A Solution for Indoor Distribution of Overhead Low-voltage Lines in Distribution Network

Qian Yong\textsuperscript{a}, Zhang Bin-Bin\textsuperscript{b}, Shen A-Mei\textsuperscript{c}, Wang Xiao-Bing\textsuperscript{d}, Ma Zhong-Wen\textsuperscript{e}

\textsuperscript{1}Tieling Power Supply Company, Liao Ning, China.
\textsuperscript{2}Tieling Power Supply Company, Liao Ning, China.
\textsuperscript{3}Yingkou Power Supply Company, Liao Ning, China.
\textsuperscript{4}Shenyang Oil Companies, Liao Ning, China.
\textsuperscript{5}Tieling Power Supply Company, Liao Ning, China.

\textsuperscript{a}E-mail: 347627260@qq.com \textsuperscript{b}E-mail: 67471229@qq.com \textsuperscript{c}E-mail: 119635169@qq.com \textsuperscript{d}E-mail: 457297739@qq.com \textsuperscript{e}E-mail: 458743149@qq.com

Abstract: The terminal of transformer station in power system is generally related to the household installation of residents. Because of the lack of the security requirements for the original installation mode, this paper presents a new design, and makes a detailed analysis of the new household device. After testing, the new device fully meets the requirements of safety and maintenance for the household distribution of overhead low voltage lines of distribution network. It can be completely applied in the household distribution of low-voltage overhead line terminal.

1. Reason for choosing the topic

At present, within the scope of the State Grid Corporation of China, household meter installation is implemented, specifically requiring residents in rural power grid areas to install every meter on the front wall of residential buildings (especially the use of electricity by low-voltage residents). The original centralized installation method needs to draw down the power supply from the main line conductor of T-connected pole to the lower end centralized meter box, and then return the wires behind meter in the meter box to pole head, and lead into each household in the overhead installation mode of parallel drawing plate and porcelain bottle (generally, the overhead household line distance falls between 10 and 30m). The household lines are easy to aging and damage in the overhead operation process due to the years of weathering and the dancing in windy weather. When the failure occurs, the worker will open the household switch in the meter box before overhaul, disconnect the wiring of the meter and form a break-off point, and carry on the next line maintenance.

Now, it is connected to meter box directly after leading out from the conductor and fixing on the wall in the overhead installation mode of parallel drawing plate and porcelain bottle. The original switch is fixed on the user's wall, and there is no apparent break-off point in this part of the overhead line. The maintenance and overhaul of the household overhead line require the maintenance workers to power down at the secondary knife switch of power distribution station. The maintenance of one household causes the large-area power outage of thousands of residents and businesses.

The low-voltage power area belongs to the comprehensive load of ordinary residents, commercial
stores, manual workshops, clinics and other loads, and the power failure of the low-voltage power grid relates to many interests.

This problem cannot be solved fundamentally, which directly affects the reliability and maintenance safety of power supply enterprises. How to not only meet the requirements of the superior level for installing meter to household, but also ensure the convenient implementation of maintenance, improve the reliability of power supply has become problems in front of the technicians.

2. Goal setting:
To design a scheme that can solve the problem of obvious break-off point in maintaining low-voltage lines, which can ensure the workers' operation safety. It can also ensure that every household's meter on the wall meets the technical requirements of the superior level. The design of the scheme must be scientific and reasonable, safe and reliable, simple and easy to implement.

3. Selection of scheme
At the beginning of May 2017, QC Group set a design objective to resolve the maintenance of low-voltage lines with an obvious break-off point. On the basis of the actual situation in the field and the working experience of the distribution network, the team members have initially established an isolation device to be installed that can not only meet the requirements of the sub-line but also form an obvious break-off point. Three technical solutions have been presupposed for this purpose:

The first solution is to install a small switch mechanism operating box on the down-lead pole, which installs the knife switch and wiring clamp inside, so as to realize the requirement of obvious break-off point in the maintenance of the faulty lines;

The second solution is to install a small switch mechanism operating box on the down-lead pole, which installs the knife switch with fuse piece inside to realize the requirement of obvious break-off point;

The third solution is to install a small switch mechanism operating box on the down-lead pole, which installs the master switch and household connection clamp inside. The zero and fire lines are wired respectively;

The first device installs a small switch mechanism operating box on the down-lead pole and installs the knife switch and wiring clamp inside. Although the requirement of effective isolation can be met, the operation of the installation of knife switch is not safe and reliable without the switch operation, and do not have the protection function such as load overload, the safety is slightly poor. Therefore, the solution is abandoned. The second device installs a small switch mechanism operating box on the down-lead pole and installs the knife switch with fuse piece inside that plays the protection effect. However, compared with the switch, the protection sensitivity is poor. Therefore, the solution is abandoned. The group members collectively determined to adopt the third solution that installs a small switch mechanism operating box on the down-lead pole, installs the master switch and household connection clamp inside and wires zero and fire lines respectively.

