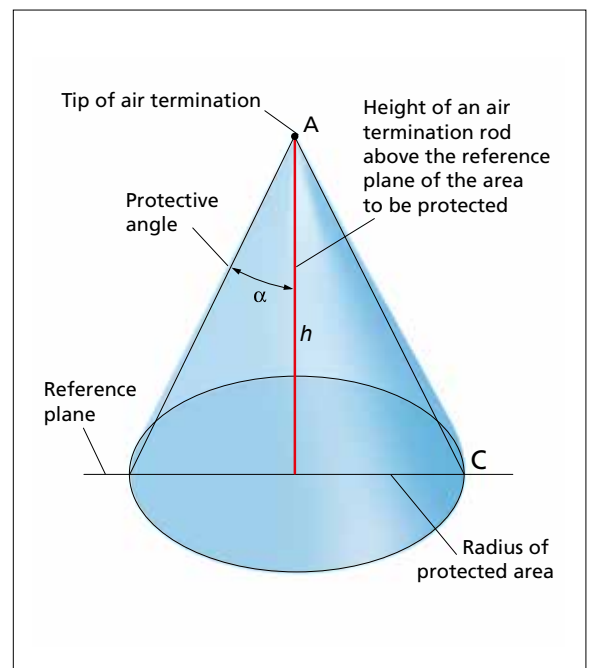


Figure 7. The protective angle method for a single air rod



The mesh method

IEC/BS EN 62305 lists four different air termination mesh sizes that are defined and correspond to the relevant class of LPS (see Table 9).

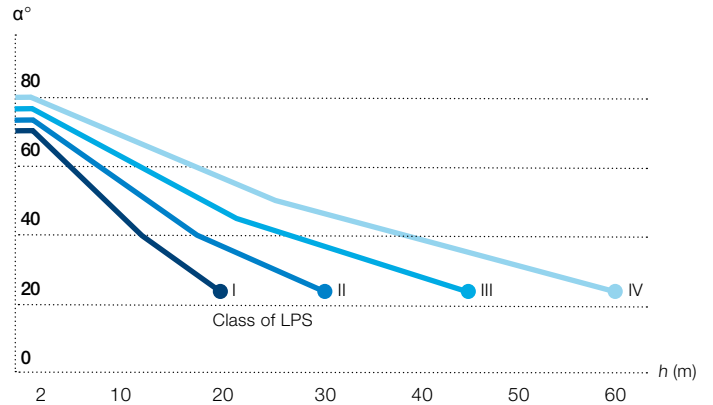
This method is suitable where plain surfaces require protection if the following conditions are met:

- Air termination conductors must be positioned at roof edges, on roof overhangs and on the ridges of roof with a pitch in excess of 1 in 10 (5.7°)
- No metal installation protrudes above the air termination system

Modern research on lightning inflicted damage has shown that the edges and corners of roofs are most susceptible to damage. So on all structures particularly with flat roofs, perimeter conductors should be installed as close to the outer edges of the roof as is practicable.

The IEC/BS EN 62305 Standard permits the use of conductors (whether they be fortuitous metalwork or dedicated LP conductors) under the roof. Vertical air rods (finials) or strike plates should be mounted above the roof and connected to the conductor system beneath.

Figure.9 Determination of the protective angle (IEC/BS EN 62305-3 Table 2)



Note 1: Not applicable beyond the values marked with ●

Only rolling sphere and mesh methods apply in these cases

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

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

The air rods should be spaced not more than 10 m apart and if strike plates are used as an alternative, these should be strategically placed over the roof area not more than 5 m apart.

