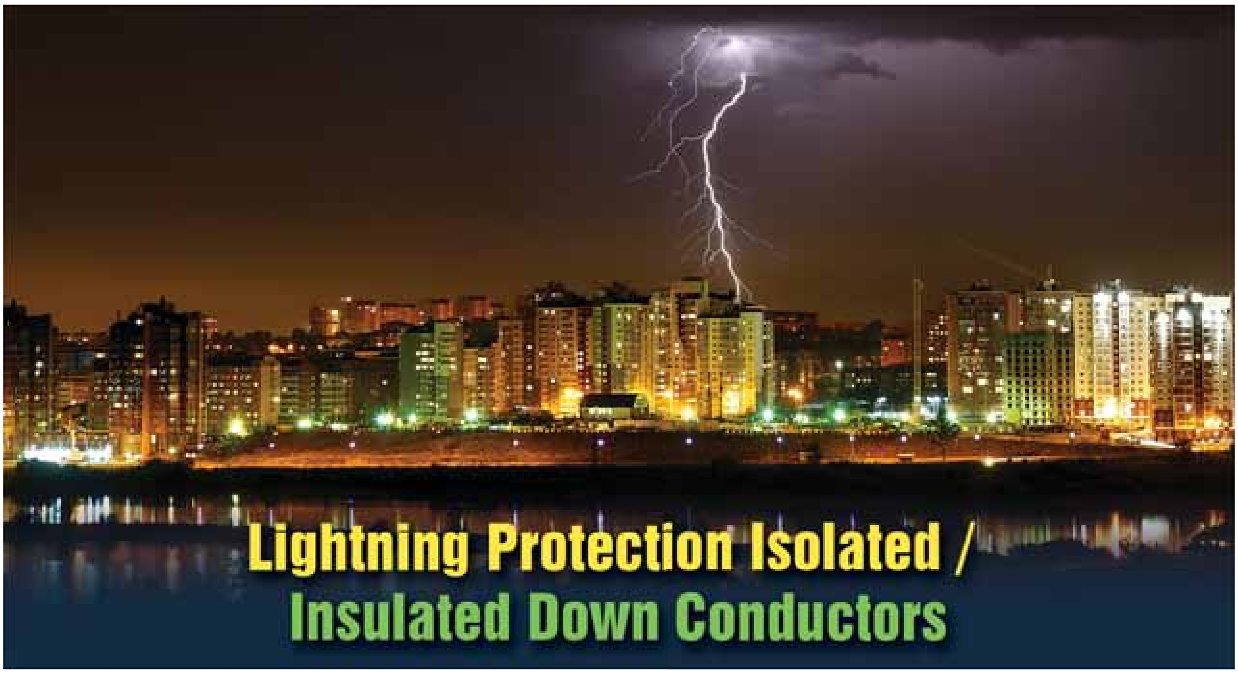
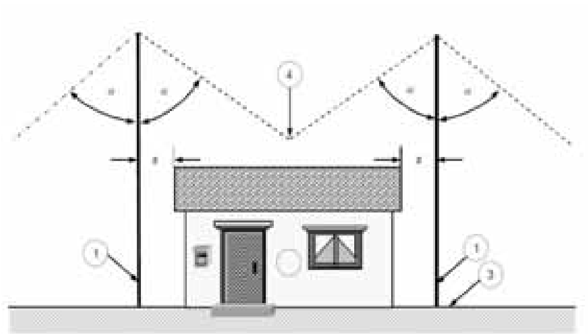



Selection of components for Lightning protection is an area where mischievous stories are considered. Be it air termination or down conductors. One such area is insulated down conductors. Manufacturers recommend insulated down conductors even for tall buildings and metallic towers as it substantially increases the cost of project and as a way to reduce competition.



Isolated lightning protection is an internationally accepted practice where a structure is protected with an LPS separate from the building. The most important calculation which is over looked in the design is the separation distance S between the structure to be protected and parts of LPS. Lightning current flow through parts of LPS create high potential difference to a grounded object isolated form LPS.

