

Lightning protection of mobile antennas and roof-mounted structures

The basic task of external lightning protection is to intercept lightning and conduct it safely to earth along the outside of the building.

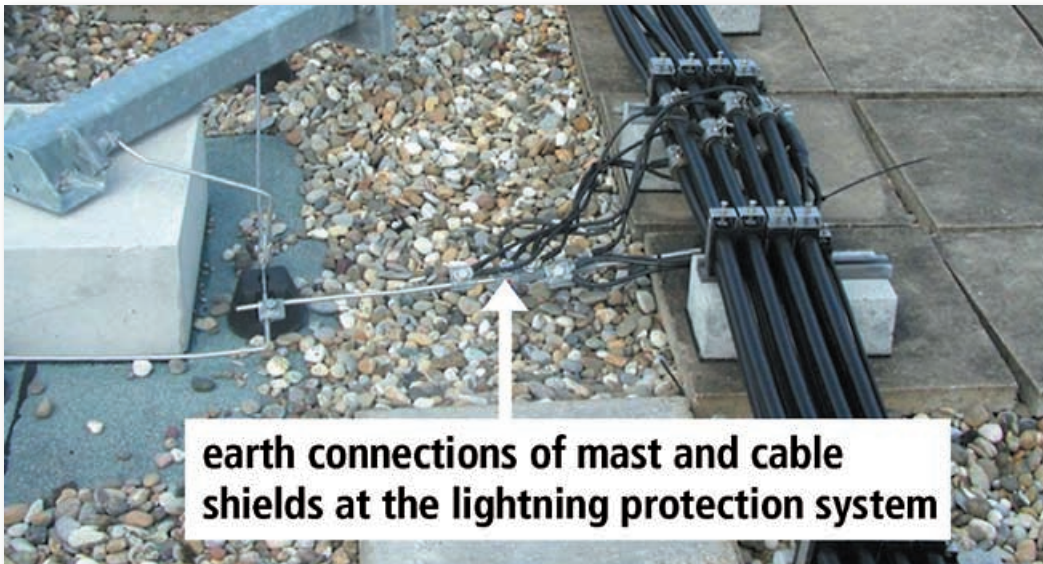


Fig. 1: The problem of insufficient separation distance at cell sites, with the antenna support and feeder cable connected directly to the external lightning protection system

In order to prevent hazardous sparkovers between external lightning protection components and internal conductive elements (electrical installations, pipework, ventilation ducts etc.) due to an indirect lightning strike, maintaining a separation distance is an important requirement to be taken into consideration at the initial specification and design stages.

In many modern installations, the roof is often used for the installation of infrastructure elements such as ventilating and air-conditioning systems, piping and cable racks, all of which are vulnerable to lightning strikes and require the maximum degree of protection. Similar considerations apply to antenna structures for mobile phone systems, which again are often

mounted on the roof of "host" buildings.

In such installations, the practical maintenance of the separation distance is often a problem. In many cases, the stylistic demands of modern architecture make it difficult to provide isolation of the down conductor separately from the normal support insulators. The new system described in this article, however, shows how lightning currents can be conducted to earth in a technically correct way without compromising the aesthetic appearance of the building.

Separation distance

Fig.1 shows the typical problem of insufficient separation distance at existing cell sites. The antenna support and the feeder cable are connected directly to the external lightning protection system. In a direct lightning strike, partial lightning currents would be transferred into the building via the feeder

a new generation of insulated down conductors.

The basic concept of the isolated down conductor is to coat the lightning current carrying conductor with insulating material to ensure that the required separation distance is maintained from other conductive parts of the building construction, electrical conductors and pipelines. The isolated conductor must, however, meet certain other criteria:

- It must be possible to make a lightning-current-proof connection between the down conductor to the air termination system by using clamps.
- The required separation distance must be maintained with sufficient electric strength in the down conductor - both in the area of the feed point and in the run of the down conductor
- There should be sufficient current-carrying capability in the cross-section of the down conductor
- The down conductor must be capable of connection to the earth termination system or the building's equipotential bonding.

Although coating the down conductor with insulating material of high electric strength can reduce the separation distance, there are certain conditions that have to be observed - partly because the resistance of the isolated down conductor is

$$s = \frac{k_i \cdot k_c}{k_m} \cdot L \text{ (m)}$$

k_i : coefficient depending on the selected protection level of the lightning protection system
 k_c : coefficient depending on the geometrical arrangement
 k_m : coefficient depending on the material of the isolating distance
 $L \text{ (m)}$: length of the down conducting device measured from the point of proximity to the next point of lightning protection equipotential bonding