Figure 8. Effect of the height of the reference plane on the protection angle

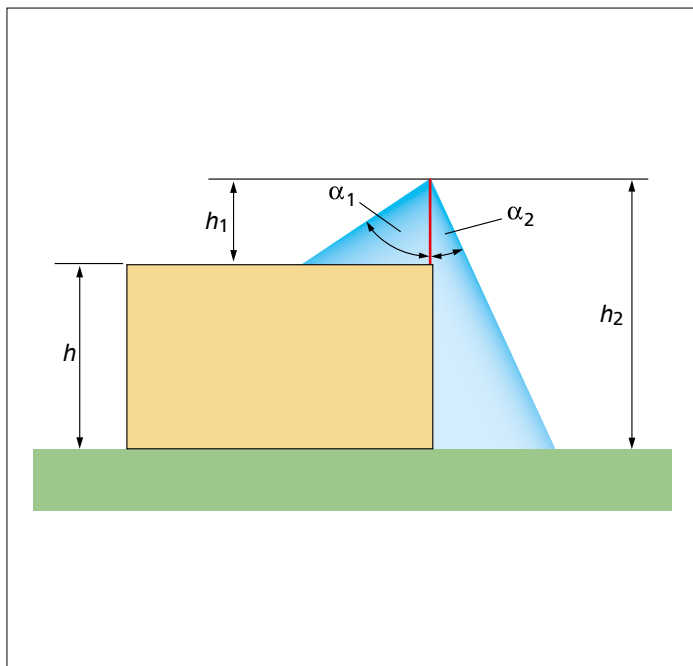
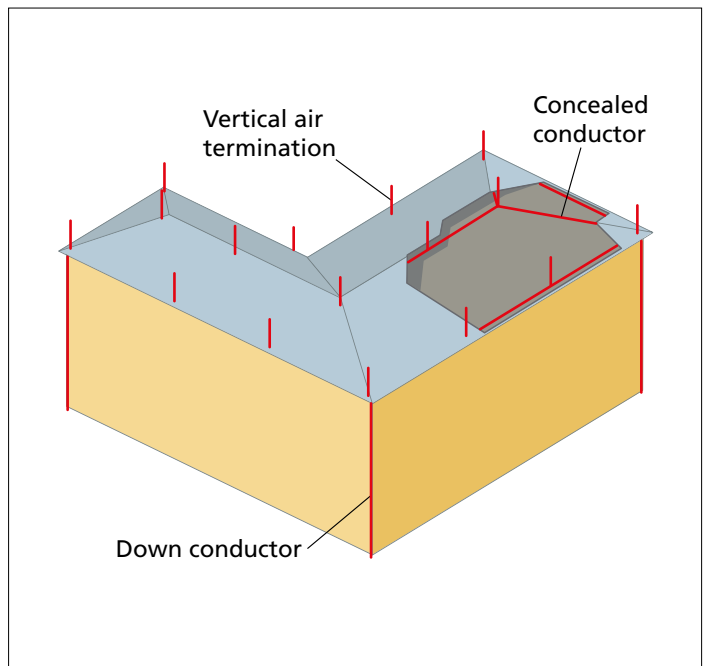


Figure 10. Concealed air termination network



Technical reference

IEC/BS EN 62305-3 - Physical damage to structures & life hazard

Non-conventional air termination systems

A lot of technical (and commercial) debate has raged over the years regarding the validity of the claims made by the proponents of such systems. This topic was discussed extensively within the technical working groups that compiled IEC/BS EN 62305. The outcome was to remain with the information housed within this standard.

IEC/BS EN 62305 states unequivocally that the volume or zone of protection afforded by the air termination system (e.g. air rod) shall be determined only by the real physical dimension of the air termination system. This statement is reinforced within the 2011 version of BS EN 62305, by being incorporated in the body of the standard, rather than forming part of an Annex (Annex A of IEC/BS EN 62305-3:2006).

Typically if the air rod is 5 m tall then the only claim for the zone of protection afforded by this air rod would be based on 5 m and the relevant class of LPS and not any enhanced dimension claimed by some nonconventional air rods.

There is no other standard being contemplated to run in parallel with this standard IEC/BS EN 62305.

Natural components

When metallic roofs are being considered as a natural air termination arrangement, IEC/BS EN 62305 offers guidance on the minimum thickness and type of material under consideration, as well as additional information if the roof has to be considered puncture proof from a lightning discharge (see Table 10).

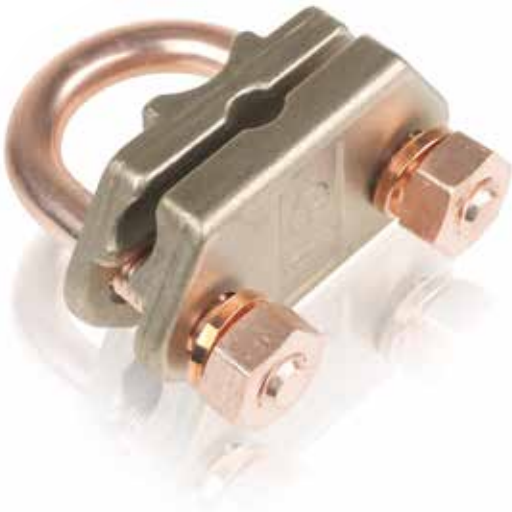


Table 10: Minimum thickness of metal sheets or metal pipes in air termination systems (IEC/BS EN 62305-3 Table 3)

Class of LPS	Material	Thickness ⁽¹⁾ t	Thickness ⁽²⁾ t'
I to IV	Lead	–	2.0 mm
	Steel (stainless, galvanized)	4 mm	0.5 mm
	Titanium	4 mm	0.5 mm
	Copper	5 mm	0.5 mm
	Aluminium	7 mm	0.65 mm
	Zinc	–	0.7 mm

⁽¹⁾ Thickness t prevents puncture, hot spot or ignition

⁽²⁾ Thickness t' only for metal sheets if it is not important to prevent puncture, hot spot or ignition problems

Table 11: Typical values of the distance between down conductors according to the Class of LPS (IEC/BS EN 62305-3 Table 4)

Class of LPS	Typical distances
I	10 m
II	10 m
III	15 m
IV	20 m

Down conductors

Down conductors should within the bounds of practical constraints take the most direct route from the air termination system to the earth termination system. The greater the number of down conductors the better the lightning current is shared between them. This is enhanced further by equipotential bonding to the conductive parts of the structure.

