Journal of Electronic Research and Application, 2024, Volume 8, Issue 1
http://ojs.bbwpublisher.com/index.php/JERA
ISSN Online: 2208-3510
ISSN Print: 2208-3502

Construction Technology of Lightning Protection Devices in Building Electrical Installation Engineering

Xuhong Du*

China Institute for Radiation Protection, Taiyuan 030006, Shanxi Province, China

****Corresponding author:*** Xuhong Du, dxh995@163.com

Abstract: To better improve the electrical safety of buildings and fulfill the role of lightning protection and grounding, this article combines cases and discusses seven aspects of lightning protection devices' construction technology. These aspects include the lightning protection classification of buildings, air terminals, down conductors, grounding devices, division of lightning protection zones, and lightning electromagnetic pulse shielding. Through the introduction of this article, readers can gain a comprehensive understanding of the application and value of lightning protection grounding construction technology in building electrical installation projects.

Keywords: Building electrical; Installation engineering; Lightning protection grounding

Online publication: January 18, 2024

1. Preface

Lightning is a highly destructive natural phenomenon that generates strong currents and high temperatures, causing significant harm to buildings, electrical equipment, communication facilities, and more. In building electrical installation projects, the design and construction of lightning protection grounding systems are crucial. These systems can effectively minimize lightning damage to buildings and electrical equipment [1-3].

As an integral part of construction projects, the design and construction of the lightning protection grounding system in building electrical installations hold immense significance for safeguarding the regular operation of the building and its electrical equipment. The design of the lightning protection grounding system is a critical aspect of building electrical installation engineering. Throughout the design process, factors such as the structural form of the building, the location and model of electrical equipment, soil resistivity, etc., must be considered to determine the optimal lightning protection grounding scheme [4-7].

In general, the lightning protection grounding system comprises components such as air terminals, down conductors, grounding devices, and others. Its design should adhere to relevant standards, such as the "Building Lightning Protection Design Code" (GB50057-2010).

2. Project

2.1. Project overview

The total area of a specific building is 162,847.2 m^2, comprising 61,618.2 m^2 underground and 101,229 m^2 above ground. It consists of two floors below ground and with a floor height of eight meters for two underground floors (4 meters for one floor underground floor). Above ground, there are 18 floors.

2.2. Building lightning protection classification

The lightning protection building designed in this project falls under Class II lightning protection. According to the "Lightning Protection Design Code for Buildings" (GB50057-2010), the classification is determined based on factors such as importance, nature of use, and the potential consequences of lightning accidents. Category II lightning-proof buildings include those with solid or critical electronic information systems, buildings of significant value, and those where the consequences of lightning strikes are severe, necessitating protection.

The building designed for this project is a residential structure with high utility value and personnel density. Moreover, it houses crucial electronic information systems. Following the specified criteria, the building is appropriately classified as a Category II lightning-proof building.

3. Lightning protection and grounding construction of building electrical installation projects

3.1. Lightning protection device

The design content of the lightning protection device in this project encompasses both external and internal components, incorporating measures to prevent the intrusion of lightning surges.

(1) External lightning protection device: To safeguard against direct lightning strikes, the external lightning protection system consists of air terminals, down conductors, and grounding devices [10-15]. Air-termination devices, utilizing φ12 hot-dip galvanized round steel, are strategically placed along the parapet, roof corners, roof ridges, eaves, and areas susceptible to lightning strikes, especially when the entire roof has an air-termination grid smaller than 10 m × 10 m or 12 m × 8 m. When the building exceeds 60 m in height, air-termination strips are initially laid along the roof's perimeter. These strips are positioned on the outer surface of the exterior wall or the vertical surface of the eaves edge. All metal objects protruding from the roof are connected to the roof lightning protection device, while non-metallic objects are equipped with air terminals before connecting to the roof lightning protection device. A circle of down conductors, spaced no more than 18 m apart, surrounds the building perimeter. Diagonal main bars (or steel components) in reinforced concrete columns are full-length welded, connecting the upper end to the lightning strip as well as the lower end to the building foundation beam and steel bar in the foundation floor. Additionally, corresponding to the down conductor used for detection, use a 40 × 4 hot-dip galvanized flat steel below 1.0 m of the outdoor floor to be led to a point greater than 1 m outside the water distribution slope for the connection of dispersion and artificial grounding. Steel bars in the building pile foundation and the foundation beam were used as the grounding device. The two steel bars were welded in the foundation beam with a length of not less than 16 mm as a ring-shaped grounding connection line. The ring-shaped grounding connection line was welded to the two vertical main steel bars in the pile foundation it passes through.

