CONNECT AND PROTECT

Interception Efficiency of CVM-based Lightning Protection Systems

nVent ERICO

INTERCEPTION EFFICIENCY OF CVM-BASED LIGHTNING PROTECTION SYSTEMS

OVERVIEW

A lightning protection system is just that—a system, or complex arrangement of physical components and calculated strategy. It comes as no surprise then, that research has shown air terminal placement to be an essential part of an efficient and effective lightning protection system. To successfully protect a building and its occupants from lightning strikes, electrical engineers must take a holistic approach, and evaluate the method for air terminal placement as critically as the products themselves.

An unprecedented field-validation study of the Collection Volume Method (CVM) for lightning protection system sheds powerful new insights on optimum air terminal placement and the validity of the CVM's claimed interception efficiency levels. "Interception efficiency of CVM-based lightning protection systems for buildings and the fractional Poisson model," published in December 2015 by Harold S. Haller and Wojbor A. Woyczynski, examines the level of interception efficiency claimed by the CVM.

The study took a two-pronged approach to validate the efficiency of a CVM-based lightning protection system:

1. Statistical Analysis of Field Data: Comparison of count data from installed Lightning Event Counter (LEC) devices to the number of events predicted by the CVM.
2. Theoretical Modeling: Explores (and confirms) the validity of the underlying theory used in the CVM, by comparing the data with theory using extensions and enhancements to theoretical models.

This study is the only one of its kind, as it demonstrated that the CVM meets its claimed interception efficiencies. In the following pages, we outline the parameters of the study, and explore its implications for facility lightning protection.

COLLECTION VOLUME METHOD

Air terminals, or lightning rods, can be placed on a structure according to various models currently used in the lightning protection field. The most common is the Rolling Sphere Method (RSM), which is based on the simple Electro Geometric Model (EGM) for striking distance. The simple EGM does not account for the physical basis of the upward leader inception process, or the importance of the structure height or geometry of objects on the structure.

Instead, the RSM uses a fixed striking distance, typically 45 meters, regardless of structure height or width. This means that a 5-meter structure is given the same capture area and strike probability as a 100-meter communications tower.

In contrast, the Collection Volume Method (CVM) determines the ideal placement of a lightning protection system. It is based on the Eriksson's Attractive Radius (Ra) Model, which uses lightning current to calculate the radius of protection provided by a lightning protection system.

The CVM considers the building's features, evaluating the physical criteria of air breakdown and the electric field intensification created by different points on a structure. It then uses this information to provide the optimum lightning protection system for that specific structure. The result is the most efficient air terminal placement for a selected interception efficiency level.

PART I: FIELD DATA COLLECTION

To test the validity of CVM-based lightning protection systems, the authors analyzed data from a multi-year study to collect lightning event field data. A study of 33 buildings was conducted between 2010 and 2012, in Kuala Lumpur, in the Klang Valley region of Malaysia. The buildings, protected by a system of air terminals optimally placed according to the CVM, were surveyed by TÜV-Hessen. The independent technical agency holds expertise in safety assessment and was responsible for collecting the field data. (This was done in part to build upon the work of prior studies, by employing a similar data collection methodology.)

The nVent ERICO Dynasphere lightning protection systems (LPS) was installed at each site, along with Lightning Event Counters (LEC). The LEC were placed around the lightning current downconductor cable to record the number of strikes to the structure's protection system.
At each inspection, TÜV-Hessen surveyed the buildings, documented evidence of lightning damage (terminal and downconductor condition, and resistance of grounding system), and recorded the LEC readings showing the number of captured lightning events.
When the average interception efficiency of the lightning protection systems was measured against the predicted average interception efficiency, the rates were nearly identical.

In total, 33 events were collected during three rounds of inspections, over a combined 37 terminal-years of exposure. Bypasses, or evidence of lightning damage, were identified at three sites. This is not surprising, considering that lightning is a stochastic natural event, and there are no lightning models that are 100% accurate. Similarly, there are no known lightning protection systems that are 100% efficient.

