Post-print of Research on Insulating Device for Securing Bypass Jumpers and Jumpers in Live-line Work on 10kV Distribution Lines

Authors: Wang Zhigang; Li Wen, Li You

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Abstract

In live-line maintenance of 10kV distribution lines, operators installing or removing bypass jumpers and disconnecting or connecting jumpers face safety risks due to the lack of suitable fixing positions on poles and equipment, which allows conductors to swing and cause short circuits or grounding faults. This paper first presents a detailed analysis and discussion of existing methods' deficiencies, then designs and develops a targeted insulated fixing device primarily composed of a telescopic insulated base, insulated support rod, and fixing mechanism. Field test verification demonstrates that the device offers strong versatility, convenient operation, and high safety/reliability. It effectively solves the problem of lacking fixing positions for bypass jumpers and jumpers during 10kV live replacement of pole-mounted equipment or jumper disconnection/connection operations, substantially improving work efficiency and operational safety. Additionally, it reduces customer outage time, enhances power supply reliability, provides robust technical support for safe grid operation and power supply continuity, and holds significant value for widespread promotion and application.

Full Text

Study of Insulation Device for Fixed Drainage Line and Jumper in Live Working of 10kV Distribution Lines

Wang Zhigang[1],[2], Li Wen[1],[2], Li You[3]
[1]. Live Working Center, State Grid Hunan Electric Power Company, Changsha 410007, China
[2]. Hunan Province Key Laboratory of Intelligent Live Working Technology and Equipment (Robot), Changsha 410007, China
[3]. State Grid Hunan Electric Power Company, Changsha 410007, China

Abstract

In live maintenance of 10kV distribution lines without power interruption, workers installing or removing drainage lines and disconnecting or connecting jumpers face safety hazards due to the lack of suitable fixation points on towers and equipment, which can lead to conductor swing causing short circuits or ground faults. This paper first analyzes in detail the shortcomings of existing methods and subsequently designs and develops an innovative insulation fixation device. The device primarily consists of a telescopic insulated base, insulated support rods, and fixation components. Field test validation demonstrates that this device offers strong versatility, convenient operation, and high reliability. It effectively solves the problem of lacking fixation points for drainage lines and jumpers during loaded replacement of pole-mounted equipment or jumper connection/disconnection operations in 10kV live working. The device significantly improves work efficiency and safety while reducing customer outage duration and enhancing power supply reliability, thereby providing robust technical support for safe grid operation and continuous power supply. The device holds high value for widespread promotion and application.

Keywords: Distribution lines; Live working; Drainage line; Jumper

1. Introduction

Currently, when performing loaded replacement of pole-mounted equipment or jumper connection/disconnection operations in China' s power industry, drainage lines and jumpers are typically fixed using insulation shielding tools. This involves applying insulation shielding to towers or crossarms and other grounded components, then placing conductors on the shielded structures or forcibly bending disconnected live jumpers and tying them back to the main line [1-6]. These approaches require extensive shielding equipment, offer low safety margins, increase labor intensity, and may cause equipment damage through forced bending. To address these issues, this paper develops an insulation fixation device that simultaneously secures same-phase drainage lines and disconnected jumpers. This solution not only meets safety regulation requirements [7] but also resolves practical operational difficulties while improving safety factors and work efficiency.

2. Comparison of Conventional Drainage Line and Jumper Fixation Methods

Currently, live workers installing or removing drainage lines and disconnecting or connecting jumpers must rely on insulation shielding tools for towers and crossarms due to the lack of dedicated fixation points on existing equipment. After shielding, conductors are placed on insulated components or forcibly bent and tied back to the main line [8-13], as shown in [Figure 1: see original paper]. This conventional approach presents several problems and safety hazards:

(1) **Extensive shielding equipment required.** Numerous locations must be insulated to ensure operational safety.

(2) **Low safety margins and equipment damage risk.** The process requires frequent installation and removal of insulation shielding tools, increasing operation frequency and the likelihood of workers simultaneously contacting objects at different potentials, which can cause accidents. Additionally, shielding tools only provide auxiliary insulation and are easily punctured or worn by sharp metal components, compromising insulation performance [14]. Furthermore, disconnected live jumpers can only be fixed through forced bending and tying, which may cause mechanical damage, strand separation, or breakage, creating hidden hazards. Alternatively, wrapping disconnected jumpers in insulation and suspending them provides neither effective swing control nor adequate workspace clearance.

(3) **High labor intensity.** The irregular surfaces within shielded areas make conventional insulation shielding difficult and complex.

