

## A Backup Protection Clamp for Changing Multi-string Strain Insulators under Live Working Condition

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### Abstract

With the development of modern electric power system, live-working is the most efficient way to reduce the repair time when there is a power failure and improve the reliability of power supply. Sometimes, there is no backup protection clamp existed when replacing the transmission line strain insulators. On the basis of the clamp insulating hook unit, the circle slipping track unit, the clamp pull rod unit, the spring lever unit and the spring ring unit, a novel backup protecting clamp is reported in this paper, which could be applied for changing multi-string strain insulators under live working condition. Maintenance workers are not necessary to enter the strong electric field for changing multi-string strain insulators during the operation process. Moreover, it is beneficial to reducing the the line outage operation time and improving the operation reliability of the power grid.

### Keywords

Backup Protection, Clamp, Multi-String Strain Insulators, Live Working Condition.

### 1. Introduction

With the sustainable development of national economy, the size of power grid continues to expand. State Grid and Southern Power Grid Corp have also developed development ultra-high voltage transmission strategy to optimize the distribution of state power resource [1-2]. However, the ultra, extra-high voltage transmission line, strain insulators and their accessories face the threat of high altitude, pollution and other severe complex environment [3-4]. Presently, most of the 110 kV and above voltage level transmission line strain towers are multi-string strain insulators type [5-6]. Sometimes these insulators are needed to be maintained and replaced when they are polluted or damaged (Fig. 1).



Fig. 1 The photograph of a transmission line in Chongqing area

In order to further meet the requirement of power supply reliability of backbone network, live line operation is the most important way in the current transmission line maintenance work in the ultra high voltage transmission line. At present, most of the domestic live line replacement of transmission line insulators has no backup protection [7-8]. Due to equipment or personnel operation and other reasons, it will lead to wire loss, wire slippage and other security risks, causing great security risk to the power grid. Thus, it is an urgent problem to be solved in the work of the high voltage transmission

line and a novel backup protecting clamp is reported in this paper. It has an important academic significance and engineering application value in guaranteeing the safety, economic, reliable and stable operation of the whole power system.

## 2. The design of the backup protection clamp

When we use the traditional power cut way to replace the transmission line multi-string strain insulators, there is no voltage on the high-voltage transmission line [7-8]. Operators can climb up the tower directly and put a the backup protection on the transmission line to avoid the slippage or loss of the transmission line during the replacement process.

With the development of modern electric power industry, live working mode is the most important and common way used in the maintenance of power transmission line. At present, most of the domestic live line replacement of transmission line insulators is based on frame auxiliary replacement method and has no backup protection. Operator are forced to enter into the high electric field with the assistance and protection of the insulating ladders. Then, these works are located in high electric field and equal to the high voltage of transmission line. If the operators do not enter into the strong electric field, the backup protection can not be completed. During the maintenance process, wire loss, wire slippage or other security risks would possibly occur due to equipment or personnel operation and other reasons. And it may cause great security risk to the power grid in turn and bring serious threat to the workers. Thus, it is an urgent problem to be solved in the work of the high voltage transmission line and a novel backup protecting clamp is reported in this paper (Fig. 2).

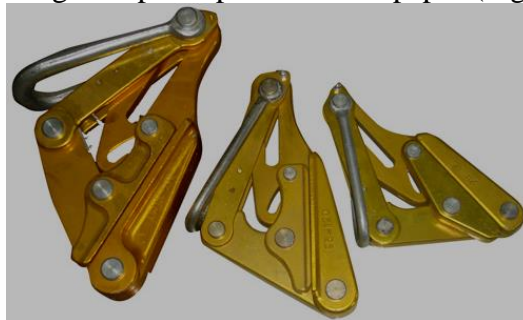


Fig. 2 The picture of a power cut operation clamp

Traditional backup protection clamp for power cut operation is mainly made up of the clamp main board, the clamp connection board, the clamp pull arm, the upper vice jam, the under vice jam, the pull rod and hinge pins. On the basis of the a traditional clamp for power cut operation, a hook unit, a spring baffle rod and a spring pull unit are added and designed to develop a novel backup protecting clamp is reported in this paper, which could be applied for changing multi-string strain insulators under live working condition. The structure of the novel backup protecting clamp is demonstrated in Fig. 3.

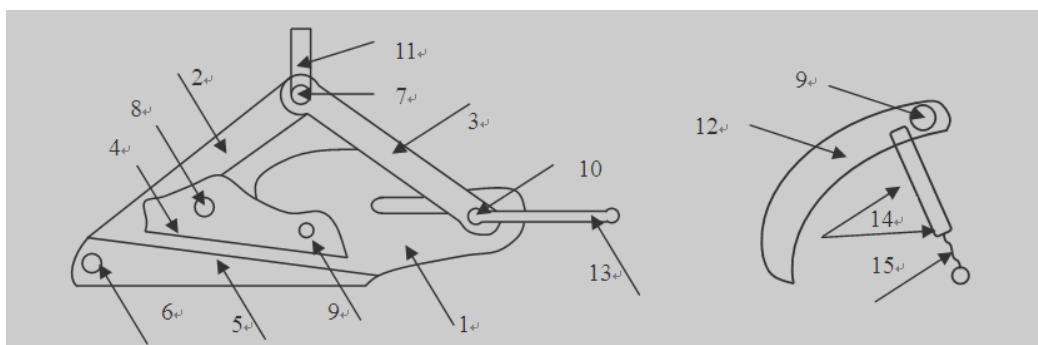


Fig. 3 The structure of live line replacement backup protection clamp

As shown in Fig. 3, The improved backup protection clamp mainly include the clamp main board 1, the clamp connection board 2, the clamp pull arm 3, the upper vice jam 4, the under vice jam 5, the hinge pins 6-10, the clamp insulating hook 11, the circle slipping track 12, the clamp pull rod 13, the spring lever 14, the spring ring 15. The under vice jam 5 is located in the lower part of the clamp main

