APPLICATION OF PSL□-12/4 LIGHTNING PROTECTED SUPPORTING INSULATOR IN DISTRIBUTION LINE

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ABSTRACT
Insulated conductor has many advantages and the insulated rate of 10KV overhead distribution lines at present is considerably high; however, insulated conductor will surely break when stricken by lightning. The defect that relay protection may not act after the conductor is broken will bring an even greater hidden danger to the circuit. This paper describes the operation situation of lightning protected supporting insulator to prove that the lightning protection function of lightning protected insulator on circuit is effective and remarkable via analyzing typical cases of lightning accident. Installing grounding device on lightning protected insulator is not only favorable to release lightning current but is able to play a function of lightning protection as well. Suggestions on improvement of the lightning protected insulator in future popularization and application of lightning protected insulator are proposed in this paper.

KEY WORDS
insulated conductor; lightning protected supporting insulator; lightning current; lightning

1 BACKGROUND OF LIGHTNING PROTECTED INSULATOR APPLICATION
In order to reduce failures in overhead distribution line caused by external factors such as tree, bird and accumulated snow, etc. and improve reliability of power supply, developed countries began to adopt overhead insulated conductor during late 60s last century. Insulated overhead distribution line has been basically achieved in Japan. China began to implement pilot urban overhead distribution network insulation improvement during the 80s last century and the steps of the improvement were sped up in municipals such as Shanghai and Beijing in the 90s. The insulated rate of the 10KV overhead distribution lines in suburbs is considerably high and insulation of 10KV overhead distribution line has already become a developing tendency. Insulated conductor has really solved the problems of gallery and safety that bare conductor is unable to solve and compared with cable, the advantages of insulated conductor such as saved investment and quick construction are remarkable. However, compared with bare conductor, the lightning withstand property of insulated conductor is remarkably different. When the over-voltage of direct lightning or inductive lightning functions being on bare conductor and cause insulator flashover, the follow-up industrial frequency short circuit current arc shifts along the conductor against the direction of power supply so the conductor will not be seriously burnt. However, it is different in insulated conductor. The over-voltage of lightning first breaks the insulating layer of the conductor and then causes flashover of insulator. The broken insulating layer will be in a pin-socket state and the follow-up industrial frequency short circuit current arc is stopped by the surrounding insulating material so the arc root can only burn at the pin-socket; therefore, the conductor will be completely burnt broken within an extremely short period of time. Japan conducted researches during early days of the 70s last century and concluded that when stricken by lightning, insulated conductor would surely break and after the conductor broke, the relay protection might not act and the hidden danger thus caused would be extremely great. As the consumptions of insulated conductor increase continuously, conductor break failure caused by lightning has occurred many times within our company in recent years and the safety of pedestrians and distribution network are seriously threatened. The problem of broken line caused by lightning not only affects the safe operation of the network but seriously hinders the popularization of 10KV overhead line insulation; therefore, the problem must be appropriately solved so as to ensure the popularization of insulated overhead distribution line and the safe operation of overhead insulated distribution network.

2 PURPOSE OF PSL□—12/4 LIGHTNING PROTECTED SUPPORTING INSULATOR APPLICATION
Relevant departments of our company conducted comparison, analysis and research of various lightning protection measures for insulated conductor at present in
China and finally selected PSL □-12/4 lightning protected supporting insulator (hereinafter briefly called lightning protected insulator – please see fig. 1) Co-developed by Shanghai Electric Power Corporation and Shanghai Electro-technical Porcelain Factory as the lightning protection measure against line breaking for Minghang Power supply Branch based on above described situation.

The structure of the product is simple, reliable and suitable to the demand of fully insulated overhead conduct. The erection mode and dimension are the same as that of original PS-15 supporting insulator. The product possesses dual functions of lightning protection and supporting and the price is low. Please see Table 1, Table 2 and table 3 respectively for technical parameters.

3 RESULT OF APPLICATION

Our branch began to popularize and adopt the two kinds of lightning protected insulators in large scale on 73 10KV insulated lines in 2005 on the basis of test operation of the product in 2004 combined with line maintenance, liberation and technical improvement and insulation construction. Totally 552 sets of such insulators were installed in 2005 and 296 sets were installed during the first half of 2006.

In view of the operation situation of the 848 sets of lightning protected insulators installed on totally 73 10KV lines of Minghang branch, the result is very good and the lightning protected insulators have all played their protection function that they should play. After the insulated lines protected by lightning protected insulators are stricken by lightning, no line breaking accident occurs and only lightning protected insulators are damaged. No damaged conductor is discovered so the lightning protected insulators have well played the function of protecting conductor and releasing lightning current.

