DETERMINING THE ΔL OF AIR TERMINALS

The testings were conducted under atmospheric conditions of thunderstorms and to the specification of proposed NFPA781 Code.

The Radius of Protection Zone (NFPA781 Code):

$$Rp = h\sqrt{\frac{2D}{h} - 1 + \left(\frac{2D}{h} + \frac{\Delta L}{h}\right)\frac{\Delta L}{h}} = \sqrt{2Dh - h^2 + (2D + \Delta L)\,\Delta L}$$

For Franklin Rod:

$$\Delta L = 0 \quad \text{and} \quad Rp = \sqrt{2Dh - h^2}$$

D is determined by empirical Whitehead's relationship between the leader current and striking distance (Fractal model).

$$\text{"D"} = 10\, I^{.65} \text{ meter } (I \text{ is in KA})$$

h is the height of air terminal.

It is clear that ΔL (delta L) is proportional to the value of D, therefore ΔL = KD and K is the coefficient of proportionality, and characteristic of the individual E.S.E. Air Terminal tested.

Therefore in general:

$$Rp = \sqrt{2Dh - h^2 + K(2+K)\,D^2}$$

The value of D defines the intensity of a lightning strike because it is related to the current of the last fractal jump, and also provides frequency probability of lightning strikes.

In the testing laboratory ΔL can be determined using formula given in proposed NFPA781 Code:

$$\Delta L = 10^6 \left(\Delta T_{Fr.} - \Delta T_{E.S.E.}\right) \text{ meters.}$$

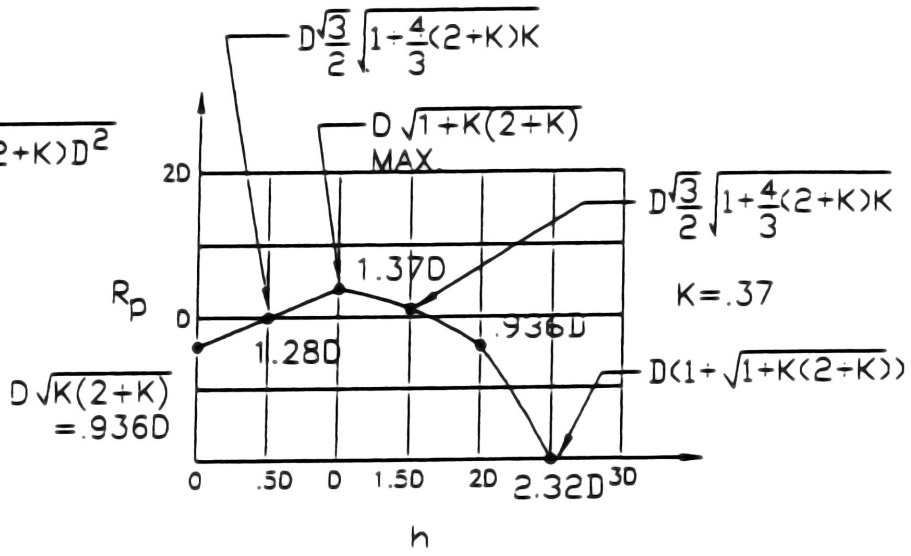
Therefore to obtain the actual value for lightning strike in the field, one has to multiply ΔL(laboratory) by the scale factor which can be taken as 250, which is the ratio of the ceiling of thundercloud to the height of testing cell.

The value of D can be obtained from the current of flashover, and K is thus determined for the tested air terminal. Each type of E.S.E. Air Terminal will have its own K value.

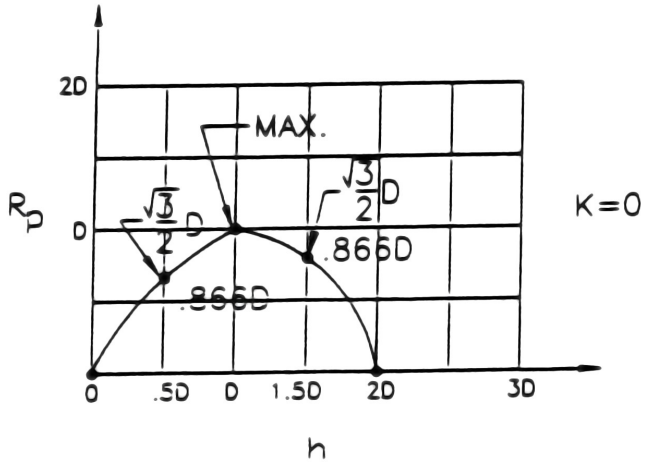
RADIUS OF THE PROTECTION ZONE FOR E.S.E. AND FRANKLIN AIR TERMINALS

$$R_p = \sqrt{2Dh - h^2 + K(2+K)D^2}$$

$$\Delta L = KD$$



E.S.E. AIR TERMINAL



FRANKLIN AIR TERMINAL

TABLE I

Low intensity Lightning . ($\triangle$ L=.250)
Protection zone on the roof of building .

Lightning current I in Kiloamps	Frequency of lightning strikes in %	"D" the last Fractal jump in meters	12"(1') Franklin rod protection Zone Rp	12"(1') ESE Air Terminal Zone Rp	23'(7m) Franklin Roof Protection Zone Rp	23'(7m) ESE Air Terminal Protection Zone Rp
$\geq$ 2.9KA	99.9%	20m(66')	3.5m(11')	16m(51')	15m(50')	21m(70')
$\geq$ 5KA	99%	28m(92')	4m(14')	21m(70')	19m(61')	28m(92')
$\geq$ 10KA	92%	45m(147')	5m(17')	34m(112')	24m(79')	41m(136')
$\geq$ 25KA	50%	81m(266')	7m(23')	61m(201')	34m(111')	69m(228')

ADDENDUM

True scale factor can be computed to a reasonable degree of accuracy by three possible methods of choice:

1. True ratio of voltage of lightning to the voltage of flashover in the laboratory.

2. True length of lightning to the height offlashover in laboratory (considering the dependence of voltage on length of spark).

3. By ratio of size of material lightning cell to the size of the laboratory cell.