Lateral connections sometimes referred to as coronal bands or ring conductors provided either by fortuitous metalwork or external conductors at regular intervals are also encouraged. The down conductor spacing should correspond with the relevant class of LPS (see Table 11).

There should always be a minimum of two down conductors distributed around the perimeter of the structure. Down conductors should wherever possible be installed at each exposed corner of the structure as research has shown these to carry the major part of the lightning current.

Natural components

IEC/BS EN 62305 encourages the use of fortuitous metal parts on or within the structure to be incorporated into the LPS. That these are welded, clamped with suitable connection components or overlapped a minimum of 20 times the rebar diameter. This is to ensure that those reinforcing bars likely to carry lightning currents have secure connections from one length to the next.

When internal reinforcing bars are required to be connected to external down conductors or earthing network either of the arrangements shown in Figure 6 is suitable. If the connection from the bonding conductor to the rebar is to be encased in concrete then the standard recommends that two clamps are used, one connected to one length of rebar and the other to a different length of rebar. The joints should then be encased by a moisture inhibiting compound such as Denso tape.

If the reinforcing bars (or structural steel frames) are to be used as down conductors then electrical continuity should be ascertained from the air termination system to the earthing system. For new build structures this can be decided at the early construction stage by using dedicated reinforcing bars or alternatively to run a dedicated copper conductor from the top of the structure to the foundation prior to the pouring of the concrete. This dedicated copper conductor should be bonded to the adjoining/adjacent reinforcing bars periodically.

If there is doubt as to the route and continuity of the reinforcing bars within existing structures then an external down conductor system should be installed. These should ideally be bonded into the reinforcing network of the structures at the top and bottom of the structure.

