LIGHTNING PROTECTION ACCORDING NFC 17-102

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Abstract- Ese lightning protection have been widely used for protect structure including their contents as well as persons. But with the wide applications and demand, new problem arise, the most serious incident structure struck by lightning even already put ese lightning protection near location, because of the failure of protection led to debate whether the lightning rod was proven or not proven function to protect, made it difficult for ESEAT to get permission to install it on buildings on Jakarta. The Topics in this paper analyze, compare and It was found that the lightning protection results fully comply with NFC 17-102 during last 7 years for 250 building / area with near 1000 unit ESEAT succcessfuly protected the building without significant incident..

Scope : external lightning protection.

Keywords : Lightning protection, ESE, Installation, Proven.

1. INTRODUCTION

Lightning is natural phenomenon, Under estimating the effects of lightning on implementation lightning protection system can lead to injuries, death, building fire / damage, destruction of electrical and electronic equipment.

Protection of structures against lightning has been study from a long time, Benyamin Franklin (1706-1790) research protecting structures against the effect of direct lightning discharged with his famous invention, the lightning rod which is still used today as an air termination system, and many research after this to more understand lightning characteristics to make more safety design of lightning protection, last lightning research on jatiluhur (began 2012) International Lightning research and test Jatiluhur which use Rocket triggered lightning , target on research to understand characteristics lightning on tropic area and test ESE (Early streamer emission) Lightning protection on Jatiluhur Situ. (figure 1)
Base on many research and experience, many standards and regulation release for better lightning protection. For International Most famous is IEC 62305 (conventional system)

Figure 1, ICLRT (International Center Lightning research Test) Team front of launching rocket situ jatiluhur

for ESE system is NFC 17-102, and for Indonesia regulation PerMen 02-1989, on PerMen 02-1989, LPS (lightning protection system) conventional, Mesh and electrostatic (ESE) valid to use.

2. LIGHTNING PHENOMENON

LIFE CYCLE

Four main stages along the life span of a thunderstorm cloud:

1. Columns of warm air begin to rapidly burst upward through the atmosphere in a process called convection.
2. As the massive volumes of air rise, they condense in the cooler surrounding air when they reach the upper border to the atmosphere: Often this 'cap' is the tropopause. The air is instead forced to spread out, giving the storm a characteristic anvil shape: the *cumulonimbus* cloud.
3. The water droplets merge into heavy droplets and freeze to become ice particles. As these fall they melt, to become rain. While updrafts are still present, the falling rain creates *downdrafts* as well. The presence of both updrafts and downdrafts during this stage can cause considerable internal turbulence.

4. In the *dissipation stage*, updraft conditions no longer exist, and the storm is characterized largely by weak downdrafts. Because most of the moisture has precipitated out, there is not sufficient moisture in the lower air to sustain the cycle and the thunderstorm dissipates

LIGHTNING DISCHARGE

- Ionization of elevated points and apparition of the corona effect
- Downward step leaders
- Upward streamer
- Connection
- Returns stroke

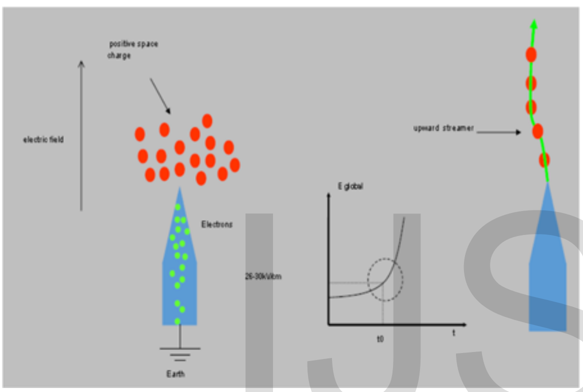

Figure 2 -upward streamer

Upward streamer triggered by downward leader, for the first triggered it is potential strike lightning,

THE ELECTRO GEOMETRICAL MODEL

The electro geometrical model takes into account :

- The relation between downward leader current and the electromagnetic field value
- The relation between downward leader current and estimated peak current (I) on first return stroke (in KA)
- Electromagnetic field value at ground level allowing the development of a upward : 300 kv / m

On this base we can calculation for put lightning protection, D(meter) = 10 x $I^{2/3}$, thanks to this model LPS standard define theoretical values D specified protection level

IEC 62305 have 4 class of lightning protection, which every subject will calculation put on which class. Every class have different value D for calculation position of lightning rod

