Study on the Electrical Performance of 10kV Composite Material Crossarm

Jiqun Wen, Xiong Wu*, Rui Ke, Fan Shen, Duan Mei, Wei Guo
NARI Group Co., Ltd., Nanjing 210003, Jiangsu, China
Wuhan Nari limited company, State Grid Electric Power Research Institute, Wuhan 430074, China
Hubei Provincial Key Laboratory of Lightning Strike Risk Prevention, Wuhan 430074, China

*Corresponding author: hustwuxing@163.com

Abstract. The composite material crossarm has excellent insulation, water repellency, light weight and high strength, which can effectively improve the safety level of the power line. Research results showed that the dry flash lightning voltage and wet flash frequency voltage of the composite crossarms were increased by 50% and 39% respectively, compared to the angle steel crossarms fixed with the same size insulator and the same air gap; corresponding wet frequency withstand voltage and filthy resistance voltage were increased by 117% and 30%, respectively; and the wet and filthy flashover all occurred on the surface of the composite material crossarms.

1. Introduction
With the upgrade of distribution network lines, distribution network lines have been upgraded to overhead insulated conductors in large areas. The insulated conductor wires have increased significantly. Lightning strikes or heavily polluted line sections frequently cause ablation and disconnection of insulated conductors, according to the data [1-3], the number of lightning strikes and insulator breakdown accidents on insulated lines under running accounted for 74.9% of the total number of accidents, and the lightning breakage rate was 96.8%. China's 10kV overhead insulated lines have been damaged up to 100 times per year due to lightning strikes or dirty flashovers, which has caused seriously damage to the power supply reliability and personal safety of the power grid. The composite material crossarms utilized its good insulation properties, and which cooperated with the insulated wire to improve the insulation level of the line and prevent wire breakage due to lightning strikes. Hu Yi et al. [4] have carried out relevant lightning protection, pollution and mechanical performance studies on pin insulators, round bar composite insulation crossarms and insulated composite tower head with composite insulators. The results showed that the lightning flashover voltage and pollution flashover voltage of the line were significantly increased, which could effectively solve the accidents of induced lightning and pollution flashover disconnection of insulated wires. However, the installation and fixation of the round bar insulation crossarm is extremely inconvenient, while the rectangular cross-section rectangular tube composite material crossarm [5, 6] does not have this problem. Herein, the electrical performance of the 10kV rectangular cross-section composite crossarm was studied in detail for the rectangular tube composite crossarm, discuss the external insulation characteristics of rectangular tube...
composite crossarms, and provide technical support for the promotion and application of composite crossarms.

2. Test device and method
10kV rectangular tube composite material crossarm electrical test: 10kV composite material crossarm lightning impact test, wet power frequency flashover and withstand test, power frequency pollution flashover and withstand test. The corresponding composite crossarm electrical test was carried out in the high-voltage test hall of the electrical industry electrical equipment inspection and testing center. The high-voltage termination was connected to the analog conductor at the end of the composite insulator, the ground wire was grounded through the shaft of the support, and the tower head was fixed to carry out phase ground lightning and power frequency experiments, and the wiring of the test product was shown in Figure 1. The horizontal-ground distance distribution network of the horizontal arm refers to the 10kV double-circuit distribution network horizontal arm line, the minimum horizontal phase-ground spacing is 350mm and the vertical phase distance is 800mm (Figure 2).

![Figure 1. Electrical prototype test of 10kV square tube composite crossarm.](image1)

![Figure 2. Structure of a 10kV double circuit composite crosshead.](image2)

3. Test results and discussion
The 10kV composite material crossarm lightning impact test is phase-to-ground lightning impact. Adjust the distance between the hanging point of the insulator and the pole shaft to 350mm, the analog wire
(iron rod) at the end of the insulator is connected to the high voltage end, record the discharge path. The test layout and lightning flashover are shown in Figure 3, and the test results are shown in Table 1.

Phase-to-ground lightning flashover discharge path is the air between the simulated wire and the steel pipe shaft. For the insulation coordination of insulator and insulation crossarm, the insulation creepage distance was indirectly increased, so that the air between the insulated wire and the pole shaft was breakdown first. The lightning impulse test was pressurized 30 times, including 15 times flashovers and 15 times withstands. When the distance between the hanging point of the pin insulator and the shaft of the steel pipe was 350mm, the phase-to-ground lightning impulse 50% discharge voltage (U50) of the composite material crossarm and the pin insulator was 202.77kV.

