A REVIEW STUDY ON LIGHTNING PROTECTION SYSTEM RISK ASSESSMENT AND APPLICATION

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ABSTRACT

In the blink of an eye, a lightning strike may deliver thousands of mega-amperes of electricity. As a consequence, if the strike is not grounded, it may cause severe damage to household and industrial equipment and devices. As a result, the current transmission system requires a lightning protection system. Lighting is an inevitable natural occurrence. As a result, studying lightning's qualities and characteristics is essential for developing a lighting protection system. Each application has its own set of requirements that must be met. The location and user of the lighting protection system determine the kind of lighting protection system. A public space, transportation system, power system transmission, and generating system, all of which contain renewable energy sources, are examples of various types of locations. Each region may achieve a different degree of security. The potential and probability of transitory effect on all applications, including public areas, power system lines, and producing systems, is assessed in this study. The evaluation included a countermeasure that addressed a few procedures to evaluate the impact of lightning and protective countermeasures.

KEYWORDS: *Industrial, Charge, Lightning Protection System, Surge Protection Devices.*

1. INTRODUCTION

Lightning is a dangerous yet beautiful natural sky phenomenon. Lightning, as the name suggests, is a dazzling flash of light produced by electrical discharges that occur all over the globe, whether in metropolitan areas, rural areas, or even in open fields. Lightning is caused by a disproportion of charges between thunderclouds and the earth or the clouds themselves, according to hypothesis. The majority of lightning strikes occur between clouds, with the exception of lightning striking the earth, which is a rare occurrence **[1–6].**

In the blink of an eye, a lightning strike may deliver thousands of mega-amperes of electricity. Lightning is most likely to strike the closest point on Earth to it, which has a large potential for positive charges. In other words, a towering building, structure, electrical tower, or even trees that may discharge electricity to the ground are considered the nearest point. An exterior lightning protection system's job is to safely intercept, conduct, and disperse a lightning strike. The structure of a building, its electrical systems, and the people who work around or inside it are all at danger without such a system. Lightning strikes may harm or kill people in a variety of ways. Within or around a structure, lightning strikes (or even electrical discharges caused by adjacent lightning) may produce fires, explosions, chemical release, or mechanical disturbance.

Humans (and animals) in close proximity may be injured or even killed by the step and contact voltages produced by a lightning strike. When designing a lightning protection system, we at Furse are well aware that all of these risks must be addressed and mitigated. With over a century of experience, our assistance and skills have helped hundreds of companies, big and small, achieve successful lightning protection. Human activity outfitted with electrical and technological equipment, whether utilized at home or at work, is well known to be extremely vulnerable to a lightning strike. When lightning struck, the resulting overcurrent created a massive transient on the circuit line **[7]–[9].**

One of the main factors to electrical device damage, failure to function, and destruction is transient or surge. As a result, it is critical to have a protective system in place to withstand the effects of a lightning strike (Figure 1). A lightning protection system (LPS) is frequently built to reduce the potential damage caused by a lightning strike. The main purpose of LPS is to safeguard the structure of the building as well as any important equipment within or on the structure. By channeling the energy and its contents around the cage to the ground, LPS acts as a Faraday Cage, protecting less equipment from the danger of external electric fields. A good LPS seems to offer the lowest resistance route for a surge to go to the ground and dissipate the transient.

