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Research on Safety Protection for Live Working on 1000kV AC Transmission Line with AC and DC Multi-circuit Transmission Lines

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Abstract. In recent years, in order to save line corridors and reduce the scope of demolition, some new transmission modes for high voltage AC and DC power transmission line are proposed. According to the characteristics of the parallel transmission line, this paper studies the distribution characteristics of the electric field intensity of multi circuit parallel transmission lines and the single circuit transmission line. Comparing and analysing the simulation results of the electric field strength, the safety measures for live working of 1000kV AC transmission line with multi circuit parallel transmission lines is put forward. That is the electric field protective equipment and measures used in the live line work of the 1000kV UHV AC single circuit line can meet the requirements of the live operation of the 1000kV UHV AC double circuit line.

1. Introduction

With the rapid development of AC and DC transmission project construction, the transmission voltage level is higher. The number of extra high voltage and ultra-high voltage AC and DC transmission lines are increasing, and the transmission line corridor is becoming more and tenser. Meanwhile, the transmission line construction must also meet the requirements of the environment.[1-2] In recent years, in order to save line corridors and reduce the scope of demolition, some new transmission modes for high voltage AC and DC power transmission line are proposed, such as multi loop, parallel erection and so on.[3-4]

There are four parallel erection of high voltage transmission line in the province, including: two ±800kV extra-HVDC transmission lines, ±500kV double circuit ultra-HVDC transmission line, and 1000kV extra-high-voltage AC transmission lines.

According to the characteristics of the parallel transmission line, this paper studies the influence of the electric field on the human body, and verifies the safety and feasibility of the live line work on the multi circuit transmission line. And compared with the single tower with the voltage level of live working methods, the safety measures for live work is put forward.

2. Calculation and analysis of electric field
Because of the low frequency electric field of operating transmission line, the electric field can be regarded as an electrostatic field when the finite element method is used to calculate the electric field. The field of each tower in typical operations is calculated based on multi circuit transmission lines running at the same time.[5-6]

For the analysis of parallel multiple loop circuit of UHV AC double circuit lines on the same tower space field intensity level, the simulation calculation model is considering the tower and the DC line operation mode of the electric field, and ignoring the effect of insulator effect on electric field distribution. The conductor is equivalent to single conductor to be calculated. The tower surface is considered as a conductor plane. The earth is considered as an infinite conductor plane. Finally, the calculated results are compared with the spatial field strength of single circuit.

2.1. Calculation parameters

When the electric field intensity is calculated, the related calculation conditions are as follows. The electric field of 1000kV transmission line is calculated by reverse order, and the maximum operating voltage of the system is 1100kV. The voltage of B is \( \frac{1100}{\sqrt{3}} \sqrt{2} \) kV, and the voltage of A and C were respectively loaded with \( \frac{1100}{\sqrt{3}} \sqrt{2} \cos(0+120) \) kV and \( \frac{1100}{\sqrt{3}} \sqrt{2} \cos(0-120) \) kV. The polarity of the DC transmission line is set to the left as the negative pole and the right as the positive pole, and its voltage is calculated in accordance with the rated operating voltage.

2.1.1. Structure of towers

Figure 1 shows the tower section model of multi circuit transmission line with same corridor. Figure 2 shows the structure of transmission line tower.

![Figure 1. Location map of the tower with transmission corridor.](image1.png)

![Figure 2. Structure of AC and DC transmission lines tower.](image2.png)
2.1.2. Transmission lines parameters. Transmission line parameters are set as shown in Table 1.

| Line name | 1000kV AC | ±800kV DC(1) | ±800kV DC(2) | ±500kVDC |
|-----------|-----------|--------------|--------------|----------|
| Wire type | 8×ACSR-   | 6×ACSR-      | 6×JL/G3A-    | 4×ACSR-  |
|           | LGJ630/45 | 720/50       | 900/40       | 720/50   |
| Split interval/mm | 400 | 450 | 450 | 450 |
| Subwire radius /mm | 16.8 | 15.14 | 16.93 | 15.14 |
| Calculating radius/mm | 441.21 | 344.66 | 351.14 | 258.2 |
| Hanging point distance/m | 13 | 11 | 11 | 7 |

2.2. Results of calculation
The electric field distribution on the vertical cross section of the tower and the conductor is shown in Figure 3(a). Figure 3(b) shows the contour map of the electric field strength on the plane.

![Figure 3](image)

From Figure 3, it shows that the electric field distributions on the right side of DC (1) transmission lines, on the left side of DC (2) transmission lines and the double direct current transmission line are obviously distorted.

3. Safety protection for live working on 1000kV AC high voltage transmission line
Comparing the electric field intensity of 1000kV transmission line key points under multi circuit transmission line parallel erection condition with the electric field intensity of 1000kV single circuit transmission line with the cathead tower, safety protection measures for live working of 1000kV AC transmission line with AC and DC multi-circuit transmission lines can be obtained.

3.1. Analysis of space electric field of multi circuit transmission line tower
Figure 4 shows the location of the point where the electric field intensity is calculated.
Figure 4. Distribution map of space electric field and its contour

The electric field distribution of the central section of the line tower is shown in Figure 5(a). Figure 5(b) shows the contour map of the electric field strength.

