

INDELEC's Position on Recent Publications discussing ESE Lightning Protection Systems

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ARTICLE INFO	ABSTRACT
Keywords: Lightning protection Early Streamer Emission (ESE) Triggered lightning Lightning attachment Cachoeira Paulista Lightning research Connected air terminals Field data Lightning protection systems	This article presents INDELEC's perspective on the publication "<i>Revisiting test data of ESE rods in Cachoeira Paulista (Brazil, 2000-2005)</i>", which reexamines data from the Brazilian rocket-triggered lightning campaign conducted between 2000 and 2005. While acknowledging the scientific value of the Cachoeira Paulista program and its contribution to the understanding of lightning attachment processes, INDELEC emphasizes that the campaign was conceived as a research initiative rather than a certification program for evaluating lightning protection technologies. INDELEC further highlights the inherent limitations of triggered-lightning experiments and the continuing evolution of lightning science, where attachment processes remain subject to ongoing research. The article also explains how the knowledge gained during the campaign contributed to the development of successive generations of INDELEC lightning protection technologies and advocates a new data-driven approach based on connected air terminals capable of monitoring real lightning events under actual operating conditions.

The recent publication "*Revisiting test data of ESE rods in Cachoeira Paulista (Brazil, 2000-2005)*"¹ revisits experimental data collected during the Brazilian triggered-lightning campaign conducted between 2000 and 2005. While the authors do not intend to endorse or debunk Early Streamer Emission (ESE) technology, its conclusions clearly question the performance of ESE air terminals and, more broadly, raise doubts about the effectiveness of all types of lightning rods.

As one of the industrial partners involved in the original research program, INDELEC considers important to provide context regarding both the objectives of these experiments and the limits of the conclusions that can reasonably be drawn from them.

1- A Test Campaign Designed for Research, Not for Product Certification

The Cachoeira Paulista project was an ambitious international research collaboration involving research institutes, universities, and industrial partners. Its objective was to improve the understanding of lightning attachment mechanisms under controlled conditions using rocket-triggered lightning.

From the outset, the campaign was conceived as a research and development initiative rather than a certification program intended to validate or invalidate a particular lightning protection technology. The number of successful events remained extremely limited. Of the 57 launches conducted over five years, only 21 successfully triggered lightning, and only 2 altitude-triggered flashes actually attached to objects located on the test platform.

The authors themselves acknowledge this limitation, stating repeatedly that the results are not statistically significant and cannot be considered proof against ESE technology.

For INDELEC, this point is essential: scientific conclusions regarding the comparative performance of different air terminals require sufficiently large datasets collected under representative conditions. That is exactly the expectation

¹ JOSÉ CLAUDIO DE OLIVEIRA E SILVA, MARCELO M. F. SABA, NATÁLIA NUNES SOLÓRZANO, "*Revisiting test data of ESE rods in Cachoeira Paulista (Brazil, 2000-2005)*", *Electric Power Systems Research* 263 (2027) 113771

of one of the authors, Jose Claudio de Oliveira e Silva, as stated in his paper “Study of a large-scale experiment to prove or disprove the alleged superior performance of ESE air terminals”² (Ground 2023).

The Cachoeira Paulista campaign did not provide such a dataset.

The number of relevant lightning attachment events was too small to establish statistically robust conclusions regarding comparative interception efficiency. Any attempt to claim definitive proof of superiority is scientifically questionable.

Instead of publishing on the performance of the products used during the Cachoeira Paulista campaign, INDELEC chose to use the knowledge generated by the campaign for its intended purpose: research and product development.

The measurements and observations collected during the project contributed directly to the evolution of INDELEC's technologies. The findings supported improvements made to the *Millennium* generation of air terminals introduced in the early 2000s and later contributed to the development of the *OptiMax*® technology, now integrated into the *Prevectron*®3 generation.

In other words, the value of the campaign lay primarily in improving understanding of lightning attachment processes and refining product design, rather than providing a binary demonstration of whether one type of rod "wins" over another.

