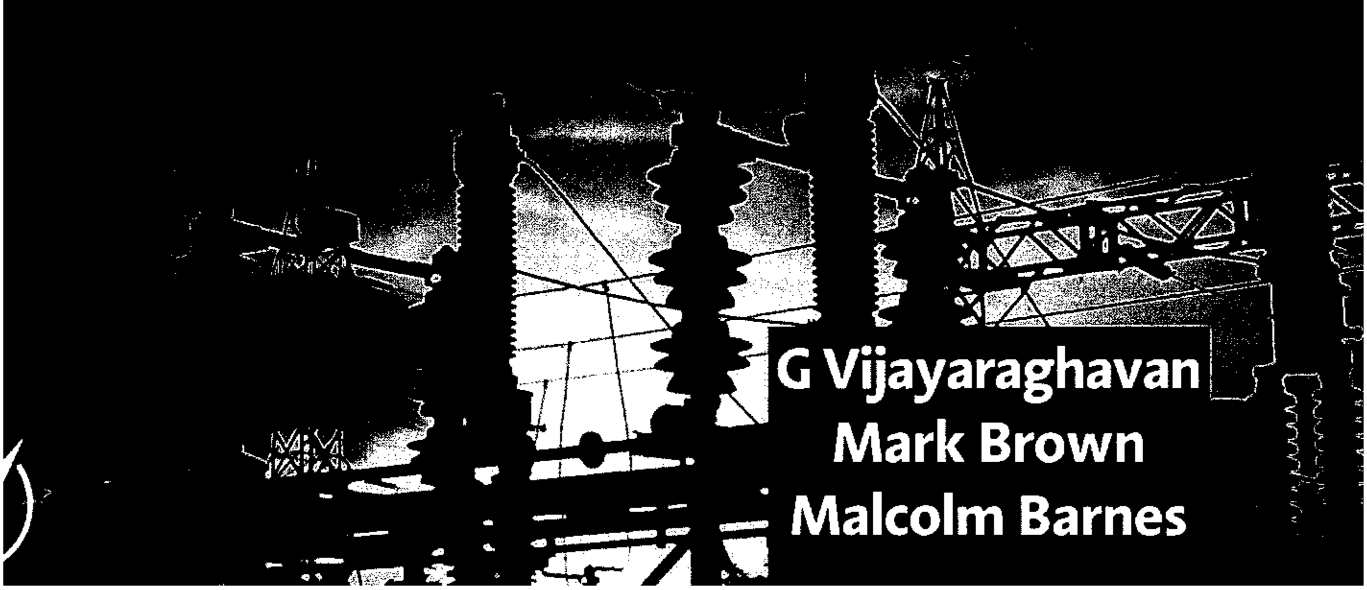
Practical Grounding, Bonding, Shielding and Surge Protection



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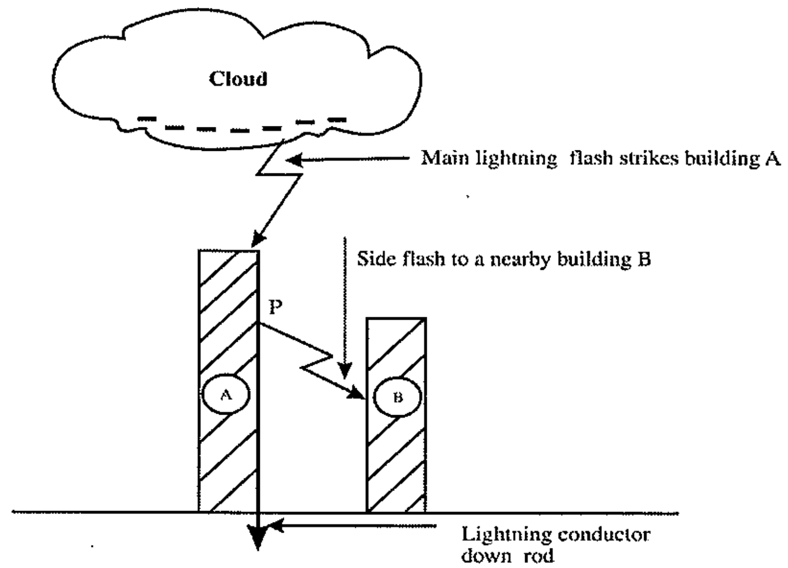

Figure 4.15
How side flashes are caused

4.5 Planning for lightning protection

The protection to be given for a structure or facility against lightning strikes is based on the probability of lightning strike (as detailed in the previous section) and the extent of risk of damage or disruption that a lightning strike can cause. Based on the latter criterion, structures can be divided into various classes in ascending order of protection requirement.

