

# **A Practical Guide to Lightning Protection in Australia and New Zealand**

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## **Background**

The current standard for lightning protection in Australia and New Zealand is AS/NZS 1768:2007 and has recently been revised, released in January 2007.

This standard has a comprehensive risk assessment section that is based on IEC standards, well written rules for the design of lightning protection systems, guidance on selection of surge protection, guidance on designing for specific areas like explosive sites and general recommendations on the practices that should be used when designing a lightning protection system.

This standard covers a wide range of structures that are used in commercial and industrial applications. There are some applications where it becomes difficult to use the standard in its entirety.

This paper discusses the design of a lightning protection system (LPS) as per the prescribed rules in AS1768. It also looks at special applications where it is either very difficult or impractical to adhere to AS1768, and offers alternative practical methods. For example, when designing a lightning protection system for a building where columns containing steel reinforcement are not available for use as down conductors close to the perimeter, and it is not architecturally possible to run dedicated downconductors, it is impractical to follow the guidelines set out in the Standard. This and other examples are discussed in this paper. In these cases sound engineering practices need to be used to supplement the core ideas contained within the standards.

## **Designing a LPS Using AS1768**

The rules contained in AS1768 are prescriptive and allow specifying engineers to follow and implement the key guidelines. These are summarised below.

### *Rules for air terminals (Clause 4.3.2 of AS1768)*

- (a) First, provide air terminals to protect the most vulnerable parts (points and corners); second, use the rolling sphere method (RSM) to check if the less vulnerable parts (edges) are protected and, if not, add more terminals to protect them; third, also check if the least vulnerable parts (such as flat surfaces) are protected and, if not, add more terminals.
- (b) Air terminals shall be placed on or close to the most vulnerable parts; if a strip conductor is used, it shall be directly on the part it is to protect; if a vertical rod is used, its length shall be not less than 500mm, and it shall preferably be mounted on the part it is to protect or within 1m or 1/2 its length, whichever is the smaller.

### *Protection of roofs (Clause 4.11.2 of AS1768)*

Horizontal conductors such as strap or cable on parapets and metallic objects such as architectural features, flagpoles, metal railings, steel plant surrounds and roof access

ladders may be used as air terminals to protect a planar roof surface. When positioned at a height of not less than 500mm above the area to be protected and in accordance with the design rules (see Clause 4.3) and the RSM (see Clause 4.4.2), the conductors or objects will be at a suitable height to achieve the selected interception efficiency.

*Rules for downconductors (Clause 4.3.3 of AS1768)*

- (a) Main conductors shall interconnect all air terminals and shall form one or more paths to earth via downconductors, such that the spacing between the downconductors does not exceed 20m.
- (b) A downconductor shall be connected directly below an air terminal used to protect the most vulnerable parts; if the air terminal is on an exposed roof corner, its downconductor will also act as a continuation of the air terminal to protect the vertical edge below it, as is required for tall structures

*Route of Downconductors (Clause 4.12.2 of AS1768)*

The route followed by downconductors should be in accordance with the following recommendations:

- (a) Downconductors should be distributed around the outside walls of the structure. It is undesirable to locate downconductors in areas where persons are liable to congregate. The walls of light wells may be used for fixing downconductors, but lift shafts should not be used for this purpose.
- (b) Where the provision of suitable external routes for downconductors is impracticable or inadvisable, e.g. buildings of cantilever construction from the first floor upwards, downconductors may be housed in an air space provided by a non-metallic, non-combustible internal duct.

*Rules for earth terminations (Clause 4.3.4 of AS1768)*

- (a) Low earth resistance is desirable and all practical measures should be taken to achieve 10Ω or less for the whole interconnected LPS earth termination network.

There shall be equipotential bonding at ground level for all metallic surfaces. If the risk assessment indicates a need for SPDs, these shall be installed and bonded in accordance with Section 5.

- (b) There shall be one earth termination per downconductor.

A typical LPS when designed to comply with AS1768 will be depicted by the building in Figure 1.

