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# Analysis and Research on 10kV Distribution Network Faults

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**Abstract:** The 10kV distribution network is an essential component of the power system, and its stable operation is crucial for ensuring reliable power supply. However, various factors can lead to faults in the distribution network. In order to enhance the safety and reliability of power distribution, this paper focuses on the analysis of faults in the 10kV distribution network caused by natural factors, operational factors, human factors, and equipment factors. It elucidates the various hazards resulting from distribution network faults and proposes corresponding preventive measures for different types of faults in the 10kV distribution network. The aim is to mitigate or reduce the impact of distribution network faults, ensuring the safe and stable operation of the distribution system.

**Keywords:** 10kV distribution network; Line faults; Fault hazards; Preventive measures

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## 1. Introduction

With the continuous development of science, technology, and economy in China, the distribution network lines and operational efficiency in the power industry have significantly improved, including the 10kV distribution network lines [1]. However, due to factors such as terrain, environment, climate, and the equipment itself, various faults may still occur in the 10kV distribution network lines during practical operation, such as power outages and line tripping, ultimately affecting the stable operation of the power system. To address potential issues, preventive measures need to be taken to minimize fault losses and ensure the normal operation of the power system.

## 2. Common faults of 10kV distribution lines

The causes of faults in 10kV distribution lines are numerous, ranging from internal factors to external forces. **Figure 1** shows the percentage distribution of 10kV distribution line faults in a certain city in 2022.

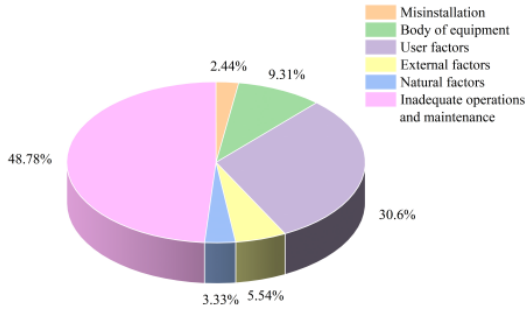


**Figure 1.** Percentage of 10kV distribution network faults in 2022

From **Figure 1**, we can observe that the 10kV distribution line faults in this region involve various factors such as "natural factors," "external forces," and "equipment factors." The following analysis will delve into the issues associated with each of these fault categories [2].

## 2.1. Natural factors

The types of 10kV distribution network faults caused by natural factors are numerous. **Figure 2** shows the distribution of 10kV distribution network faults triggered by natural factors in a certain city [3].

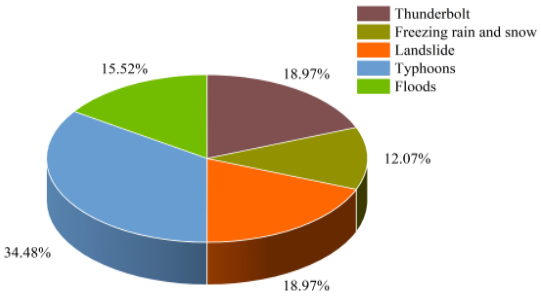


**Figure 2.** 10kV distribution network faults caused by "natural factors" in a city

From **Figure 2**, we can see that the "natural factors" causing 10kV distribution network faults in this area include "thunderbolts," "typhoons," "floods," "landslides," "rain, snow, and ice," among others, with "typhoons" causing the most distribution network faults.

### 2.1.1. Lightning fault

The 10kV distribution network, being elevated and of considerable length, is susceptible to extreme weather conditions, particularly thunderstorms during the summer. Lightning strikes may damage the insulation layer, increasing the risk of short circuits. Factors such as inadequate clearance between distribution lines and the ground, short span distances, and improper placement of lightning protection lines may also contribute to lightning-related faults. In mountainous or valley terrain, maintenance becomes more challenging [4]. For example, in a certain city, a lightning strike damaged the lightning arrester on Phase C of the LinKa Substation, resulting in a 10kV distribution network fault.

### 2.1.2. Typhoon fault

Typhoon weather conditions are severe, often accompanied by strong winds and heavy rainstorms. Strong winds can cause 10kV distribution poles to collapse and wires to break. Wind disasters can also destroy surrounding trees, affecting the distribution network. Continuous rainfall can erode equipment, reduce insulation, and

increase the risk of short circuits. Groundwater may inundate switchgear and substations, leading to faults.

