

Analysis of Lightning Protection Technology for Radio and Television Transmitting Stations (Postprint)

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Abstract

Radio and television transmission stations enable residents to receive high-quality signals when viewing television programs; therefore, their installation locations should be reasonably selected to ensure the proper transmission and reception of radio signals. However, due to the presence of numerous electronic facilities within signal transmission stations, they are susceptible to lightning strikes, which can trigger disasters, resulting in casualties and property damage, and compromising the stability of people's lives. In response, this paper conducts comprehensive investigations and analyses from multiple perspectives to explore methods for enhancing lightning protection technologies for radio and television transmission stations, thereby safeguarding their operational safety and stability.

Full Text

Analysis of Lightning Protection Technology for Radio and Television Transmission Stations

Abstract: Broadcasting and television transmission stations enable residents to receive high-quality signals when watching television programs, necessitating rational site selection to ensure proper radio signal transmission and reception. However, these stations contain numerous electronic facilities that are vulnerable to lightning strikes, which can cause catastrophic disasters resulting in casualties and property damage, thereby threatening public safety and stability. This paper examines and analyzes various approaches to improving lightning protection technology for broadcasting and television transmission stations to maintain their operational security and stability.

Keywords: Broadcasting and television transmission station; Lightning protection technology; Measures discussion

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Broadcasting and television transmission stations primarily function to receive and transmit signals, enriching people's information exchange methods and facilitating daily communication. They also serve as fundamental infrastructure ensuring normal corporate operations, making the improvement of lightning protection technology for these stations particularly crucial. With current information technology development, numerous new electronic facilities have been installed to enable transmission stations to receive signals of greater intensity and variety. However, this has simultaneously increased the probability of lightning strikes, necessitating reasonable and effective lightning protection technologies to minimize personnel injury and economic losses caused by lightning strikes.

1. Real-World Hazards of Lightning to Transmission Stations

Lightning is a natural phenomenon with enormous impact and destructive power, capable of generating million-volt impulse currents within extremely short timeframes. These currents produce powerful physical phenomena such as thermal effects with extensive hazardous ranges, significantly affecting the stable transmission and reception of signals at broadcasting and television transmission stations. Since these stations are often situated in relatively elevated locations, their probability of lightning strikes increases accordingly. Due to their special nature and importance, lightning strikes can cause internal electronic equipment to malfunction, potentially resulting in substantial economic losses. The primary hazards can be summarized as follows:

To meet real-world power supply demands, cables are typically buried underground, but some lack shielding protection and are thus vulnerable to lightning currents. When lightning strikes outdoor power lines, it can easily damage interconnected electrical equipment. When lightning current flows through ground wires, voltage drops occur that can cause current backflow effects on various electronic equipment within the station, resulting in economic losses. After lightning strikes a lightning rod, current flows through ground wires into the earth, causing uneven potential distribution in the ground grid and abnormal potential increases in local areas, affecting secondary facilities through ground potential rise. When lightning current flows along signal circuits, it can generate abnormal electromagnetic fields that cause overvoltage in signal transmission cables, damaging low-voltage electrical facilities and potentially triggering explosions that endanger lives and cause property damage.

2. Preliminary Considerations and Proposed Solutions

2.1 Rational Use of Lightning Protection Electromagnetic Shielding Films

Since broadcasting and television transmission stations are frequently used for signal and data transmission, their cable structures are highly complex. If improperly arranged, severe electromagnetic induction interference may occur, requiring particular attention to prevent mutual interference between various circuits, such as cables carrying the same type of signals. Wrapping signal transmission line interfaces with lightning protection electromagnetic shielding films can effectively shield electromagnetic pulses on various leads while allowing normal signal transmission. By collecting various antenna feed lines together, grounding them, and constructing cable routing bridges for shielding purposes, cable routing can be standardized. Shielding films should be applied at cable interfaces, with both ends of the bridge connected to the grounding grid. Additionally, attention must be paid to connecting feed lines to the tower body at approximately 6-meter intervals. After crimping the terminal connections at the tower base, they should be insulated, and lightning arresters should be installed on feed lines to prevent tower lightning attraction from damaging electronic equipment.

2.2 Welded Grounding Grid

When implementing a welded grounding grid for the entire system, galvanized flat steel can be employed, with graphite blocks reinforced at the four tower footings. As a non-metallic material, graphite possesses strong stability and corrosion resistance, and can function as a high-resistance resistor when large currents pass through, suppressing the impact of high currents and thereby preventing reverse breakdown. In practical applications, graphite can minimize environmental and climatic impacts while significantly reducing grounding resistance. Establishing a common grounding grid can effectively reduce potential differences between equipment rooms and towers caused by independent grounding networks, thereby accelerating the discharge of lightning currents.