Class of LPS	Radius of the rolling sphere (r)
I	20m
II	30m
III	45m
IV	60m

Figure 3 - IEC 62305-3 class of protection level

The Protection Level is correlated to the damage probability on the considered structure

- Protection Level IV (low): 80% efficiency of the lightning protection system: the most powerful lightning discharges shall be captured by the system, the risk of damages caused by low-intensity lightning discharges is lower than the "tolerable risk".
- Protection Level I (high): 98% efficiency. Even the low intensity discharges must be captured by the lightning protection system to maintain the risks lower than the "tolerable risk"

Standard Specifications		Protection levels			
	Unit	I	II	III	IV
Rolling sphere peak current	kA	3	5	10	16
Rolling sphere radius	m	20	30	45	60
Maximum peak current	kA	200	150	100	100
Minimum peak current	kA	3	5	10	16
Additional measures	kA				
Probability in which lightning parameters are lower to maximum values		0.99	0.98	0.97	0.97
Probability in which lightning parameters are higher to minimum values		0.99	0.97	0.91	0.84
Protection effectiveness		98%	95%	90%	80%

Figure 4 - Standard specifications

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3 .RISK MANAGEMENT

ACCORDING IEC 62305

For better lightning protection risk evaluation and measures became very urgent matter, fully understood about characterization of lightning discharge may more easy to understand risk management lightning protection.

Risk management created by the international committee of IEC, translated in the standard IEC 62305 – lightning protection. IEC 62305 most acceptable on the world.

Rolling sphere method accept by IEC 62305 and suitable in all case for lightning calculation.

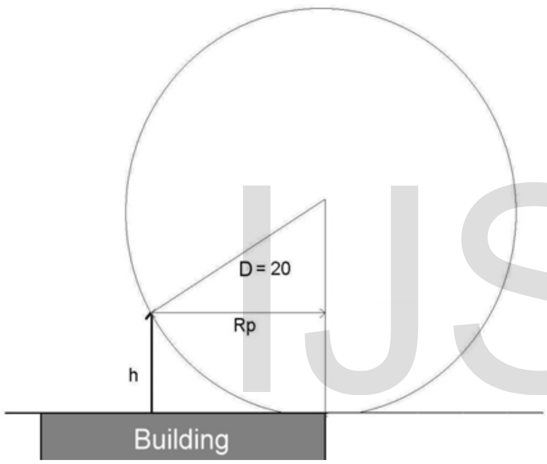

Figure 5 - rolling sphere method

h = height of air termination above reference plane of the area to be protected

rp = radius protection

D = Rolling sphere radius (meters)

Over more than 200 years, Franklin's concept of Lightning protection concept fundamentally still same as the today external lightning protection system.

The external lightning protection composed by 3 interconnected systems :

- Air terminal system
- Down conductor system
- Earth termination system

IEC 62305-3, value distance of Down conductor is correlated with separation distance. Typical value of distance between down conductor are given below table.

Class of LPS	Typical distances m
I	10
II	10
III	15
IV	20

Figure 6 - class protection IEC 62305-3

Earth termination system : to minimizing any potentially dangerous over voltages, the shape, and dimension of earth termination are important criteria low earthing resistance with max 10 ohm are recommended.

4. NF-C 17-102 : 2011

NF-C 17-102 IS French standard on ESE rods, this standard be most acceptable for ESE lightning rod, and last UL already give certification for ESE rod base on NF-C 17-102 : 2011.

Basic calculation radius protection, still use rolling sphere plus Δ cause upward streamer more early Δ t compare to simple rod (conventional).

5.2.3.2 Protection radius.

The protection radius of an ESEAT is related to its height (h) relative to the surface to be protected, to its efficiency and to the selected protection level (see Annex A).

$$R_p(h) = \sqrt{2rh - h^2 + \Delta(2r + \Delta)} \quad \text{for } h \geq 5 \text{ m}$$

and

$$R_p = h \times R_p(5) / 5 \quad \text{for } 2 \text{ m} \leq h \leq 5 \text{ m}$$

where

$R_p(h)$ (m) is the protection radius at a given height h

h (m) is the height of the ESEAT tip over the horizontal plane through the furthest point of the object to be protected

r (m) 20 m for protection level I

30m for protection level II

45m for protection level III

60m for protection level IV

Δ (m) $\Delta = \Delta T \times 10^6$

Field experience has proved that Δ is equal to the efficiency obtained during the ESEAT evaluation tests