### 2.1.3. Flood, landslide, rain, snow, and ice freezing faults

In summer, heavy rainfall often leads to flooding in low-lying areas. Floodwaters may submerge facilities such as cable wells and substations, causing short circuits and insulation damage, thereby affecting reliability and maintenance. Heavy rain can trigger landslides, potentially crushing distribution lines and poles, resulting in interruptions, collapses, and breaks. In winter, accumulated ice and snow increase the load on the lines, causing breaks, tower collapses, and pole collapses.

## 2.2. Inadequate maintenance and improper operation

From **Figure 3**, we find that the causes of inadequate maintenance and improper operation leading to 10kV distribution network faults in a certain city include "tree barriers," "bird damage and other animals," "untimely elimination of defects," and "inadequate inspections."

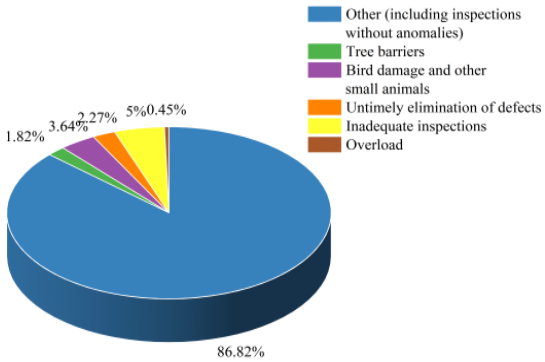


**Figure 3.** Failure of 10kV distribution network caused by "inadequate maintenance and improper operation"

### 2.2.1. Animal-related faults

Except for winter, rodents such as rats and birds are active in other seasons, possibly perching or foraging on the 10kV distribution network lines, leading to faults. High line temperatures attract birds to perch or nest, which may cause accidental contact and result in short circuits or tripping, leading to load losses [5]. Trash piles attract rats for foraging, and their climbing on distribution equipment leads to grounding or short circuits. Aging and sealing issues in electrical rooms attract rats, resulting in distribution faults.

### 2.2.2. Vegetation-related faults

Wild plant growth can be rapid and may entangle the 10kV distribution network lines, damaging the insulation layer and causing short circuits. Severe weather conditions such as strong winds or hailstorms can result in the breaking or collapse of surrounding trees, which may contact the lines and cause line faults. For instance, in a certain city, a line fault was discovered due to tree branches falling onto high-voltage wires. When the branches contact the wires, the action of rainwater may lead to short circuits, affecting normal operations.

## 2.3. Human factors

According to **Figure 4**, we can observe that the "human factors" contributing to 10kV distribution network faults include "theft," "construction work," "vehicles," "external fires," and "foreign objects." Among these, the occurrences of faults caused by "foreign objects," "vehicles," and "construction work" are relatively high in this region.

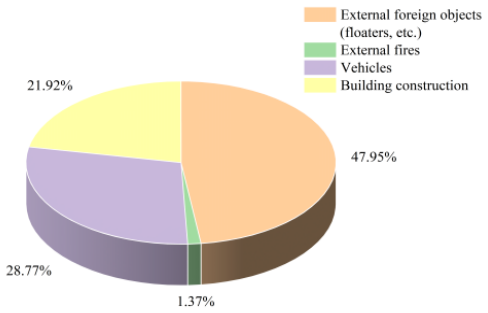


**Figure 4.** 10kV distribution network faults caused by "human factor"

(1) Faults caused by human intervention may result in 10kV distribution network failures. For instance, engineering construction projects may overlook potential damage to surrounding distribution network lines, traffic accidents can lead to the collapse or tilting of utility poles, criminal activities such as theft of materials or malicious damage to lines, and incidents where kites flown in public places become entangled with the lines due to strong winds or operator error, causing line faults.

(2) Inadequate management mechanisms may contribute to various faults in the 10kV distribution network, including equipment shortages, incomplete line inspections, and low levels of maintenance personnel competency, making it difficult to promptly identify and repair issues. The lack of effective review and supervision mechanisms can result in construction quality issues and project delays, with work plans unable to be completed on time. Even after the completion of construction projects, safety hazards may persist, potentially leading to subsequent faults.

## 2.4. Equipment factors

The 10kV distribution network faults caused by equipment factors in a certain region are illustrated in **Figure 5**.