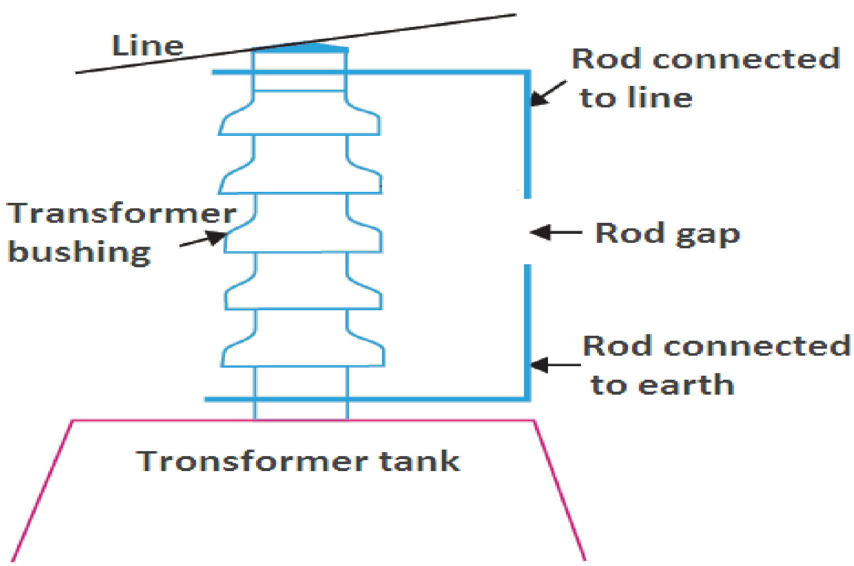

Figure 1: The above figure shows the Rod gap Lightning Arrester [10].

To evaluate a single installation of a protective measure, many factors were taken into consideration, including the likelihood of occurrence, the probability of maximum current of a lightning strike, and, last but not least, the cost. The financial element was important since it would help with the pre-installation and post-installation of any preventive measure. Typical fuses and circuit breakers, on the other hand, are insufficient to inhibit the high conductivity of lightning-induced transients. As a result, a backup solution such as installing a surge protector on a conduction connection becomes critical. Surge protection devices (SPD) are used to help the whole protection system in the event of a transitory danger, such as voltage or current, caused by lightning or switching.

There are several different kinds of SPDs on the market, depending on their intended use, functionality, and location. However, the primary purpose of SPD is to redirect and safeguard the equipment as well as the surrounding area's safety. Various kinds of intelligent systems, ranging from tiny and cost-effective varistor to bulky based intelligent systems, have been researched for decades. Many research have been conducted in order to find a viable technique for reducing the impact of a lightning strike's surge. Researchers have used a novel technique called the spark gap system in SPD to reduce the impact of transients. As a result, in order to get a better knowledge of SPD in the context of lightning protection, this study examined every SPD currently available commercially and analyzed their properties. This research is also looking at the best protection technique for each application in the generation-to-distribution system electrical connection.

A lightning arrester or surge diverter is a device that is used to safeguard the equipment at substations from traveling waves. To put it another way, a lightning arrester directs an abnormally high voltage to the ground while maintaining supply continuity. It is linked between the line and the ground, in tandem with the equipment at the substation that has to be safeguarded. As illustrated in the diagram below, when a traveling wave approaches the arrestor, it flashes over at a certain voltage. Between the line and the ground, the arrestor offers a conducting route for low-impedance waves. The line's surge impedance limits the amount of current that may go to ground.

1.1. Lightning Protection System:

As stated in IEC 62305, lightning protection systems (LPS) are now regarded a need for every structure to be installed in order to safeguard both the structure and the material inside it. It covers both the equipment and the people within the building's safety. As previously mentioned, every element of installing the LPS must be considered, including safety, LPS design, and installation costs. Since lightning strikes are unpredictable, economic factors play a significant role for LPS. When compared to total lightning, there is a nearly 5% chance of lightning striking the ground. The LPS were classified in this study based on their location and application. The category area is public area, transportation system, and power system transmission and generation system which include renewable energy source (Figure 2).