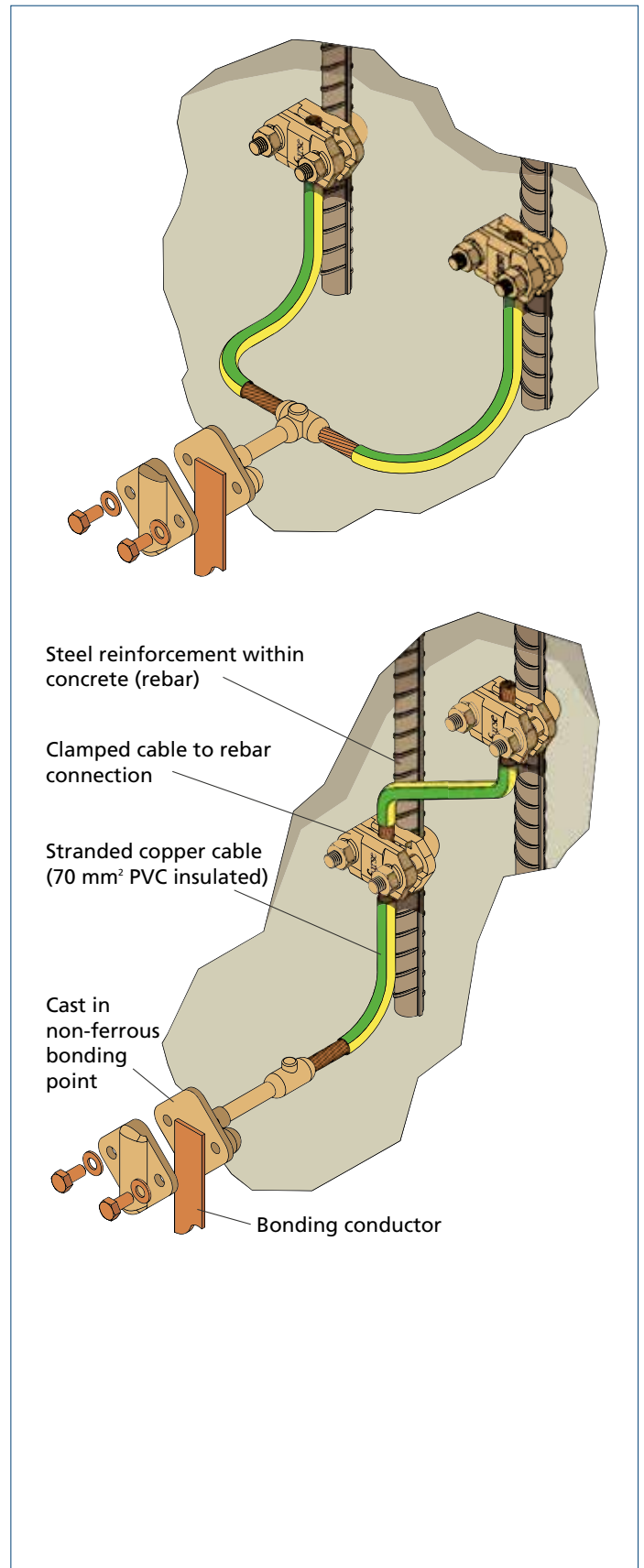


Figure 11. Typical methods of bonding to steel reinforcement within concrete

Technical reference

IEC/BS EN 62305-3 - Physical damage to structures & life hazard

Earth termination system

The earth termination system is vital for the dispersion of lightning current safely and effectively into the ground.

The standard recommends a single integrated earth termination system for a structure, combining lightning protection, power and telecommunication systems. The agreement of the operating authority or owner of the relevant systems should be obtained prior to any bonding taking place.

A good earth connection should possess the following characteristics:

- Low electrical resistance between the electrode and the earth. The lower the earth electrode resistance the more likely the lightning current will choose to flow down that path in preference to any other, allowing the current to be conducted safely to and dissipated in the earth
- Good corrosion resistance. The choice of material for the earth electrode and its connections is of vital importance. It will be buried in soil for many years so has to be totally dependable

The standard advocates a low earthing resistance requirement and points out that the earthing system should have an overall resistance to earth path of 10 Ohms or less. Three basic earth electrode arrangements are used:

- Type A arrangement
- Type B arrangement
- Foundation earth electrodes

Type A arrangement

This consists of horizontal or vertical earth electrodes, connected to each down conductor fixed on the outside of the structure.

Type B arrangement

This arrangement is essentially a fully connected ring earth electrode that is sited around the periphery of the structure and is in contact with the surrounding soil for a minimum 80% of its total length (i.e. 20% of its overall length may be housed in say the basement of the structure and not in direct contact with the earth).

Foundation earth electrodes

This is essentially a type B earthing arrangement. It comprises conductors that are installed in the concrete foundation of the structure. If any additional lengths of electrodes are required they need to meet the same criteria as those for type B arrangement. Foundation earth electrodes can be used to augment the steel reinforcing foundation mesh.

Separation (isolation) distance of the external LPS

A separation distance (i.e. the electrical insulation) between the external LPS and the structural metal parts is essentially required. This will minimize any chance of partial lightning current being introduced internally in the structure.

This can be achieved by placing lightning conductors sufficiently far away from any conductive parts that have routes leading into the structure. So, if the lightning discharge strikes the lightning conductor, it cannot 'bridge the gap' and flash over to the adjacent metalwork.



Internal LPS design considerations

The fundamental role of the internal LPS is to ensure the avoidance of dangerous sparking occurring within the structure to be protected. This could be due, following a lightning discharge, to lightning current flowing in the external LPS or indeed other conductive parts of the structure and attempting to flash or spark over to internal metallic installations.

Carrying out appropriate equipotential bonding measures or ensuring there is a sufficient electrical insulation distance between the metallic parts can avoid dangerous sparking between different metallic parts.

Lightning equipotential bonding

Equipotential bonding is simply the electrical interconnection of all appropriate metallic installations/parts, such that in the event of lightning currents flowing, no metallic part is at a different voltage potential with respect to one another. If the metallic parts are essentially at the same potential then the risk of sparking or flashover is nullified.

This electrical interconnection can be achieved by natural/fortuitous bonding or by using specific bonding conductors that are sized according to Tables 8 and 9 of IEC/BS EN 62305-3.