Class 1

Structures, which need very little or no additional protection except connecting them to an effective ground electrode, come under this category. These are all-metal structures, buildings with metallic roofing, side cladding and metallic frame work, stand-alone metallic masts, etc.

Class 2

Structures that have a metallic roof, side cladding and non-conductive framework are in this category. Protection to these structures is provided by down conductors bonded to the roof and side members and connected to ground electrodes.

Class 3

These include metallic frame buildings with non-metallic roof and side cladding. In this case, air terminations on the top of the building and on other non-conducting surfaces connected to the metal frame of the building are required to protect the insulating surfaces from being punctured by lightning.

Class 4

This class includes completely non-metallic structures such as buildings and tall chimneys/stacks constructed of reinforced concrete or masonry. These structures need

extensive protection using air terminations, down conductors and grounding electrodes. An example of such protection is shown in Figure 4.16.

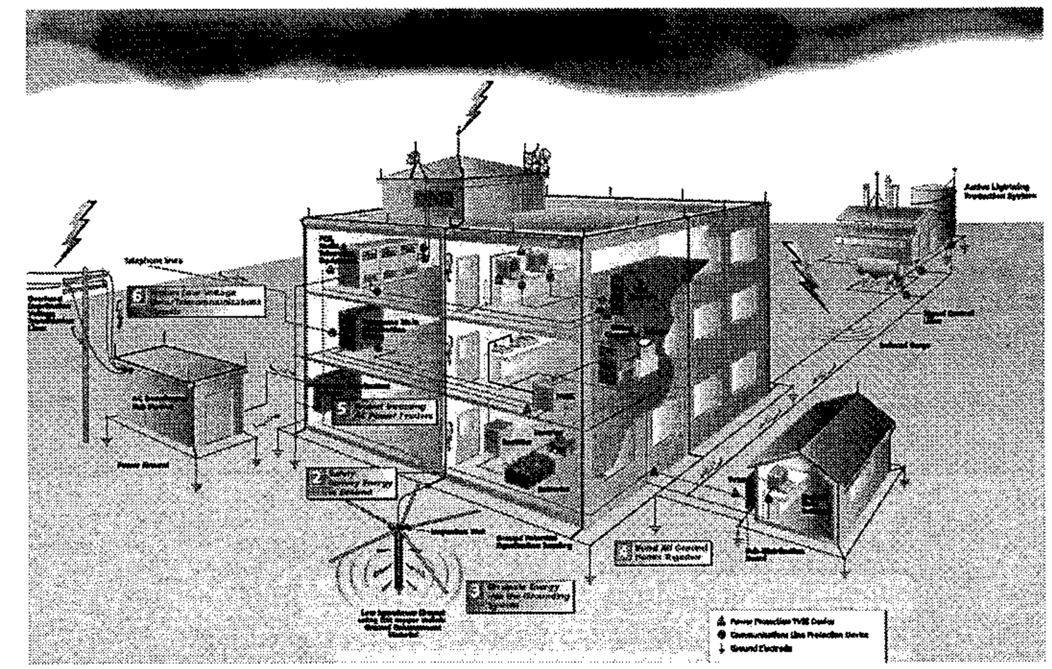

Figure 4.16
Example of lightning protection of a class 4 structure

Class 5

Buildings of historic or public importance or those containing valuable materials, places where a large number of people can gather at a time and public utilities such as power plants, water works, etc. come in this category and need utmost attention while planning protection.

4.6 Improvements to lightning protection

The protection to buildings and structures can be improved by better methods of prediction and by the use of active protection systems. We will cover them briefly below. In 1979, Eriksson presented an improved model, which allows for the intensification of ambient electric field created by a grounded structure. Eriksson's work was a fundamental step forward in lightning protection design, since it supported the field observations that the majority of lightning flashes terminate on the corners and nearby edges and other sharp features of unprotected structures, i.e. the points of highest electric field intensification. The ERICO scientists and engineers extended Eriksson's basic model for application to practical structures back in the late 1980s. This has been done through computer modeling of electric fields around a wide range of 3D structures and by application of the concept of 'competing features' to determine whether a structure is protected. This relatively new method has been known worldwide as the collection volume method (CVM) (refer to Figure 4.17).