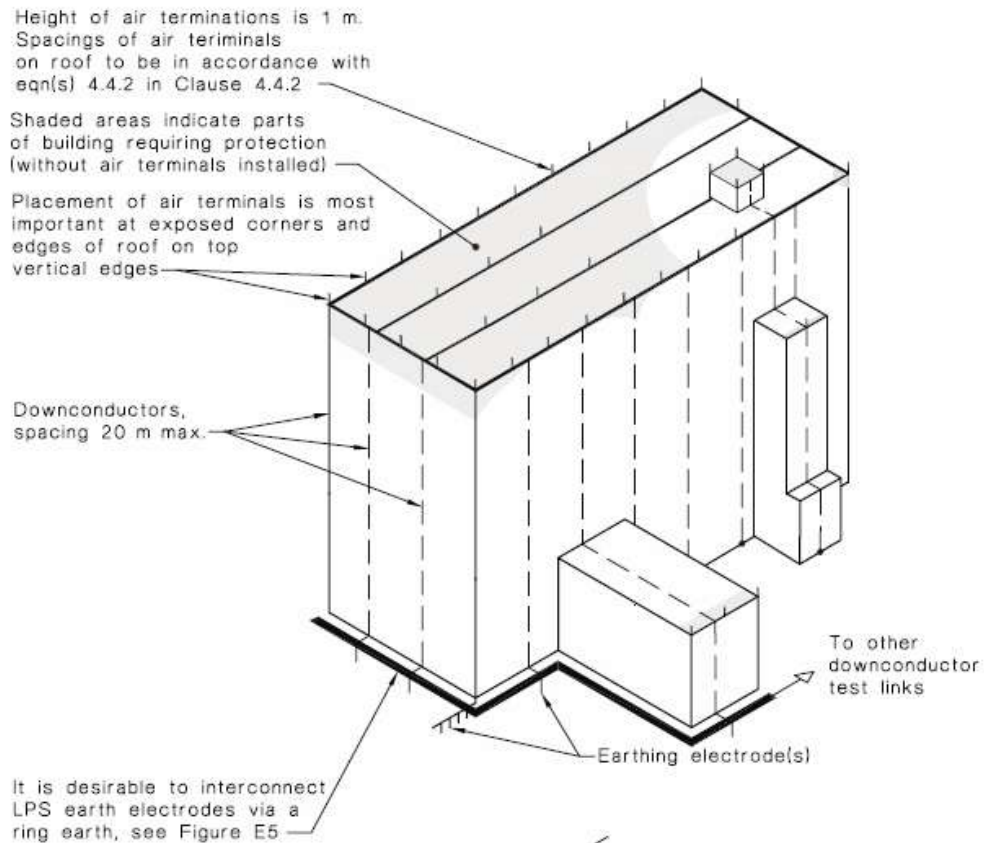


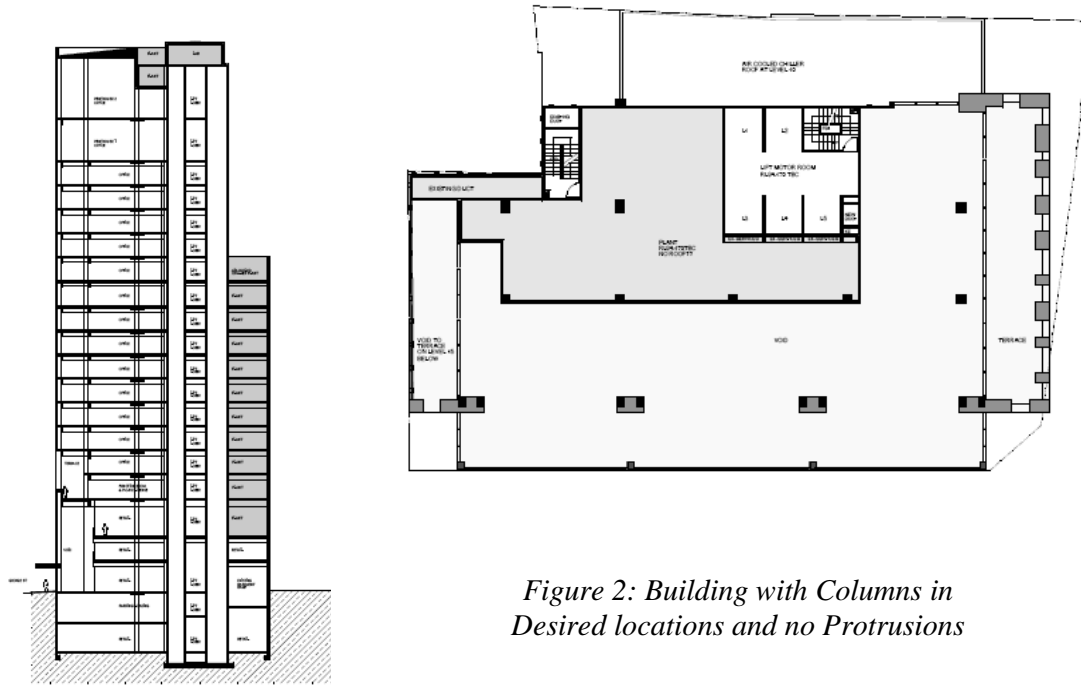
Figure 1: Typical LPS employing vertical air terminals, for Protection Level III, AS1768:2007