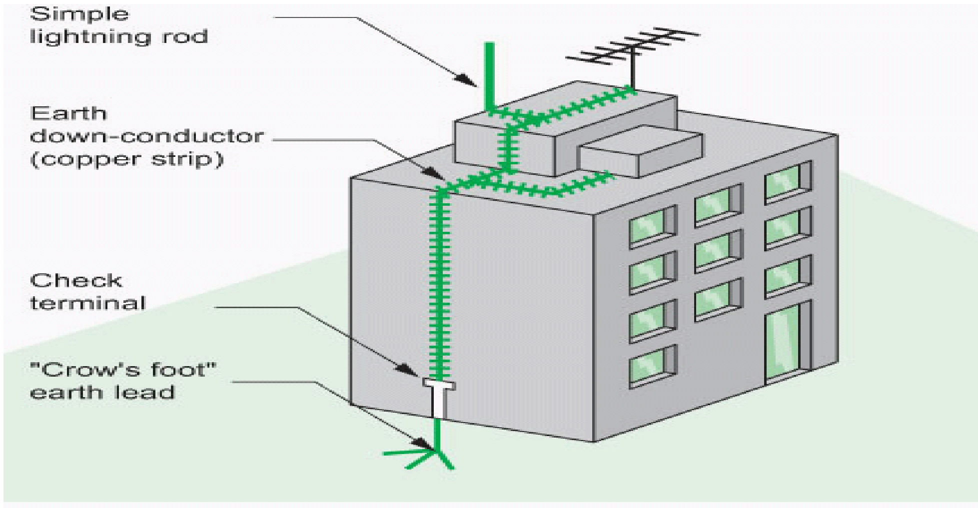

Figure 2: The Above Figure Illustrate the Grounding and bonding are the basis upon which safety and power quality are built [10].

In today's world, the majority of lightning protection in new construction is linked to electronic gadgets, appliances, and equipment such as closed circuit television (CCTV), computer networks, and so on. Due to the vulnerability of electrical equipment to lightning surges and strikes. A lightning countermeasure must be installed in a structure with a well-equipped electrical system, in addition to lightning terminals installed to deflect direct stroke to the ground. Lighting countermeasures include transient diversion and balance, shielding, and grounding. Surge protection devices (SPD) are often installed to help in the protection of the whole system by redirecting overcurrent in a short amount of time and avoiding surge damage to electronic equipment.

A model was created in 2008 to mimic the impact of surges on electrical equipment in a building. The equivalent circuit of the equipment was changed from a typical resistive load to an inductive, capacitive, or a mix of these. Still, the circuit's architecture was cascading all of the loads, but with an SPD in the middle to send the transient to the ground. The findings revealed that various types of total equipment utilized in a facility require varying levels of security. According to the findings, the kind of cable used in a building has a significant impact on the emergence of surge oscillation.

1.2. Transmission of Power in the Power System:

A surge arrester with adjustable ultra-high voltage (UHV). Similar to traditional MOV surge arresters, the UHV controlled arrester was tested on a field with a rating of 828kV. The controllable UHV arrester was linked in series with the fixed arrester, and the controllable UHV arrester is represented by MOV2, which is connected below the fixed arrester and has a rated voltage of 124.2kV, which is 15% of the overall rated voltage for the arrester. The controlled UHV arrester was attached to the control unit in parallel. A group of researchers worked with an energy provider to conduct an experiment to assess the incidence of a short circuit in an air switch on a distribution line. Regardless of the outcome, the air switch in an open position may produce a spark, which, depending on the gap, could cause a short circuit failure (Figure 3). The surge arrester at the air switch, however, cannot be removed for lightning protection.

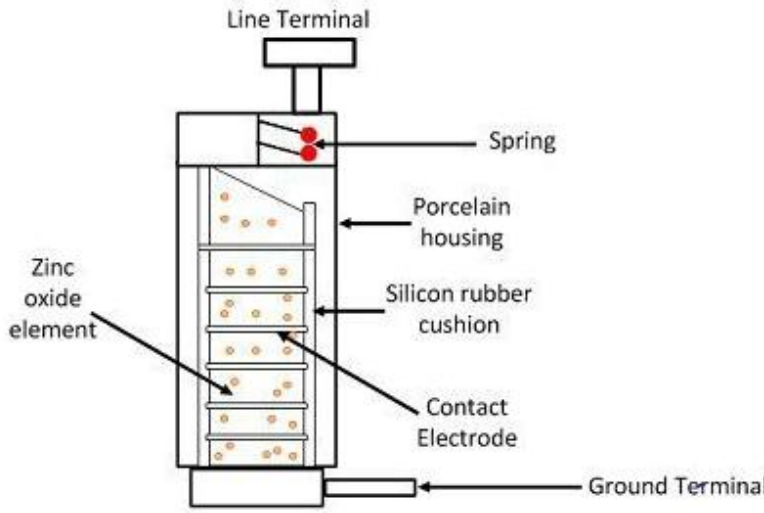

Figure 3: The Above Figure Illustrates the Label Diagram of Metal Oxide Surge Arrester.