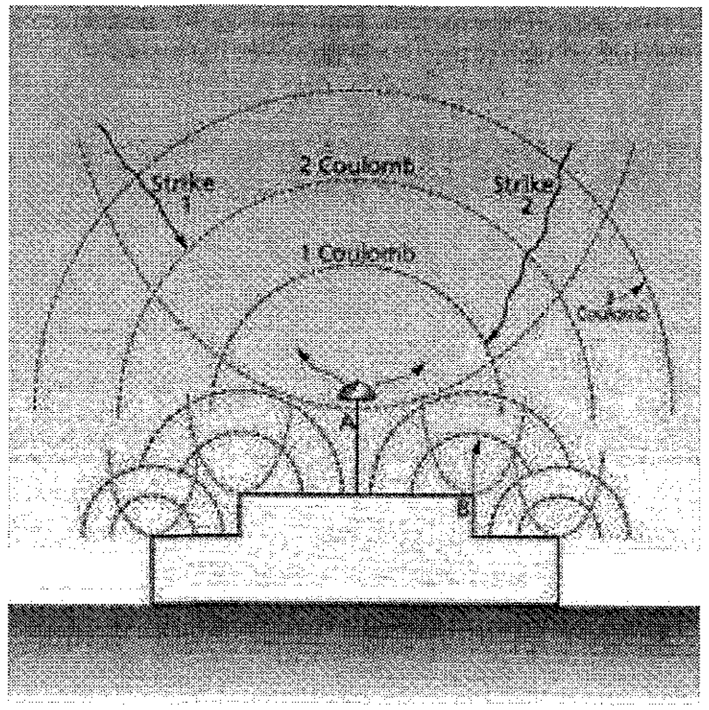

Figure 4.17
Collection volume method

The CVM takes the physical criteria for air breakdown, together with a knowledge of the electric field intensification created by different points on a structure and uses this information to provide the optimum lightning protection system for a structure, i.e. the most efficient protection design for the required protection level. Using the modern risk management approach, the CVM output depends on user-selected protection levels as per the previous rolling sphere method.

Active protection systems are also being offered by several vendors and are claimed to offer a higher degree of protection compared to the passive systems comprising air terminations and down-comers described earlier. The efficacy of many of these systems is however to be proven under actual installation conditions. The basic principle behind these systems is as follows. The active air terminations provided in these systems (which are vertical rods with an active component at their tip) generate a high electrical field as soon as a downward leader from a cloud starts toward the ground and immediately cause an upward leader to emanate from the air termination. Though a normal air termination also behaves in roughly the same fashion, the active protection systems react much faster. As a result the upward leader from the active air termination reaches out much higher resulting in the lightning strike to be invariably directed to the ground through the protection system.

4.7 Factors governing decision whether or not to protect

Standard AS 1768 provides clear guidelines to take a decision to provide or not to provide lightning protection to a building or structure based on an assessment of risk involved. The assessment is done in terms of the likelihood of the structure being struck and the consequences of any such strike. The use of the structure, the nature of its construction, the value of the contents and the prevalence of thunderstorms in the area can all be considered in making the assessment.

A decision to provide lightning protection may, however, be taken without any risk assessment, for example, where there is a desire that there should be no risk to a structure at all.

Examples of such structures are:

- Those in or near which large numbers of persons congregate
- Those concerned with the maintenance of essential public services
- Those in areas where lightning is prevalent
- Very tall or isolated structures and
- Structures of historic or cultural importance.

Where it is thought that the consequential effects will be small and that the effect of a lightning flash will most probably be merely slight damage to the structure, it may be economic not to incur the cost of protection but to accept the risk. Even then, it is better to make an assessment so as to give some idea of the magnitude of the risk that is being taken.

The need to protect electronic equipment and to protect persons against potential differences associated with metallic services increases with the building area. In such cases even though the construction of the structure does not warrant protection, appropriate measures must be taken to avoid risk to persons and equipment.

The standard also stipulates that any structure which is entirely within a zone protected by an adjacent object or objects (whether protected or not) should be deemed to be protected, that is no separate protection is necessary for such structures.

The standard defines a set of five indices:

1. Index A type of structure
2. Index B type of construction
3. Index C height of structure
4. Index D situation (location)
5. Index E lightning prevalence (thunderstorm days/year).

The sum of these indices (R) can be used to determine the need for protection. For more details, the relevant standard may be referred.

4.8 Effect of lightning strike on electrical lines

The foregoing discussion concentrated on the principles of lightning strikes and how their effects can be mitigated. However, lightning strikes on electrical lines or substations are those that cause problems in the distribution network which come right into our residences and offices. A full discussion on the protection of transmission and distribution lines from direct lightning strikes is beyond the scope of this book. We will, however, briefly touch upon this aspect further.

A direct strike on a conductor of a power line causes extremely high voltage pulses at the strike point, which are propagated as traveling waves in either direction from the point of strike. The crest of the pulse can be calculated as:

$$V = I \times Z$$

Where V is the crest voltage, I is the peak lightning current and Z is the impedance seen by the pulse along the direction of travel.

Impedance Z is equal to half the surge impedance of the line when struck at mid-point and can be approximately as much as 150 Ω. Thus for a peak current of 40 kA, the voltage of the pulse can be as high as 6000 kV. Since the basic insulation level of most