

Development of a Voltage Resistance Device for Low Voltage Cables

Chuanbo Liu¹, Chuanzong Zhao¹, Fuliang Zhang¹, Liu Wang¹, Yuanlin Song¹,
Zhitong Liu², Yi Wang¹, Qinghao Wang¹, Jiatian Bai¹

¹Fushun Power Supply Company, Liaoning Electric Power Company Limited, State Grid, China

²Shenyang Power Supply Company, Liaoning Electric Power Company Limited, State Grid, China

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Abstract. Because the cable is laid underground, the space is not occupied, and an underground cable channel can accommodate a plurality of lines, and is favorable for the city street beautiful, so the cable is used more and more widely. With the increasing number of low-voltage cables, cable accident rate is also increasing. This paper expounds the insulation resistance and DC withstand voltage test is not applicable to rubber cables, and pointed out the shortcomings of AC voltage withstand test. In order to solve the problem of low voltage cable to be able to run safely, it is very significant to develop a kind of low voltage cable voltage withstand device.

Introduction

In 1897, Shanghai, the first cable was put into use, marking the official start of the use of cables, so far has been more than 100 years. At present, the research, manufacture and application of power cable in our country have been developing rapidly. From the power station to the urban and rural power grid, from the distribution station area to the factory and streets, cable lines with its unique characteristics, more and more widely used in many occasions. In many cases, the effect can not be replaced by overhead lines[3].

Overhead lines are bare wires or insulated wires to be laid overhead. Overhead lines through the insulator to achieve electrical insulation, mechanical fixed. The cable structure is more complex than overhead lines, which not only has a cable core (conductor), also has an insulating layer and protective layer coated on the insulating layer, the protective layer can prolong the cable insulation performance. For cables with a higher voltage level, there is a shielding layer outside the conductor and the insulating layer, and the shielding layer is made of a semi conductor or a metal material.[1]Power cable can be laid in a variety of environments, such as underground and underwater. Power cable can meet the needs of long-term, safe transmission of electrical energy [1].

Compared with the overhead line, cable has the following advantages: Because the cable is laid underground, the space is not occupied, and an underground cable channel can accommodate a plurality of lines, and is favorable for the city street beautiful. Natural meteorological conditions (such as lightning, wind and rain, salt fog, pollution, etc.) and the surrounding environment on the impact of the cable is very small. Cable is hidden in the ground, the power supply reliability is higher, people are more secure. Cable line operation and maintenance costs are relatively small.

Cable Test Method

With the increasing number of low-voltage cables, cable accident rate is also increasing. Cable is to meet the safe operating conditions, it can be judged by cable test. In order to identify the performance and quality of the cable to carry out tests[2].Cable in the production, storage, transportation and installation process, due to the quality of materials, construction factors or mechanical damage and other reasons, the cable line in the installation of the completion may leave a defect [2].After the cable line is put into operation, the following types of defects may be produced. Defect type 1, the operation of the line overload, resulting in damage to the cable overheating. Defect type 2, line laying environment, leading to the cable protection layer of chemical corrosion and electrolytic corrosion. Defect type 3, due to the various underground

pipeline construction, cable protection layer by external damage, resulting in insulation defects. These defects are gradually developed in the operation of the cable lines, which directly threaten the reliability of power supply. In order to detect insulation defects and avoid cable accidents, it is very necessary to carry out electrical test on cable circuit.

Test methods for low voltage cables, 3 methods are commonly used, that is, the insulation resistance table method, DC voltage withstand method, AC voltage withstand method.

Method 1, insulation resistance method

Through the insulation resistance method, it can be found that the cable is affected with damp, aging and penetrating defect. Insulation resistance method can not determine whether the cable to meet the power supply requirements. AC voltage withstand test is the most effective method to judge whether the cable can meet the operating conditions. Most of the cable insulation resistance value is very low, such as 2M ohm, 1M ohm, 0.5M ohm. Whether the insulation resistance value of the cable can meet the power supply conditions, this is the scene of the staff confused. For example, when the insulation resistance of some cables is more than 10M ohm, it will cause the phase to discharge or phase to ground. The insulation resistance value of some cables can be safely operated in the 0.5-2M ohm range.