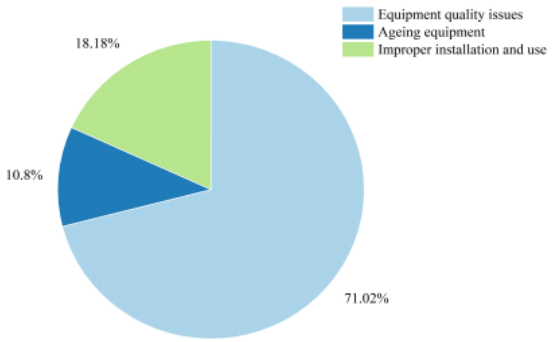


**Figure 5.** Percentage of 10kV distribution network faults in the "equipment factor"

According to **Figure 5**, it can be observed that in this region, the 10kV distribution network faults caused by "equipment factors" are mainly attributed to issues such as "equipment quality issues" and "improper installation and use," with a small portion resulting from "aging equipment".

### 2.4.1. Aging equipment

The aging of distribution equipment is one of the causes of faults in 10kV distribution network lines. The limited service life of equipment makes it susceptible to corrosion or damage due to surrounding environmental factors[6]. Over time, equipment undergoes wear and tear, corrosion, degradation in electrical performance, and

reduction in insulation performance and mechanical safety factors, leading to short circuits or leakage issues, thereby causing faults.

### 2.4.2. Improper installation and use

Improper installation and usage of equipment in 10kV distribution network lines are among the causes of faults. Incorrect connections or poor contacts can lead to disconnections, short circuits, or overloads. Overloading of transformers or three-phase imbalances can result in faults, affecting the operation of the lines. Excessive current or voltage can raise equipment temperatures, affecting normal operation and leading to short circuits or other faults.

### 2.4.3. Equipment quality

The quality of distribution network equipment is one of the causes of faults. For example, during line inspections by the municipal power department, it was found that the heating transformer cables at a university dormitory in a certain city had been pierced, affecting the distribution network lines. Manufacturing processes may have technical issues leading to poor equipment quality, resulting in failures during long-term use. The 10kV distribution network line faults caused by equipment quality issues in a certain area are illustrated in **Figure 6**.

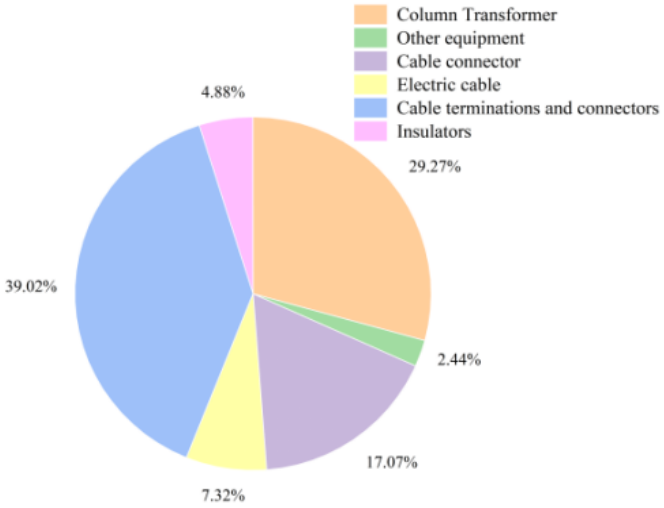


**Figure 6.** Distribution network faults due to "equipment quality"

**Figure 6** illustrates that in this area, cables, pole-mounted transformers, and surge arresters are prone to issues. Poor cable joints can lead to overload, overheating, and discharge, causing faults. Insulation damage can result in leakage, short circuits, or discharge, leading to faults [7]. Quality issues with surge arresters often stem from poor sealing, inadequate pressure resistance of the resistance sheets, and non-compliance in manufacturing, resulting in short lifespans and poor quality, leading to equipment failures, short circuits, lightning strikes, or overvoltage, impacting power consumption.

## 3. Preventive measures for 10kV distribution network faults

### 3.1. Strengthening lightning protection measures

To reduce lighting faults in 10kV distribution network lines, it is necessary to enhance the insulation level of the

system. High-quality lightning protection devices should be installed on tall utility poles to safeguard insulation and prevent interruptions or short circuits caused by lightning strikes. Lightning protection gaps in open areas should be controlled to enhance lightning protection performance. The insulators should be replaced with those with lightning protection performance to reduce the frequency of faults. Electricity departments should analyze the distribution pattern of lightning strikes and formulate improved lightning protection measures.

