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OPTIMIZATION OF CABLE GROUNDING SYSTEMS: ADDRESSING COMMON ISSUES WITH PRACTICAL SOLUTIONS

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Abstract: *Cables in urban areas predominantly lie in the essential underground infrastructure of the entire city. The unique positioning of these cables makes it challenging to detect and address grounding faults promptly and accurately. Consequently, it is imperative for power professionals to grasp the primary classification factors for grounding faults in cables, along with relevant search techniques, analysis methods, and advanced countermeasures. This knowledge equips them to swiftly pinpoint specific fault locations in the event of grounding faults in cables, enhancing operational efficiency and the speed of fault resolution. This approach aligns with the fundamental concept of cost reduction and efficiency improvement in power engineering operation and maintenance, ultimately leading to increased profitability while optimizing physical efficiency.*

Keywords: *Grounding Faults, Cable Fault Detection, Power Engineering, Fault Resolution, Urban Cable Infrastructure*

1. Introduction

The cables in the urban area can basically be said to be located in the basic underground position of the entire urban area. Due to the unique reasons for laying these types of cables, it is not particularly easy to find the faults that occur when there are grounding faults in the cables, and to carry out corresponding correct and timely maintenance. Therefore, it is necessary for relevant power personnel to understand and learn the main classification reasons for grounding faults in cables, and master the relevant main search techniques, corresponding analysis methods, and advanced countermeasures [1-2]. At the critical moment, when the corresponding cable has a grounding fault, it can accurately find out the specific and accurate fault points of the relevant cable, it can also improve the actual operation efficiency of the cable and the corresponding speed of fault handling. It can achieve real and timely fault repair response, thoroughly implement the main concept of cost reduction and efficiency increase in the operation and maintenance of power engineering. At the same time, it can also maximize the Profit maximization of the maintenance and daily operation of power engineering while improving physical efficiency [3].

2. The main types of cable failures

In today's society, the short circuit faults of power cables that we can come into contact with can be roughly divided into the following four common situations [4].

a) The first scenario is a fault caused by the insulation of single-phase or multiphase conductors to ground, which causes high resistance, low resistance, and high metallicity.

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b) The second scenario is a fault caused by a broken wire. During the operation and maintenance of high-voltage power cables in daily operation, if a wire break occurs in the single-phase or multiphase conductor parts of the cable, it can directly reduce the direct and indirect stability of power cable supply.

c) The third scenario is a flashover fault. This type of fault is a special type of fault where the power cable itself is suddenly broken down by high voltage during overload operation, and then returns to its original state to continue operation.

d) The fourth type is a composite fault. This refers to the occurrence of various types of faults in high-voltage power cables during operation. The above four situations can summarize the main factors and specific causes of cable faults in current power engineering, and can be said to be a highly valuable classification for reference.

3. Analysis of the main grounding faults in cables in current power engineering

Cables in urban power engineering are generally laid underground in urban areas, while urban underground pipelines are usually complex and limited in space. If the surrounding area of the power grid project is excavated again after the successful completion of the specific cable laying in the power engineering, and other specific activities of power engineering construction are carried out, power workers or other types of workers are very likely to damage the cables, causing some special cable grounding comprehensive faults [5-7]. The production of cable joints in power engineering is actually very convenient and easy to operate, but due to this reason, some power engineering construction units do not attach importance to the specific local construction quality of welding and other links. In the actual welding process of grounding wires, there are often violations of regulations and operations. In addition, some power engineering technicians have limited welding capabilities and are concerned that the cable insulation may be burned during the welding process. Therefore, they have replaced complex welding processes with simple steps such as binding, which can easily cause abnormal loosening of the grounding wire and copper tape shielding layer of high-voltage power cables, laying a significant safety hazard for the safe operation of future power engineering [8]. In areas with special geological conditions such as coal mines and mining areas, the grounding grid is a composite of shielding layer and sheath of cables and low-voltage cables due to construction conditions. In this special situation, accidental cracking of the metal shielding layer of high-voltage cables or accidental detachment of the cable grounding wire can also cause grounding faults in high-voltage cables. For high-voltage cables, the copper strip shielding layer is usually single core and three core, and manufacturers must use fusion welding technology or copper welding technology to fix the copper strip connection when producing cables, in order to barely meet the basic industry process standards [9-10]. However, in the actual production process of power engineering, some power suppliers and manufacturers still use simple traditional processes such as soldering to make cables, and then overlap them and fix them with plastic bags. This is clearly an irresponsible and non-compliant production behavior habit, these extremely irresponsible behavior habits have also laid the groundwork for safety hazards and major safety concerns in the future occurrence of cable grounding faults [11].

4. Test Method and Optimization Application of Cable Grounding Fault

Electric power employees should make accurate judgments, timely detection, and maintenance of various problems caused by cables, whether due to external factors or their own reasons. Common testing methods for grounding fault points include but are not limited to the following three types [12].

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a) Cable low resistance grounding fault. This type of fault refers to a low insulation resistance of one core wire of a cable to ground, but good continuity of the core wire. Therefore, this type of fault has the characteristic of strong concealment, and can be tested by using circuit fixed point transmission.

b) Two phase short circuit fault. When it is being measuring, you can use any faulty core wire as the grounding wire and connect the other faulty core wire to the bridge. The calculation formula and measurement method are the same as for single-phase low resistance grounding faults.

c) Three phase short circuit fault. During measurement, it is necessary to borrow other parallel circuits or install temporary circuits as circuits. A high resistance grounding fault in a cable refers to the insulation resistance value between the conductor and the aluminum sheath or conductor, which is much lower than normal resistance, but is higher and the continuity of the core wire is good. This type of fault can be measured using the high-voltage bridge method.

d) Due to the high current at the fault point, it is necessary to use a high-voltage DC power supply to ensure that the power supply passing through the fault point is not too small. Flashover fault. This type of fault shows good insulation resistance of each phase and good wire continuity, so it can be roughly concluded that each fault point has been closed.