![Figure 3. The layout of lightning impulse test and the path diagram of lightning impulse discharge.](image)

**Table 1.** The test results of lightning impulse for 10kV composite cross arms.

| Loading voltage time | Withstanding voltage (kV) | Flashover voltage (kV) |
|----------------------|---------------------------|------------------------|
| 1                    | 194.7                     | 207.1                  |
| 2                    | 197.2                     | 208.1                  |
| 3                    | 195.8                     | 208.1                  |
| 4                    | 199.3                     | 209.1                  |
| 5                    | 197.4                     | 202.2                  |
| 6                    | 195.5                     | 221.2                  |
| 7                    | 194.4                     | 205.4                  |
| 8                    | 194.7                     | 203.7                  |
| 9                    | 185.6                     | 197.6                  |
| 10                   | 190.0                     | 202.7                  |
| 11                   | 194.4                     | 206.2                  |
| 12                   | 197.0                     | 230.2                  |
| 13                   | 195.7                     | 212.0                  |
| 14                   | 198.4                     | 200.6                  |
| 15                   | 198.9                     | 214.3                  |

| U50 (kV)              | 202.77                    |

In the phase-to-ground wet power frequency flashover test, the average voltage was 89.52kV for 5 times, the wet power frequency withstanding voltage of 1min was 76kV, which is 7.6 times of the normal power frequency operating voltage (Table 2). Wet industrial stroboscopic flashover path was along the surface of wire-insulator-composite crossarm-steel pipe shaft, flashover channel occurred in the water film on the surface of insulator and composite crossarm (Fig.4), and flashover channel was continuous water on the surface of the insulator and crossarm, which formed a through flashover channel.
Figure 4. The sample layout of wet power frequency test and surface flashover.

Table 2. Wet power frequency test results of 10kV composite cross arms.

| Project Voltage Value (kV) | Average (kV) |
|----------------------------|-------------|
| Flashover Voltage          | 92.4, 87, 91.8, 90.6, 85.8 | 89.52kV |
| Withstand Voltage          | 76          | 76kV/1min |

In the pollution test, the maximum withstands voltage of the test sample at a given pollution degree which obtained according to the requirements of GB / T 4585-2004. Spread the pin insulator and the composite material crossarms with the mixture of SDD / NSDD (salt dense / grey dense) at the mixing ratio of 0.1:1.0 mg / cm² evenly. The average value of the phase-to-ground artificial pollution flashover voltage of the insulating composite material crossarm was 33.5kV, the average withstand voltage of 15min was 28.5kV, the average withstand voltage of 100min was 27kV (Tab. 3). When the crossarm was carried on the frequency power of 28.5kV, its flashover occurred at 15min, flashover path was on the wire-insulator-composite material crossarm-steel pipe shaft, and flashover channel was along the dirty surface between the conductor-insulator-composite material crossarm and steel pipe shaft (Figure 5).

Figure 5. Arrangement of contamination test and flashover discharge along the sample’s surface.

Table 3. Contamination test result of 10kV composite cross arm.

| Project Voltage Value (kV) | Average (kV) |
|----------------------------|-------------|
| Flashover Voltage          | 35.4, 32.3, 32.8 | 33.5V |
| Withstand Voltage          | 28.5         | withstand/15min |
|                            | 27.0         | withstand/100min |
When the distance between insulator hanging point and steel pipe shaft is 350mm, the lightning impulse flashover voltage of the combination of FPQ-20/3.0 type pin insulator and angle steel crossarm is 132kV, while with the same insulator and insulation distance, the lightning flashover voltage of the composite insulator and the composite material crossarm is 202.77kV, which is about 50% higher than that of the angle steel crossarm; the combined power frequency wet flashover voltage of the pin insulator and angle steel crossarm is 64kV, while the composite crossarm is 89.52kV, and which is increased by about 39.9% compared to the angle steel crossarm; the wet withstand voltage of the combination of the pin insulator and angle steel crossarm is 35kV, and corresponding withstand voltage of the composite crossarm is 76kV, which is increased by 1.17 times; the pollution withstand voltage is 27kV, which is also nearly 30% higher than that of the angle steel crossarm which withstand voltage is 21kV.

4. Conclusion
The external insulation using composite material crossarms is higher than that of the corresponding metal angle steel crossarms fixed with the same specification of insulators. when the minimum distance between the hanging point of the insulator and the pipe shaft is 350mm, comparing to metal angle steel crossarms, the corresponding dry lightning flashover voltage and wet power frequency flashover voltage, wet power frequency withstand voltage and dirty weathering voltage of composite material crossarms all have been increased by 50%, 39%, 117% and 30%, respectively. Here fore, composite material crossarm can greatly improve the insulation level of the distribution line, prevent lightning flashover or lightning disconnection accidents caused by induced lightning in distribution lines, significantly improve the reliability of the distribution network power supply, especially suitable for lightning frequent, humid, heavily polluted and high-reliability power lines.

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