ADVANTAGES OF USING EARLY STREAMER EMISSION AIR TERMINALS IN PROTECTING POWER INSTALLATIONS

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REZUMAT. **Lucrarea prezintă o analiză a utilizării paratrăsnetelor active pentru protecţia instalaţiilor energetice. Se prezintă pe scurt principiul de funcţionare şi elemente constructive ale acestor paratrăsnete. Se arată metodologia de calcul a razei de protecţie în funcţie de înălţimea h de instalare şi de înălţimea h_x a obiectelor protejate, utilizând metoda sferei fictive. Se prezintă, ca exemplu, protecţia unei staţii 110 kV cu suprafaţa de 8700 m². Se prezintă atât varianta protecţiei clasice, cu paratrăsnete verticale pasive cât şi varianta protecţiei cu paratrăsnete active. Se face o analiză comparativă tehnico-economică a celor două variante. În final se trag concluzii privind eficienţa utilizării acestor paratrăsnete.**

Cuvinte cheie: PDA – paratrăsnet cu dispozitiv de amorsare, metoda sferei fictive, zone de protecţie.

ASTRACT. **The paper presents an analysis of usage of active air terminals for the protection of power installations. It summarizes the operating principle and the construction elements of these air terminals. It shows the methodology for calculating the protection radius in relation to the installation height, h, and to the height of the protected objects, h_x, using the rolling sphere method. An example is presented for the protection of a 110 kV station over a surface of 8700 m². The paper presents both the classic protection option, with passive vertical air terminals and the active air terminals protection option. A comparative technical and economic analysis is made for the 2 options. Finally, conclusions are drawn regarding the efficiency of the air terminals.**

Keywords: ESE - early streamer emission air terminals, rolling sphere method, zone of protection.

1. INTRODUCTION

Since 1753, when Benjamin Franklin invented the lightning rod, it has been improved continuously, reaching the state of the art early streamer emission air terminals today. An early streamer emission air terminal is an air terminal equipped with a device that generates an upward propagating streamer much faster than a regular air terminal. It intercepts the downward leader of the lightning discharge, thus leading to a more rapid orientation of lightning.

The first active air terminals had a radioactive discharge device. The radioactive materials generate weak emissions of alpha particles with relatively long life times. These types of ESEs are quite controversial due to the reduced operating efficiency [1]. Non radioactive ESEs are based on generating a discharge channel produced by an electronic device on detection of the electrostatic field produced by the lightning strike downward leader.

Lightning formation is preceded by an increase in the electric field of over 10kV/m. This natural energy is gathered directly in the primer device of the ESE which, in this case, is in the pre-control state. As the discharge approaches the earth, there is a sudden and intense growth of the electric field, creating a strike risk area. If this risk area is contained within the protection area of the air terminal, the sudden electric field variation activates the control system of the ESE, which, by synchronizing with the approaching lightning, provides a controlled and safe discharge path to the ground. The main characteristic of the ESE is the striking advance time Δt, with values of 10÷60 μs [3], [4]. The forward speed of the discharge channel, v, is approximately of 1 m/μs [6].

In this paper, the authors analyze the use of an ESE solution to protect energy facilities against direct lightning strikes. A comparison is made between conventional air terminals and ESEs. To determine the protection zone, in both cases the rolling sphere method is used.

2. COMPARING THE PROTECTION ZONES

Conventional air terminals, as well as ESEs, have protection zones that depend, at least for power installations, on the protection current value.

The protection current, I_p, is the amplitude of the lightning current which, in hitting the protected installations, generates a surge voltage wave which does not exceed the lightning strike impulse voltage of the installation equipment.

According to [5], the orientation radius of the lightning strike, R (in m) depends on the amplitude of the lightning current I (in kA), through the following relation:

$$R = k \cdot 8 \cdot I^{0.65} \quad (1)$$

where k=1 for horizontal air terminals and k=1.2 for vertical ones. For lightning currents $I \geq I_p$ lightning at a distance greater than the orientation radius given by the protection current cannot hit the protected object.

Figure 1 shows the protection zone for 2 conventional vertical air terminals.