Method 2, DC withstand voltage method

DC voltage test, can determine the cable damp, deterioration and local defects. However, through the practical application and theoretical analysis show that the DC voltage withstand test is applied to plastic insulated cables (including XLPE insulation, insulation rubber, plastic insulation), there will be some disadvantages of [3].

(1)The DC voltage method, plastic cable defect is not easy to be found. The electric field strength under DC voltage is related to the volume resistivity of the medium. The medium of the extruded insulation cable, such as cross linked polyethylene, belongs to the integral structure. Moisture and impurities in the insulation are dispersed, and the distribution is not uniform. In the medium, the perfoliate channel is not easy to be formed. When DC voltage withstand test is carried out, the electron is injected into the polymer field and space charge is formed in the medium, which leads to the distortion of the electric field and the decrease of the electric field strength. Under the condition of DC voltage, the cross - linking polyethylene insulation material has higher discharge inception voltage, slower growth rate of the discharge channel, and the insulation is not easy to be broken down, and the defect is not easy to be found.

(2)When DC voltage withstand test, it is not effective to detect insulation defects, but it may cause damage to the insulation. Under the condition of AC electric field, the insulation aging is very slow, and the cable can keep the insulation level in a long time. However, under the conditions of the DC test voltage, it will accelerate the aging of insulation, resulting in insulation damage, as well as the occurrence of insulation breakdown accident (after the operation). If the DC voltage withstand test is not carried out, the cable can maintain the normal operation for a long time.

(3)For the cross linked polyethylene insulated cables, under the condition of high voltage, the DC voltage withstand test can not reflect the insulation level of the whole line. With the change of temperature and electric field strength, the resistance coefficient of the crosslinked polyethylene insulation layer is changed under the condition of DC voltage. Due to temperature difference, the electric field strength of insulation layer is different. Under the same thickness, the breakdown level of insulation layer will decrease with the increase of temperature. This phenomenon is also related to the thickness of the insulation layer, the greater the thickness, the more serious the situation. High voltage cross linked polyethylene cable insulation layer is relatively thick, so the DC withstand voltage test is not suitable for cross linked polyethylene cables, especially the (high voltage grade) cross linked polyethylene cable [3].

Method 3, AC withstand voltage method

AC withstand voltage test method is used to identify the insulation strength of power equipment, which is the most rigorous, most effective and most direct test method. AC withstand voltage test method is of decisive significance to determine whether the power cable meets the operating conditions. It is an important means to ensure the level of cable insulation, effectively avoid the

occurrence of insulation accidents.

In short, the DC withstand voltage test method can not be used for the identification of rubber cable. AC voltage withstand test method is the most effective test method to determine the safe operation of the cable.

The Problem of AC Voltage Withstand Method in Low Voltage Cable Test

The schematic diagram of the voltage resistance device for low voltage cables is shown in Figure 1. Cables rated less than or equal to 1kV are referred to as low voltage cables, usually with three voltage levels, 220/380V, 450/750V, 0.6/1kV. According to three kinds of different grades of low-voltage cables, the voltage of the test voltage is 660V, 1350V and 1800V. However, the existing test transformer ratio is 250 (50000/200), in the low voltage side loading 1V voltage, high voltage side output voltage is 250V. In order to get different voltage at high voltage side, the voltage at the low voltage side needs to be loaded with 2.64V, 5.4V, 7.2V. In the high-pressure side, the voltage regulator can not accurately control the output voltage [2].

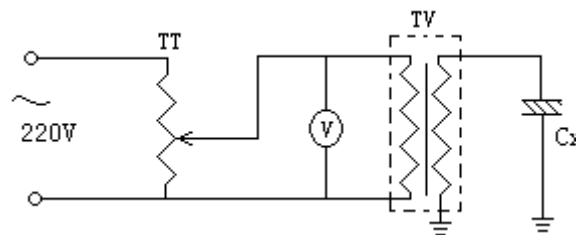


Fig. 1 Schematic diagram of the voltage resistance device for low voltage cables
Note: TT- voltage regulator. TV- Test (boost) transformer. Cx- test cable.

