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Analysis and Study on Safety Warning Distance of Human Body Near The Transmission Lines

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Abstract. When new overhead transmission lines are built near live lines, they must be affected by the induced electricity generated by the nearby lines. Existing industry standards have stipulated such situations and proposed the safety distance that should be maintained during construction. However, there are still many occurrences of safety accidents or hidden dangers outside the safe distance. The article analyzes and studies the construction of human body under different live voltages with different types of towers (500kV cat head tower, 500kV wine glass tower, 500kV drum tower, ±800kV T tower, 1000kV drum tower, 1000kV wine glass tower). The specific situation of electric field distortion, combined with the 25kV/m DC electric field strength limit and the 10kV/m AC electric field strength limit set by the International Non-Ionizing Radiation Protection Committee, are calculated to give the safety warning distance of the human body in the vicinity of the live line.

1. Computing environment

Using ANSYS software to analyze and calculate the electric field environment, natural conditions assume. Altitude: 500m; Wind speed: 29m/s; Ice cover: 10mm; Terrain: plain. The situation of the ground conductor near the live lines project is shown in Table 1:

Table 1. Situation of ground conductors near live lines

Voltage	500kV	±800kV	1000kV
Tower shape	Wine cup type (single back) Cat head type (single back) Drum type (double back)	T type	Wine cup type (single back) Drum type (double back)
Wire type	JL/G1A-630/45	JL/G3A-1250/70	JL/G1A-630/45
Splitting number	4	6	8
Ground model	JLB40-150	JLB20A-185	JLB20A-185
Splitting distance	500mm	500mm	500mm

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Typical span	420m	540m	580m
Typical sag	15m	25m	26m

2. Split conductor equivalent radius

Using the equivalent radius method recommended by the Special Committee for International Radio Interference (CISPR), the basic idea is to replace the split conductor with a single equivalent conductor, then calculate the total charge of each equivalent conductor, and then calculate the field strength of the conductor surface. The equivalent radius of the split conductor is:

$$R_i = R\sqrt[m]{\frac{mr}{R}} \tag{1}$$

In formula (1), R_i is the equivalent radius of the split conductor, m is the number of splitting of the conductor, r is the radius of the sub conductor, and R is the radius of the split circle, as shown in Figure 1.

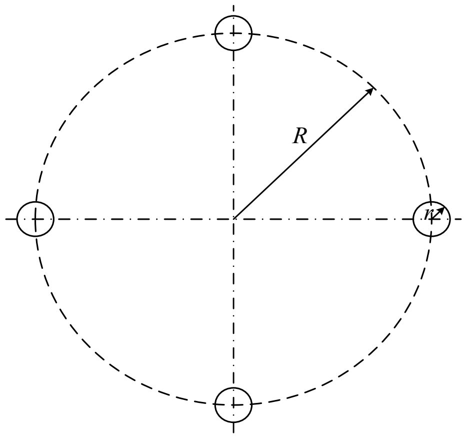

Figure 1. Split conductor equivalent radius

For the calculation of several wire types involved, the calculation results of the equivalent radius of the split conductors are shown in Table 2:

Table 2. Equivalent radii of split conductors

Voltage level	500kV	±800kV	1000kV
Wire type	JL/G1A-630/45	JL/G3A-1250/70	JL/G1A-630/45
Splitting number m	4	6	8
Splitting distance	500mm	500mm	500mm
Split circle radius R	353.5mm	500.0mm	653.7mm
Sub-wire radius r	14.2mm	20.0mm	14.2mm
Equivalent radius Ri	223.8mm	394.2mm	525.3mm

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3. Near ±800kV T-tower DC transmission line

Figure 2 shows the peak electric field of a human body near a ±800kV T-tower DC transmission line. The corresponding safety alert distances are shown in Table 3. When the height of the human body to the ground is 0-15m, with the increase of the horizontal distance from the nearby line, the change trend of the peak electric field of the human body first increases and then decreases, which is consistent with the conclusion that the electric field below the line is mainly concentrated near the line. When the height of the human body to the ground is 20-65m, the peak electric field of the human body decreases with the increase of the horizontal distance from the nearby line. This change trend reflects the influence of the electric field near the line on the human body. Judging from the values of the human safety warning distance shown in Table 3, the human body warning distance of the ±800kV T-tower HVDC transmission line is relatively small, and the human body warning distance is within 4.8-8.7m in the 30-60m height range. It shows that the ±800kV T-tower direct current transmission line can be compactly constructed.