(2) Internal lightning protection device: On the ground floor of the building, the following objects should

be connected to the lightning protection equipotential nearest to the lightning protection device: the building's metal body, metal devices, electrical and electronic systems, and entrances and exits from the building metal pipelines. The external lightning protection device and the metal body of the building, metal devices, and the electrical and electronic systems in the building should meet the separation distance requirements. Among them, in buildings with metal frames, or where steel bars are connected and electrically connected in buildings with reinforced concrete frames, there is no requirement for the separation distance between metal objects or wires and down conductors.

(3) Measures to prevent side lightning strikes: Objects protruding horizontally from the exterior wall, when the ball with a radius of 45 m drops vertically from the roof perimeter lightning strip to the ground and touches the object that protrudes from the exterior wall, corresponding lightning protection measures should be taken. For buildings higher than 60 m, the upper part that accounts for 20% of the height and exceeds 60 m shall be protected against side strikes. The prevention of side strikes shall comply with the following regulations: (i) For the upper part of the building that accounts for 2% of the height and exceeds 60 m, sharp objects, corners, edges, equipment and significantly protruding objects shall be treated according to the protective measures on the roof; (ii) For 20% of the area and exceeding 60 m, the arrangement of air-terminations shall comply with the requirements for this type of lightning protection buildings, and the air-terminations shall be arranged mainly on corners, edges, and significantly protruding objects; (iii) When the minimum dimensions of external metal objects complied with the provisions of the standards, and when external down conductors were arranged at the vertical edges of the building, they can be used as air terminals; (iv) When reinforced concrete inner steel bars and metal frames of buildings met the specifications and used as a down conductor or connected to a down conductor, they can served as an air-termination device; (v) To prevent the intrusion of lightning waves, surge protection devices should be installed at the incoming lines of the power supply system and distribution system; (vi) The distribution lines leading from the distribution box should pass through steel pipes. One end of the steel pipe should be connected to the distribution box and PE line, while the other end should be connected to the electrical equipment's shell and protective cover, with a roof lightning protection device nearby. A jumper is necessary if the steel pipe is disconnected in the middle due to equipment connections.

3.2. Grounding system

The low-voltage power distribution grounding type of this project adopts the TN-S system. The lightning protection grounding and the grounding for strong and weak current systems share a unified grounding plate. The grounding resistance should not exceed 1 Ω. If actual measurements fall short of this requirement, an outdoor artificial grounding electrode should be added, forming a grounding network by welding externally thrown steel bars.

(1) General equipotential bonding measures: Conduct equipotential bonding of protective trunk lines, equipment incoming main pipes, and building metal components inside the building. Establish a total equipotential zone (40 × 4 hot-dip galvanized flat steel) along the interior of the building's exterior wall on the underground floor, connecting all metal pipes entering and exiting the building to it. The general equipotential zone should be securely connected to the grounding device using the main bars in the structural wall and column. Use 40 × 4 thermal galvanized flat steel as the grounding down conductor in distribution rooms, equipment rooms, etc. For each weak motor room, employ two insulated BVR wires for grounding, with the lower end connected to the basic grounding body and the

upper end connected to the grounding terminal box in the machine room. Connect the entire length of metal cable trays and metal brackets to the grounding trunk line at a minimum of two places, with connection points every 20 or 30 m for lengths exceeding 30 m. Ensure reliable connections of the starting and ending ends of the cable tray to the grounding grid. Locally, connect the bottom and top ends of vertically laid metal pipes and metal objects to the grounding device.

(2) Local equipotential bonding (LEB) measures: Install a LEB 0.3 meters above the ground in an appropriate part of the bathroom in the bathing facility. Use two 25 × 4 hot-dip galvanized flat steel pieces to connect the LEB sub-board to the room floor and the mixed side. Connect all metal pipes and metal components in the room to the structural steel bars in the wall using BVR-1 × PC1C pipes, which are then connected to the PE wires of the sockets. Equip general socket circuits with leakage protection switches with a leakage action current of 30 mA. Ensure all lighting fixtures are PE-lined. Establish an equipotential bonding box in the power distribution room. Connect metal devices not charged under normal circumstances to the equipotential junction box, equipment, pipes, components, and other primary metal objects in the building. These connections should reach the nearest lightning protection grounding device or the protective grounding device of electrical equipment. The main equipotential plate is brass, and equipotential connections use various equipotential clips, with welding on metal pipes strictly prohibited.

3.3. Surge protection

Install a Class I test surge protection device (SPD) at the low-voltage power incoming cabinet in the power distribution room. Place another Class I SPD at the LPZ0/LPZ1 boundary, such as the incoming line of the low-voltage distribution cabinet. The SPD's voltage protection level (U_p) should be less than or equal to 2.5 kV. The SPD's impulse current (I_{imp}) of each protection mode should be equal to or greater than 12.5 kA (10/350 μs).