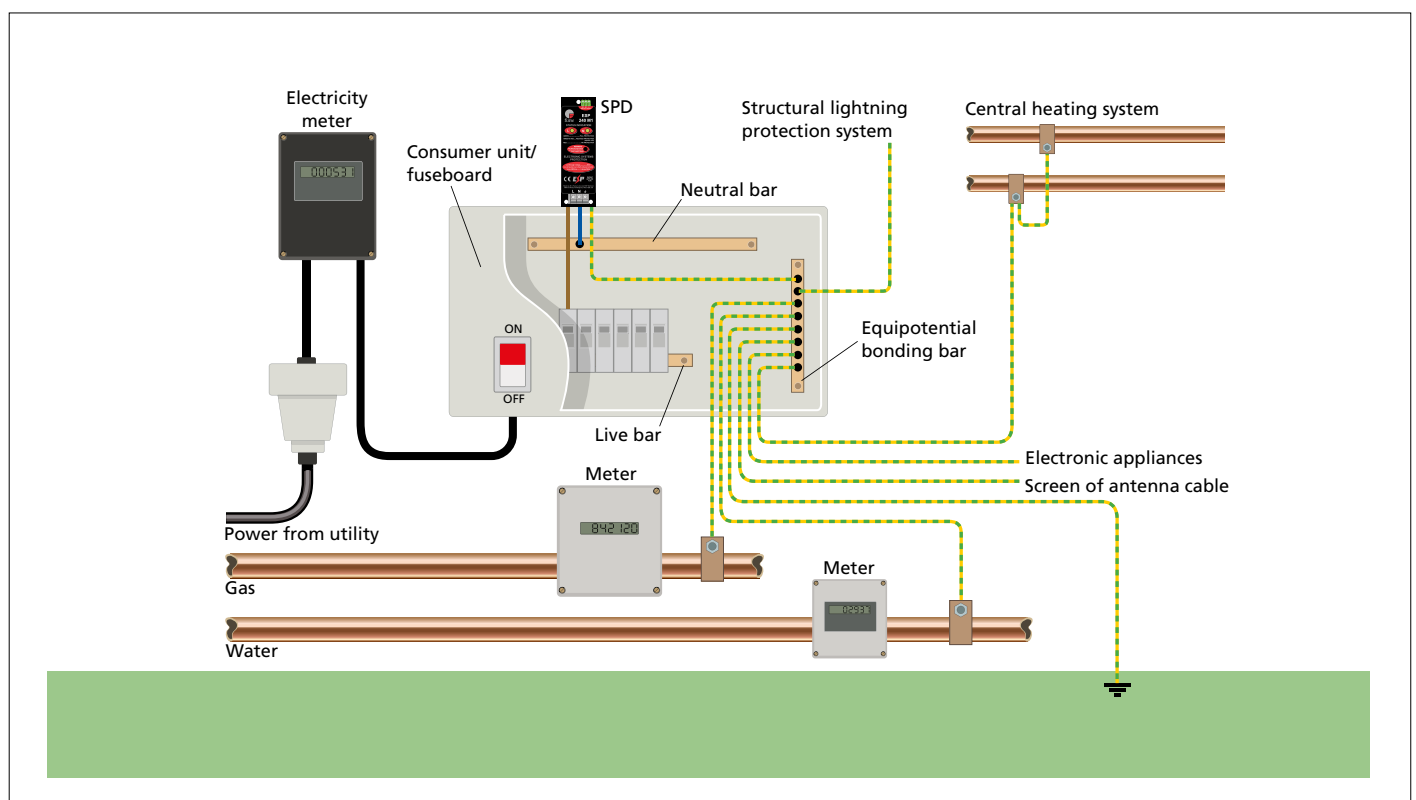
Bonding can also be accomplished by the use of surge protective devices (SPDs) where the direct connection with bonding conductors is not suitable.

Figure 7 (which is based on IEC/BS EN 62305-3 fig E.43) shows a typical example of an equipotential bonding arrangement. The gas, water and central heating system are all bonded directly to the equipotential bonding bar located inside but close to an outer wall near ground level. The power cable is bonded via a suitable SPD, upstream from the electric meter, to the equipotential bonding bar. This bonding bar should be located close to the main distribution board (MDB) and also closely connected to the earth termination system with short length conductors. In larger or extended structures several bonding bars may be required but they should all be interconnected with each other.

The screen of any antenna cable along with any shielded power supply to electronic appliances being routed into the structure should also be bonded at the equipotential bar.

Further guidance relating to equipotential bonding, meshed interconnection earthing systems and SPD selection can be found in the Furze guide to BS EN 62305.

Figure 12. Example of main equipotential bonding



Technical reference

IEC/BS EN 62305-4 - Electrical & electronic systems within structures

Electronic systems now pervade almost every aspect of our lives, from the work environment, through to filling the car with petrol and even shopping at the local supermarket. As a society, we are now heavily reliant on the continuous and efficient running of such systems.

The use of computers, electronic process controls and telecommunications has exploded during the last two decades. Not only are there more systems in existence, the physical size of the electronics involved has reduced considerably (smaller size means less energy required to damage circuits).

IEC/BS EN 62305 accepts that we now live in the electronic age, making LEMP (Lightning Electromagnetic Impulse) protection for electronic and electrical systems integral to the standard through part 4. LEMP is the term given to the overall electromagnetic effects of lightning, including conducted surges (transient overvoltages and currents) and radiated electromagnetic field effects.

LEMP damage is so prevalent such that it is identified as one of the specific types (D3) to be protected against and that LEMP damage can occur from ALL strike points to the structure or connected services - direct or indirect - for further reference to the types of damage caused by lightning see Table 5 on page 16/5. This extended approach also takes into account the danger of fire or explosion associated with services connected to the structure, e.g. power, telecoms and other metallic lines.