The field collection provided Haller and Woyczynski with enough count data to complete a statistical analysis of the CVM. When the average interception efficiency of the lightning protection systems was measured against the predicted average interception efficiency (on which the CVM-optimized terminal placement had been based), the rates were nearly identical. Overall, estimates of the strike "yield" demonstrate that the interception efficiency predicted by the CVM is consistent with the observed capture frequency.

PART II: FRACTIONAL POISSON PROCESS MODEL FOR PREDICTING AVERAGE STRIKES PER YEAR

Analyzed field data was also compared to mathematical models of the CVM. Through a new mathematical model, Haller and Woyczynski were able to replicate the characteristic randomness of a natural event like a lightning strike.

This randomness, called burstiness, is an essential feature of stochastic time dependence of incidence of lightning strikes. It is commonly observable in many time-dependent phenomena, such as natural disasters, data, email, network and/or vehicular traffic. But it is a difficult characteristic to represent in a mathematical model, and one that past studies have been unable to replicate.

Employing a novel methodology of fractional Poisson, the authors reproduced the burstiness of lightning strikes. This allowed the authors to investigate the validity of the underlying theory of the CVM. Their model confirms that the interception efficiency of a CVM-based lightning protection system is consistent with claims of 84% - 99% effective, based on the desired level of protection.

IMPLICATIONS FOR FACILITY LIGHTNING PROTECTION

As Haller and Woyczynski concluded, the actual (field-tested) efficiency of a CVM-based lightning protection system is consistent with the projected (theoretical) efficiency. Field data and theoretical modeling both validated the use of CVM-based lightning protection systems.

Thus, study findings show that enhanced air terminals with CVM placement, such as the nVent ERICO System 3000, offer a zone of protection consistent with claimed interception efficiency—up to 84% - 99%, based on the desired level of protection.

What then, does this mean for future lightning protection system installation projects? Based on the study's findings, the CVM offers the same levels of protection when compared to the leading approach, the Rolling Sphere Method (RSM). Therefore, the CVM and CVM-based systems should be considered as a viable option for future projects. Specifically, a CVM-based system may be advantageous when:

- Complex architecture does not allow for application of a standard installation method.
- The architecture of a structure deems the application of a conventional lightning protection system impractical.
- No installation method has been specified and an enhanced solution is advantageous.

Further, the findings underscore the importance of a holistically designed system when planning for facility lightning protection.

NVENT ERICO SYSTEM 3000 LIGHTNING PROTECTION PRODUCTS

Pentair is committed to the development of lightning protection standards around the world. Laboratory testing, using some of the largest outdoor test laboratories, and countless research studies have also been used in the research process. This extensive research has resulted in some of the most up-to-date published technical papers and journals.

System 3000 products have evolved from this research activity, with earlier versions of System 3000 products, providing a building block for the latest advancements through extensive field studies, leading edge indoor and outdoor high voltage testing, and computer modeling research support.

System 3000 products, when used together, create a technically advanced lightning protection system. The unique features of this system allow the achievement of reliable lightning capture and control, when combined with CVM placement.

The Dynasphere air terminal provides a preferred point for lightning discharges that would otherwise strike and damage an unprotected structure and/or its contents. The Dynasphere is optimally connected to an nVent ERICO Ericore downconductor and low impedance grounding system to provide a totally integrated system.

NVENT ERICO SIX POINT PLAN OF PROTECTION

The nVent ERICO Six Point Plan of Protection provides a coordinated approach to lightning protection, surge and transient protection, and grounding:

1. Capture the lightning strike to a preferred point.
2. Convey this energy to the ground.
3. Dissipate the energy into the grounding system.
4. Bond all ground points together.
5. Protect incoming AC power feeders.
6. Safeguard low voltage data/ telecommunications circuits.

The methodology embraces all aspects of potential damage, from the obvious direct strike to the more subtle mechanisms of differential Earth potential rises and voltage induction at service entry points.

Visit us online at nVent.com/ERICO/Lightning to:

- Learn more about System 3000.
- Request a consultation with an nVent ERICO lightning protection expert.
- Register for an upcoming engineering training seminar.