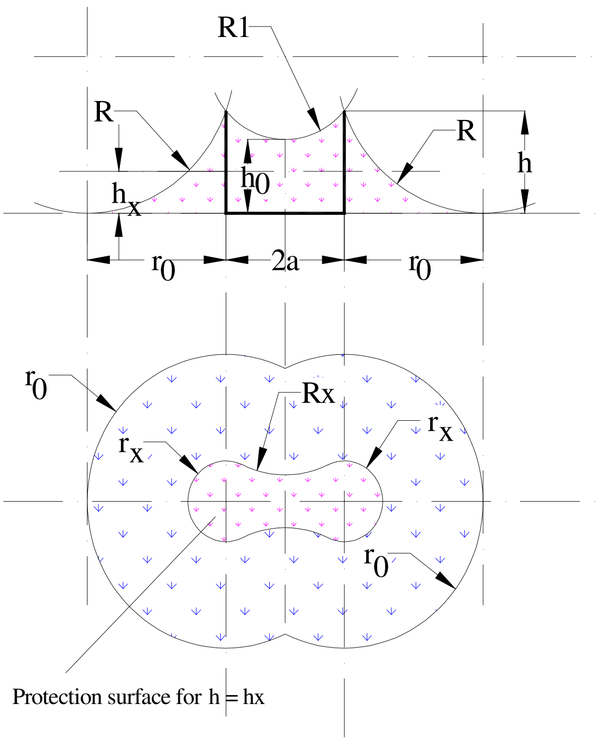

Fig. 1. The protection zone for two air terminals of equal heights h

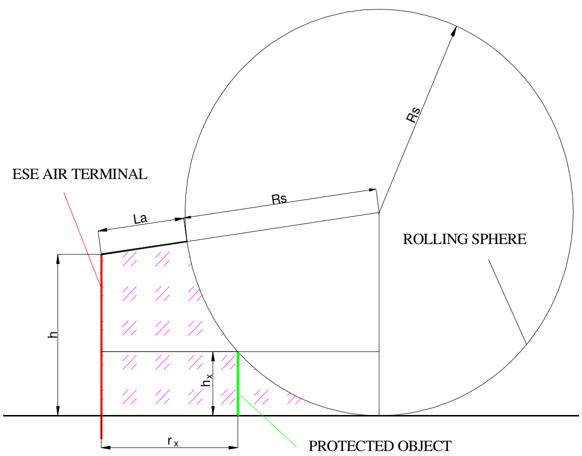

Fig. 2. The protection zone for an ESE of height h

From figure 1, results the protection radius r_x at height h_x:

$$r_x = \sqrt{h \cdot (2 \cdot R - h)} - \sqrt{h_x \cdot (2 \cdot R - h_x)} \quad (2)$$

Figure 2 shows the protection zone for an ESE. From the figure results the protection radius r_x at height h_x:

$$r_x = \sqrt{(L_a + R)^2 - (R - h)^2} - \sqrt{R^2 - (R - h_x)^2} \quad (3)$$

where L_a is the advance length:

$$L_a = v \cdot \Delta t \quad (4)$$

For example, given an air terminal with height h=17.6 m, for a protection current I_p=9kA, results the following protection radius at height h_x=11.6 m. Table 1 shows an over 10 times increase of the protection radius when using an ESE.

Table 1

Comparing protection radiuses

Air terminal	**Protection current I_p [kA]**	**Rolling sphere radius [m]**	**L_a [m]**	**Protection radius, r_x, at height h_x=11.6 m [m]**
Conventional	9	40.04	-	4.98
ESE	9	40.04	60	69.31

3. SOLUTIONS FOR A 110 KV SUBSTATION

Figure 3 shows the protection zones for the conventional lightning protection option. When using a single ESE, the protection zone is given in Figure 4.

As seen, in the conventional case 14 air terminals are installed at heights h=17.6 and h=19.6 m. When using an ESE, it is centrally placed at h=17.6 m.

In terms of costs, for the presented example, the costs are comparable (about 10 thousand lei).