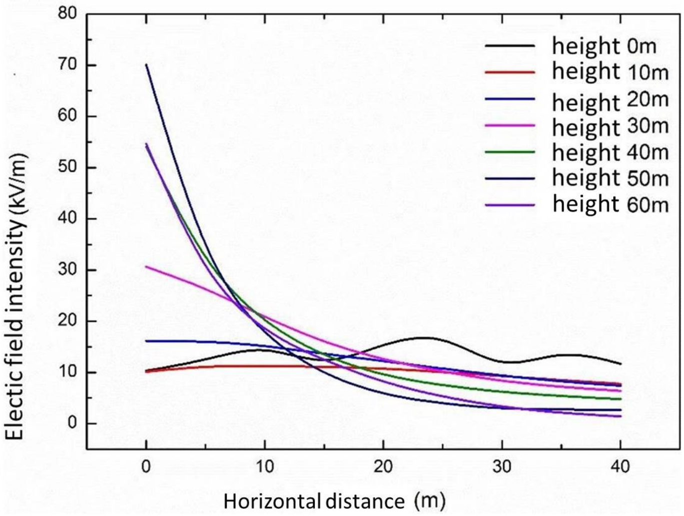

Figure 2. The distribution of human body peak electric field near ±800kV T-tower DC transmission line

Table 3. Human safety warning distance of ±800kV T-type tower DC transmission line

Height to ground (m)	≤25	30	35	40	45
Horizontal distance from nearby lines (m)	Not limit	7.4	8.7	7.5	4.8
Height to ground (m)	50	55	60	65	
Horizontal distance from nearby lines (m)	6.6	7.0	6.8	Not limit	

4. Near 1000kV drum tower AC transmission line

Figure 3 shows the peak electric field of a human body near a 1000kV drum tower AC transmission line. The corresponding safety alert distances are shown in Table 4. Compared with the direct current situation, the peak electric field strength of human body adjacent to the 1000kV drum tower AC transmission line is obviously increased, and the change is most obvious at a height of about 60-70m. In Table 4, the human safety warning distance near the 1000kV drum-type tower AC line is overall higher, and the safety warning distance at the height of 60-70m is even close to 40m. It should be noted that since the harmonic analysis solution result is a sine steady-state solution, the actual electric field strength will still fluctuate near the solution result for the AC power transmission. Therefore, the actual safety warning distance value will also fluctuate near the data results in Table 4. In general, the 1000kV drum tower AC transmission line is not suitable for compact construction.

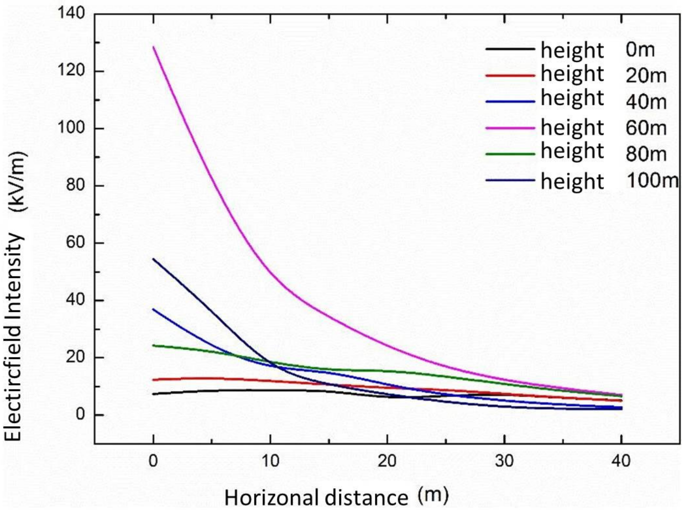

Figure 3. Peak electric field distribution of human body near 1000kV drum tower AC transmission line

Table 4. Human Security Warning Distances for AC Transmission Lines Adjacent to 1000kV Drum Towers

Height to ground (m)	≤10	15	20	25	30
Horizontal distance from nearby lines (m)	Not limit	12.2	16.3	20.1	23.7
Height to ground (m)	35	40	45	50	55
Horizontal distance from nearby lines (m)	24.4	22.8	18.6	23.2	30.9
Height to ground (m)	60	65	70	75	80
Horizontal distance from nearby lines (m)	33.8	36.9	36.4	34.5	31.2
Height to ground (m)	85	90	95	100	/
Horizontal distance from nearby lines (m)	24.9	13.4	14.4	15.9	/

5. Near 1000kV wine glass tower AC transmission line

Figure 4 shows the peak electric field of a human body near a 1000kV wine glass tower DC transmission line. The corresponding safety alert distances are shown in Table 5. Compared with the case of a 1000kV drum tower, the peak electric field intensity of the human body near the 1000kV wine cell tower AC line is slightly lower, and the change is most pronounced at a height of about 60m, but it is still significantly higher than the DC case. In Table 5, although the human safety warning distance near the 1000kV wine glass tower AC line is slightly lower than that of the 1000kV drum tower, the human body safety warning distance value at the height of 25-35m is still close to 30m, which is still not suitable for compact construction.

