HMS

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"EARLY STREAMER EMISSION LIGHTNING PROTECTION SYSTEMS FOR HEAVY MOVABLE STRUCTURES/MOVABLE BRIDGES"

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Early Streamer Emission Lightning Protection Systems
For Heavy Movable Structures/Movable Bridges

Movable Structures and Bridges are considerable challenges for lightning protection systems and are becoming more challenging as improvements in technology are specified for the new projects and retrofitted into the old structures. Engineering the most efficient and effective protection from lightning takes much more today than referencing a style of lightning protection system and a standard of installation. Studies must be taken to gain a much clearer picture of what is being protected, how is the structure to be protected, and what will be required to maintain these systems to secure the level of protection engineered for the structure.

This papers information concerning the style of lightning protection will be centered on the Early Streamer Emission (ESE) air terminals. The ESE systems are based on an improvement in the performance of the traditional Franklin Rod. Different methods are used to accomplish the advancement in performance.

Three important parts of a lightning protection system must be identified for discussion:

1. Grounding System
2. Transient Voltage Surge Suppression (TVSS)
3. Lightning Protection System (Up Top)

GROUNDING SYSTEM

The grounding system of the lightning protection system is the "foundation" and should be so treated. This system will be handling the "load" of the lightning discharge and should therefore be engineered carefully and with great attention to detail.

Grounding systems should be engineered to be able to handle the amount of energy that is common from lightning strikes in the area where the structure is located. Information concerning the common intensity of lightning strikes are available from a few U.S. Government agencies. The system should be designed by first taking ground resistance testing of the soil around the location of the structure. Comparisons of various grounding schemes should then be considered. Using the ground resistance readings, calculations using IEEE methods, should be used to design the best system for the site and the equipment the ground system is to protect.

Consideration should be taken to possible deterioration of the grounds caused by the natural conditions around the site of the structure. If the site is close to moisture, such as a river bank, the grounding system design should consider the ground water table and the possibility of flooding. Grounding systems should not be designed where they are consistently in water. Care must be taken to find the best site for the grounding system as close to the structure as feasible but at least two feet from the real foundation of the structure.

If the structure is near salt water, steps must be taken to lessen the deterioration of the grounding system by utilizing a protective/conductive coating such as tinned coated copper, for longer life expectancy of the grounding system.

The typical frost line of the location should be taken into consideration when designing the ground system. When a ground system is in frozen soil the resistance readings can increase by as much as 30-40%. Increase in resistance can be the cause of trouble in today's delicate electronics that control many of the systems located within these structures. Grounding systems should be designed to be below the frost line or to utilize other grounding enhancements that deter the effects of frozen soil on the grounding system.

Low impedance of the ground system and the low resistance to ground of the electrode are of great importance in the working of the grounding system. Grounding systems for ESE lightning protection systems should be designed to not exceed 10 Ohms and 5 Ohms or less is desired.

Common bonding of all grounded systems that enter the structure are extremely important to the safety required by adhering to the National Electrical Code. If the ground system chosen for the site includes a ground loop cable the bonding of these grounded systems becomes much easier than if only ground electrodes are utilized. Bonds to grounded systems, such as water pipes, drainage pipes, the electrical ground, the telephone ground, rebar, etc...must be accomplished with a full size conductor, minimum of 28 strands of #14 copper conductor.

It is recommended that as many of the underground connections as possible be made by using exothermic welding. Mechanical connections are acceptable where exothermic welding is impracticable. Inspection wells should be utilized in the grounding system for future inspection of the ground electrode and the connection of conductors to the electrode. The inspection wells also allow the annual or semi-annual resistance testing recommended for these critical grounding systems.

TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS)

TVSS is required with a lightning protection system on each incoming electrical service, telephone service, radio and TV cables that enter the structure. TVSS is essential in the protection scheme for the structure. When a direct lightning strike occurs or when a strike is only close to the structure, induced voltages occur on all of these systems. These induced voltages are damage causing "spikes" which in turn damage the electronics within the structure. Lightning strikes that hit electrical or telephone lines have an excellent conductor into the heart of the structure and the computers and controllers that operate the structure. TVSS takes these over voltages to ground at a preset level, taking the over voltage off the line.

Selection of the right TVSS product can be quite perplexing. Each of the electrical, telephone, radio and TV services have different requirements to evaluate.

The electrical service TVSS should be designed to withstand the common lightning discharge intensity in the area of the structure with a 50% safety factor for the above average strike. A 240 KA per phase rated TVSS is recommended for each of the main electrical services on movable structures. Because of the amount of internally generated "spikes" on the electrical systems caused by the extensive use of motors common in these structures, secondary TVSS protection is recommended for critical operation panels. A 80 KA per phase rated TVSS is recommended for this application. Lower KA per phase ratings on secondary panels may be required to insure that the clamping voltage of the TVSS is below the deterioration voltage of the equipment it is to protect.

Electrical TVSS products have two basic types, parallel and series. The series products are installed in series with the electrical service. They are typically the best in performance, because of the factory installed wiring versus the field installed wiring of the parallel product. A consideration of the series suppression technique is that the price can be up to 10 times that of the parallel suppressors and that the electrical system has to be shut down to service the series suppressor. The series suppressor has not been as successful in the market place as the parallel suppressor because of these two factors.

The parallel electrical suppressors have the same KA per phase rating as the series but the primary difference is that they are installed in parallel with the electrical service. Parallel suppressors are normally installed with a disconnect, which can be factory installed. If the product requires service, the complete electrical service does not need to be shut down. Only the use of the disconnect to separate the product from the electrical service need be utilized.