Lightning is not the only threat

Transient overvoltages caused by electrical switching events are very common and can be a source of considerable interference. Current flowing through a conductor creates a magnetic field in which energy is stored. When the current is interrupted or switched off, the energy in the magnetic field is suddenly released. In an attempt to dissipate itself it becomes a high voltage transient.

The more stored energy, the larger the resulting transient. Higher currents and longer lengths of conductor both contribute to more energy stored and also released! This is why inductive loads such as motors, transformers and electrical drives are all common causes of switching transients.



Motors create switching events

Significance of IEC/BS EN 62305-4

Previously transient overvoltage or surge protection was included as an advisory annex in the BS 6651 standard, with a separate risk assessment. As a result protection was often fitted after equipment damage was suffered, often through obligation to insurance companies. However, the single risk assessment in IEC/BS EN 62305 dictates whether structural and/or LEMP protection is required hence structural lightning protection cannot now be considered in isolation from transient overvoltage protection - known as Surge Protective Devices (SPDs) within this new standard. This in itself is a significant deviation from that of BS 6651.

Indeed, as per IEC/BS EN 62305-3, an LPS system can no longer be fitted without lightning current or equipotential bonding SPDs to incoming metallic services that have 'live cores' such as power and telecoms cables which cannot be directly bonded to earth. Such SPDs are required to protect against the risk of loss of human life (including permanent injury) by preventing dangerous sparking that could present fire or electric shock hazards.

Lightning current or equipotential bonding SPDs are also used on overhead service lines feeding the structure that are at risk from a direct strike. However, the use of these SPDs alone “provides no effective protection against failure of sensitive electrical or electronic systems”, to quote IEC/BS EN 62305 part 4, which is specifically dedicated to the protection of electrical and electronic systems within structures.

Lightning current SPDs form one part of a coordinated set of SPDs that include overvoltage SPDs - which are needed in total to effectively protect sensitive electrical and electronic systems from both lightning and switching transients.

Lightning Protection Zones (LPZs)

Whilst BS 6651 recognized a concept of zoning in Annex C, IEC/BS EN 62305-4 defines the concept of Lightning Protection Zones (LPZs). Figure 8 illustrates the basic LPZ concept defined by protection measures against LEMP as detailed within part 4.

Within a structure a series of LPZs are created to have, or identified as already having, successively less exposure to the effects of lightning.

Successive zones use a combination of bonding, shielding and coordinated SPDs to achieve a significant reduction in LEMP severity, from conducted surge currents and transient overvoltages, as well as radiated magnetic field effects. Designers coordinate these levels so that the more sensitive equipment is sited within the more protected zones.

The LPZs can be split into two categories - 1 external zone (LPZ 0) and usually 2 internal zones (LPZ 1, 2) although further zones can be introduced for a further reduction of the electromagnetic field and lightning current if required.

External zones

LPZ 0 is the area subject to direct lightning strokes and therefore may have to carry up to the full lightning current. This is typically the roof area of a structure. The full electromagnetic field occurs here. It also covers the area not subject to direct lightning strokes and typically includes the sidewalls of a structure. However the full electromagnetic field still occurs here and conducted partial lightning currents and switching surges can occur here.

Internal zones

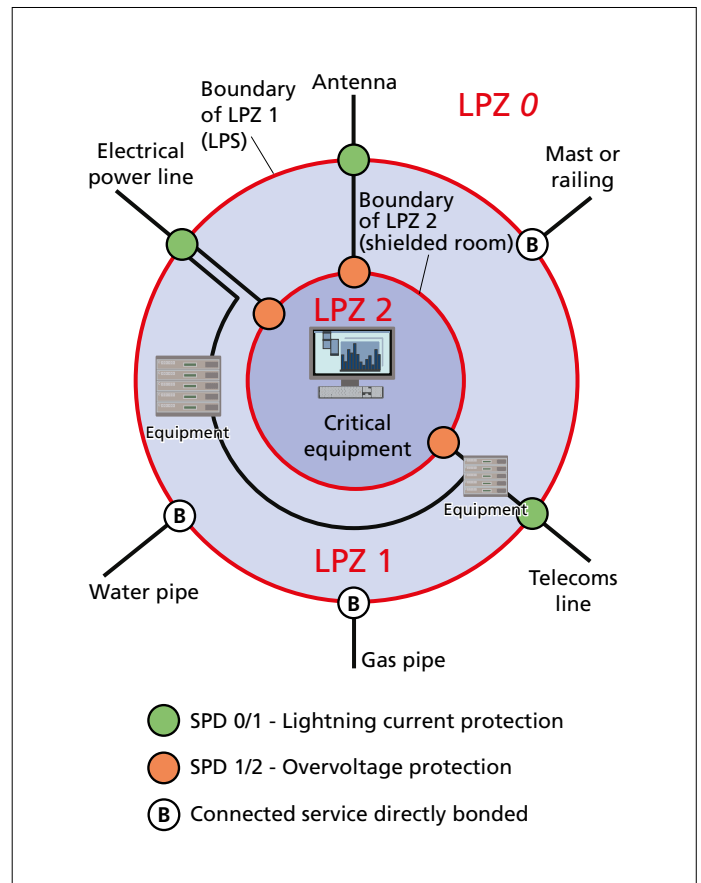
LPZ 1 is the internal area that is subject to partial lightning currents. The conducted lightning currents and/or switching surges are reduced compared with the external zones LPZ 0. This is typically the area where services enter the structure or where the main power switchboard is located.

