

Research on the Protection Performance Testing Technology of Explosion-Proof Electrical Appliances in Mines

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Abstract. Based on an analysis of the current situation of safety production in mines and the testing of protection characteristics of explosion-proof electrical appliances, a testing system and method for the protection performance of explosion-proof electrical appliances in mines are proposed. The system performs tests such as overload tests, short-circuit tests, phase-loss tests, leakage lock and unlock tests, and action characteristic tests, providing a reference for the development of intelligent testing technology for explosion-proof electrical appliances in mines.

Keywords: Low-voltage electrical appliances; disconnecting tests; electric arc; image enhancement.

1. Introduction

In recent years, significant progress has been made in China's mine safety production, with the total number of safety accidents and fatalities decreasing annually. However, the situation remains complex and severe, facing safety risks arising from an irrational mine industry structure, increasing disasters, tense mining and extraction succession, an uncertain external environment, and insufficient experience and capability of personnel. Electromechanical accidents refer to safety production accidents caused by the failure of equipment such as explosion-proof electrical appliances in mines. Currently, electromechanical accidents have become one of the main types of accidents affecting mine safety, and these accidents can also lead to secondary incidents such as gas explosions and transportation accidents.

The safety of explosion-proof electrical appliances in mines has become a key factor influencing mine safety production. Explosion-proof electrical appliances in mines refer to the electrical equipment in the mine's power grid, distribution, and control systems, including low-voltage explosion-proof feeder switches, high-voltage explosion-proof distribution devices, multi-circuit combination switches, low-voltage vacuum electromagnetic starters, electrical control boxes, and general-purpose switchgear for mines. These devices play crucial roles in the mine power supply system, such as switching and disconnecting branch grids, connecting and disconnecting electrical devices, and fault monitoring and protection. Overload tests, short-circuit tests, phase-loss tests, leakage lock and unlock tests, and action characteristic tests are important indicators for evaluating the safety capabilities of explosion-proof electrical appliances, and are key testing items in product type tests for these appliances. The current testing systems for the protection characteristics of explosion-proof electrical appliances in mines are complex in structure, with low measurement accuracy and poor automation levels, which affects the inspection cycle and efficiency of product testing.



Figure 1: Low-Voltage Multi-Circuit Explosion-Proof Vacuum Electromagnetic Starter for Mines

2. Testing System

The protection performance testing system for explosion-proof electrical appliances in mines mainly consists of a distribution switchgear, low-voltage protection cabinet, adjustable voltage test power supply A, large current generation device, current testing unit, display screen, PLC system, control panel, communication interface, industrial computer, adjustable resistor, electromagnetic relay, voltage converter A, switch, warning unit, timer, voltage converter B, voltage testing unit, humidity sensor, temperature testing unit, circuit resistance testing unit, and resistance testing unit. The structural diagram is shown in Figure 2.

The distribution switchgear, low-voltage protection cabinet, adjustable voltage test power supply A, large current generation device, and adjustable voltage test power supply B form the power distribution system, which provides test current and control voltage for overload tests, short-circuit tests, and phase-loss tests of explosion-proof electrical appliances in mines. The voltage converter A, switch, and voltage converter B are used to adjust the test current and control voltage. The humidity sensor and temperature testing unit are used to measure the temperature and humidity of the test environment. The circuit resistance testing unit, resistance testing unit, leakage signal detection unit, adjustable resistor, and electromagnetic relay are used to test the leakage lock and unlock functions of the explosion-proof electrical appliances.