2- Lightning Science Remains an Evolving Discipline

Despite significant advances over the past decades, lightning physics remains an active area of scientific investigation.

Many aspects of leader initiation, propagation, and attachment processes are still being studied. New measurement techniques, sensors, high-speed imaging systems, and data acquisition technologies continue to improve our understanding of these mechanisms.

The 2021 article “Close View of the Lightning Attachment Process Unveils the Streamer Zone Fine Structure”³ by one of the authors (Marcello Saba) with Diego Rhamon R. da Silva, John G. Pantuso, and Caitano L. da Silva is a typical example of ongoing research.

3- The Limits of Triggered-Lightning Experiments

Triggered-lightning experiments represent an important research tool, but they also have inherent limitations.

The lightning channel is artificially initiated using rockets and wires, creating conditions that differ from naturally occurring lightning. Even altitude-triggering techniques, which more closely reproduce natural downward leaders, cannot fully replicate the enormous variability observed in real thunderstorms.

Furthermore, attachment conditions are influenced by numerous parameters including:

- Leader characteristics;
- Electrical field distribution;
- Environmental conditions;
- Site topography;
- Wind effects;
- Soil characteristics;
- Relative geometry of nearby structures.

² JOSÉ CLAUDIO DE OLIVEIRA E SILVA, “Study of a large-scale experiment to prove or disprove the alleged superior performance of ESE air terminals”, International Conference on Grounding & Lightning Physics and Effects, Belo Horizonte, Brazil, May 2023

³ MARCELO M. F. SABA, DIEGO RHAMON R. DA SILVA, JOHN G. PANTUSO, CAITANO L. DA SILVA, “Close View of the Lightning Attachment Process Unveils the Streamer Zone Fine Structure”, Advancing Earth and Space Science, Geophysical Research Letters, Research Letter 10.1029/2022GL101482, 2022

As a result, a small number of triggered events collected on this only one location cannot be considered fully representative of the diversity of lightning phenomena encountered worldwide.

This is why the scientific community continues to regard lightning attachment as a field requiring further research and data collection.

INDELEC believes that future progress will come less from isolated experimental campaigns and more from the analysis of large volumes of real-world lightning data collected under actual operating conditions.

4- A New Generation of Research Based on Connected Air Terminals

Today, technological advances make it possible to move beyond the limitations of historical testing programs.

Connected lightning protection systems are capable of continuously monitoring air terminals installed across a wide variety of sites and geographical regions.

These connected installations create opportunities to analyze:

- Real lightning events rather than artificially triggered discharges;
- Hundreds of lightning occurrences over extended periods;
- A wide range of climates and lightning densities;
- Different installation configurations;
- Different structure heights and environments;
- Various lightning current characteristics.

This approach provides access to significantly larger and more representative datasets than those available from historical triggered-lightning campaigns.

Most importantly, it allows researchers to observe lightning under genuine operational conditions, where the complexity and variability of natural phenomena can be captured and analyzed.

5- INDELEC's Commitment to Scientific Integrity

INDELEC has always supported independent scientific research into lightning protection and continues to collaborate with researchers and technical experts worldwide.

The company recognizes the value of the Cachoeira Paulista experiments and the contribution they made to the understanding of lightning behavior. However, INDELEC does not believe that the limited number of recorded events justifies definitive conclusions regarding the effectiveness of lightning rods (either conventional rods or ESE air terminals).

The campaign's results should therefore be viewed within their proper scientific context: a valuable research effort that generated useful technical insights, but one that did not produce a sufficiently large or representative dataset to conclusively establish the performance of one technology over another.

As lightning science continues to evolve, INDELEC remains committed to advancing knowledge through rigorous research, innovation, and the analysis of real-world lightning events. The emergence of connected lightning protection systems now opens the door to an unprecedented quantity of field data, enabling a deeper and more representative understanding of lightning attachment mechanisms than it was possible twenty years ago.

Through this data-driven approach, INDELEC intends to contribute to the next generation of lightning research while continuing its mission of improving the protection of people, infrastructure, and critical assets against one of nature's most complex and powerful phenomena.