

Analysis of High Voltage Electrical Interlocking Test

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Abstract: The importance of high-voltage electrical switching tests in the stable operation of power systems is self-evident. This critical step comprehensively evaluates the performance of electrical equipment, ensuring that it meets design requirements and operational standards, thereby providing solid quality assurance for the safe operation of equipment. With the continuous progress and innovation of technology, the methods and means of switching tests are also continuously improving and advancing towards more efficient and precise directions from traditional testing techniques. Therefore, high-voltage electrical switching tests play an indispensable role in power systems and are crucial for ensuring stable and safe power supply.

Keywords: high-voltage electrical; switching test; analysis

Introduction

This paper discusses the importance of high-voltage electrical switching tests and the main issues they address, such as poor equipment grounding, leakage, and overload. In response to these issues, the paper provides an in-depth analysis of the principles and applications of switching test methods, including insulation resistance and polarization index measurements, direct current leakage current measurements, alternating current withstand voltage tests, dielectric loss factor measurements, and partial discharge tests. These methods play a key role in accurately assessing the insulation performance of electrical equipment, identifying potential fault points, and ensuring the safe and stable operation of power systems.

1. Overview of High-Voltage Electrical Switching Tests

High-voltage electrical switching tests are a crucial

aspect of ensuring the safe and stable operation of power systems. After the installation, maintenance, or modification of electrical equipment, switching tests comprehensively assess the performance of the equipment to verify whether it meets design requirements and operational standards. This process involves a comprehensive evaluation of various aspects of equipment, including insulation performance, mechanical strength, and electrical characteristics, serving as the final quality checkpoint before equipment is put into operation. The rigor of switching tests directly affects the reliability of the power system. During the tests, professionals must adhere to strict operating procedures and utilize advanced testing instruments and equipment to accurately measure various parameters of electrical equipment. Even minor deviations could indicate potential safety hazards, emphasizing the importance of the accuracy and completeness of test data. Additionally, high-



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voltage electrical switching tests carry the mission of technological innovation and inheritance. With the continuous development of power technology, the methods and means of switching tests are also advancing. New testing technologies and more efficient detection algorithms contribute to enhancing the accuracy and efficiency of tests.

2. Major Issues in High-Voltage Electrical Switching Tests

2.1 Poor Equipment Grounding

Poor equipment grounding is a challenging and significant issue in high-voltage electrical switching tests. The grounding device, as an essential component to ensure the safe and stable operation of electrical equipment, may be improperly set up, directly affecting the grounding effectiveness of the entire equipment. In practice, due to negligence or insufficient professional knowledge of the installation personnel, the grounding device may not be set up according to standards and specifications, resulting in excessively high grounding resistance that fails to meet the normal operating requirements of the equipment. Additionally, loosening or poor contact of the grounding wire is also a common cause of poor equipment grounding. Prolonged use and vibration may lead to loosening of grounding wire fastening screws or oxidation and corrosion at the connection between the grounding wire and the grounding electrode, resulting in poor contact. These conditions increase the resistance of the grounding circuit, leading to poor grounding conditions. The consequences of poor equipment grounding are severe. It not only results in excessive dielectric losses of the tested equipment, reducing its service life and efficiency, but may also cause electrical faults such as equipment overheating and insulation breakdown. Furthermore, if poor grounding conditions are not promptly addressed, they may pose a threat to the personal safety of operators and increase the risk of safety accidents.

2.2 Equipment Leakage

Equipment leakage is a common problem in high-voltage electrical switching tests, with various causes related to the quality and condition of the equipment itself, as well as external environmental factors and the skill level of operators. (1) The deterioration of equipment insulation performance is the main

cause of leakage. During prolonged operation, the insulation material of the equipment may be affected by factors such as electricity, heat, and chemicals, leading to a gradual decline in insulation performance and increased risk of leakage. (2) Incorrect wiring or poor contact is also a significant cause of equipment leakage. During installation or maintenance, incorrect wiring or loose contact may form potential leakage channels, causing current to flow abnormally through paths other than the designated route back to the power source. (3) External environmental factors such as temperature and humidity may also affect the leakage performance of equipment. For example, in high-temperature and high-humidity environments, the insulation performance of equipment may decrease, increasing the likelihood of leakage. (4) The skill level of operators is also a crucial factor influencing equipment leakage issues. Improper operation or lack of necessary skills and knowledge during installation, commissioning, or maintenance processes by operators may lead to problems such as incorrect wiring or poor contact, thereby causing equipment leakage.