### CASE STUDY 1: Building with columns in desired locations and no protrusions

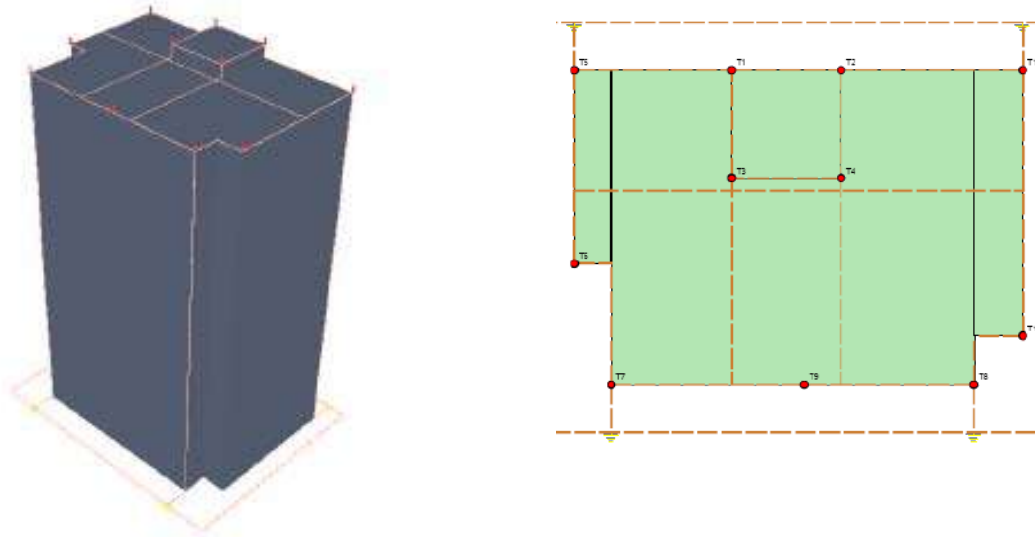
The first case study of an actual building involves a structure that has columns distributed around the perimeter. It has square corners and vertical air terminations can be placed at these corners in accordance with AS1768. It does not have any cantilevered or protruding parts and hence it is possible to place the downconductors directly below each air terminal. The earthing system can also be designed to meet the requirements of AS1768. The façade is continuous and it is bonded to the steel within the building by virtue of construction.

Figure 2 shows the elevation and the plan of this building. Figure 3 shows the design calculated by ERICO's Lightning Protection System Design (LPSD) software depicting the locations of air terminals, down conductors and earthing points.

So in summary, for this relatively simple geometrical shaped building the AS1768 design rules are straight forward to apply. Other than the obvious aesthetic objections of conventional systems, there are still concerns regarding exposed metallic components and the associated weathering and corrosion issues. Additional costs for inspection and on going maintenance also need to be considered with exposed metallic components.



*Figure 2: Building with Columns in Desired locations and no Protrusions*



*Figure 3: LPS Design by ERICO LPSD Software Depicting the Locations of Air Terminals, Downconductors and Earthing*

## CASE STUDY 2: Buildings with inadequate number of columns for use as downconductors and protruding roof features

The buildings depicted in Figure 4 are apartment blocks constructed using modern building techniques. There are no continuous columns around the perimeter of the buildings. Most of the building members are pre-cast concrete and there may be no continuity of the steel within the concrete columns around the perimeters. The façade is protruding at the upper part of the building, a significant distance from any vertical members. There are overhanging balconies protruding from the side of the buildings.



Building A



Building B

*Figure 4: Buildings with Protruding Parts and Inadequate Number of Columns for Use as Downconductor*

It is not possible to apply the rules of AS1768 to this building without several deviations. Let us now discuss the rules that will be difficult to meet.

### *Rules for air terminals*

Technically all the rules for air termination can be achieved. However the question to ask during the design is whether the architect(s) will accept vertical rods of greater than 500mm height visible at all the protruding corners and the edge of the building.

### *Rules for downconductors*

The rules state that the main conductors shall interconnect all air terminals and shall form one or more paths to earth via downconductors, such that the spacing between the downconductors does not exceed 20m. There are not many columns around the building that could be used as downconductors in this case.