At the LPZ1/LPZ2 boundary, if a Class II test SPD is installed in the distribution box or floor distribution box, the SPD's U_p should be less than or equal to 2.5 kV, the SPD's nominal discharge current (I_n) of each protection mode should be equal to or greater than 20 kA (8/20 μs).

For the third level (LPZ2 and subsequent lightning protection zone boundaries, such as equipment room distribution boxes or information equipment power ports requiring specific protection), install a Class II test or Class III test SPD. Ensure that its I_n is not less than 20 kA (8/20 μs).

4. Summary

Lightning protection grounding technology plays a crucial role in building electrical installation projects, effectively shielding buildings and electrical equipment from potential lightning damage. In environments with frequent lightning activity, structures and equipment are susceptible to strikes, leading to equipment damage and, in extreme cases, personal accidents. Hence, the adoption of effective lightning protection grounding technology becomes imperative to redirect lightning safely into the ground, preventing harm to buildings and electrical equipment.

The implementation of lightning protection and grounding construction technology encompasses various stages, including design, construction, and acceptance. In the design phase, the scheme should consider factors such as the building's structural form, the location and model of electrical equipment, and soil resistivity. During construction, adherence to construction drawings and relevant specifications is essential to ensure that the construction quality meets specified requirements. The acceptance phase involves testing and inspecting the lightning protection grounding system to guarantee its performance aligns with the design requirements and ensures safe usage.

Future trends in lightning protection grounding technology primarily focus on enhancing the reliability and stability of grounding systems, thereby reducing the likelihood of accidents. Additionally, there is a drive towards developing more efficient and cost-effective lightning protection grounding materials and equipment. The integration of intelligence into lightning protection grounding systems, along with remote monitoring and management capabilities, is gaining importance. Exploring environmentally friendly and sustainable lightning protection and grounding technologies represents another key direction for future development.

Disclosure statement

The author declares no conflict of interest.

References

[1] Wu C, 2023, Lightning Protection and Grounding Construction Technology for Building Electrical Installation Projects. Jiangsu Building Materials, 2023(5): 78–79.

[2] Chen S, Dai Y, Yang X, 2023, Application of Lightning Protection Grounding Technology in Building Electrical Design. Electronic Technology, 52(7): 292–293.

[3] Yang X, You Z, Dai Y, 2023, Application of Lightning Protection Technology in Building Electrical. Electronic Technology, 52(7): 296–297.

[4] Hu J, 2023, Research on Electrical Design of Prefabricated Residential Buildings – Taking Building A as An Example. Real Estate World, 2023(11): 46–48.

[5] Chen W, 2023, Analysis of Design and Construction Technology in Building Electrical Engineering. Integrated Circuit Applications, 40(6): 230–231.

[6] Xu J, 2023, Research on Construction Quality Control of Lighting System in Building Electrical Engineering. Light Source and Lighting, 2023(4): 48–50.

[7] Kong X, Xu F, 2023, Analysis of Installation and Construction Technology of Building Electrical Equipment. China Equipment Engineering, 2023(8): 232–234.

[8] Wu C, 2023, Lightning Protection and Grounding Construction Technology for Building Electrical Installation Projects. Stone Materials, 2023(4): 90–92.

[9] Chen X, 2023, Design Analysis of Power Supply and Distribution System Based on High-Rise Building Electrical Engineering. Jiangxi Building Materials, 2023(3): 130–131.

[10] Li J, 2023, Installation and Construction Technology of Building Electrical Power Supply and Distribution. Jiangsu Building Materials, 2023(1): 88–89.

[11] Shu J, 2023, Lightning Protection Grounding Technology and Its Application in Building Electrical Engineering. China High-Tech, 2023(4): 107–109.

[12] Cui Q, 2023, Analysis on the Lightning Protection Grounding Technology Application in Building Electrical Installation. Sichuan Building Materials, 49(2): 223–224.

[13] Wang L, Wang L, 2022, Lightning Protection and Grounding Design in Building Electrical Engineering. Integrated Circuit Applications, 39(9): 184–185.

[14] China Machinery Industry Federation, 2010, Design Code for Protection of Structures Against Lightning, GB 50057—2010. Ministry of Housing and Urban-Rural Development of the People's Republic of China and General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China

[15] Cao H, Huang X, Mei Y, et al., 2015, Technical Code for Inspection of Lightning Protection System in Building, GB/T 21431—2015. General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China and China National Standardization Administration Committee.