board 1, and the clamp main board 1, the clamp connection board 2 and the under vice jam 5 are hinged together by hinge pin 6. The clamp connection board 2 is hinged with the clamp pull arm 3 by hinge pin 7, where the clamp insulating hook 11 is set. The position of upper vice jam 4 and the sit of the under vice jam 5 correspond to each other, which is applied to locate the high voltage transmission line for backup protection. The left side of the upper vice jam is hinged with the clamp connection board 2 by hinge pin 8. The right side of the upper vice jam is hinged with the circle slipping track 12 by hinge pin 9. The spring ring 15 is arranged below the spring lever, which is used for connecting insulating pull ropes.

### 3. Performance tests of the backup protection clamp

In this manuscript, performance test of the backup protection clamp was conducted based on the laboratory test platform. It contains two parts, grip test of the backup protection clamp before and after wire tightening.

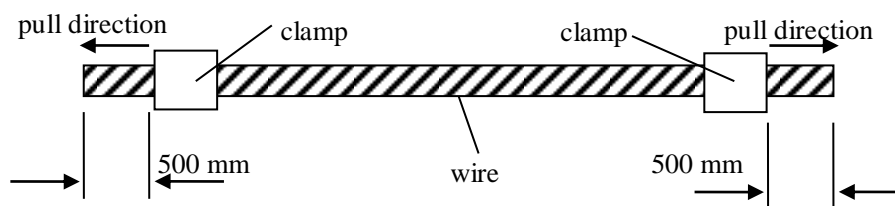


Fig. 4 The block diagram of the structure of the grip test of the backup protection clamp

The block diagram of the structure of the grip test of the the backup protection clamp is carried out as shown in Fig. 4. Firstly, the traction force is slowly increased to 60 kN in 6 minutes, and maintains for another 10 minutes. During the test, the backup protection clamp is closely bitten to the transmission line with no wire loosening, slipping and breaking (Table 1).

Table 1 the grip test of the clamp after wire tightening

	pull force / kN	hold time / min	wire slip / mm
1	20	10	non
2	30	10	non
3	40	10	non
4	50	10	non
5	60	10	non

Firstly, the transmission line is pre tightened until no sound could be heard in the pre tight area. And then, grip test of the backup protection clamp after wire tightening is conducted. The traction force is set to 20,30,40,50,60 kN, respectively during the experiment test. No wire slip, loss or break is measured. All results show that the improved backup protection clamp is beneficial to improve the operation reliability of the power grid.

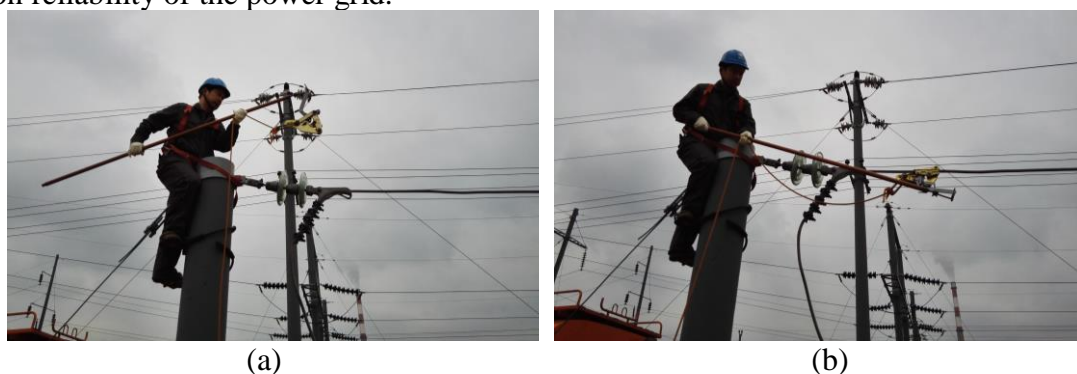


Fig. 5 The block diagram of the structure of the grip test of the backup protection clamp

Based on the fabricated backup protection clamp, a on site experiment is further conducted in one certain transmission line in Chongqing area. Fig. 5 (a) and (b) are the practical operating figures .

The successful fabrication of the backup protection clamp makes changing multi-string strain insulators under live working condition into reality. During the maintenance process, the operator could complete the replacement of transmission line multi-string strain insulators without entering into the strong electric field.

#### 4. Conclusion

On the basis of the clamp insulating hook unit, the circle slipping track unit, the clamp pull rod unit, the spring lever unit and the spring ring unit, a novel backup protecting clamp is reported in this paper. It makes the replacement of multi-string strain insulators under live working condition reality. During the maintenance, workers are not forced to the strong electric field. It is beneficial to reducing the the line outage operation time and improving the operation reliability of the power grid. Meanwhile, the backup protecting clamp is easy to carry and use simply, which can be extended to different voltage grade transmission lines, various types of insulators with different length.

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