2.3 Comprehensive Multi-Faceted Protection Measures

High-voltage power cables essentially function as overhead cables before connecting to transformers. Since they are mostly directly exposed to sunlight and air, they can easily withstand extremely large current flows when struck by lightning. Therefore, primary lightning protection measures should be implemented, utilizing the instantaneous current-releasing capability of lightning arresters. Power supply lightning arresters should be installed at the input ports of all electronic equipment, including power supply transformers, employing advanced German technology that enables monitoring of equipment status through observation of fault indicator lights to determine whether failures have occurred. In practice, lightning arresters should be regularly inspected and replaced. Additionally,

secondary lightning protection measures can be adopted using German technology to filter and eliminate residual voltage, further preventing lightning wave overvoltage from entering electronic equipment. Since power supply lines are separate and non-interfering, installation can be positioned near power input terminals, and following the principle of proximity, grounding wires should be connected to equipotential bars to prevent cross-discharge of lightning currents.

2.4 Remote Monitoring of Lightning Protection Devices

To enable remote monitoring of lightning protection devices, a system composed of a monitoring center, detectors, and signal collectors must be established. Detectors continuously monitor the operational status of lightning protection devices, while signal collectors organize data information and transmit it to the control center. In case of anomalies, the system can promptly issue alarms and activate pre-installed lightning protection facilities to reduce lightning damage. Additionally, before lightning arrives, the control center can disconnect power to protected facilities connected to other circuits and reactivate lightning protection devices for protection.

3. Key Factors Determining Effective Lightning Protection Operations

3.1 Implementation of Grounding Protection

During lightning protection implementation, facilities with metal casings at broadcasting and television stations should first be grounded. To mitigate equipment impacts from grounding, single-point grounding is generally applied for low-frequency equipment, while multi-point grounding is required for high-frequency equipment, thereby preventing grounding devices from affecting normal electronic equipment operation. When designing grounding wires, reasonable line lengths should be selected, and materials with larger diameters should be chosen to ensure normal short-circuit current discharge.

3.2 Mitigating Direct Lightning Strike Damage

To mitigate damage from direct lightning strikes, lightning rods can be reasonably utilized. However, since lightning discharge is susceptible to many external interference factors, lightning rods cannot completely guarantee the safety of electronic facilities within transmission stations. Therefore, actual environmental requirements must be considered to reasonably establish the protection range of lightning rods, typically setting the shielding failure rate at 1%, with scientific calculation of height requirements. When lightning discharge positions are relatively close to the ground, they may cause local concentration of electric fields in surrounding air, affecting the lightning leader discharge process and causing lightning to discharge to the lightning rod. The lightning rod, through its grounding device, allows lightning current to flow into the earth, thereby protecting electronic equipment. This principle enables lightning rods to adapt

to lightning protection work in any location. When using lightning rods for line lightning protection, to prevent overvoltage damage, the entire line must have high overvoltage withstand capability. In practice, to ensure timely lightning current discharge, lightning rods must be well grounded to prevent reverse breakdown caused by increased potential on the rod. Therefore, lightning rods are generally applied for building lightning protection. When applying lightning rods for lightning protection purposes, surrounding environmental conditions should be investigated beforehand. If the area is prone to strong winds, lightning rods must be reinforced to prevent breakage or detachment that would impair their protective function.

3.3 Important Factors for Lightning Protection System Operation

Based on lightning protection standards and protection requirements for buildings, the design concept of lightning protection zones should be constructed. For example, electromagnetic pulses generated by lightning vary in intensity due to regional differences, so this factor should first be noted during design. Lightning protection zones should be divided according to different regional characteristics, and then the equipotential connections of these zones should be established, preferably using metal objects or direct connections. If signal circuits cannot be directly connected, reasonable lightning protection equipment should be selected after zone division based on actual conditions. Practical experience demonstrates this approach effectively suppresses lightning impact. When designing grounding network routes, to achieve equipotential connections, all grounding wires and equipment rooms should be uniformly connected to maximize potential difference reduction between different areas.

4. Conclusion

Lightning protection projects for broadcasting and television transmission stations are extremely urgent. The main principle of lightning protection should be maximizing equipotential bonding between various facilities. Currently, grounding methods are primarily employed for lightning protection work. When implementing lightning protection for broadcasting and television transmission stations, geographical location and environmental characteristics of the area should first be investigated, combined with equipment performance characteristics, to ultimately select reasonable lightning protection measures. Additionally, regular inspection of all electronic equipment is essential to troubleshoot problems and ensure stable operation of broadcasting and television transmission stations.

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