To comply with the Standard practically, one of two things can be done:

- I. A bare conductor made of metallic tape or round bare conductor, be run on the surface of the building. Aesthetically this may not be acceptable in many buildings, but will be the ideal technical solution.
- II. Cable downconductors run just on the inside of the finished wall in accordance with this rule. It may be difficult to find straight routes for this in concealed locations around the perimeter. But if these can be found then this solution will be the second best option technically.

In some instances, installers choose available steel columns, either in the core of the building or find columns that are several metres inwards from the perimeter. These installations cannot be deemed compliant to the intent of AS1768. This is because a lightning strike that hits an air termination mounted on the outer peripheral of the roof cannot be expected to travel a large horizontal distance to an inner downconductor. If the solutions under I and II above cannot be achieved, then AS1768 cannot be complied with and the designer may need to look at an alternative engineered system like the ERITECH System 3000.

The second part of the rule states that, a downconductor shall be connected directly below an air terminal used to protect the most vulnerable parts; if the air terminal is on an exposed roof corner, its downconductor will also act as a continuation of the air terminal to protect the vertical edge below it, as is required for tall structures.

It can be seen by visual examination that the only way that this condition can be met on Building B is if it is architecturally acceptable to run a downconductor on the surface at the corners. This condition cannot be met on building A because the corner is made up of protruding balconies.

#### *Route of Downconductors*

The rule for routing of downconductors states that they should be distributed around the outside walls of the structure. It is undesirable to locate downconductors in areas where persons are liable to congregate. The walls of light wells may be used for fixing downconductors, but lift shafts should not be used for this purpose.

It further states that the provision of suitable external routes for downconductors is impracticable or inadvisable, e.g. buildings of cantilever construction from the first floor upwards, downconductors may be housed in an air space provided by a non-metallic, non-combustible internal duct.

The first part of the rule on routing can only be achieved if downconductors are routed on the outside of the building or installed inside on, or very close to the outside wall.

The second part of the rule on routing is often stretched to the limit and it is not uncommon to find downconductors a large distance in from the perimeter. It can be argued that running downconductors close to the perimeter on this type of building is not practical. However, common sense tells us that if lightning rods or air terminations are on the corners of the building than it is illogical to have downconductors a long way in from the perimeter. If the routing suggested above cannot be achieved, then

AS1768 cannot be complied with and the designer needs to look at an alternative engineered system like ERITECH System 3000.

#### *Rules for earth terminations*

The rule for earth termination states that low earth resistance is desirable and all practical measures should be taken to achieve  $10\Omega$  or less for the whole interconnected LPS earth termination network.

There shall be equipotential bonding at ground level for all metallic surfaces. There shall be one earth termination per downconductor.

This rule can be easily met for most buildings of this type. The snag is that the downconductor route influences the earth termination location. In practice an earth termination installed a long way in from the perimeter cannot be deemed to meet the intent of AS1768.

The attempts to apply the design rules contained in AS1768 in its entirety, on these two buildings will fail. Hence it can be demonstrated that these buildings cannot be fitted with a LPS to comply with AS1768. The compliance to AS1768 is not mandatory. In addition to this the AS1768 standard is applicable to a wide range of structures and not all structures. Once it is observed that AS1768 cannot be applied to a building, we have two options for a design. The first option is to persevere with the Standard and install a non-complying conventional system as described above. The second and most times preferred option is to consider non-complying enhanced systems like ERITECH System 3000. In both these choices we deem that AS1768 is not applicable to the building in its entirety.

### **CASE STUDY 3      Buildings of Irregular Shape**

The discussions we have gone through for Case study 2 can also be applied to the buildings in Figure 5 below. The rules in AS1768 that cannot be met for these buildings are for downconductor placement around the perimeter and underneath the lightning rods at the corners. Subsequently the rules for placement of earth terminations cannot be met either. The rules for air termination placement, may possibly be achieved in Buildings A and B, but may not be acceptable from an aesthetics point of view. In the circular Building C on the right, the application of this rule is not possible

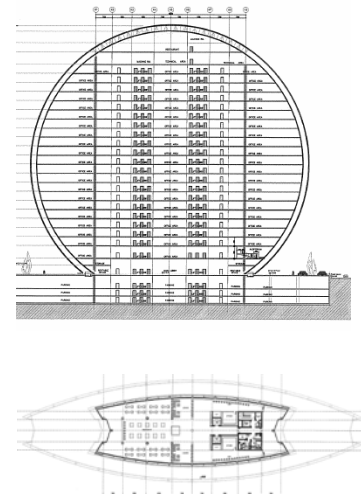
Any LPS that will be installed on these buildings will be a deviation from the Standard. The options for the designer again are either to install a non-compliant conventional LPS or alternatives like ERICO's System 3000. The question that needs to be asked is whether the designed system will perform satisfactorily as a LPS. In order to determine this, the installed system needs to undergo additional scrutiny as to the engineering design underlying both the hardware and positioning method, as well as an examination of the success in the field these systems have had in the past. Criteria for selection is expanded upon in the conclusion to this paper.