LPZ 2 is an internal area that is further located inside the structure where the remnants of lightning impulse currents and/or switching surges are reduced compared with LPZ 1. This is typically a screened room or, for mains power, at the sub-distribution board area.

Protection levels within a zone must be coordinated with the immunity characteristics of the equipment to be protected, i.e., the more sensitive the equipment, the more protected the zone required.

The existing fabric and layout of a building may make readily apparent zones, or LPZ techniques may have to be applied to create the required zones.

Figure 13. Basic LPZ concept - IEC/BS EN 62305-4



Technical reference

IEC/BS EN 62305-4 - Electrical & electronic systems within structures

Surge Protection Measures (SPM)

Some areas of a structure, such as a screened room, are naturally better protected from lightning than others and it is possible to extend the more protected zones by careful design of the LPS, earth bonding of metallic services such as water and gas, and cabling techniques. However it is the correct installation of coordinated Surge Protective Devices (SPDs) that protect equipment from damage as well as ensuring continuity of its operation - critical for eliminating downtime. These measures in total are referred to as Surge Protection Measures (SPM) (formerly LEMP Protection Measures System (LPMS)).

When applying bonding, shielding and SPDs, technical excellence must be balanced with economic necessity. For new builds, bonding and screening measures can be integrally designed to form part of the complete SPM. However, for an existing structure, retrofitting a set of coordinated SPDs is likely to be the easiest and most cost-effective solution.

Coordinated SPDs

IEC/BS EN 62305-4 emphasizes the use of coordinated SPDs for the protection of equipment within its environment. This simply means a series of SPDs whose locations and LEMP handling attributes are coordinated in such a way as to protect the equipment, by reducing the LEMP effects to

a safe level. So there may be a heavy duty lightning current SPD at the service entrance to handle the majority of the surge energy (partial lightning current from an LPS and/or overhead lines) with the respective transient overvoltage controlled to safe levels by coordinated plus downstream overvoltage SPDs to protect terminal equipment including potential damage by switching sources, e.g. large inductive motors. Appropriate SPDs should be fitted wherever services cross from one LPZ to another.

Coordinated SPDs have to effectively operate together as a cascaded system to protect. For example the lightning current SPD at the service entrance should handle the majority of surge energy, sufficiently relieving the downstream overvoltage SPDs to control the overvoltage.

Poor coordination could mean that the overvoltage SPDs are subject to too much surge energy putting both itself and potentially equipment at risk from damage.

Furthermore, voltage protection levels or let-through voltages of installed SPDs must be coordinated with the insulating withstand voltage of the parts of the installation and the immunity withstand voltage of electronic equipment.



Enhanced SPDs

Whilst outright damage to equipment is not desirable, the need to minimize downtime as a result of loss of operation or malfunction of equipment can also be critical. This is particularly important for industries that serve the public, i.e. hospitals, financial institutions, manufacturing plants or commercial businesses, where the inability to provide a service due to the loss of operation of equipment would result in significant health and safety and/or financial consequences.

Standard SPDs may only protect against common mode surges (between live conductors and earth), providing effective protection against outright damage but not against downtime due to system disruption.

IEC/BS EN 62305 therefore considers the use of enhanced SPDs (SPD*) that further reduce the risk of damage and malfunction to critical equipment where continuous operation is required. Installers will therefore need to be much more aware of the application and installation requirements of SPDs than perhaps they may have been previously.

Superior or enhanced SPDs provide lower (better) let-through voltage protection against surges in both common mode and differential mode (between live conductors) and therefore also provide additional protection over bonding and shielding measures.

Such enhanced SPDs can even offer up to mains Type 1+2+3 or data/telecom Test Cat D+C+B protection within one unit. As terminal equipment, e.g. computers, tends to be more vulnerable to differential mode surges, this additional protection can be a vital consideration.

Furthermore, the capacity to protect against common and differential mode surges permits equipment to remain in continued operation during surge activity - offering considerable benefit to commercial, industrial and public service organisations alike.