Fig. 2: Formula for calculating separation distance

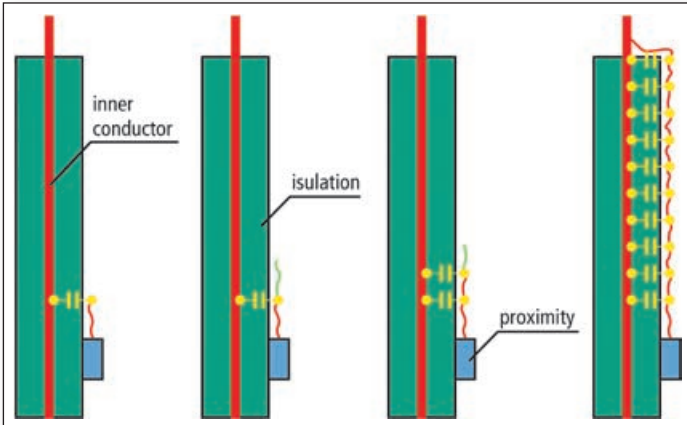


Fig. 3: Basic development of creepage discharge at a conventionally insulated down conductor without special coating

determined by the physical arrangement of the system and partly because of the effects of creepage discharges.

Although the use of unshielded, isolated down conductors is technically possible, it has limitations because - even at relatively low induced impulse voltages - creepage discharges can occur in the area between earthed metal conductor holders and the feed point which can lead to a total sparkover on the surface over long conductor lengths.

Creepage discharges can present critical problems in any areas where insulated material, metal (at high voltage or under earthed conditions) and air come together, leading to a greatly reduced voltage resistance. The problems occur when the normal (perpendicular to the surface of the insulating material)

components of the electric field cause the voltage to rise above the inception voltage of the creepage discharge, and the field components cause the creepage discharge to spread tangentially (in parallel with the surface of the insulating material) (Fig.3).

The inception voltage of the creepage discharge determines the resistance of the complete insulation arrangement and is equivalent to a lightning impulse voltage of 250 - 300 kV.

Coaxial insulated down conductor

In order to address the above challenges, a new type of coaxial single-conductor cable known as the HVI Conductor has been developed which makes it possible to prevent the occurrence of creepage discharges and al-

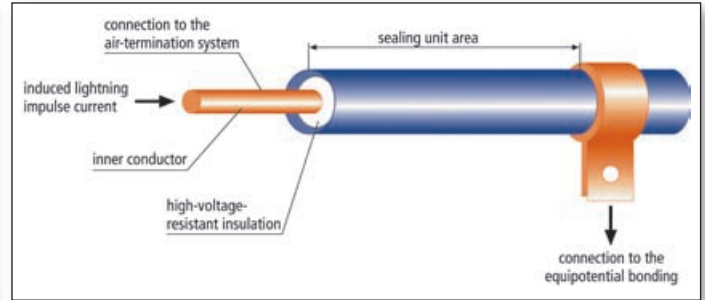


Fig. 4: Construction of the HVI isolated down conductor with field control and semi-conductive sheath

lows lightning currents to be conducted safely to earth. This conductor provides control of the electric field by incorporating a semi-conductive external shield whose electrical conductivity ensures that the lightning current is guided into the cable and conducted safely while maintaining the separation distance (Fig.4). The semi-conductive shield of the coaxial single-conductor cable insulates the electrical field without affecting the magnetic field surrounding the current-carrying inner conductor.

Coaxial cables with semi-conductive sheath

The optimisation of the field control provided by the semi-conductive sheath of the HVI conductor is further enhanced by the development of a specially adapted cable sealing end with a length of 1.50 m, allowing the realisation of an equivalent separation distance of 0.75

m in air or 1.5 m in solid construction materials.

This cable sealing end allows connection to the feed point of the air-termination system and to the building equipotential bonding system, with the two connections separated by a predefined distance (Fig.5). When compared with a coaxial cable with a metal shield, the complete semi-conductive cable sheath has a much higher resistance. As a result, no noticeable partial lightning currents can be displaced into the building, even if the cable sheath is connected to the equipotential bonding system in several places. The maximum cable length of the insulated down conductor depends on the required separation distance and can be calculated with a simple formula.

Application to mobile antenna sites

Antennas for mobile phone systems sites are often installed on

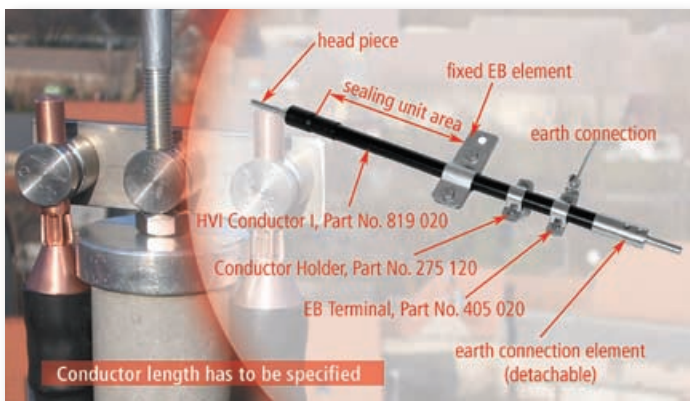


Fig. 5: The HVI isolated down conductor used as a component in an integrated protection system (the DEHNconductor system)