Building A



Building B



Building C

Figure 5: Three Building of Irregular Shapes

#### CASE STUDY 4: Industrial applications where isolation of energy is desired

In all the three examples in Figure 6 the structures are fully metallic, however it is preferred to isolate the bulk of lightning energy from the structure either because of the sensitive nature of the contents (hazardous or explosive), or because of the array of electronic equipment and sensors installed on these structures. Building A below is an ammunition storage facility. The client has installed the ERITECH System 3000 on a separate free standing mast so that lightning would strike the Dynasphere air terminal rather than the building.

On Structure B the radar antennae on top is rotational. It will be difficult to apply AS1768 rules for air termination placement on this structure. Similar structures have suffered severe lightning damages in the past. Hence relying totally on the metallic structure to carry the lightning current does not provide the facility owner with confidence in a Standard compliant LPS. The client has installed ERITECH System 3000 to overcome these risks. The Dynasphere is installed on a composite mast (upper section insulating FRP connected to metallic lower mast section). The ERICORE downconductor runs in the core of the composite mast down to the ground. It contains the bulk of the lightning energy other than magnetically induced secondary effects, which the structure handles without a problem.

Structure C is also made from steel. However a lightning strike conducted down the path of this steel in an explosive or hazardous environment does not give the facility manager confidence in a Standard compliant design. The Dynasphere is installed on a fibre glass mast. The ERICORE downconductor runs in the core of the composite mast and down to the ground.





Building A



Structure B



Structure C

*Figure 6: Structure where Lightning Energy Needs to be Isolated from the Structure*

### **CASE STUDY 5: Applications where there is no structure to install LPS on**

The structures shown in Figure 7, all have one thing in common. There is no actual structure to install the LPS on. Structure A is part of a large gas receiving station. Structure B is an area of a large mining facility where chemicals are stored and used in various processes. The chemicals are kept close to ground level and the area is a large open space. Structure C is a storage area for hazardous chemicals used in a manufacturing facility.

*Figure 7: Structures without facility to install LPS on*



Structure A



Structure B



Structure C

It is not possible to apply the AS1768 rules for placement of air terminations on these structures without installing large independent masts and catenary cables suspended at suitable heights between these masts. This is sometimes done for smaller facilities such as explosive storage huts. But it is highly impractical to replicate this on large structures with wide open areas.

In all these 3 examples, the ERITECH System 3000 is installed on free standing masts separate to the facility. The LPS earth systems are necessarily connected to the facility structure and electrical earths to provide one equipotential earth plane.

## Conclusion

The AS1768 standard for lightning protection is intended to be applicable to a wide range of structures that are used in commercial and industrial applications. There are some applications where it becomes difficult to use the standard in its entirety. Solutions for these applications need to be engineered and purpose designed for each structure. These solutions may be either a non-compliant conventional system or an alternative specially designed LPS such as the ERITECH System 3000 as described in APPENDIX 1.

In order to determine which enhanced LPS are effective systems, the following suggested criteria must be examined:

1. What are the design principles underlying the air terminal (theoretical calculations, research and development, computer modelling and high voltage laboratory testing results);
2. What history of supply is able to be proven by the supplier (actual field installations and testing of completed systems); and
3. What design method is used to position air terminals and calculate protection radii (technical peer reviewed papers available, supported by actual field installations and verified testing).