The basic principle of the scheme is:
To design a switch mechanism box between the lead-out position of conductor and the parallel plate riser is convenient to dismantle or replace low-voltage overhead lines and to power off nearby. The mechanism box should have the waterproof function and equip the switch, branch clamp, concentrated clamp, waterproof casing inside. The outside of box has supporting insulating porcelain bottle. After installation, lead any phase conductor to the switch upper terminal of the box body via the waterproof casing. After leading out the switch lower terminal, connect the fire line to the left lead-in point of fire line branch clamp and connect the zero line to the left of zero line concentrated clamp, bind the lines in the front of meter to supporting insulating porcelain bottle. After binding and fixing, lead the conductor fire line to multiple line holes on the right of branch clamp (the left and right sides of aluminum branch clamp are fixed with in screw tightening type). Connect the zero wire directly to the concentrated clamp. In this way, it is only necessary to disconnect the low-voltage branch box switch when the overhead line in the household fails to be repaired (set up a master switch rather than branch switch considering the economy and reliability) and form an obvious break-off point by disconnecting the fire line and zero line of concentrated clamp on low-voltage branch device and carry out necessary repair operations. The specific design structure refers to Figure 1, the overall connection mode of device refers to Figure 2.
Figure 2. Brief diagram of overall connection mode of the indoor distribution box for low-voltage transmission lines

During the trial-production stage, QC group and the technical personnel of the distribution operation and maintenance have repeatedly researched and changed the design drawings and the scheme, and the requirements of the line material and the connecting device and the materials have been modified. The electric conductivity of the device was greatly improved by setting the wire clamp as aluminum wire clamp. In order to prevent the box from getting wet by water, the inclined design was designed in the waterproof casing. The device has been tested many times after the prototype was designed. During the test, the device shows the characteristics of simple design, durability, material saving, practicality and easiness to operate. After the maintenance personnel unpack the box, a screwdriver is needed to successfully remove and replace a faulty household line. And the safety risk of the enterprise maintenance personnel was greatly reduced at a safety angle, and the power supply reliability of the user was improved.

4. Countermeasure development and implementation

After the scheme was determined, the group developed a countermeasure implementation plan and repeatedly modified the scheme and technical details. It took 4 months to develop the household box for low-voltage lines of rural power network and pass the joint test and acceptance of the production technology department and safety supervision department of the company. In September 2017, the device was applied in the basic distribution network in good condition, and the maintenance staff generally reflected that the design was reasonable and simple and easy to use.

5. Effect confirmation

After statistical analysis, the comparison of the blackout time after the application of this technology:

A total of two persons are needed for low-voltage maintenance (one operator and one supervisor should be present at the same time). The original operation needs to operate the secondary knife switch in the power distribution station. The power outage time should be determined according to the distance from power distribution station to users. Considering the distance of 300m from the users to power distribution station and the repeated operation by walking, the power outage operation time is 30 minutes in addition to the operation time (the time of walking 600m plus the operation time of secondary knife switch).
After the low-voltage line of the rural network is adopted to separate the incoming line box, the personnel only need to directly access the pole for operation. Without considering the operating time, the operation time of the blackout is up to 5 minutes.

The operation time of blackout is saved by 83.33% after adopting the rural grid (agricultural area power grid) low-voltage household box device. It greatly shortens the operation time of the power outage, avoids the trouble of maintenance personnel running back and forth between the power distribution station and the users, and reduces the labor intensity.

The original operation needs to operate the secondary knife switch in the power distribution station. The direct result is to shut down all the load on the whole power distribution station. Based on the standard of 100 households of a comprehensive distribution station, the number of blackouts before and after using the low-voltage household box device of rural power network was compared. When the device is used, only 1 to 3 households (determined by the number of households in the nearest connection on the indoor pole) are required, and after removing the zero line and the fire line of the faulty user, the power of the non-fault users can be restored immediately. The number of households in power outage decreased by 97%. The device has applied for utility model patent protection to the State Intellectual Property Office at present.

Reference

[1] 《Technical Specification for Design of High Voltage Distribution Devices》 China Electric Power Publishing House 2007.03.01
[2] National Standard 《3-110kV Design Specification for High Voltage Distribution Devices》 GB50060-2008
[3] 《Regulations for Electric Power Safety of State Grid Corporation》 (Collocation Part)