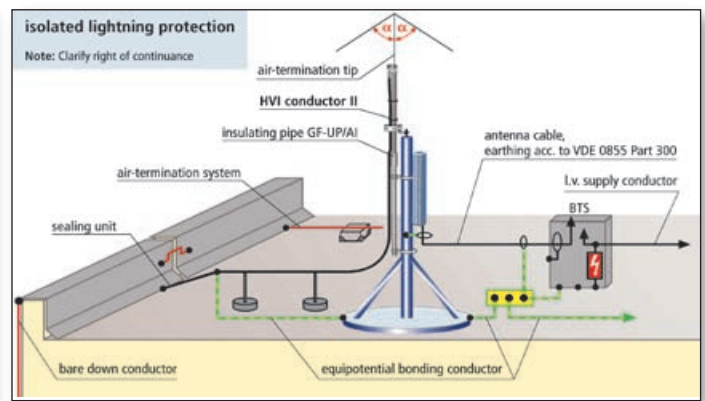


Fig. 6: Integration of a new 2G/3G antenna into an existing lightning protection system by using the HVI isolated down conductor



Fig. 7: The DEHNconductor system with the HVI isolated down conductor used to provide electrical isolation of a 2G/3G antenna system from the building

host buildings. Generally, there is an agreement between the operator of the antenna site and the owner of the building that the installation of the cell site must not put the building at additional risk.

From the point of view of lightning protection, this means that no partial lightning currents from a lightning strike on the antenna assembly can be conducted into the building to threaten electrical and electronic installations.

In a typical installation, the air-termination rod, which is isolated by an insulating pipe made of nonconductive material, is fixed onto the antenna frame construction. The height of the air-termination rod depends on the frame construction and any possibly electrical installations or cable racks within the protection area of the rod (Figs. 6 and 7).

Protection of roof-mounted structures

Metal and electrical roof-mounted structures that protrude above roof level are exposed points for lightning strokes. With conductive connections of pipelines, ventilation ducts and electrical conductors to the inside of the building, they also pose a risk of displacing partial lightning currents.

Preventing partial lightning currents from entering the building can be achieved by installing an isolated air-termination system via the isolated down conductor. This ensures that the complete rooftop electrical and metal installation is situated within the



Fig. 8: Roof-mounted ventilation system with electrically isolated air termination system and spanned cables

area protected against lightning strokes. The lightning current is directed to “bypass” the building to be protected and to spread over the earth-termination system (Figs. 8 and 9).

Visual integration

As mentioned above, the visual integration of down conductors in modern buildings can present aesthetic challenges. The HVI conductor, however, can be installed along the facade or integrated into the facade of a building, opening up a number of design possibilities for the architect without compromising the need for the required separation distance (Fig. 10). Functionality and design can sit side by side, making this innovative technology an important aspect of modern architecture.

Conclusion

The HVI insulated coaxial conductor provides a simple method of conducting lightning currents to the earth-termination system of a structure without the need for special separation distances from metal and conductive elements to be observed. Additional measures for the isolation of air-termination systems and down-conductor systems are not necessary. Because the new conductor provides its own separation distance, it makes life much easier for designers and installers of lightning protection systems. The external appearance impression of the building is not impaired, which makes the designer and the owner of the building much more likely to be happy with the overall lightning protection system. ■



Fig. 9: Roof-mounted air-termination rod and elevated ring conductor with connection to the isolated down conductor

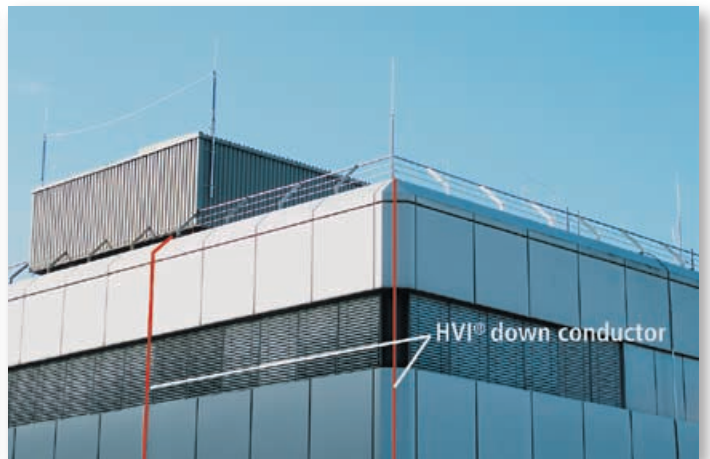


Fig. 10: Air-termination system with spanned cables and isolated down conductor