## Further Reading

### International, refereed journal papers:

- D'Alessandro, F. & Berger, G., 1999, "Laboratory studies of corona emissions from air terminals", *J.Phys.D.:Appl. Phys.*, 32, 2785-2790.
- D'Alessandro, F. & Gumley, J.R., 2001, "A 'Collection Volume Method' for the placement of air terminals for the protection of structures against lightning", *J. Electrostat.*, 50, 279-302.
- D'Alessandro, F. & Gumley, J.R., 2001, "New perspectives on the protection of structures against lightning", *J. Electr. Electron. Eng. Aust.*, 21(2), 73-82.
- Petrov, N.I. & D'Alessandro, F., 2002, "Assessment of protection system positioning and models using observations of lightning strikes to structures", *Proc. Roy. Soc. Lond. A*, 458, 723-742.
- Petrov, N.I. & D'Alessandro, F., 2002, "Theoretical analysis of the processes involved in lightning attachment to earthed structures", *J.Phys.D.:Appl. Phys.*, 35, 1788-1795.
- Petrov, N.I. & D'Alessandro, F., 2002, "Verification of lightning strike incidence as a Poisson process", *J. Atmos. Sol. Terr. Phys.*, 64, 1645-1650.
- D'Alessandro, F., 2003, "The use of 'field intensification factors' in calculations for lightning protection of structures", *J. Electrostat.*, 58, 17-43.
- D'Alessandro, F., 2003, "Striking distance factors and practical lightning rod installations: a quantitative study", *J. Electrostat.*, 59, 25-41.
- Petrov, N.I., Petrova, G.N. & D'Alessandro, F., "Quantification of the probability of lightning strikes to structures using a fractal approach", *IEEE Trans. Dielectr. Electr. Insulat.*, 10, 641-654, 2003.
- D'Alessandro, F., Kossmann, C.J., Gaivoronsky, A.S. & Ovsyannikov, A.G., "Experimental study of lightning rods using long sparks in air", *IEEE Trans. Dielectr. Electr. Insulat.*, in press, 2003.

### **International conference papers:**

- Gumley, J.R., D'Alessandro, F. & Kossmann, C.J., 1999, "A new, high voltage, arbitrary waveform generator that can simulate the electric fields due to an approaching lightning downward leader", Proc. of Fifth International Symposium on Lightning Protection, Salvador, Brazil, pp. 126-129.
- D'Alessandro, F., 1999, "A statistical study of the effectiveness of an air terminal used in the lightning protection of structures in Hong Kong", Proc. of International Conference on Electrical Engineering 1999, Kowloon Shangrila, Hong Kong, pp. 244-247.
- Petrov, N.I. & D'Alessandro, F., 2000, "Lightning to earthed structures: comparison of models with lightning strike data", Proc. 25th ICLP, Rhodes, Greece, pp. 346-351.
- D'Alessandro, F. & Gumley, J.R., 2000, "The development of the three dimensional 'Collection Volume Method' as an improved electrogeometric model for the protection of structures", Proc. 25th ICLP, Rhodes, Greece, pp. 311-317.
- D'Alessandro, F. & Darveniza, M., 2001, "Field validation of an air terminal placement method", Proc. of Sixth International Symposium on Lightning Protection, Santos, Brazil, pp. 234-239.
- D'Alessandro, F., 2002, "Sensitivity analysis of factors affecting the striking distance of practical lightning rod installations", 26th ICLP, Krakow, Poland, pp. 247-253.
- D'Alessandro, F., Kossmann, C.J., Gaivoronsky, A.S. & Ovsyannikov, A.G., 2002, "Investigations of upward leader initiation in the high voltage laboratory", 26th ICLP, Krakow, Poland, pp. 259-264.
- D'Alessandro, F., 2002, "Scientific validation of a placement method and proposal for inclusion in lightning protection standards", 26th ICLP, Krakow, Poland, pp. 797-802.

## APPENDIX 1 : DESCRIPTION of ERITECH SYSTEM 3000

### ERITECH® SYSTEM 3000

#### What is the ERITECH® SYSTEM 3000?

The ERITECH® SYSTEM 3000 is a technically advanced lightning protection system. The unique features of this system allow the achievement of reliable lightning capture and control.

The ERITECH® DYNASPHERE air terminal provides a preferred point for lightning discharges which would otherwise strike and damage an unprotected structure and/or its contents. The ERITECH® DYNASPHERE is optimally connected to an ERITECH® ERICORE downconductor and low impedance grounding system in such a way as to provide a totally integrated system.

