PRINCIPLE AND TECHNICAL MEASURE FOR THE ANTI-ICING OF TRANSMISSION LINE

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***Abstract*:** The technical principle based on suiting measures to local conditions for the anti-icing/snowing was put forward. With our country's anti-icing/snowing work experience for many years and from the point of view of "avoiding, anti-icing, de-icing, modification, prevention", detailed technical measures were raised. The feasibility of each measure was analyzed and suggestion for the implementation of each measure was given.

1. THE TECHNICAL PRINCIPLE FOR THE ANTI-ICING

The 5-word policy of "avoiding, anti-icing, de-icing, modification, prevention" was summed up after years of our country's anti-icing work. The main idea of "avoiding, anti-icing, modification, prevention" is to take effective technological measures to make sure that the transmission line is not covered with ice, or even if covered, the total icing load can be controlled at the range of affordable limit of the transmission line.

1) "avoiding" is to try to avoid crossing mountain pass, yakou, tuyere, lakes and so on when selecting the line path.

2) "anti-icing" is to improve the design standards, resist ice load, and assure the safety and reliability of line.

3) "modification" is to change the path to avoid heavy ice region after the line was harmed by ice because of the lack of comprehensive consideration of former design.

4) "prevention" is to research new craftwork and material to prevent line icing.

① Anti-icing wire

② Anti-icing/snowing ring

③ Material of earth wires and insulators for the anti-icing

a) Paint electric coating material on the surface of the insulator

b) Paint solar-thermal coating material on the surface of the conductor-grounding wire and the insulator

c) Paint hydrophobic coating material on the surface of the conductor-grounding wire and the insulator

④ Change the structure of line insulator string to prevent ice flashover

2. MEASURES AND APPLICATION

(1) According to the ordering "avoiding, anti-icing, prevention, modification" principle, comprehensive anti-icing measures should be taken for protection of the transmission lines based on the local specific situation, ice region grade and operation experience.

(2) At the time of the anti-icing, the galloping of icing lines and wind oscillation accidents should be taken into account comprehensively.

(3) For the heavy ice region, the mechanical strength of the tower material should be reinforced, the key is to earth-line stents; at some partial segments that icing is very serious, lines for the anti-icing should be used.

(4) For medium and heavy ice region, changing the structure and form of the line insulator strings is an effective measure for the anti-icing and preventing ice flashover.

(5) For the guide and earth lines at the tuyere section of lines in medium ice region, installing anti-icing/snowing ring and anti-icing hockey is appropriate.

(6) Research on the hydrophobic material for the anti-icing and application for implement craftwork.

(7) Preventing ice flashover should prevent the large number of umbrella skirts from being bridged by icing, improving the insulator string umbellate structure and decoration means, increasing insulator string length appropriately and other means can improve the ability of preventing ice flashover. The main measures are: using V type or inverted V type insulator string, test and operation experience shows that icing and melt-icing flash-over voltage of V type insulator strings are both above 20%higher than vertical insulator strings; using approach called "7+1 flower arrangement", that is, arranging fewer large-diameter insulator in porcelain or glass insulator string, the differential between large and small diameter should be above 100mm, to make the insulator string difficult to form bridge at the process of covering ice, which can partly improve the ability of preventing ice flashover.

(8) Adopt composite insulator of optimized umbellate structure. The composite insulator can defer freezing time because of the particularity of its surface's material; the optimization of umbellate structure can reduce the bridge of icing and improve ability of preventing ice flashover and greatly improve ability for preventing pollution flashover.

3. CONCLUSION

The technical principle for the anti-icing of suiting measures to local conditions was put forward based on the experience of anti-icing work which accumulated in China in the past years, combined with the most advanced research results and technology for the anti-icing in both China and the world, The feasibility of each technical measure for the anti-icing based on different conditions and environments was analyzed and reference for formulating appropriate technical measures for the anti-icing was provide.

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Keywords: transmission line; anti-icing; measures; 5-word policy

I. THE TECHNICAL PRINCIPLE FOR THE ANTI-ICING

The technique for the anti-icing should base on the principle of suiting measures to local conditions, and therefore we should track the damage situation of network facilities caused by ice, snow and freezing disaster at different regions comprehensively and analyze the icing standards of line design and count the actual icing data of icy and snowy weather over past years, then analyze the ice disaster characteristics, and take prevention measures in advance and take care of the important lines according to the laws of ice and snow disaster.