Care must be taken in the field installation of the parallel suppression equipment. Manufacturer's installation instructions must be followed very closely. The length of the wires from the panel to the parallel TVSS determines the performance of the product. If the manufacturer's length requirements are not followed, the product will not perform up to the specifications of the product. Added conductor length results in longer reaction time and therefore greater let through voltage before the parallel TVSS is set into action. This added time and added voltage can be the factor for damage or possible failure to critical equipment. If in doubt call the manufacturer for recommendations.

Both the series and the parallel suppressors come with options, such as audible alarms, remote monitoring, and surge counters. Standard equipment for either of these electrical surge suppressors should be indication lights that monitor the suppression modules for each phase, not just show that power is supplied to the unit. Bus bar internal connections are recommended in lieu of small electrical wiring used in some products. Either product should also offer a five (5) year full warranty on the suppression units. For the parallel units, spare modules may be ordered for continuous protection if modular failure occurs.

Many claims of performance have been stated in the industry. The main factor should be the performance rating, making sure that all comparisons are based on equal terms. The warranties and the guarantees should be submitted for evaluation before purchasing.

The telephone and data line TVSS is becoming more and more important as an increasing amount of information is conveyed across these lines. If these lines are fiber-optic, no suppression is required. If the telephone lines are the standard copper, then suppression must be included on each line. The types of suppression techniques vary, but most critical is the reaction time which should be less than one nanosecond and the voltages of the suppression must match the voltages used in the telephone system and the deterioration voltage of your equipment. The deterioration voltage of your equipment can be obtained from the manufacturer of the telephone equipment. Other information that must be made available is the type of connectors utilized in the telephone system so that the TVSS connectors will match the system.

Radio and TV lead wires will probably be coax conductors. The operating power of the system, the connector types used, and the model number of the cable must be obtained to insure a proper match of the TVSS product to the system. The clamping voltage of the TVSS must match the system to insure that the clamp is below the deterioration point of the equipment the TVSS is to protect.

ESE LIGHTNING PROTECTION SYSTEM

An ESE lightning protection system uses many of the same principals of the Franklin/Faraday cage system with substantial improvements in performance. To further explain some of the basic circumstances surrounding a lightning discharge, its relationship to objects on the earth and its relationship to a lightning protection system, the following is offered for consideration:

When a storm approaches a structure and finally reaches what is referred to as the "zone of influence" of that structure, electrical charges start to migrate up the outer skin of that structure. These electrical charges accumulate on sharp edges of the roof or roof top equipment. As these charges build on these sharp or pointed objects on the roof area, they are referred to as corona. If the storm is intense enough and if it is not moving too quickly across the structure, the corona build up can become strong enough to break down the atmosphere and create an "upward streamer". This upward streamer seeks to complete the circuit from the discharge of the cloud. The downward leader from the cloud seeks the least path of resistance or conductive path typically from the highest object nearest to the downward leader. The upward streamer is an attractive path to the downward leader and when the two meet the circuit is completed. If a lightning protection system is installed on the structure and has created the successful upward streamer, the lightning strike should be directed to ground through the ground conductors of the lightning protection system. When the successful upward streamer is created strong enough to capture the downward leader, it is referred to as a "hot strike".

If the storm is weak or too fast and the formation of the upward streamer is weak or too late, the downward leader sees the whole structure as equal and may strike anywhere on the structure. This is referred to as a cold strike. The cold strike is typically when most damage occurs to structures with installed Franklin/Faraday lightning protection systems. Franklin/Faraday systems are approximately 50-60% effective because of this situation.

The ESE lightning protection system insures the formation of the upward streamer, and that the formation will be earlier and stronger than the Franklin/Faraday systems. This is accomplished via various techniques depending upon the manufacturer of the ESE product. By having the formation of the upward streamer earlier and stronger from the ESE terminal, the capture of the downward leader is greatly increased. ESE terminals are approximately 85-96% effective, a 35% minimum improvement over the Franklin/Faraday systems.

ESE terminals do not "pull" lightning from the neighboring property, the systems are designed to cover the areas required for the structure. Most designed ESE systems for draw bridges only require a terminal on the top of each control house of the bridge. With only two ESE terminals, the installed cost, maintenance, and roof and roof top equipment penetrations are minimal compared to the Franklin/Faraday systems.

ESE lightning protection systems should be designed with the manufacturer of the ESE product to insure that the cones of protection fully cover the areas required and that all requirements of the warranty (five years) and $6,000,000.00 product and general liability insurance coverage is designed into the project (offered by some manufacturers).

Methods of designing lightning protection for moveable structures are more diverse when utilizing ESE terminals. ESE terminals because of their larger radius of protection can be installed upon masts not on the structure and protect adjacent structures that are within the designed cones of protection. This means that ESE lightning protection may not necessarily be required to be installed upon a structure and therefor lessen the amount of induced voltages cast upon the structure during a lightning discharge. When the structure has a moveable section, it may not be a requirement to have ESE lightning protection equipment attached to the moveable section. Therefore eliminating the concerns of jointed lightning protection fittings, which can be a weak link of the system, and conductor fatigue caused by continual bending of the conductor and eventual conductor failure.

The detailed design of all three of these parts of a lightning protection system will help to eliminate damage caused by lightning, but 100% protection from lightning has not been achieved. Careful Design, installation, and maintenance are the key to success of a lightning protection system.