The Characteristic and Chemical Analysis of Ice Coating on Transmission and Transformer Equipments in Hunan Power Grid Caused by Icing Disaster in 2008

Feng Bin, Chang Yan , Hu Xu , He Tiexiang, Zhang Yufu
(Hunan Electric Power Science and Research Institute Changsha 410007 , China)

Abstract: Due to severe icing disaster in the beginning of the year 2008,the line facilities and the transformer equipments of Hunan power grid sustained heavy losses. In this paper the equivalent diameter, density and conductivity of ice coating on the damaged electric facilities such as transmission towers, breaking and falling of insulator strings, breaking of conductors and ground wires in icing disaster were measured and the chemical composition of the coating ice and snow were analyzed by ion chromatography technique. The results showed that the icing disasters in Hunan power grid were caused by glaze ,which covered in tower the average equivalent diameter was between 30 to 85mm , covered in wires the average equivalent diameter was between 30 to 70mm.The maximum average equivalent diameter was 95 mm . The average masses varied from 0.85 g/cm^3 to 0.91 g/cm^3.Compared the data of conductivity of ice and the icing flashover performance of transmission lines, it showed the bigger the conductivity, the more icing flashover of ice-coating insulation strings, while the insulator which coated RTV paint showed few advantage against icing flashover, and generally the concentration of ions of ice were higher than no RTV painted insulators. Determination of water-soluble inorganic anions and cations in ice by gradient elution ion chromatography was developed, using the ICS2000 and ICS90.SO_4^{2-},NH_4^+ ,Ca^{2+},NO_3^-, NO_2^-, Cl^- and F^- were the marked ions of ice. $SO4^{2-}$, NO_3^- were the dominant anions, while NH_4^+ and Ca^{2+} were the major cations in ice. From 2005 to 2008, the conductivity of coating ice in the same insulators increased from 17-65μs/cm to 96-380μs/cm,while the percentage of to total ions and the ratio of $NH4^+$ to total cations increased 30% and 25% respectively. Based on aboved-mentioned analysis, some recommendations are put forward.

Key words: icing and snow disaster; Hunan power grid; glaze;
ion chromatography; chemical analysis

0 Introduction

Since entering the 21st century, demand for electricity in china has been very high due to the rapid development of economy. At the same time, requirements from electricity consumers for higher supply reliability, excellent power quality and satisfactory services have emerged. While under the extreme weather condition , ice storm may happen. If ice accumulated on transmission lines ,the risk of blackout will be increased which can cause great losses.

Ice can accumulate on overhead transmission lines under some specific meteorological conditions thus become a big problem. Meanwhile shed bridging of insulator and the pollution in the ice cause the icing flashover frequently, and the differential icing is the main reason of the conductor galloping and the breakage of equipment in power transformation. In the beginning 0f 2008,a serious icing and snow disaster occurred in partial area of hu'nan province caused the havoc of power grid equipments and power supplies were interrupted in some regions, the people's normal life and economic activities were severely affected.

Insulator icing is a special form of pollution. Generally speaking, icing flashover of insulator

happens under operation voltage only as pollution exists on the insulator surface before icing. So it is necessary to explore the composition of the ice coating the electrical facilities. In this paper, the equivalent diameter, density and conductivity of ice coating on the damaged electric facilities in 2008 icing disaster were measured and the chemical composition of the coating ice and snow were analyzed. Particular attention was given to the following conditions: the species of water-soluble inorganic anions and cations in ice, the icing flashover performance of transmission lines and the conductivity of ice coating the insulator which coated RTV paint or without RTV paint.

1 Experiment

The damage conditions and causations of facilities such as damage of transmission tower, breaking of conductors and ground wires, damage of fittings, breaking and falling of insulator strings were investigated on the ground. The ice accretions on the above equipments were carefully collected by transparent tight plastic bags. The equivalent of ice coating on the damaged electric facilities were measured by square caliper, while the weight and the density of ice samples were examined by standard methods on the spot. After ice melt, the conductivity of the water was measured and the chemical composition of the coating ice and snow were analyzed by ion chromatography technique in laboratory. A method was developed for the simultaneous determination of sulfate, phosphate, nitrate and halide ions （F-,Cl-,Br-） by ion chromatography using ICS-90 ion chromatography system with suppressed conductivity detection. The chromatographic separation was performed on a Ion Pac As18 anion-exchange column with potassium hydroxide as eluent, and the injection volume was 250μL. The effects of the nature of eluent, eluent concentration and column temperature on the separation and the retention factors of the anions were investigated. The optimized chromatographic conditions for the determination of the anions were as follows： 23.0 mmol/L potassium hydroxide as eluent, a column temperature of 30 ℃ and a flow rate of 1.1 mL/min. Under the optimal conditions, the anions were baseline separated. Moreover, the symmetries of peaks were better. The method is simple,accurate and reliable,and has better practicability. The cations such as calcium ,magnesium, potassium, sodium and potassium were determined by ICS-2000 ion chromatography system with suppressed conductivity detection. The chromatographic separation was performed on a Ion Pac Cs12A ion-exchange column with methanesulfonic acid as eluent, and the injection volume was 250μL. The optimized chromatographic parameters were as follows： 20.0 mmol/L potassium hydroxide, eluent flow rate 1.0 mL/min. For each experiment, the validity of the instrument was checked by standard solutions

2 Results

2.1 field experiment results

According to the faults caused by ice accretion happened in 2008 in hunan power grid , tower falling down, icing flashover of insulator and conductor galloping, pole leaning or collapse, the characteristics of the ice was spot investigated. Table 1 show an overview of the density, the average equivalent diameter and the masses of the glaze on the ground. It is very clear that the icing disasters in Hunan power grid were caused by glaze ,which covered in tower the average equivalent diameter was between 30 to 85mm , covered in wires the average equivalent diameter was between 30 to 70mm.The maximum average equivalent diameter was 95 mm in Line heyun II tower #64 . The average masses varied from 0.85 g/cm^3 to 0.91 g/cm^3.