Summarizing these deficiencies in existing live working methods and incorporating practical operational experience, this paper developed an insulation fixation device for drainage lines and jumpers in 10kV distribution line live working. The device solves the safety issues caused by the lack of ideal fixation points for drainage lines or jumpers during loaded replacement of equipment or no-load jumper operations on double-crossarm poles, reducing risks of single-phase grounding or interphase short circuits while decreasing worker labor intensity. A comparison of advantages and disadvantages between conventional methods and the new fixation device is presented in .

3. Composition and Technical Characteristics of the Drainage Line and Jumper Insulation Fixation Device

The drainage line and jumper insulation fixation device is simple to operate, reliable, and adaptable to various double-crossarm pole dimensions.

3.1 Device Composition As shown in [Figure 2: see original paper], the device primarily comprises a telescopic insulated base, insulated support rods, and fixation components. The telescopic insulated base utilizes springs installed within insulation plates to secure itself through spring tension. The support rod length effectively ensures safe clearance and adequate insulation distance. The fixation mechanism is flexible, reliable, and accommodates various conductor and drainage line specifications, as shown in [Figure 3: see original paper].

3.2 Material Selection and Technical Specifications For material selection, insulated components such as the base and support rods are manufactured from epoxy resin to meet insulation performance requirements. The fixation components use aluminum alloy to ensure sufficient mechanical strength while maintaining light weight. Key technical specifications are listed in .

3.3 Technical Features

(1) **Strong versatility.** The telescopic insulated base employs springs within insulation plates to accommodate various double-crossarm pole dimensions.

(2) **Convenient operation.** During loaded replacement of pole-mounted equipment or jumper operations, the telescopic insulated base is fixed on the double crossarm, and drainage lines and loaded jumpers are secured to the insulated support in one step without auxiliary tools. This simplifies operation, saves significant shielding equipment and working time, enabling safe and reliable completion of operations. Weighing only 6 kg, the device can be installed by a single worker.

(3) **High reliability.** By fixing drainage lines and jumpers on insulated supports during 10kV loaded equipment replacement or jumper operations, the device prevents single-phase grounding and interphase short circuits, reduces labor intensity, decreases operation frequency, ensures worker safety, improves efficiency, and reduces outage duration.

4. Field Operation Experiments

4.1 Experimental Procedure To verify the device' s field performance, installation and usage tests were conducted at a distribution network simulation site, as shown in [Figure 4: see original paper]. The procedure for fixing drainage lines and disconnecting loaded jumpers during single-phase disconnector replacement is as follows: Apply insulation shielding to live parts; Install the drainage line and jumper insulation fixation device; Secure drainage lines and loaded jumpers to the insulated support; Replace the single-phase disconnector; Connect the disconnector leads; Remove bypass jumpers, the fixation device, and shielding tools.

4.2 Experimental Results Field installation of the device demonstrated that during disconnector replacement, drainage lines and disconnected jumpers can be reliably secured on the insulated support. This prevents shielding tools from being punctured by sharp metal components, eliminates the need for forced bending and tying that damages conductors, and avoids suspended fixation of insulated jumpers, effectively controlling jumper swing.

5. Application Scope and Safety Precautions

5.1 Application Scope The device is applicable for loaded replacement of equipment and no-load jumper connection/disconnection operations on double-crossarm poles in 10kV distribution lines, serving to fix drainage lines and jumpers.

5.2 Safety Precautions

(1) The device must undergo regular electrical and mechanical testing.

(2) It should be stored according to live working tool requirements and inspected before field use.

(3) Ensure secure installation; workers should avoid excessive movement during installation.

6. Practical Effectiveness Analysis

Based on the device' s working principle and application scope, effectiveness is analyzed as follows:

(1) **Practicality.** Conventional methods for fixing drainage lines and jumpers during equipment replacement or jumper operations involve complex procedures, long durations, and low efficiency. The developed device provides reliable fixation with convenient operation, strong practicality, reduced working time, and significantly decreased labor intensity.

(2) **Safety.** The device secures drainage lines and disconnected jumpers on insulated supports, preventing shielding tools from being punctured by sharp metal components. It eliminates forced bending and tying that causes mechanical damage, strand separation, or breakage, and avoids suspended fixation of insulated jumpers, effectively controlling swing.

7. Conclusion

The 10kV drainage line and jumper insulation fixation device developed in this paper effectively solves the problem of lacking fixation points for drainage lines and jumpers during loaded replacement of pole-mounted equipment or jumper operations in 10kV live working. The device significantly improves work efficiency and safety, reduces customer outage duration, enhances power supply reliability, minimizes energy losses, and ensures safe grid operation and continuous power supply, demonstrating high promotional and application value.

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Note: Figure translations are in progress. See original paper for figures.