ERITECH SYSTEM 3000 includes the following elements:

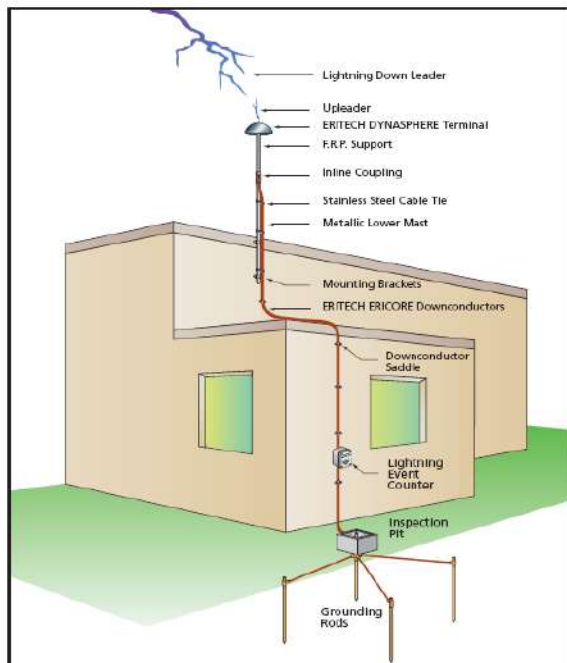
- ERITECH® DYNASPHERE air terminal
- ERITECH® ERICORE downconductor
- Lightning event counter
- Purpose designed low impedance grounding system.

These components form an integral part of the ERICO® Six Point Plan of Protection. Each component must be considered independently and ultimately integrated together to form the complete lightning protection system. Without such integration there is limited protection.

While it is possible to implement a hybrid system using other components, it is important to realize that inefficiencies in any substitute represents an inefficiency in the protection system as a whole.



There is no known method of preventing the occurrence of a lightning discharge. The purpose of a lightning protection system therefore, is to control the passage of a discharge in such a manner that prevents personal injury or property damage. The need to provide protection should be assessed in the early stages of the structure design.



#### 1. The Air Terminal

The primary function of an air terminal, or air termination system, is to capture the lightning strike to a preferred point, so that the discharge current can be directed via the downconductor(s) to the grounding system.

#### 2. The Downconductor

The function of a downconductor is to provide a low impedance path from the air termination to the ground system so that the lightning current can be conducted to earth, without the development of excessively large voltages.

In order to reduce the possibility of dangerous sparking (side-flashing), the downconductor route(s) should be as direct as possible with no sharp bends or stress points where the inductance, and hence impedance, is increased under impulse conditions.

#### 3. The Grounding System

The grounding system must have a low impedance to disperse the energy of the lightning strike. Because the lightning discharge consists of high frequency components, we are particularly concerned with the frequency-dependent electrical parameter of a grounding system – impedance – as well as low resistance grounding.

Grounding systems are highly variable from site to site due to geographical considerations. The grounding grid should minimize the ground voltage potential rise and minimize the risk of injury to personnel or damage to equipment.

## **APPENDIX 2 : SPECIFICATION of ERITECH SYSTEM 3000**

### **1.0 General**

- 1.1 The lightning protection system shall include components as follows: air termination(s), mechanical support(s), low impedance insulated down conductor(s), performance recording equipment, and a low impedance grounding system.
- 1.2 The lightning protection system shall employ an air terminal of the type designed to minimise corona emissions and optimise streamer inception when optimum pre-determined conditions are met.
- 1.3 The lightning protection system shall be mounted adequately rated for wind shear loading. Guying kits shall be provided as appropriate to local environmental conditions, or based on mast arrangement selected.
- 1.4 The design of the components shall be traceable to long-term practical field studies, laboratory testing, fundamental scientific principles, and statistical levels of the lightning event as documented in international standard.
- 1.5 The lightning protection shall be designed by a company engaged in the manufacture and development of lightning system components, of types, sizes and ratings as shown, who can show evidence or support that their products have been in satisfactory service for not less than 10 years.
- 1.6 The lightning protection system shall be installed strictly to the manufacturer's instructions.

### **2.0 Air Termination**

- 2.1 The air termination shall respond dynamically to the appearance of a lightning down-leader, shall be designed to trigger in relation to the optimum pre-determined conditions for upward leader inception, the triggering conditions must dynamically adjust to reflect the down leader intensity, building height above ground and the other factors that effect the electric field intensification above the air terminal.
- 2.2 The air terminal shall incorporate a curved conductive surface spaced from a permanently grounded central finial. During triggering of the air terminal the curved conductive surface shall be temporarily grounded, thereby producing a "snap" increase in electric field directly above the air terminal.
- 2.3 The air termination shall be designed with a range of optimal finial tip radii to match the different electric field conditions the terminal will be subjected to at various installation heights above the ground plane, or different positions on a structure for optimum performance.
- 2.4 Arcing at the finial tip is not to be continuous and shall only occur during the process of lightning leader approach. Arcing shall not occur solely due to electrostatic field build-up created by the presence of charged overhead thunderclouds.

