THE RELATION BETWEEN POWER LINE ICING AND METEOROLOGICAL CONDITIONS IN GUIZHOU, CHINA

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1. INTRODUCTION

Power line icing is a serious problem during winters in China and has been studied for many years by individual provincial meteorological bureaus yet there are no systemic studies at the national level. A comprehensive, quantitative study, however, has been stymied because of inconsistencies between the various data sets, lack of quality control and differences in how data are reported. As a result, we initiated a new study to try and provide a higher quality data set that can provide new information useful for relating the power line icing features to the meteorology so that avoidance strategies can be developed through modern weather prediction.

Continuous observations were made over 152 hours of temperature, wind direction and speed at a sports stadium and under a television tower midnight on January 3th,1990 to 8:00 on January 9th,in the Lou mountains, Guizhou province. An additional 81 hours of continuous measurements were made of temperature, wind direction and speed, ice diameter and the thickness and icing damage to cables in Liupanshui-Panxian, JiuZun, Shuicheng county and Kaiyang county were also made.

2. THE METEOROLOGICAL CONDITIONS OF THE FORMATION OF POWER LINE ICING

Glaze is a hard ice which is made when the supercooled water drop comes into contact with things on the ground. While rime is an ivory-white ice crystal which is made by condensation of vapor in the air or when the supercooled fog-drop is directly frozen on a solid object. The phenomenon is called power line icing when glaze, rime or snow is frozen on the power line.

Power line icing is formed by some combinational meteorological conditions. According to observations of weather station, power line icing is often appeared when the wind velocity is under 5m/s, the air humidity is between -10℃ and 0℃ and the relative air humidity is over 95%.When the real disaster is caused to the power line, it should meet the following three conditions:

1) the supercooled water drop or cloud droplet exists and there is additional water vapor;
2) the wind velocity is 3~5m/s,and southeaster is better to the increase of ice;
3) it is the most serious when the temperature is -6~-3℃.

3. THE ANALYSIS OF METEOROLOGICAL CHARACTERISTICS DURING POWER LINE ICING

When glaze or rime weather occurs, power line icing does not always appears. The temperature and air humidity should be in a certain scope, the wind velocity should not be too high and the wind direction should be propitious to the formation of icing.

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1). The influence of temperature to the formation of power line icing

Table 1 Temperature and weather between 1990 and 1994 during the observation of power line icing

Time	fog			Rime&glaze			Power line icing		
	frequency	temperature (℃)	Average temperature (℃)	frequency	temperature (℃)	Average temperature (℃)	frequency	temperature (℃)	Average temperature (℃)
1990y 1#	32	-2.5～5.0	1.40	7	-0.8～-0.2	-0.47	5	-0.6～-0.2 (glaze)	-0.42
1990y 2#	35	-1.0～6.7	1.46	5	-0.6～0.5	-0.22	naught		
1994y Loumountain	naught			non-stat			28	-6.0～-1.8 (rime)	-4.49

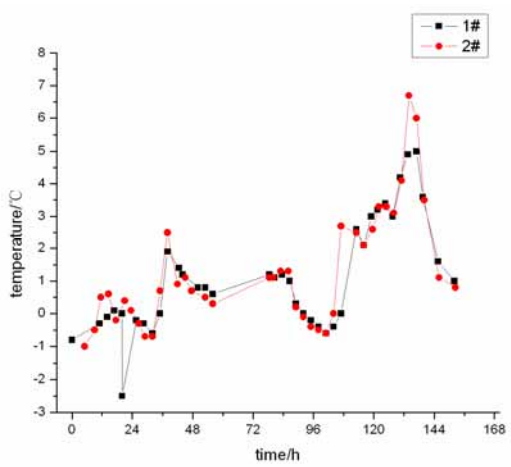

Fig. 1 Temperature changes with time during the observation of power line icing on Lou mountain in Zunyi city (the number of samples of the two observation points respectively is 39,40,totalling 79)

Temperature range is closely related to the type of icing. It influences the type of power line icing by influencing the freezing course of supercooled water drop. The temperature of the formation of icing in Zunyi ranges form -6.0~-1.8℃, got from Table 1.

From figure 1, when the ice crystals and the supercooled water drop coexist, the ice crystals will grow more quickly than the other one. In the progress of the power line icing, the ice increases when the supercooled water droplet diffuses and deposits on the wire. According to the meteorological record, fog sustained during all the observations in 1990.Trends of temperature changes are almost the same, and the overall trend of temperature is upward, with small fluctuations in the middle. When the temperature substantially decreased, fog gradually dissipated.