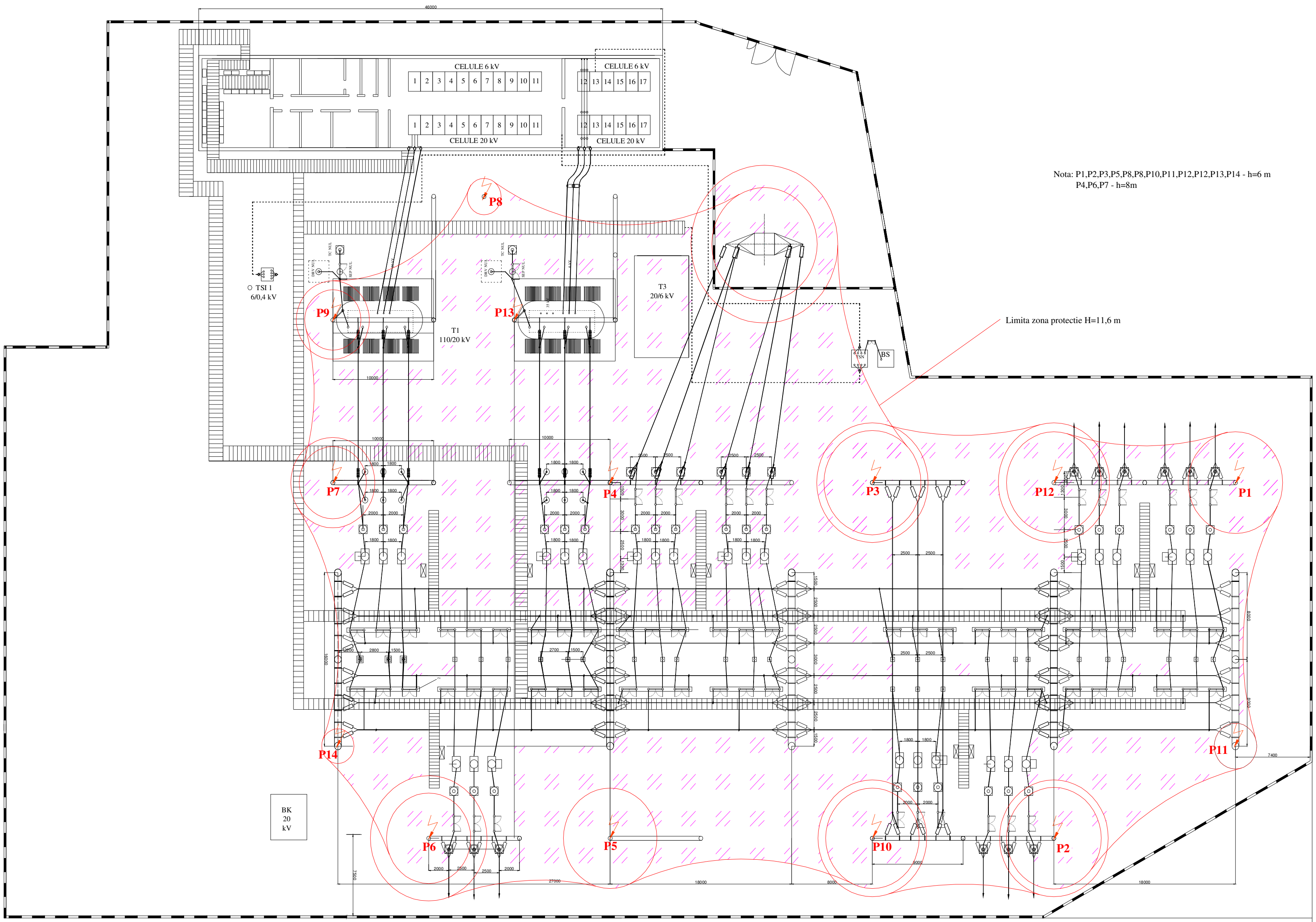

Fig. 3. Protection zones, conventional option

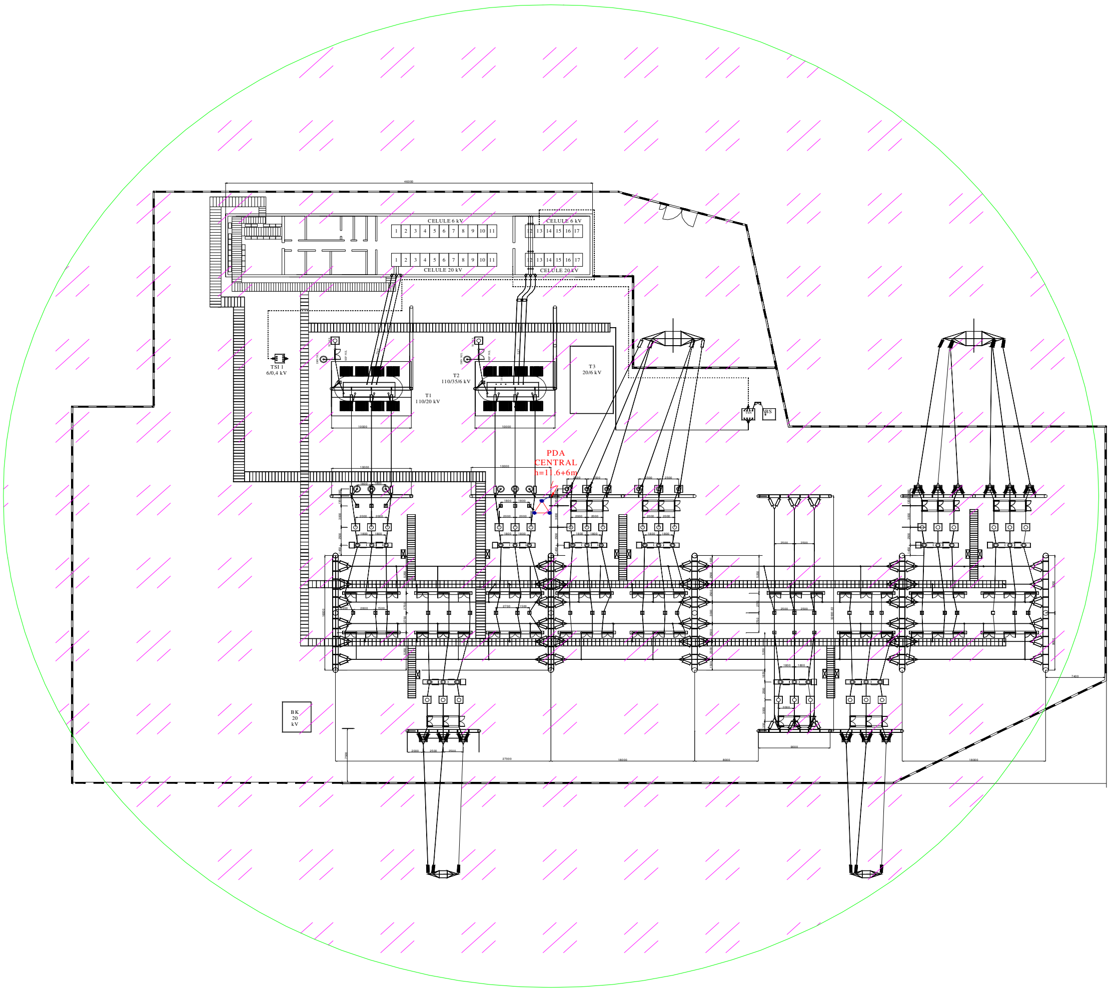

Fig. 4. The protection zone when using a centrally placed ESE

4. CONCLUSIONS

The analysis performed in this paper shows the following:

- Using ESE's to protect constructions is generally accepted in our country, this being mentioned in specific rules [6].
- In the 90s there was a controversy between experts on confirming the advancement generated by the ESE systems; but the controversy faded once France issued NF C 17-102.
- Use of conventional air terminals in transformer stations creates risks associated to supports breaking and falling on bus bars. This risk is very high for air terminals installed between bus bars, in the case of stations with double bus bar.
- Use of ESEs leads to significant simplification of the plant protection against direct lightning strikes, drastically reducing the number of air terminals. The protected areas increase if the starter advance is high (60 µs).
- Use of ESEs significantly reduces the risk of creating serious damage when air terminals supports fail.
- The investment costs when using an ESE are comparable or even lower than the costs involved by conventional air terminals.

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