The 5-word policy of "avoiding, anti-icing, de-icing, modification, prevention" was summed up after years of our country's anti-icing work [1]. In other countries, such as Japan, Europe and other countries, there are similar guidelines. The main idea of "avoiding, anti-icing, modification, prevention" is to take effective technological measures to make sure that the transmission line is not covered with ice, or even if covered, the total icing load can be controlled at the range of affordable limit of the transmission line.

1) "avoiding" is to try to avoid crossing mountain pass, yakou, tuyere, lakes and so on when selecting the line path.

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II. THE DOMESTIC AND INTERNATIO- -NAL ANTI-ICING TECHNOLOGY OF TRANSMISSION LINE

2.1"Avoiding" ice technology

When selecting line path, the heavy ice region should be avoided and the lines should go along with the little-fluctuating terrain, and also should try to avoid crossing yakou, duct (the angle between line and the major direction of winter wind should be less than 45°) and passing easy icing areas such as lakes, reservoirs and so on. Large span distance and big fall should be avoided and going along with the leeward side or the side to the sun when climbing mountains is appropriate.

2.2" Anti-icing" technology

The quality of network plan and design should be raised. At the period of the plan and design of network, extensive research should be done to get a clear idea about the icing disaster status in the grid area in history, and thus to set the right standard for the anti-icing disasters. On March 1st, 2008, the state grid corporation of China announced that it would adjust enterprise standard of the network design and construction to raise the anti-icing ability for the grid in wide area. According to the relevant adjustment scheme announced by the state grid corporation of China: 35 to 330 kV power grid's fortification criteria was increased from 15 years to 30 years frequency, 500 kV power network's fortification criteria was raised from 30 years to 50 years frequency, 750 kV power grid's fortification criteria was 50 years frequency, the UHV engineering projects that were building requested that the disaster prevention standards was 100 years frequency.

2.2.1 Improve the line thickness standard for icing design in heavy ice region

According to <Technical code for designing 110-500kV overhead transmission line> (DL/T 5092-1999) (manuscript of new rules for permission was completed), the light ice region is where the icing thickness is below 15mm, the medium ice region is where the icing thickness is between 15mm and 20mm, the heavy ice region is where the icing thickness is above 20mm. In view of the statistics and analysis of network ice disaster accidents happened from 2005 to 2008, it was necessary to improve the thickness standards of icing design in heavy ice region.

2.2.2 Reinforce the line anti-icing strength in medium and heavy ice regions [2]

At Hunan, Yunnan and other areas, the reinforcement mode is adopted to prevent the transmission line tower from falling down because of icing and the effect is obvious. Specific means are: shorten the length of strain section and make it be less than 3km; strengthen stent of tower grounding wire and design the mechanical strength of the wire according to that the icing thickness is more than 5mm; reinforce tower, for the glass linear tower, mainly strengthen horizontal bear and curved arm component, and for the "gan" shape linear tower strengthen the main material of upper and lower plane surface of horizontal bear, and strengthen the septal surface and the main material of tower body that connected to the bear; use wear-resistant line clip.

2.3 " Prevention " ice technology

2.3.1 Anti-icing wire [3]

Compared with the traditional ASCR (aluminum conductor steel reinforced), the new anti-icing wire has smooth surface and the ice and snow are not easy to

accumulate on it, these can decrease the icing thickness on the wire surface. Belgium and domestic Hunan, Yunnan and other areas, Z type wire was used at the heavy ice region, because the smooth surface has lower drag coefficient, the accumulation of snow and frost is greatly reduced and ice and snow covering on the surface are prevented. Moreover, Z type wire has better damping characteristics, withstanding the vibrations caused by wind and bearing the higher current under the same diameter. It was commonly used for the very important lines in heavy ice region with short distance.

The structure of JRLX/T composite cored soft aluminum stranded wire (American ACCC wire) is that the core wire is single mandrel consisting of carbon fiber center layer and glass silk which can be used to substitute conventional steel core of ASCR, and the outer layer and neighbors of the aluminum wire are trapezoid section. The new wire developed by carbon fiber has significant characteristics of high temperature resistance, high capacity, low sag, low energy consumption, light weight, long life and so on, it is the only product that can replace the traditional ASCR, the aluminum alloy conductor, the aluminum-clad-steel wire and the invar steel wire, and have been put into commercial operation. Far east ACCC carbon fiber composite wires have already been used at 220kV lines in Shenzhen power company of southern grid corporation and Liaoning province power company of state grid corporation, respectively. And China became the second country in the world to adopt this advanced technology after United State in 2004.