4 ANALYSIS ON TYPICAL LIGHTNING EVENTS

Large area lightning events occurred on August 13 and August 16 and many lines of the South Urban Power Supply Company were stricken by lightning as well as many lines of Minghang Branch. The situation of the lightning currents of the two days is as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Hours of lightning</th>
<th>Lines stroked by lightning</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006.8.13</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2006.8.16</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

For example, pro-acceleration action occurred at 13: 52 on B-16 XYDH line on August 13, 2006, the switch tripped and the re-switching-on was successful. The phase A lightning protected supporting insulator of pole No. 94 was broken down by the lightning and there was an obvious discharge trace on the insulator. The phase C lightning protected supporting insulator of pole No. 96 was seriously damaged by the lightning, which made a hole in the pole. The lightning protected supporting insulators of pole No. 94 were provided with a grounding device but pole No. 96 was not. (Please see Fig. 2 – Fig. 6)
Another example, pro-acceleration action occurred on J-13 LYJM north line in case of thunderstorm on August 16, 2006 and the switch tripped and the re-switching-on was successful. It was discovered in tour inspection that #22-1 was stricken by lightning (please see fig. 7 – fig. 8) and the 3-phase lightning protected supporting insulator was stricken by lightning and black trace could be clearly seen. There was no other failure in other lines. We have discovered though that trip accident caused by lightning that line break failure would be caused as lightning current is unable to be released after the line is stricken by lightning while lightning protected supporting insulator is able to effectively play the function of current release, current lead-out and conductor protection. As #22-1 of J-13 line is equipped with a grounding device, the lightning current is able to be well released and the discharge though pole tower is avoided. This lightning failure once again indicates that lightning protected supporting insulator is very useful in terms of prevent conductor from being broken by lightning.

Insulator stricken by lightning

The conductor is not damaged at all after being stricken by lightning

The lightning protected supporting insulator of pole No. 96 was seriously damaged by lightning. Without protection of grounding device, the insulator was seriously damaged.

Pole 96 was broken down as not grounded

There is a lightning trace on the lightning protected supporting insulator of pole N. 94. With protection of grounding device, the insulator was slightly damaged, comparatively speaking.
We can see the situation of Y-20 ZYZX line for a contrary example. Pro-acceleration action occurred at 13:14 on Y-20 ZYZX line in case of thunderstorm on August 13, 2006 and the switch tripped and the re-switching-on was successful. It was discovered in tour inspection that the trip of the line was caused by lightning as there was a thunderstorm at that time. The connection of pole #56 of Y-20 ZYZX line was stricken by lightning, phase A and phase B broke and there was no obvious failure in other lines. As Y-20 ZYZX line had been put into operation earlier when there was no lightning protected supporting insulator at that time and after lightning protected supporting insulator came into being, restricted by objective conditions, the line has not had an opportunity of power-off; therefore, no lightning protected supporting insulator has been installed on that line. Compared with B-16 XYDH line and J-13 LYJM north line, after the insulated conductor was stricken by lightning, as Y-20 line was not installed with lightning protected supporting insulator, the lightning current was unable to release after the line was stricken by lightning and the line break failure was caused while lightning protected supporting insulator is able to effectively play the function of current release, current lead-out and conductor protection. It can be seen that lightning protected supporting insulator is feasible and effective in terms of lightning protection of line and the effect in terms of preventing conductor from being broken by lightning is remarkable.

5 ANALYSIS OF APPLICATION AND THE SUGGESTIONS

According to the analysis on the application of lightning protected supporting insulator up till now, we emphasize following several points:

1) Lightning protected insulator has passed the test in line operation and lightning accident, the function of lightning protected insulator is remarkable and no line break failure caused by lightning has occurred on the lines equipped with lightning protected insulator; on the contrary, line break failure has occurred after the insulated conductor not equipped with lightning protected insulator is stricken by lightning.

2) The grounding device adopted for lightning protected insulator is favorable to releasing lightning current as the lightning protected insulator equipped with grounding device is comparatively less damaged after being stricken by lightning, it is able to continue the operation after lightning and wait for opportunity of power-off for being replaced. All the lightning protected insulators in countryside must be installed with grounding device to reduce the damage of cross arm and pole caused by lightning. When allowable in terms of condition, it should be ensured that grounding device should be installed every 150m for lightning protected insulators in urban areas.

3) The management and technical training of contracted construction teams should be enhanced. When installing lightning protected insulator, it must be strictly required to use special tool to peel off the insulation layer of the insulated conductor and erection should be conducted strictly according to the requirements of lightning protected insulator construction standard. It should be ensured that the core of the conductor is not damaged and the mechanical strength of the conductor and the lightning protected insulator will really play the function of protection. When installing lightning protected insulator on JKLYJ-120 conductor and JKLYJ-70 conductor, two layers of aluminum wrapping tape should be applied.

4) When it is normal in withstand voltage test after the insulator is damaged by lightning, normal operation can be conducted (Test report is attached)

5) The extent of grasping relevant properties of lightning protected insulator should be continuously improved and insulation as well as lightning protected insulator should be further popularized via data analysis and experience accumulation in future operation. All insulated conductors should be installed with lightning protected supporting insulator in future and the operation of lightning protection and measures should be accelerated.

6) The research and development of lightning protected supporting insulators for angle poles and sectional poles should be accelerated.

BIOGRAPHY

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The conductor was inspected after the aluminum wrapping tape was dismounted and the conductor was not damaged.

Fig. 8