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Lightning Protection based on Streamer Prevention Technology

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Introduction

Lightning protection technology is mostly based upon the application of Franklin rods or overhead ground wires. These options provide a preferred point of lightning strike, and with the proper network of conductors and a grounding system, dissipate the discharged current safely to Earth. This conventional technology is easy to understand and economical to install. In the years since Benjamin Franklin invented the traditional sharp Franklin Rod, many of his rods have reduced lightning damage to structures, but it is widely recognized that objects within their vicinity are sometimes struck. The need forlightning protection technologies that can reduce the probability of direct lightning strikes to protected objects is indisputable, and this paper explains the Streamer Prevention Technology that is widely used today to reduce lightning damage to facilities.

Review of research studies

Benjamin Franklin found the application of strong electric fields to an exposed, sharp electrode, such as lightning rod, causes an electric current to flow into the air [1]; we now know that this current is a result of the ionization process in the air around the tip. However, the space charge formed by the ions around the tip of the rod acts to weaken the applied electric field. This weakening causes a problem for lightning protection efforts because very strong electric fields are required above a rod to establish the conditions necessary for it to connect to approaching lightning. C.B Moore concluded, from his analysis and from the results of the lightning strike competition, that moderately blunt Franklin rods with a height-to-tip radius curvature ratio of about 680:1 are more likely to furnish return strokes, and therefore provide better protection against lightning than either very blunt rods or the traditional, sharp rods [1].

The Charge Transfer System (CTS) was recently developed to reduce the likelihood of lightning strike directly to the premises. Its idea of preventing lightning strikes is based on the point discharge phenomenon. Analysis of electric field of CTS was found to be 67[V/m], while for a Franklin Rod it was found to be 75[V/m]. The CTS devices were found to initiate ionization of air and hold a weaker electric field that prevents the formation of streamers [2].

It is generally understood that the presence and movement of space charges play a major role in lightning discharge formation and its propagation. Space charges ahead of the descending leader tip significantly contribute to such fundamental phenomenon as branching, the

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formation of leader steps as well as pauses between steps [5]. Uhling [3] experimentally investigated corona modes (space charge generation) from fine point and thin wire electrodes. Two basic corona modes were identified; a streamer mode and a streamer-less glow mode (ultra corona). In the case of fine points, streamer discharges did not originate from the very tip but from the stem, however; in the case of thin wires only the streamer-free ultra corona was encountered. In a test series with positive charges, Uhling [3] determined that the critical rate of voltage rise increased from roughly 0.1kV/micro second for a 1mm diameter wire to 1.0kV/micro second for a 0.1mm diameter wire.

Farouk A.M Rizk [4] concluded, based on theoretical analysis and experimental results, that one of the prerequisites for the beneficial effects of space charge on leader inception are strict streamer-free corona mode (ultra corona) over a wide ambient field range and stability of the ultra corona under rapid variation of the ambient field.

A simplified mathematical analysis of the effect of corona space charge on leader initiation under thunderstorm conditions is given by Aleksandrov et al [6]. The ambient ground field, and accordingly, the space potential of the spherical electrode in free space, was mostly assumed to increase linearly with time in typically 10s duration of cloud charge regeneration time. Due to electric field reduction, Aleksandrov et al [6] concluded that space charge hinders initiation and development of an upward streamer/leader from the top of a high grounded object so that the effect reduces the frequency of the appearance of upward lightning under thunderstorm conditions.

Conclusion

To further extensive research and field testing, Streamer Preventing Terminals (SPT) were designed using stainless steel wire with less than 0.1mm diameter, appropriate wire length and geometry at the tip of the air terminal to operate as an IONIZER that has the capability to create stable streamer-free corona under a wide ambient field range.

The IONIZER of the SPT distributes the current at the tip of each stainless steel wire. Under negative cloud polarity, this results in ionization of the surrounding air and continuous release of positive ions. As the ionized air around the SPT starts to drift outwards and ionize adjacent molecules a shielding space charge cloud is created around the SPT air terminal. This shielding space charge is accompanied with a neutralization of the object on which the SPT Terminals are installed. A proper grounding system at the protected facility provides a very low resistance, and low impedance ground resistance, resulting in a quick space charge cloud formation with minimal voltage stress at the air terminal tip. When effectively bonded to the proper grounding system, the emission of streamers from the SPT and the neutralized object is greatly reduced. The SPT Terminals are installed in the same specified locations for conventional air terminals, and in accordance with NFPA 780 and IEC 62305.

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