2.3 Equipment Overload

Equipment overload is a crucial issue in high-voltage electrical switching tests, and its potential risks and consequences cannot be ignored. The phenomenon of overload often results from the combined effect of multiple factors, with mismatch between the rated current of the equipment and the actual current being one of the most common reasons. If the actual current demand during operation is not accurately assessed during the design or selection of equipment, it may lead to equipment overload when subjected to excessive loads. Additionally, the operating status of the cooling system is crucial for temperature control of the equipment. If the cooling system fails or operates abnormally, such as fan failure or radiator blockage, it will severely affect the heat dissipation of the equipment. In this case, even if the load borne by the equipment does not exceed its rated value, overload may occur due to inadequate heat dissipation. Furthermore, unreasonable distribution of equipment load is also a significant cause of overload. In power systems, if the load distribution among multiple devices is unbalanced, some devices may bear excessive loads,

leading to overload.

3. Analysis of High Voltage Electrical Switching Test

3.1 Insulation Resistance and Absorption Ratio Measurement

Insulation resistance is a key indicator for evaluating the insulation performance of electrical equipment, and its magnitude directly reflects the conductivity of the insulation material. In high-voltage electrical switching tests, it is essential to use specialized insulation resistance testers to measure the equipment. Generally, the higher the insulation resistance value, the higher the insulation performance and safety of the equipment. A higher insulation resistance indicates that it is more difficult for current to penetrate the insulation material, effectively preventing electrical faults. In actual operation, the insulation of electrical equipment may be affected by various factors such as moisture and aging, leading to a decrease in insulation performance. To more accurately assess the insulation status of the equipment, it is necessary to further measure the absorption ratio. The absorption ratio refers to the change in insulation resistance value within a specified time interval. By measuring the absorption ratio, we can understand the ability of the insulation material to absorb charges and thereby judge whether there are defects in the insulation material. In the switching test, it is essential to strictly follow the prescribed methods and standards for measurement to ensure the accuracy and reliability of the measurement results. Only when both insulation resistance and absorption ratio meet the standard requirements can we consider the insulation performance of the equipment to be qualified, thereby ensuring the safe and stable operation of the power system. Through this series of tests and evaluations, we can more accurately understand the insulation condition of electrical equipment, promptly identify and solve potential insulation problems, and provide strong protection for the normal operation of the power system.

3.2 Measurement of Direct Current Leakage Current

When the insulation resistance of electrical equipment is low, in order to evaluate its insulation condition more accurately, it is necessary to perform the measurement of direct current (DC) leakage current. This measurement is achieved by applying a certain DC

voltage to the equipment and measuring the leakage current passing through the insulation material. The magnitude of the leakage current is closely related to the insulation condition of the equipment. If there are defects or aging phenomena in the insulation material of the equipment, the leakage current will increase. This is because defects and aging will enhance the conductivity of the insulation material, making it easier for the current to pass through the insulation material. Therefore, by measuring the magnitude of the leakage current, the insulation condition of the equipment can be preliminarily assessed. In practical operations, several points should be noted when performing the measurement of DC leakage current: (1) The applied DC voltage should be determined based on the rated voltage of the equipment and the characteristics of the insulation material to ensure the accuracy and safety of the measurement; (2) The environment should be kept dry and clean during the measurement process to avoid the influence of external factors on the measurement results; (3) Detailed records and analysis of the measurement results should be conducted to promptly identify and address potential insulation issues. Through the measurement of DC leakage current, a deeper understanding of the insulation performance of the equipment can be obtained, providing important basis for the acceptance and maintenance of the equipment. If the measurement results show that the leakage current is too large or too small, further inspection and treatment of the equipment are required to ensure its safe and stable operation.