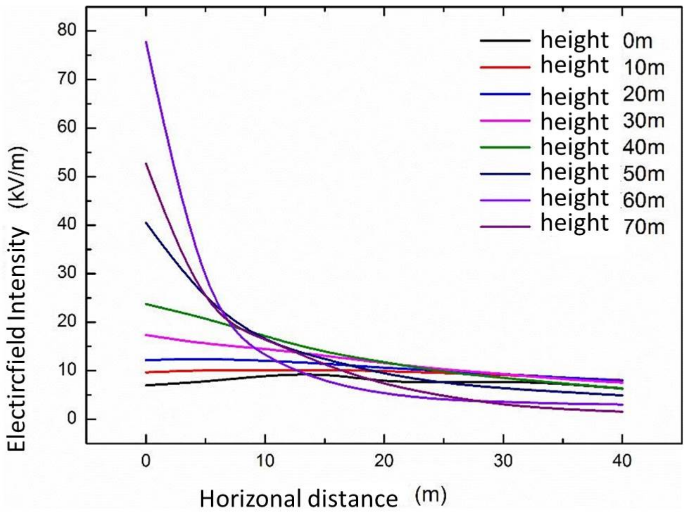

Figure 4. Distribution of human body peak electric field in AC transmission line near 1000kV wine glass tower

Table 5. Human safety warning distances for AC transmission lines near 1000kV wine glass tower

Height to ground (m)	≤5	15	20	25	30
Horizontal distance from nearby lines (m)	Not limit	18.6	22.9	26.8	27.4
Height to ground (m)	35	40	45	50	55
Horizontal distance from nearby lines (m)	27.9	24.3	23.6	19.2	13.6
Height to ground (m)	60	65	70	/	/
Horizontal distance from nearby lines (m)	14.4	15.7	16.9	/	/

6. Near 500kV drum tower AC transmission line

Figure 5 shows the peak electric field of a human body near a 500 kV drum tower DC transmission line. The corresponding safety alert distances are shown in Table 6. Compared with the case of the 1000kV drum tower, the peak electric field intensity of the human body is significantly reduced due to the low transmission voltage of the 500kV drum tower AC line. In Table 6, the human safety warning distance of the 500 kV drum tower AC line is generally within 20m.

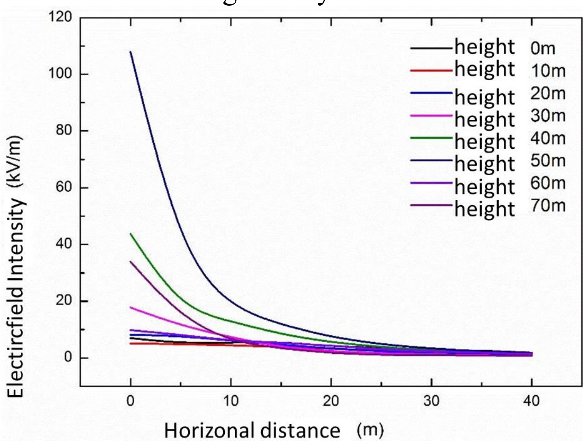

Figure 5. Distribution of human body peak electric field near 500kV drum tower AC transmission line

Table 6. Human safety warning distances for 500kV drum tower AC transmission lines

Height to ground (m)	≤25	30	35	40	45
Horizontal distance from nearby lines (m)	Not limit	6.9	8.3	12.6	19.9
Height to ground (m)	50	55	60	65	70
Horizontal distance from nearby lines (m)	19.1	12.7	Not limit	4.8	7.1

7. Near 500kV wine glass tower AC transmission line

Figure 6 shows the peak electric field of a human body near a 500kV wine glass tower DC transmission line. The corresponding safety alert distances are shown in Table 7. Compared with the case of a 1000kV wine glass tower, near the 500kV drum tower AC line, the peak electric field intensity of the human body is significantly reduced due to the low transmission voltage. Compared with the 500kV drum tower, due to the different line locations, the human body peak electric field strength near the 500kV drum tower AC line is lower, which is more suitable for compact construction. In Table 7, the human safety warning distance near the 500kV wine glass tower AC line is generally in the range of 5-10m.