All Furse SPDs offer enhanced SPD performance with industry leading low let-through voltages (voltage protection level, U_p), as this is the best choice to achieve cost-effective, maintenance-free repeated protection in addition to preventing costly system downtime. Low let-through voltage protection in all common and differential modes means fewer units are required to provide protection, which saves on unit and installation costs, as well as installation time.

Conclusion

Lightning poses a clear threat to a structure but a growing threat to the systems within the structure due to the increased use and reliance of electrical and electronic equipment. The IEC/BS EN 62305 series of standards clearly acknowledge this. Structural lightning protection can no longer be in isolation from transient overvoltage or surge protection of equipment. The use of enhanced SPDs provides a practical cost-effective means of protection allowing continuous operation of critical systems during LEMP activity.

A Guide to BS EN 62305 Protection Against Lightning

Further to this summary on IEC/BS EN 62305, we have available a comprehensive guide to the BS EN 62305 standard for those interested in learning more about the new developments governing lightning protection design and installation. This A4 Guide helps to explain in clear terms the requirements of BS EN 62305. Following the 4 sections of the standard (Part 1 - General principles; Part 2 - Risk management; Part 3 - Physical damage to structures and life hazard; and Part 4 - Electrical and electronic systems within structures) the Guide provides the information necessary to enable the reader to identify all risks and calculate the required level of protection in accordance with BS EN 62305.

To request your free of charge copy - contact us directly at any of the addresses given on the back cover or visit www.furse.com



Technical reference

IEC/BS EN 62561 series - Lightning protection system components

The IEC/BS EN 62561 series of standards focuses on design and performance of components which are to be installed in an external LPS.

Designers/users of these systems need to be assured that the components, conductors, earth electrodes etc. that will be installed have the requisite durability to survive long term exposure to the environmental elements whilst retaining the ability to dissipate lightning current safely and harmlessly to earth.

The IEC/BS EN 62561 series of standards defines the processes by which these critical lightning protection components are judged fit for purpose.

There are currently seven parts to the series:

- **IEC/BS EN 62561-1** Lightning protection system components (LPSC) Part 1: Requirement for connection components
- **IEC/BS EN 62561-2** Lightning protection system components (LPSC) Part 2: Requirements for conductors and earth electrodes
- **IEC/BS EN 62561-3** Lightning protection system components (LPSC) Part 3: Requirements for isolating spark gaps (ISG)
- **IEC/BS EN 62561-4** Lightning protection system components (LPSC) Part 4: Requirements for conductor fasteners
- **IEC/BS EN 62561-5** Lightning protection system components (LPSC) Part 5: Requirements for earth electrode inspection housings and earth electrode seals
- **IEC/BS EN 62561-6** Lightning protection system components (LPSC) Part 6: Requirements for lightning strike counters
- **IEC/BS EN 62561-7** Lightning protection system components (LPSC) Part 7: Requirements for earth enhancing compounds



Environmental ageing chamber for ammonia atmosphere ageing

Independent testing

IEC/BS EN 62561 series requires manufacturers to undertake thorough testing and performance measurement of their components in order to gain compliance.

Three specimens of the component are tested, with conductors and specimens prepared and assembled in accordance with the manufacturer's instructions, e.g. to recommended tightening torques.

Testing can include environmental preconditioning (various treatments such as salt mist spray or exposure to a humid sulphurous atmosphere etc.) followed by subjecting components to simulated lightning discharges to assess their capacity to cope with onerous conditions.

Environmental preconditioning is designed to rapidly replicate the effect of component ageing under expected environmental conditions at site, to prove the component's ability to conduct lightning over time.

Testing therefore ensures components have been appropriately constructed for their application, meet the requirements of the standard and will prove safe in use for a number of years.

Furse product tests are undertaken by an independent Certified test laboratory - The Research Development and Certification Centre, High Voltage and High Current Testing Laboratory - to ensure our products conform.

Passing the test

Each part of IEC/BS EN 62561 defines its own criteria for satisfactory performance of components.

All three specimens of a tested component must satisfy the conditions set out by IEC/BS EN 62561 in order for the testing to be deemed successful.

Following testing, a full test report with certification should be produced by the independent laboratory for all components satisfying the test criteria.

IEC/BS EN 62561 requires manufacturers to retain the test report along with adequate documentation to support testing and product application, including installation instructions.

Furse component performance

By choosing lightning protection components conforming to the IEC/BS EN 62561 series, the designer ensures he or she is using the best products on the market and is in compliance with IEC/BS EN 62305.

Furse structural lightning protection and earthing components are therefore rigorously tested to this standard.

Through independent testing, Furse products are proven to withstand the constant exposure to the environment as required by an LPS, thereby ensuring they will continue to dissipate lightning current safely and harmlessly to earth over the long term.

All Furse connection components are designed to conform to the IEC/BS EN 62561 test procedures.

Figure 14. Furse lightning protection components, showing results after environmental preconditioning and lightning discharge testing