The Overall Design of Pressure Resistant Device

To develop a kind of equipment for judging whether the low voltage cable is satisfied with the condition of power supply. One of the research condition of the device, there is a special transformer, the ratio of transformation value is 15 (3000/200). If the low voltage side voltage is 1V, the output voltage of the high voltage side is 15V. In the cable voltage test, low voltage side voltage can be selected as 44V or 90V or 120V, which can solve the problem that the output voltage can not be controlled. The voltage regulator section is shown in figure 2. The Schematic diagram of test (boost) transformer is shown in figure 3.

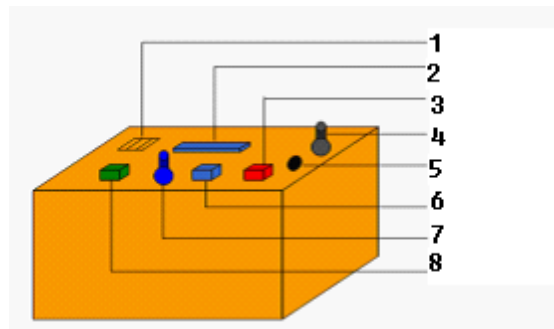


Fig.2 voltage regulator section

Note: Operating box size: length 260mm, width 180mm, height 110mm. 1- voltage output socket. 2- voltage display. 3- power switch. 4- operating box body grounding terminal. 5- power jack. 6- voltage output switch. 7- voltage regulation knob. 8- over current automatic trip switch.

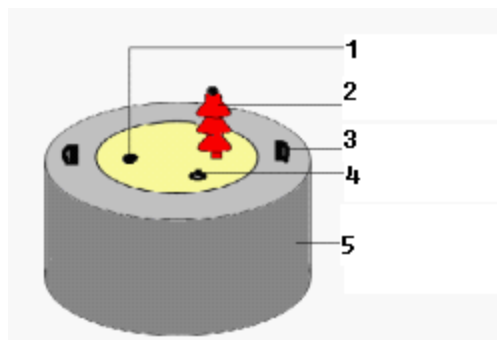


Fig. 3 Schematic diagram of test (boost) transformer

Note: The numerical ratio of the transformer is 15 (3000/200). The capacity of the transformer is 1kVA. Size: height 200mm, diameter 240mm. 1- Grounding terminal of device. 2- pure porcelain high voltage bushing. 3- handle position. 4- low voltage input terminal. 5- oil immersed transformer.

Field Application Examples

July 10, 2015, Dongzhou people's activity center, 3# box transformer low-voltage cable repair work record. 3# box changes the cable specifications are 450/750V. Short circuit between the A phase and the B phase, causing the 3# box to change the power supply interrupted. Staff rushed to the scene to carry out repair work. The cable is repaired, the staff conducted a test of the cable, the specific results are as follows: the insulation resistance value (A - E) is 7M ohms; the insulation resistance value (B - E) is 5 M ohm, the insulation resistance value (C - E) is 5 M ohm. In order to test the repaired cables meet normal operation conditions, low voltage cable voltage withstand device is applied. AC withstand voltage test, the specific results are as follows: the pressure value is 1350V. Equipment ratio value is 15. Therefore, the low-voltage side of the voltage is adjusted to 90V, can achieve high voltage side output 1350V. The application of the device not only can successfully complete the cable voltage withstand test, but also provides reliable data for the operating personnel.

Conclusion

Advantages of the device, the transformer ratio is small, only 15. Test voltage is easy to control, is suitable for all kinds of low-voltage cable AC voltage withstand test. Instrument light, easy to carry, test transformer weight is only 6kg, the weight of the operation box is 4kg, test wiring is more convenient.

Although the design and manufacture of low voltage cable voltage withstand device is more complex, but it is convenient to use, and can solve practical problems, is widely used in the field work. The device has been widely used in Fushun area, with good application effect, and it has extensive application value and application prospect.

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