- 2.5 The materials of the air terminal shall be non-corroding in hostile environments. The centre grounded electrode tip shall be at least 20mm diameter, the curved conductive surface shall be of a conductive material of minimum thickness for air terminations as defined in IEC61024.
- 2.6 The size of the collection volume and calculation of attractive radius of the air termination shall be traceable to known and acceptable lightning research and statistics.
- 2.7 The air terminal shall be installed strictly to the manufacturer's instructions.
- 2.8 The isolating material supporting the curved conductive surface from the centre grounded electrode is to be manufactured from a glass/mineral reinforced polypropylene. This material shall exhibit the following properties, high impact strength, UV stabilized, high electrical dielectric, high comparative tracking index and operating heat capability up to 120°C continuous.
- 2.9 The protective zone provided by the air termination shall be such that it becomes the preferred strike point for all discharges exceeding a peak amplitude return strike current of XkA according to the statistical level Y per AS/NZS1768 and IEC61024. The design shall take account of upward leader competing projections on the structure.

Strike Current (X)	Levels of Protection (Y)	Exceedance Probability
2.9 kA	Protection Level I – Very High	99%
5.4 kA	Protection Level II- High	97%
10.1 kA	Protection Level III – Medium	91%
15.7 kA	Protection Level IV - Low	84%

### **3.0 Air Termination Support**

- 3.1 The air terminal support shall consist of a minimum of 2m of insulating re-enforced fibreglass cylindrical mast. The conductor shall pass through the centre of the mast, with the high voltage termination contained to the upper 1m of the mast.
- 3.2 The support shall be securely bolted to other mast materials with guy wires used where necessary to enable the air termination and mast system to withstand maximum locally recorded wind velocities.

### **4.0 Downconductor**

- 4.1 The down conductor shall consist of a polyethylene tubing, combined copper stranded and wound tape conductor, triple semi-conductive/insulation/semi-conductive layer, outer copper conductor, conductive compound sheath, all concentrically arranged.
- 4.2 The main copper conductor shall be made of electrical grade copper, with a minimum cross sectional equivalent to 50mm<sup>2</sup>. The main conductor shall consist of copper strands helically bound by a copper tape conductor designed to evenly distribute the lightning currents concentrically along the conductor length. The outer diameter of the conductor shall be no less than 35mm.

- 4.3 In the final 3m to the ground and where it is exposed to human intervention, the down conductor shall be placed in a protective PVC pipe of 3mm minimum wall thickness so as to avoid mechanical damage and increase human safety. The down conductor shall not be routed through a ferrous metal pipe or tubing, so to avoid a resulting higher surge impedance.
- 4.4 The down conductor should not be subject to bends of less than 0.5m radius and shall be secured to the structure by approved metallic fastenings at least every 2m.
- 4.5 Insulation breakdown ratings between conductors shall be no less than 250kV, i.e. core to screen 250kV based on 1/50 $\mu$ s wave shape as defined under ANSI C62.41.

## **5.0 Performance recording equipment**

- 5.1 Each protection system shall be supplied with a lightning event counter. The lightning event counter shall have an electronic register that activates one count for every discharge where the peak current exceeds 1500A. The test wave shape shall be the 8/20 $\mu$ s standard as defined by ANSI C62.41
- 5.2 The lightning event counter shall be robust, easy to install and housed in a IP67 rated enclosure. The counter shall operate from the energy of the lightning discharge and not rely on external or battery power to operate.
- 5.3 The lightning event counter shall be installed in a readily accessible manner so that readings can be taken at regular intervals. It shall be positioned such that its operating temperature is within the range -10°C to +50°C.

## **6.0 Grounding**

- 6.1 The grounding system reading shall not exceed 10  $\Omega$  static impedance except with prior approval by the site engineer or manufacturer of the lightning protection system.
- 6.2 Grounding shall be affected by copper wire or tape buried below the frost line (or to 600mm deep in non freezing locations) or by deep driven UL listed copper bonded steel core ground rods with at least 0.25mm (10mil) copper thickness.
- 6.3 Bonding of the grounding system to metallic parts of the building, the structural reinforcing steel of the building and to arriving services is recommended. The resistance should be measured and the 10 $\Omega$  requirements achieved before such bonding is affected.
- 6.4 Electrically conductive Ground Enhancing Materials may be used to achieve low ground resistance provided the materials are mixed and strictly in accordance with the manufacturer's instructions.