TABLE 1

An Overview of the Weight,Density and the Thickness of ice sample

Sampling site	Date	thickness(mm)	weight(g)	volum(cm^3)	density(g/ cm^3)
line gang,ai tower#306~#307	1.21	60	——	——	——
Line yifu tower#28~#29	1.21	16	54	60	0.90
Line fushaI tower#2	1.21	25	33	37	0.90
Fuxing Substation 5031circuit breaker TA A phase	1.21	——	62	68	0.91
Fuxing Substation porcelain insulator string	1.21	——	21.5	25	0.86
Line heyun II tower #63 column	1.26	85	53	62	0.85
Line heyun II tower #63 conductor	1.26	50	32	48	0.85
Line yebai II tower #23 column	1.26	25	50	57	0.88
Line yebai II tower #23 conductor	1.26	12	——	——	——
Line yebai II tower #24 column	1.26	67	——	——	——
Line yebai II tower #23 conductor	1.26	47	——	——	——
Line aihe I conductor between tower #12~#13	1.28	50	36.5	43	0.85
Line aihe I I tower #3 conductor	1.28	73	38	44	0.85

2.2 laboratory experiment results

The RTV coating material has perfect performance of anti-pollution flashover, but for the anti-icing flashover, the research in domestic and abroad have also reported fresh. Comparing the insulators with or without RTV coating, the 2008 and 2005 ice disaster in hunan power grid show that RTV coating material exerts no effect on increasing flashover of iced insulators. The conductivity and the chemical composition of the ice-water of various types of insulators showed in Table 2 gives a strong evidence. The concentration of the natural pollutants attached in insulators with RTV coating were even higher than those with no RTV painted insulators. It seemed that the hydrophilicity of RTV layer changes the ice status of insulator string surface, and creates many minute airspaces in the ice layer. These airspaces are inclined to cause partial discharge

and damage RTV layer, hence to increase the leakage current of insulators.

TABLE 2

The Ice-water of The Insulators With or Without RTV Coating

Sampling site	Date	Conductivity (μs/cm)	F^- (ppm)	Cl^- (ppm)	NO_2^- (ppm)	NO_3^- (ppm)	$SO^2_4^-$ (ppm)
Chaoyang substation 608TA ice (with RTV coating)	2008.1.25	378	0.21	4.18	0.060	22.14	27.12
Chaoyang substation 608TA ice (without RTV coating)	2008.1.25	308	0.21	3.87	0.050	26.82	36.33

Using the ICS2000 and ICS90 ion chromatography system with suppressed conductivity detection, the chemical compostion of ice samples were detected.(table3) SO_4^{2-},NH_4^+,Ca^{2+},NO_3^-, NO_2^-, Cl^- and F^- were the marked ions of ice. $SO4^{2-}$, NO_3^- were the dominant anions, while NH_4^+ and Ca^{2+} were the major cations in ice. From 2005 to 2008, the conductivity of coating ice in the same insulators increased from 17-65μs/cm to 96-380μs/cm,while the percentage of to total ions and the ratio of $NH4^+$ to total cations increased 30% and 25% respectively. So it is necessary to clean the equipments in substation where suffered severe pollution in winter to avoid ice flashover.

TABLE 3

The Chemical Compostion of Ice Samples

Sampling site	Date	Conductivity (μs/cm)	F^- (ppm)	Cl^- (ppm)	NO_2^- (ppm)	NO_3^- (ppm)	$SO^2_4^-$ (ppm)
Line fusha I tower #1	2008.1.23	96.1	1.15	1.67	0.040	7.89	7.96
Fuxing Substation 5031 TA phase A	2008.1.23	151	0.85	1.62	0.020	11.81	14.10
Fuxing Substation 5031 circuit breaker phase B	2008.1.23	168	0.94	2.05	0.020	13.41	15.37

Fuxing Substation 5031circuit breaker snow	2008.1.23	515	0.75	5.43	0.120	37.01	46.72
Line heyun II tower #63 column	2008.1.26	149	0.16	2.17	0.060	13.32	18.52
Line aihe I Tower #3 snow	2008.1.28	30.7	0.84	2.12	0.010	1.48	2.23
Yuntian substation insulator ice	2008.2.2	43.9	0.15	1.78	0.040	3.77	3.75
Fuxing Substation 5031circuit breaker	2005.2	17.0	0.18	0.22	0.004	0.46	9.57
Fuxing Substation 5031 circuit breaker phase B	2005.2	17.0	0.10	0.15	0.005	2.44	3.36

3.conclusion

3.1 The icing disasters in Hunan power grid were caused by glaze, which average masses varied from 0.85 g/cm^3 to 0.91 g/cm^3.

3.2 The chemical composition of the ice-water of various types of electrical facilities showed that $SO4^{2-}$, NO_3^- were the dominant anions, while NH_4^+ and Ca^{2+} were the major cations in ice. While the insulator which coated RTV paint showed few advantage against icing flashover, and the concentration of ions of ice were even higher than no RTV painted insulators