In Malaysia, a thorough investigation was carried out to determine the suitability of a surge arrester for a 500kV transmission line. Because a double circuit trip is not permitted at high voltage levels. The installation of a surge arrester, together with increased ground resistance, was required to prevent any unanticipated events caused by a lightning strike. Since 1960, the impact of shielding failure on transmission lines has been studied using an electro geometric model. Until date, the model has undergone a lot of changes, including merging the old model with the leader progression model (LPM). LPM is a sideliner acknowledged since the structural model is almost identical to the actual mechanism of lightning. However, owing to shielding failure, the precise solution of the criteria is still unclear. Various initial features to the leader progression model have been suggested in a large number of prior research.

1.3. System of Generation:

Renewable energy is quickly expanding these days, and it has become a significant source of electricity in certain areas. The wind turbine, as a sustainable energy source, has attracted a growing number of academics who want to learn more about it. Because the construction is tall and made of low resistance and conductive materials, wind turbines have attracted natural phenomena such as lightning strikes throughout the nation.

As a result, the protection of wind turbines against lightning strikes has lately attracted the attention of experts and has become spectacular news. The installation of wind turbines requires a large flat region or the open sea. The wind turbine seems to be the lone construction that is 70 meters tall when contrasted to other structures that are much smaller. An observation at a wind turbine in Japan revealed that lightning strikes not just downward, from cloud to ground, but also in the other direction, from ground to clouds. The results of the experiment revealed that the amount of pollution in a certain region has an impact on the likelihood of a lightning strike. This was corroborated by a few researchers who found that towering buildings or structures draw more lightning attention than low structures.

Meanwhile, the danger of exposure was greater on the offshore side, where the grounding and environment were not conducive to the tall construction of the wind turbine. The focus of the simulation is on the distribution of the electric field throughout the blade. According to both findings, installing SPD at a wind farm is a must, although other factors like as lightning stoke must be taken into account. Even if it does not contribute to total destruction, a single wind blade is expensive. The behavior of lightning transients on the wind turbine was studied via a monitoring study. The casing was tested at a current of approximately 16kA. However, a lightning strike produces considerably more amperes. The polarity of the lightning that was tested was negative, indicating that it might do the least amount of harm. Because the polarity of lightning is a completely different level, which may be bipolar or positive, they said that a high preventive measure must be implemented to avoid significant harm.

2. DISCUSSION

In today's world, a lightning protection system is both necessary and obligatory for buildings to meet the stated standards. As a result, this article explains how to assess the requirements of any LPS, especially when installing a surge protection device. From the reviewed article, a few important issues stood out, such as the need to plan for any building, particularly one that is open to the public, while also considering public safety. The chance and possibility of a lightning strike are still in the early stages. On the junction of the equator line, there have been many lightning strikes. As a result, any structure that may be deemed tall near the equator line, such as in Malaysia, should have adequate safety protection. Apart from constructing an air terminal to disperse lightning to the ground, an SPD is also required, especially when the grounding system is overburdened with high resistivity soils.

The equipment, particularly electrical and digital gadgets, is next considered in the second section. Because it was already shown in the reviewed article that electrified wires attract more lightning strikes. As a result, any electrical equipment installed now or in the future must be approximated. The computation is almost certainly a prerequisite for SPD implementation. Finally, the position of the electrical equipment placed inside the building, so that any SPD that needs to be installed is put at the proper area. The SPD's distance from the rest of the equipment determines how well it is protected. The closest equipment to SPD is given the greatest level of protection.

3. CONCLUSION

This article discusses a few recent advances in lightning protection systems (LPS) for common applications. Public area, power system line, generating system, and transportation are the categories in which the applications are separated. Each application consists of a location and any associated lightning research. The LPS is a necessity in the public space, which includes people's safety, even if some individuals are irresponsible. Except in rare instances, the usual procedure was followed for power system lines. However, if there is a risk of lighting strike failure, the safeguard is still in place. So, if a new type or extra installation is required, implement it. The same may be said about the producing system. The demand is determined by the renewable energy source's environment.

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