Figure 5. Distribution map of space electric field and its contour

Table 2 shows the simulation results of the calculation of the electric field strength of the tower of the double circuit transmission line.

| Calculation point | Electric field intensity (kV/m) | Calculation point | Electric field intensity (kV/m) |
|-------------------|-------------------------------|-------------------|-------------------------------|
| 1                 | 26.4                          | 6                 | 74.7                          |
| 2                 | 591.1                         | 7                 | 10.9                          |
| 3                 | 93.3                          | 8                 | 714.0                         |
| 4                 | 14.0                          | 9                 | 31.1                          |
| 5                 | 867.7                         | 10                | 27.5                          |

As can be seen from the table 2, the distribution of the electric field intensity has the following characteristics.

1) The electric field intensity on the surface of the conductor is maximum. Along with the increase of the distance of the conductor, the electric field intensity decays rapidly.

2) The electric field intensity of tower surface with the same height of the conductor, the insulator strings on the cross arm and the lower of the conductor is relatively large because they are close to the conductor.
3) The electric field intensity at the corner intersection with the tower of tower cross arm is relatively small.

3.2. Analysis of electric field of single circuit tower
For the convenience of analysis and comparison, 1000kV cathead tower with single circuit is selected as the research object. Figure 6 shows the location of the point where the electric field intensity is calculated.

![Figure 6. Distribution calculation of the electric field intensity of space electric field and its contour](image)

The electric field distribution of the central section of the line tower is shown in Figure 7(a). Figure 7(b) shows the contour map of the electric field strength.

![Figure 7. Distribution map of space electric field and its contour](image)

Table 3 shows the simulation results of the calculation of the electric field strength of transmission line with the cathead tower.

| Calculation point | Electric field intensity (kV/m) | Calculation point | Electric field intensity (kV/m) |
|-------------------|---------------------------------|-------------------|---------------------------------|
| 1                 | 26.1                            | 4                 | 40.0                            |
| 2                 | 1039.4                          | 5                 | 1116.9                          |
| 3                 | 32.6                            | 6                 | 5.0                             |

From the results in Table 3, we can know that the maximum electric field strength of the wire surface. Along with the increase of the distance to the wire, the electric field intensity is quickly fading.
3.3. **Comparison and analysis of results**

Comparing the electric field strength of the typical operation line tower working position of multi loop parallel charged transmission line and independent single cathead tower corridor, the calculation results show that electric field strength has the following characteristics and rules for 1000kV UHV ac electrification double circuit tower.

The electric field strength of the surface of the conductor is the largest for the two kinds of transmission lines, and the value of the field strength is basically equivalent. The maximum value of electric field strength on the surface of the conductor of the single tower transmission line is slightly larger than that of the electric field strength on the surface of the double tower of the tower. The surface electric field intensity of the single tower body is larger than that of the surface electric field strength of the tower body with double circuit lines on the same tower. The electric field strength of the surface of the single tower window is larger than that of the surface electric field strength. The electric field intensity at the intersection of the tower cross arm and tower body and in the tower window corner are relatively small.

4. **Conclusion**

By the above analysis, it can be known that the electric field protective equipment and measures used in the live line work of the 1000kV UHV AC single circuit line can meet the requirements of the live operation of the 1000kV UHV AC double circuit line. That is live working personnel (including the ground potential conditions of live working personnel) should be wearing a full set of 1000kV special shielding clothing.

Special shielding clothing is made of shielding clothing cloth that its shielding efficiency is not less than 60dB and other parameters are in line with standard of GB6568.1-2008 "live working with shielding clothing". Shielding clothing should be made a coat and trousers with a hat brim integrally and increase the style. Other potential operators should also be put on the mesh face shield which is not less than 20dB.

**References**

[1] Research Status and Development Trend of Live Working Key Technology, HU Yi, LIU Kai, PENG Yong, SU Ziming, WU Tian. High Voltage Engineering, 2014.07

[2] Live Working on EHV/UHV Transmission Lines, HU Yi, LIU Kai, LIU Ting, XIAO Bin, PENG Yong, SU Ziming. High Voltage Engineering, 2012.08

[3] Safety Protection for Live Working on Transmission Line, HU Tao, HU Yi, LI Jing lu, Long lihong. High Voltage Engineering, 2006.05

[4] Safety Hazard and its Prevention for Hot-line Work of 500 kV Transmission Line, XIE Yu-gan. Industrial Technology Innovation, 2016.05

[5] Simulation Analysis of Electric Field Protection for Live-Working on 1 000 kV and 500 kV AC Four-Circuit Transmission Lines on One Tower, SU Zi-ming, PENG Yong, LIU Kai, LIU Ting, XIAO Bin, WU Tian, TANG Pan. Electric Power, 2014.02

[6] Computation of Body Surface Electric Field during Live Working on 1 000 kV AC Compact Transmission Lines, FANG Yaqi, PENG Yong, SU Ziming, TANG Pan, LIU Kai, WU Tian, WANG Linong. Electric Power, 2015.10