- air-termination mast
- protected structure
- ground being the reference plane
- intersection between protection cones S separation distance
- protection angle complying with

The general equation for the calculation of s as per IS/IEC 62305 is given by

$$s = \frac{k_i}{k_m} \times k_c \times l \quad \text{(m)}$$

$k_i$ depends on the selected class of LPS

$k_m$ depends on the electrical insulation material

$k_c$ depends on the partial lightning current flowing LPS parts

$l$ is the length, in meters, along the air-termination and the down- conductor from the point, where the separation distance is to be considered, to the nearest equipotential bonding point or the earth termination

| Class of LPS | Ki |
|---|---|
| I | 0.08 |
| II | 0.06 |
| III-IV | 0.04 |
| Material | Km |
| Air | 1 |
| Concrete, brick, wood | 0.5 |
| Number of down conductors n | Kc |
| 1 (only in case of isolated LPS) | 1 |
| 2 | 0.66 |
| 3 and more | 0.44 |

NOTE 1 When there are several insulating materials in series, it is a good practice to use the lower value for km.

NOTE 2 In using other insulating materials, construction guidance and the value of km should be provided by the manufacturer

NOTE3 Values of Kc apply for all type B earthing arrangements. For type A earthing arrangements, the resistance of neighboring earth electrodes do not differ by more than a factor of 2. If the earth resistances of single earth electrodes differ by more than a factor of 2, kc = 1 is to be assumed.

Potential difference with respect to the structure created in the isolated LPS part depends primarily on the steepness of the lightning current waveform (di/dt) as well as the impedance of the conductor where it flows. The above calculations provided by IS/IEC 62305-3 is an useful tool to calculate the separation distance required between LPS and protected structure.

Manufacturers of LPS recommend special high voltage XLPE insulated cable to substitute this separation distance. Some cables available in the market claim to substitute a distance up to 0.75 meters. Generally these cables are used in short length to isolate an electrical apparatus near the route of LPS to avoid flash over form LPS to equipment. Unfortunately the same cables are used even in tall metal towers with out understanding the basic science behind.

## Case 1

Separation distance between single down conductor and a 30 meter concrete tower in case of LPL 1 can be calculated as

*s (in meters) = (0.08/0.5)* 1*30 = 4.8 meters In case of 2 down conductors S is 3.2 meters*

Even if an insulated conductor (equivalent to 0. 75 meter separation) is used for this application, this cable need to be kept 4.0 meters (4.0 in case of 1 down conductor & 2.5 in case of 2 down conductors) away from the tower. If this distance is lesser, there will be a flash over from the from the conductor to the tower, which defeats the purpose of special expansive cable.

## Case 2

Separation distance between single down conductor and a 30 meter metallic tower in case of LPL 1 can be calculated as

*s (in meters) = (0.08/1)* 1*30 = 2.4 meters In case of 2 down conductors S is 1.6 meters*

Separation distance required in addition to the special cable is 1.65 and 0.85 meters respectively.

Considering least impedance offered by the metallic tower compared to the special down conductor cable will result in puncturing of cable at several locations creating flashover to tower defeating the purpose of special cable.

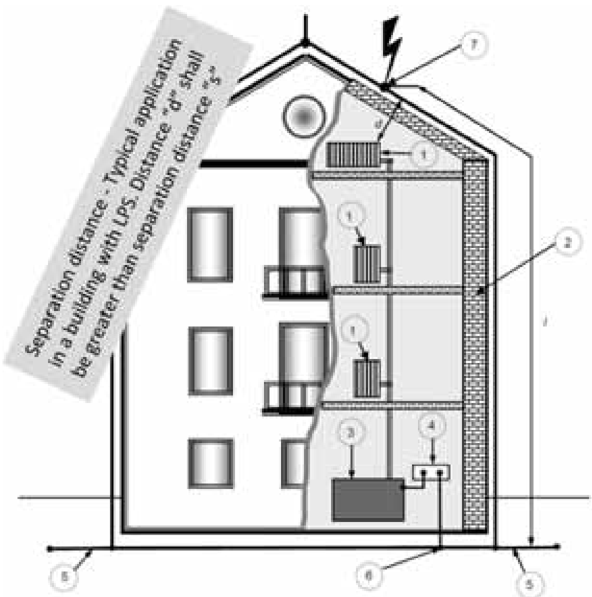
Note: Case 1 & 2 Distance will substantially increase with height

Another way of calculating the separation distance is with he simple formula Length X rate of change of current which results in

$$U_L = L * \frac{di}{dt} = 30\,\mu H * \frac{50\,kA}{0.25\,\mu s} = \underline{6000\ KV\ or\ 6MV}$$

With air breakdown voltage of 2 MV/meter, the separation distance required is 3 meters for the subsequent lightning strike.