5. Comprehensive optimization of cable search methods

We will compare and analyze the mainstream grounding fault detection measures one by one.The bridge method, which is mainly used in current power engineering, is mainly based on the principle of double arm bridges for detection. We can accurately short-circuit the fault phase of the high-voltage cable to be detected with the non fault phase of the high-voltage cable, forming a closed connection circuit. At the same time, we can adjust the position of the bridge's double arm resistors with adjustable properties in a timely manner. In this way, when the bridge is in a balanced state, the resistance product values on both sides of the bridge arm will be equal, and then the corresponding fault distance will be measured using the positive proportional relationship between cable length and resistance. The personnel involved in the relevant power engineering have preliminarily determined that the fault in this section of the line belongs to a broken line fault. This way, the staff can scientifically test the transmission line using a professional cable fault tester based on the principle of a double arm bridge. After the staff excavates, the actual fault location confirmed on site is consistent with the bridge detection results. Direct flash method is an abbreviation of DC high-voltage flashover detection method, which is very effective in measuring flashover breakdown faults. In the specific routine testing process, it utilizes professional high-voltage power cable fault detection instruments to apply the continuously increasing DC voltage of the cable to the high-voltage cable being tested before the fault resistance value is too high and the resistance channel is truly formed. In this way, when the voltage reaches a specific value, the cable fault point will be broken down by the high-voltage load, forming a cable flashover. Then, through the influence of flashover arc, the corresponding voltage undergoes short circuit and open reflection. In this way, under multiple reflections between the fault point and the input end, the electrical energy will be completely consumed. The impulse flashover method, also known as the impulse high-voltage flashover method, has a wide testing range and is suitable for testing many high-voltage cable flashover faults. Its application method is roughly similar to the DC high-voltage flashover method, except for adding a spherical discharge chamber between the cable and the capacitor. When the capacitor is charged and the voltage rises to a specific value, the ball shaped discharge will occur breakdown discharge. After the cable line obtains an instantaneous high voltage, if the instantaneous high voltage is higher than the critical breakdown voltage

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at the fault location, the corresponding fault location will generate breakdown discharge phenomenon, and the current and voltage signals will be transmitted to both ends instantaneously. When the staff receives this signal, they can measure the length of the fault. There are many signal sampling methods for the impulse flash method, and the most common ones should be the current sampling method and the voltage sampling method. Especially the second type of voltage sampling method has strong anti-interference and accurate testing. Due to this reason, its application is also more common, which reflects its strong applicability and universality.

6. Other mainstream fault finding methods

The low-voltage pulse method is mainly used for testing short faults, open circuit faults, and low resistance faults in high-voltage cables in power engineering activities. In addition, it can also measure the length of cables and the propagation rate of electromagnetic waves. Moreover, through the lowvoltage pulse testing method, the staff can accurately distinguish the joints, terminal positions, and intermediate positions of high-voltage cables. In the specific testing, the staff needs to inject a lowvoltage pulse into the high-voltage cable in advance. When the pulse encounters a short circuit point, intermediate joint, or fault point during the propagation process inside the cable, it will generate corresponding pulse reflection. Afterwards, the reflected signal will propagate to the measurement point, and the measuring instrument will accurately record it accordingly. The principle of the low-voltage pulse method is simple and does not require a high-voltage pulse generator, so it is relatively easy to implement. Moreover, this method only needs to know the propagation speed of the pulse in the cable, and can display the waveform collected by the low-voltage pulse on the LCD screen, thereby mastering the situation of various joints inside the cable. However, when encountering high resistance faults and flashover faults, the reflection pulse of the low voltage pulse is very small and difficult to detect, so it is not applicable. The sound wave method is generally applied to flashover ground faults and high resistance ground faults, mainly using high-voltage pulse generators to complete fault point testing. During the specific testing process, the staff needs to emit high-voltage pulses into the corresponding high-voltage power cable. When the high-voltage pulses are transmitted to the fault point, they will release huge energy to instantly break through the grounding point and emit a brief sound. Then the installed pickup will amplify the sound, so that the staff can accurately determine the grounding fault point of the highvoltage cable. The cable burning through method mainly relies on professional cable burning through instruments to emit high-voltage small currents into the corresponding high-voltage faulty cables, thereby maintaining the high-voltage cables in a short-circuit heating state. In this way, the external insulation layer of the cable will experience aging and carbonization under high heat, and the staff can immediately accurately identify the relevant cable fault points. Because the nature of the cable fault is a high resistance fault, the staff cannot accurately test its fault point through pulse detection.

7. Conclusion

Overall, the application of power engineering cables not only does not affect the aesthetics of normal urban environments, but also greatly facilitates the daily electricity consumption. And due to its advantages in underground power transmisson, work and life of ordinary residents in urban areas become much better. However, the problem that arises from this is that finding cable faults in power engineering is a highly challenging engineering task. For different mainstream types of cable faults in power engineering, there are also significant differences in the troubleshooting techniques and methods adopted by maintenance personnel in power construction. Due to the occurrence of this situation, it

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requires relevant power engineering personnel to fully combine their rich search experience in the practical search process, and flexibly switch to fault search techniques in a timely manner. Only in this way can relevant fault points be quickly and accurately identified, and the occurrence of safety accidents in related power engineering can be efficiently avoided.

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