According to incomplete statistics, the number of the JRLX/T overhead lines that have already been put into operation formally have reached more than 30 and the overall length is over 1200 kilometers, the products have been used to transmit power at 220kV and 110kV networks in Fujian, Jiangsu, Hubei, Liaoning, Shanghai, Tianjin and other provinces, and their performance is good. In addition, the projects of JRLX/T composite cored soft aluminum wire in Hebei, Nei Monggol, Anhui, Shandong, Shanxi, Xinjiang and many other provinces also are to be constructed.

2.3.2 Anti-icing/snowing ring [4]

Water films will appear on the surface of the line when the water-drops or fog-drops hit the wire and the latent heat released when freezing has not been sent out to the environment entirely, and the water films will form minute “rivers” on wire and flow along the wire. The anti-icing ring can prevent the “rivers” from being formed by water-drop or fog-drop and let them leave the line. The main purpose of using anti-icing ring is to make the ice covering on the lines and ground wires fall off piecewisely, thus to avoid crash accidents of lines caused by galloping of lines and ground lines because the ice covering on them fall off simultaneously. In Nanyang in Henan province, Kunming and Liupanshui, the anti-icing rings of similar principle are researched and applied and all get some good action.

2.3.3 Material of earth wires and insulators for the anti-icing

Minimize binding force between the ice and the surface of equipments and make the ice easy to fall off and put away through painting anti-icing materials on the surface of the earth wires or insulators. If there are other methods can be used, such as wind, vibration, heat sources, etc, it will get better anti-icing effect. Currently, there are three research methods:

(1) Paint electric coating material on the surface of the insulator

By adding certain conductive fillers to the formulation of the coating materials, the coating layer will form a semiconductor material which has good electric performance under the action of tiny leakage current. When the insulators painted with this kind of coating material are running on the lines, there will be leakage currents flowing through the coating layer on the surface of insulators, the joule heat, heat of field effect and the insulator intrinsic dielectric loss that generated by the coating leakage current will heat up the surface of the insulator, and thus can prevent ice freezing on the surface of insulators effectively in cold environment.

(2) Paint solar-thermal coating material on the surface of the conductor-grounding wire and the insulator[5]

Solar-thermal coating material is to use the coating layer that can absorb sunlight energy to achieve anti-icing. The ideal coating layer besides should have excellent optical selective, it should satisfy long-term stability of optical performance, weatherproof, low price and free from pollution to the environment and other conditions. The selective absorption rate of different spectrums of this coating material can be improved through the strict control of diffuse reflection.

(3) Paint hydrophobic coating material on the surface of the conductor-grounding wire and the insulator

The anti-icing action of hydrophobic coating material is to reduce the adhesive force between the ice and guide(or ground) lines or insulators through painting hydrophobic coating material on transmission guide(ground) line or insulator surface, although it cannot completely prevent ice forming and adhering, it can make the freezing rain or snow slide under the action of the nature force such as wind or the force generated by the swing of the wires and insulators before the ice freeze or bond to guide(ground) line or insulator surface, or it can implement anti-icing through obviously decreasing the adhesion between the ice or snow and the wire or insulator.

2.3.4 Change the structure of line insulator string to prevent ice flashover [6]

According to the statistics of the ice disaster, the ice flashover basically occurs on trailer strings other than strain strings, V-shape strings and inverted V-shape strings, which shows that the odds of the ice flashover are closely related to the assembly type of insulator strings. There are several reasons. First, it is not easy for strain strings, V tape strings and inverted V strings to bridge the gap between the umbrellas; Second, those types of strings have good effect of self-cleaning and dirt retention on the strings are not so much; Third, the water film which is crucial to the ice flashover is difficult to form on those types of strings when the ice are melting.

In the line insulator in medium and heavy ice region, flower string arrangement of large and small diameter spaced at regular intervals can be adopted, and for the duplex strings, the string spacing should be enlarged and the effective will be better.

III. MEASURES AND APPLICATION

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prevention, modification" principle, comprehensive anti-icing measures should be taken for protection of the transmission lines based on the local specific situation, ice region grade and operation experience.

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