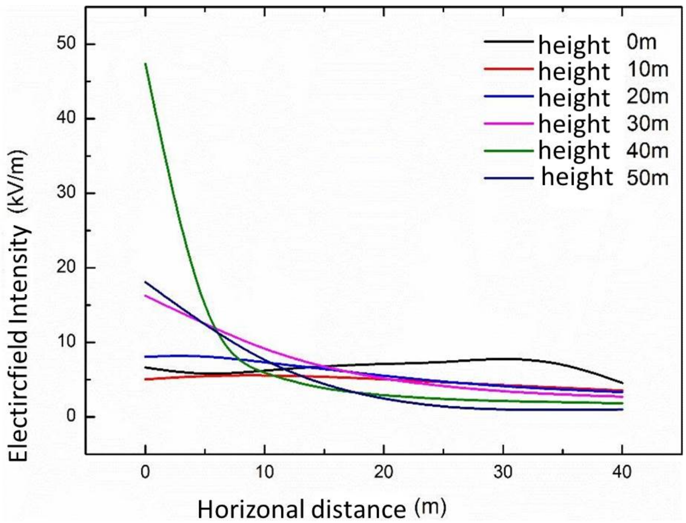

Figure 6. Distribution of human body peak electric field in DC transmission line near 500kV wine glass tower

Table 7. Human safety warning distances for DC transmission lines close to a 500kV wine glass tower

Height to ground (m)	≤20	25	30	35	40
Horizontal distance from nearby lines (m)	Not limit	5.5	8.2	9.1	6.3
Height to ground (m)	45	50	/	/	/
Horizontal distance from nearby lines (m)	8.8	7.4	/	/	/

8. Near 500kV Cat Head Tower AC Transmission Line

Figure 7 shows the peak electric field of the human body adjacent to the 500kV cat head tower AC transmission line. The corresponding safety alert distances are shown in Table 8. Similar to the situation of the 500kV wine glass tower AC transmission line, the human body peak electric field strength of the 500kV cat head tower AC transmission line is also at a low level, both of which are lower than the 500kV drum type tower, which is determined by the line location and arrangement. Both the wine glass tower and the cat's head tower belong to a single-circuit line, in which the one-phase conductor and the other-side conductor have a weak influence on the electric field strength of the adjacent human body, while the drum tower belongs to a double-return circuit. The three phases A, B and C are all opposite. The electric field strength in the immediate vicinity of the human body has a direct effect, resulting in the above differences. In Table 8, the human safety warning distance of the AC line near the 500kV cat's tower is also generally within the range of 5-10m, only slightly exceeding 10m in the height of 20m.

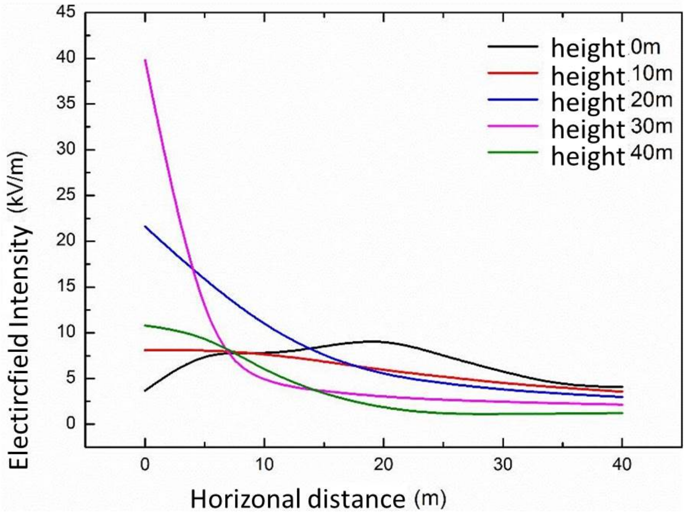

Figure 7. Distribution of human body peak electric field near AC transmission line of 500kV cat head tower

Table 8. Human safety warning distances for AC transmission lines near the 500kV cat head tower

Height to ground (m)	≤10	15	20	25	30
Horizontal distance from nearby lines (m)	Not limit	6.2	10.7	8.9	4.5
Height to ground (m)	35	40	45	/	/
Horizontal distance from nearby lines (m)	5.2	2.3	Not limit	/	/

9. Conclusion

Calculating the electric field strength of the 6 types of lines studied, and according to the international non-ionizing radiation protection committee's 25kV/m DC electric field strength limit, 10kV/m AC electric field strength limit, the results show that adjacent UHV lines or towers the human safety alert distance has two dimensions, horizontal and vertical, and there is an association between the two dimensions. In the case where the height to the ground does not exceed 5m, the horizontal distance from the adjacent lines is within the scope of human safety, and no warning is required. At other heights, the horizontal distance of human security warning distance is related to the height of the ground.

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