Insulated cables are handy in some cases eg. where a roof mounted electrical apparatus need isolation from an LPS component and practically there is no space around this equipment to install an LPS component. Such cases the separation distance are lesser than 0.75 meters. Insulated special conductors in short length of up to 3 to 4 meters will help to solve the above problem. IS/IEC 62305 says "In structures with metallic or electrically continuous connected reinforced concrete framework a separation distance is not required". Because in such buildings and metallic towers it is not possible to isolate lightning current, major portion of




| | |
|---|---|
| *1* | *metallic radiator/heater* |
| *2* | *wall of brickwork or wood* |
| *3* | *heater* |
| *4* | *equipotential bonding bar* |
| *5* | *earth-termination system* |
| *6* | *connection to the earth-termination system or to the down- conductor* |
| *7* | *worst case* |
| *d* | *actual distance where separation distance is required* |
| *l* | *length for evaluation of separation distance, s* |

| Lightning Current Parameters | Symbol | Unit | LPL | | | Effect of Lightning |
|---|---|---|---|---|---|---|
| | | | I | II | III | IV |
| **First positive Impulse** | | | | | | |
| Peak Current | I | kA | 200 | 150 | 100 | Mechanical |
| Impulse charge | QSHORT | C | 100 | 75 | 50 | Thermal (arc) |
| Specific Energy | W / R | MJ/Ω | 10 | 5.6 | 2.5 | Mechanical & Thermal |
| Average Steepness | $d_i$ / $d_t$ | kA / µS | 20 | 15 | 10 | Surges and flashover |
| Time Parameters | $T_1$ / $T_2$ | µS / µS | 10/350 | | | |
| **First Negative Impulse** | | | | | | |
| Peak Current | I | kA | 100 | 75 | 50 | Mechanical |
| Average Steepness | $d_i$ / $d_t$ | kA / µS | 100 | 75 | 50 | Surges and flashover |
| Time Parameters | $T_1$ / $T_2$ | µS / µS | 1 / 200 | | | |
| **Subsequent impulse** | | | | | | |
| Peak Current | I | kA | 50 | 38 | 25 | Mechanical |
| Average Steepness | $d_i$ / $d_t$ | kA / µS | 200 | 150 | 100 | Surges and flashover |
| Time Parameters | $T_1$ / $T_2$ | µS / µS | 0.25 / 100 | | | |
| **Long Stroke** | | | | | | |
| Long stroke charge | Q | C | 200 | 150 | 100 | Thermal (arc) |
| Time parameter | $^{T}$LONG | s | 0.5 | | | |
| | | | | | | |
| **Flash** | | | | | | |
| Flash charge | $^{Q}$FLASH | C | 300 | 225 | 150 | Thermal (arc) |

of lightning current will flow through the metallic tower rather than the insulated cable.

It is wise to consider lightning parameters while selecting LPS components. Lightning parameters in IS/IEC 62305 explains first positive or negative impulse and subsequent impulses. In general less than 5 % strikes are of positive in nature and more than 95 % strikes are negative strikes. Lightning is also are of repetitive nature. Hence experience and knowledge of the designer plays a major role in the designing of LPS

Each of the single parameters (I, Q, W/R , di /dt) tend to dominate each failure mechanism. The mechanical effects of lightning are related to the peak value of the current (I), and to the specific energy (W/R). The thermal effects are related to the specific energy (W/R) when resistive coupling is involved and to the charge (Q) when arcs develop to the installation. Over voltages and dangerous sparking caused by inductive coupling are related to the average steepness (di/dt) of the lightning current front. Handling each effect of lightning need a clear understanding of the problem & the ways to handle it for a typical structure.

For calculation of separation distance, most important parameter to be considered is the average steepness of lightning impulse. In this case First negative strike and the subsequent strikes stands more dangerous than the first positive strike.

It is a practice in the industry to use SPD's with high discharge current handling capacities in the order of 100's of KA's (8/20) current or 25 and 50 KA (10/350) current, expecting a big SPD to handle large current and provide protection. But the fact is in reality impulse currents are much lower than these values, but are of repetitive nature with in few seconds.

A big SPD may not handle repetitive impulse as these tests are not mandatory yet. Large number of failures are due to the repetitive surges rather than a surge with a high impulse current.

## Conclusion

Insulated special cables offering separation distances equivalent up to 1 meter are recommended for some LPS application. These cables need to be applied based on the separation distance explained in IS/IEC 62305. For metallic towers and tall RCC structures, these expansive cables do not improve the reliability of installation. ■

**_Mr S Gopakumar_**

*Managing Director of CAPE electric pvt ltd.*