NF-C 17-102 point 5.2.3.2

On NF-C 17-102, Δt most important to calculation Rp (Radius protection range), all calculation Rp comes from rolling sphere method (see figure 7)

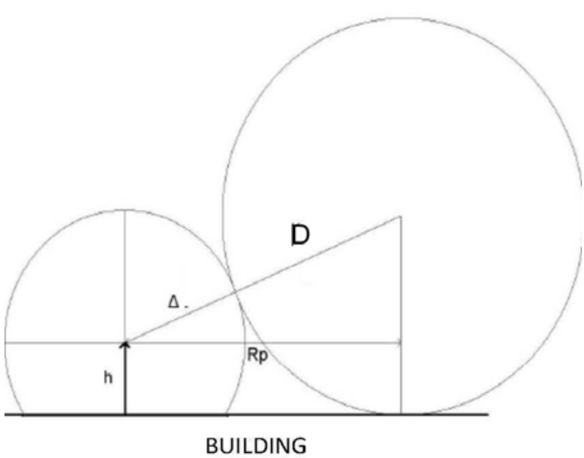

Figure 7- calculation Rp ESE with Rolling method

h = height of air termination above reference plane of the area to be protected

rp = radius protection

D = Rolling sphere radius (meters)

$\Delta = \Delta t \times 10^6$

Δt = Early upward streamer compare to simple rod.

Δt proved in the evaluation test.

On figure 2, Rp can calculation by phytagoras method

Δ+D = hypotenuse

D-h = cathetus 1 (upright side)

Rp = cathetus 2

Rolling sphere on right side on figure 7 is same with rolling sphere on figure 5.

Same rolling sphere method between simple rod/franklin rod, according IEC 62305 and ESEAT (early streamer air terminal emission) according NFC 17-102.

For high rise building (greater than 60 meter) additional protection against direct lightning strike for highest 20% structure height or any point above 120 meters.

For Down conductor minimum 4 and interconnected by ring.