## 3.2. Enhancing natural disaster prevention

The impact of natural disasters on 10kV distribution network lines is mainly from extreme weather conditions such as floods, landslides, heavy rainfall, snow and ice, and typhoons. Establishing an early warning system and formulating corresponding disaster response plans are essential to protect the lines. During the flood season, enhance inspections and monitoring to promptly address abnormal water levels and rainfall to prevent distribution network failures. Utilizing advanced distribution network equipment to withstand natural disasters is advisable. Strengthening intelligence gathering is crucial to focus on preventing faults in areas prone to frequent natural disasters.

## 3.3. Prevention of animal damage to 10kV distribution network lines

To reduce the hazards posed by birds and rodents to 10kV distribution network lines, preventive measures need to be taken. Residents should be discouraged from accumulating garbage near utility poles, and garbage removal should be carried out to reduce rodent attraction. Damaged or poorly sealed electrical rooms and distribution equipment should be repaired, and rodent traps should be installed to prevent damage. Reflective devices should be installed near the towers to reduce bird nesting. Insulation devices should be installed for external joints and equipment to prevent rodents or birds from climbing and nesting, leading to line short circuits, ensuring safe operation.

## 3.4. Prevention of vegetation damage to 10kV distribution network lines

Strengthening prevention measures against vegetation-induced faults in 10kV distribution network lines is necessary. For remote areas, enhanced inspections should be conducted according to the vegetation growth seasons, with timely management of nearby trees, vines, and other plants to avoid disrupting line operations. Increasing public awareness and encouraging residents to participate in vegetation-clearing efforts are important. In particularly remote and densely vegetated areas, enhancing the insulation performance of the lines and implementing insulation improvements can reduce the frequency of faults. For instance, trees planted by residents may pose risks to the lines, so timely communication and negotiation to address potential hazards, explaining the dangers of tree barriers, and resolving issues through legal channels are necessary.

## 3.5. Proper handling of 10kV distribution network faults caused by human factors

(1) Safety should be prioritized during construction by strengthening monitoring of distribution network lines and setting up warning signs to remind construction workers to safeguard equipment safety.

(2) Reflective devices or warning signs should be installed around traffic arteries to reduce damage to equipment from vehicle collisions.

(3) Supervision and inspections should be strengthened, and severe penalties should be imposed on illegal activities that damage distribution network equipment. Electrical knowledge should be publicized to enhance safety awareness, and community-based prevention and control measures should be implemented. and reduce accidents.

(5) Technical training and assessment for maintenance personnel should be enhanced to improve their

professional competence and safety awareness and ensure the reliability of line maintenance.

(6) Strengthen regulatory review to ensure construction quality, establish clear rewards and penalties, reduce laxity, and promote construction according to plan.

### 3.6. Protective measures regarding equipment factors

(1) To address the issue of improper equipment installation and use, targeted training should be provided to operators and maintenance personnel to enhance safety awareness.

(2) To reduce equipment aging, regular inspections and maintenance of distribution network equipment should be conducted to remove dust and debris, prolonging their service life. Severely aged equipment should be promptly replaced to reduce failures.

(3) During construction, attention should be paid to material selection and control, with strict oversight of material and equipment quality. Using equipment that complies with national standards ensures the safe and stable operation of the line.

## 4. Conclusion

The paper mainly analyzes and studies three aspects of a 10kV distribution network: common faults, the hazards associated with these faults, and how to prevent different types of faults. The following conclusions have been drawn:

(1) There are various factors that can cause faults in a 10kV distribution network, including natural, operational, equipment, and human factors. Different factors lead to different types of faults, and each major factor encompasses many minor factors that impact the safety of the distribution network. For instance, within natural factors, phenomena like lightning, typhoons, rain, snow, and freezing temperatures each pose varying degrees of risk to the distribution network. The proportion of distribution network faults varies among different regions, with operational and equipment issues being the most prominent contributors in certain cities.

(2) Corresponding preventive and remedial measures are proposed for different faults in the distribution network. It is important to select appropriate methods to mitigate the hazards of 10kV distribution network faults, improve the reliability of the network, and ensure its safe and stable operation.

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## Disclosure statement

The authors declare no conflict of interest.

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