3.3 AC Withstand Voltage Test

The AC withstand voltage test is a crucial test in evaluating the insulation performance of electrical equipment. It directly examines whether the insulation system of the equipment can withstand the effects of normal working voltage and overvoltage by applying AC high voltage higher than the rated voltage on the equipment. This test not only tests the quality of the insulation materials of the equipment but also verifies the rationality of the overall insulation structure design of the equipment. Before conducting the AC withstand voltage test, it is essential to accurately determine the test voltage level and duration based on factors such as the rated voltage of the equipment, characteristics of the insulation materials, and expected working environment. During the test process, personnel need

to be fully focused and closely observe the changes in the equipment's condition. If abnormal phenomena such as breakdown or flashover occur in the equipment under high voltage, it indicates serious defects in its insulation performance. The test must be immediately stopped, and thorough troubleshooting must be conducted. The importance of the AC withstand voltage test is self-evident. It is a key step in ensuring the safe operation of electrical equipment and an effective means of preventing insulation failures during operation. Through this test, potential hazards in the insulation system of the equipment can be detected and addressed promptly, thereby avoiding serious accidents such as breakdowns and short circuits during normal or abnormal operation. Therefore, in the commissioning test of electrical equipment, the AC withstand voltage test is indispensable and meaningful.

3.4 Measurement of Dielectric Dissipation Factor

The measurement of dielectric dissipation factor is an essential means of evaluating the insulation quality of electrical equipment. The dielectric dissipation factor refers to the energy loss of insulation materials under an alternating electric field, reflecting the performance and quality of the insulation materials. By measuring the dielectric dissipation factor, it is possible to determine whether the insulation material is aging, damp, contains impurities, or has other defects. During the measurement of dielectric dissipation factor, specialized testing instruments and equipment are required. In the testing process, an alternating voltage is applied to the insulation material, and the phase difference between the current and voltage is measured. Based on the phase difference and the magnitude of the applied voltage, the dielectric dissipation factor can be calculated. The magnitude of the dielectric dissipation factor is closely related to the performance of the insulation material. If the dielectric dissipation factor is large, it indicates significant energy loss of the insulation material under an alternating electric field, which may be due to aging, dampness, or other quality issues. In this case, further treatment or replacement of the insulation material is necessary to ensure the normal operation and safety performance of the equipment. In the commissioning test of electrical equipment, the measurement of dielectric dissipation factor is an indispensable step. By measuring the dielectric dissipation factor, potential problems with

the insulation material can be detected promptly, and corresponding measures can be taken to ensure the safe operation and service life of the equipment.

3.5 Partial Discharge Test

The partial discharge test is a crucial and effective method for evaluating the insulation performance of electrical equipment. The core principle of this test lies in the fact that when there are insulation weak points or potential fault points inside electrical equipment, these areas may experience partial discharge phenomena under high electric field intensity. By artificially applying a certain voltage to the equipment and using high-precision detection instruments to capture these weak discharge signals, we can gain a comprehensive understanding and evaluation of the equipment's insulation condition. During the partial discharge test, it is essential to first select an appropriate test voltage. This voltage typically needs to be higher than the normal operating voltage of the equipment but not excessively high to avoid damage to the equipment. The selection of the test voltage should be based on factors such as the rated voltage of the equipment, the performance of the insulation material, and the purpose of the test. Next, the test voltage is applied to the equipment, and the equipment is scanned comprehensively using partial discharge detection instruments. These detection instruments typically have high sensitivity and wide-band characteristics, allowing them to accurately capture various types of partial discharge signals, such as corona discharge, air gap discharge, and surface discharge. During the test, close attention should be paid to changes in the readings on the detection instruments and any abnormal signals that may appear. Once partial discharge signals are detected, the location, magnitude, and phase of the signals should be immediately recorded, and analysis and judgment should be made based on the structure and operating environment of the equipment.

Conclusion

In conclusion, high-voltage electrical handover tests are an indispensable component in ensuring the safe and stable operation of power systems. Through comprehensive testing and evaluation of electrical equipment, potential safety hazards can be identified and addressed promptly, providing solid assurance for the normal operation of equipment. With the continuous

progress and innovation of technology, we have reason to believe that future handover tests will be more precise and efficient, injecting new vitality into the sustainable development of power systems. Therefore, we should attach great importance to the role of high-voltage electrical handover tests, continuously improve and enhance the level of testing, to ensure the stable and reliable operation of power systems and meet the growing electricity demands of society.

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