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5. LIGHTNING IN INDONESIA

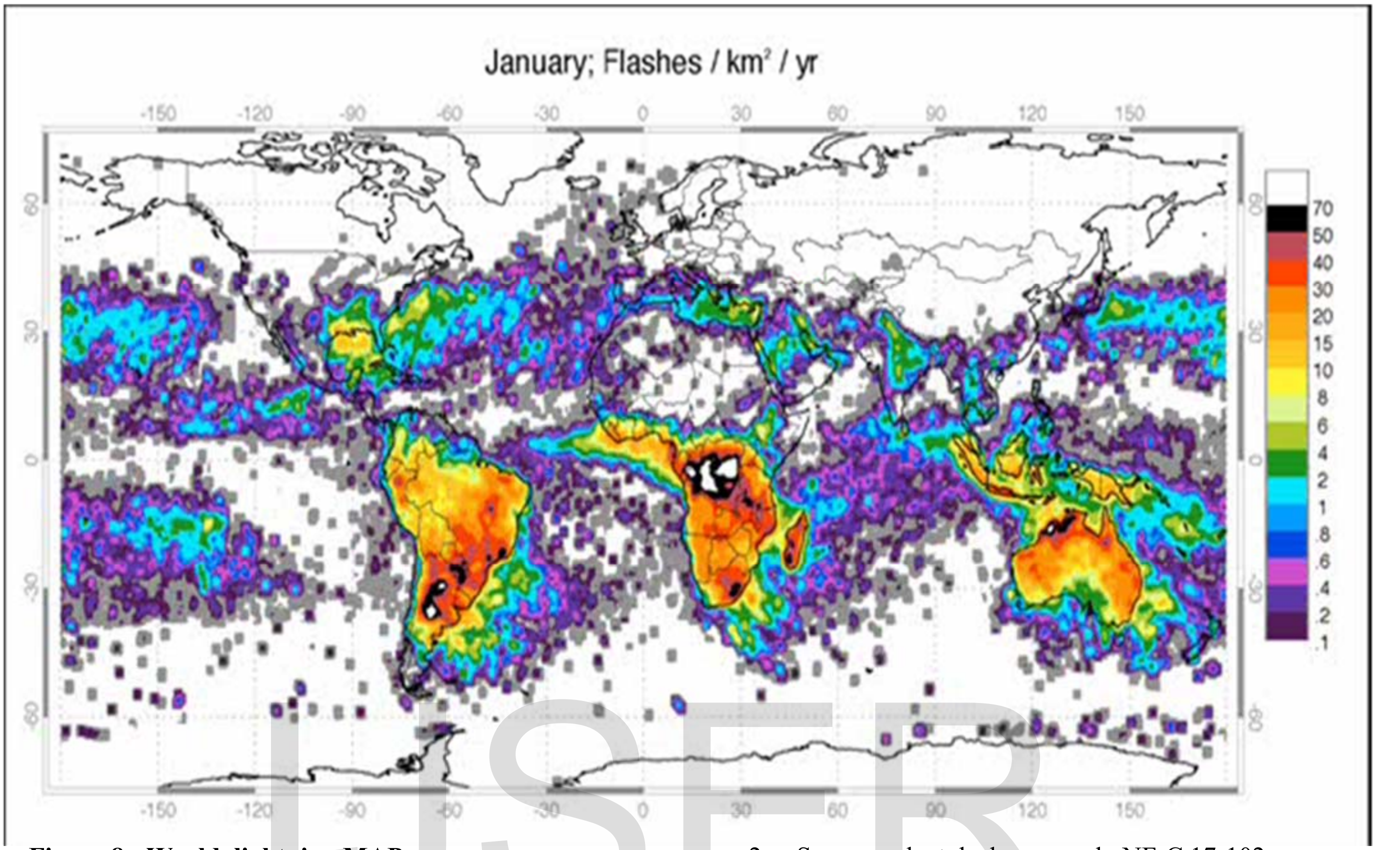

Figure 8 - World lightning MAP

Lightning density = number of flash / year / km²

Base world lightning MAP, Indonesia have very high lightning density.

Compare to French (country NF C 17-102 standard come from) more high lightning density, it is mean more risk to strike lightning.

6. PRACTICAL ESEAT ISSUES IN INDONESIA

ESE Air terminal are installed on many high rise in Indonesia because relative more cheaper compare to Conventional, but later often fail protection and after investigation ESEAT installation, found 3 major practical point not standard cause fail protection :

1. Some product not have comply international standard or country standard, only claim by own manufacture. Sometimes can not support with any technical only marketing brochure.
2. Some product declare comply NF-C 17-102 but can not give any test certificate which require on NF C 17-102 such as Δt
3. ESEAT use only one down conductor an put inside building near electrical device/ cable, NF-C 17-102 require minimum 4 down conductor for high rise, Kep Men 2/ 89 (Indonesia regulation) require minimum 2 down conductor

- For point 1 & 2, it is very difficult to proven their product work as they marketing claim, Most even accident on structure struck by lightning even already install this " radius lightning protection"
- For no 3, usually some accident on electrical or electronic device.

V = IR x L di/dt

Because Voltage will be rise a lot during lightning strike. And current only flow on single cable inside building.

Sometime we need combine with conventional (hybrid) cause ESEAT cannot protect with h below 2 meters or have another object near ESEAT with h below 2 meter, because ESEAT work with different E field in the air (figure 9) between main rod (which connect to ground, E value near 0 V) to wings or other with E on air value to trigger early upward streamer

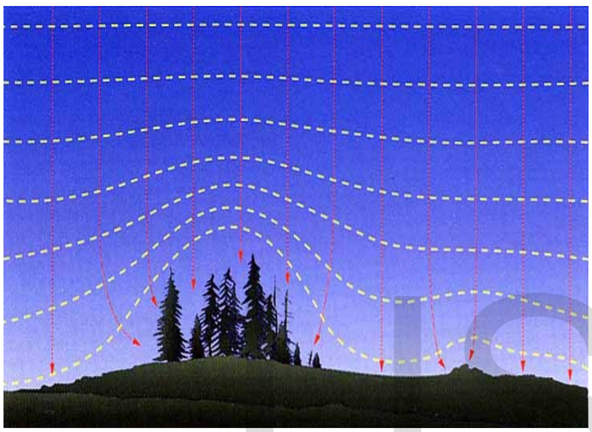

Figure 9, E field

During 7 years, by using planning, calculation and installation that fully comply with NFC 17-102 and sometime added minor modifications for around 250 building/area with near 1000 unit ESEAT, up to now we have Zero fatal accident.

7. Conclusion

We Cannot under estimate the risk of lightning because Indonesia have high lightning density.

ESEAT which full comply NFC-17-102 : 2011 on manufacture and installation and little modified proven can protect against lightning.

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