2) The influence of wind direction and wind speed to power line icing

The growth of supercooled water drop, namely riming，exists during collision and freezing of it ,in the course of the formation of both glaze and rime. The increase of ice can be figured out by continuing coagulation equation：

$$\frac{dm}{dt} = EA_s q_w \left| v_s - v_w \right|,$$

E is the coagulation coefficient of supercooled water drop and ice crystal. A_s is the section of the ice crystal, q_w is content of water vapor in the cloud, v_s and v_w is respectively the landing speed of ice crystal and water drop. For the power line icing in the practical circumstances, icing on the wire could be regarded as ice crystal, and the icing thickness could be considered as the section of ice crystal. Consequently, the increase of power line icing is related to coagulation coefficient, the content of water vapor in the cloud and the landing velocity of water drop. The influence of the landing velocity of water drop to the increase of icing is mainly considered in this paper. For Non-quiescent air, the landing speed of water drop is also influenced by the direction and velocity of wind.

Table 2 Frequency of wind directions during observations of power line icing in Zunyi city in 1990 and 1994

	Wind direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	C
1990y	frequency	6	1	9	0	4	0	15	1	18	1	4	0	4	0	7	1	7
1994y	frequency	0	2	5	0	9	1	8	0	1	0	0	0	0	0	0	0	0
add up	frequency	6	3	14	0	13	1	23	1	19	1	4	0	4	0	7	1	7

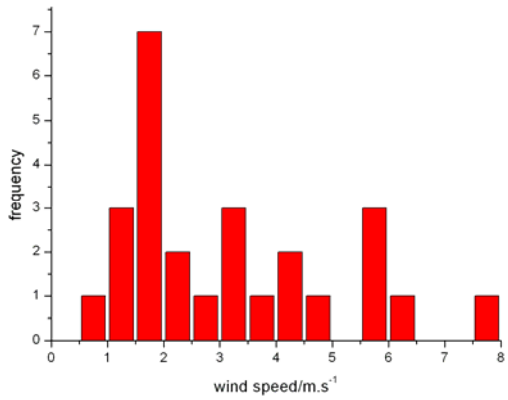

Fig. 2 Frequence of wind speeds during observations of power line icing in Zunyi city in 1994(26 samples)

When power line icing happened on Lou mountain in 1994, east accounted for maximum proportion, with southeaster also for a sizeable one, got from Table 2.

From figure 2, the wind velocity when power line icing appeared was mostly between 1.0~4.5m/s.That is because low wind speed goes against supercooled water drop adhesion to the wire; and when the wind speed is too high, the degree of wire oscillation will increase, which would change the molecular dynamical structure, accordingly the adhesion force of icing would be reduced and thus the ice falls.

4. ANALYSIS OF ICING CHARACTERISITICS

Macro characteristics of power line icing as follow:

We can find from the meteorological records in Shuicheng and Kaiyang that the longer time the ice accretion sustains, the higher the icing accident probability is. Both of their critical icing day is the fourth day of the icing days. After that time, the icing accident probability shows a rising trend.

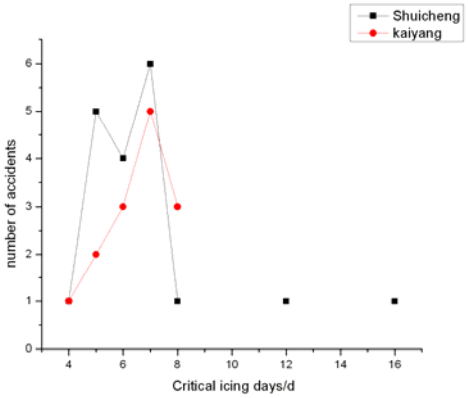

Fig. 3 Critical icing days of icing accidents in Shuicheng city and Kaiyang city(19 samples in Shuicheng city and 11 in Kaiyang)

Table 3. Icing accident probability in Shuicheng county and Kaiyang county during 1967~1989

Icing days	Shuicheng			Kaiyang			Add up		
	Icing times	Accident times	disaster	Icing times	Accident times	disaster	Icing times	Accident times	disaster
3～10	23	9	39%	25	6	24%	48	15	31%
11～20	13	11	85%	19	6	32%	32	17	53%
21～30	2	2	100%	1	1	100%	3	3	100%

5. SUMMARY

1). Power line icing by rime happens most frequently when the temperature ranges from -6.0～-1.8 C, 2) the growth of the ice is proportional to the wind speed, 3) four days of sustained meteorological conditions that produce icing is the critical time period after which the probability of cable damage begins to increase., 4) the changes in the ice diameter and thickness represents different phases of a icing process, i.e. steady increases in the diameter and thickness represents the development phase, no increase represent the maintenance phase and steady decrease is the dissipative stage.

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