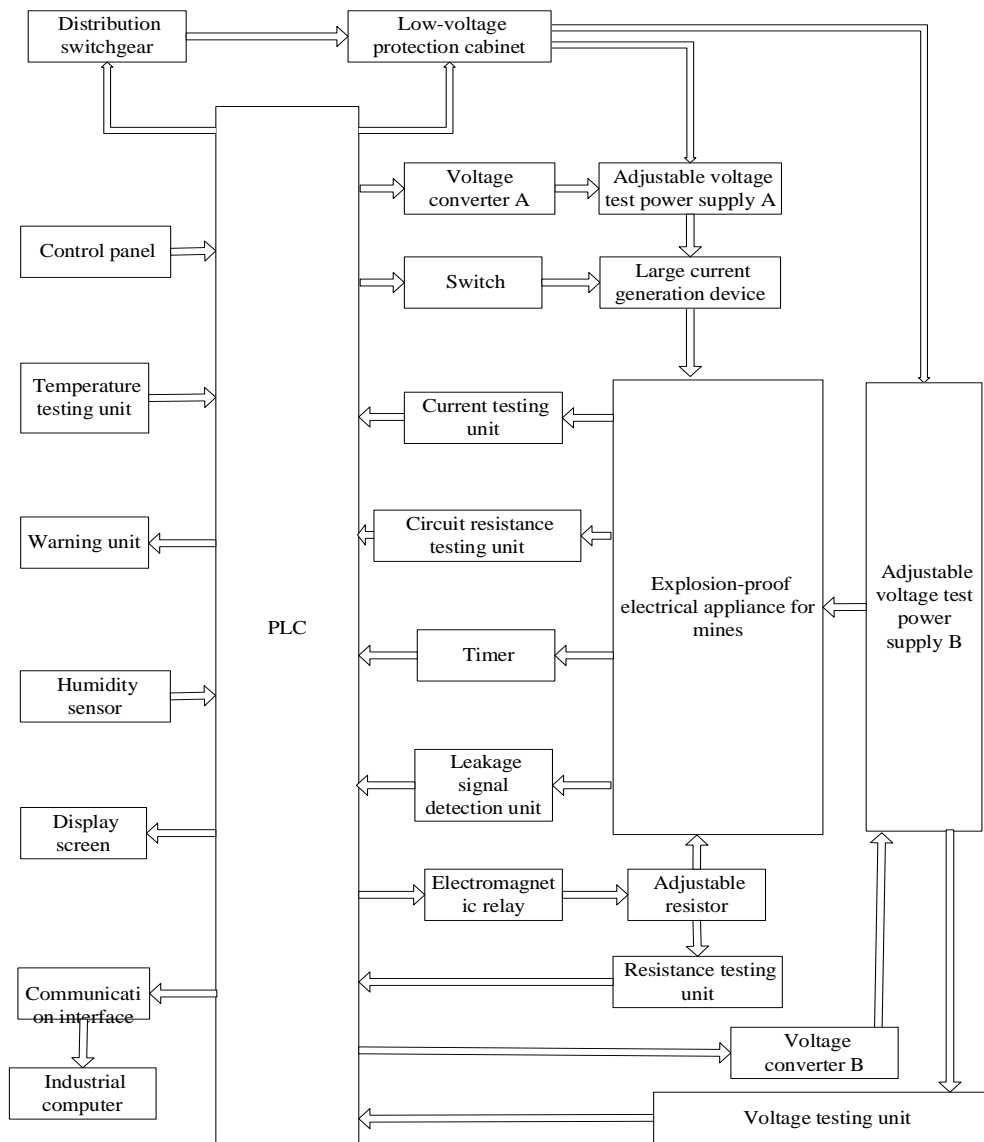


Figure 2: Schematic of the Protection Performance Testing System for Explosion-Proof Electrical Appliances in Mines

The intelligent testing system for safety parameters of explosion-proof electrical appliances in mines uses the simulated current method to conduct overload tests, short-circuit tests, and phase-loss tests. The large current generation device outputs test current based on the parameters and test requirements of the explosion-proof electrical appliance being tested. The timer collects the action time of the explosion-proof electrical appliance, and the PLC system calls the testing system database. According to the test type and action time, the system automatically determines the qualification of the corresponding test item. The processes for the overload test, short-circuit test, and phase-loss test are as follows:

1. Check if the tested explosion-proof electrical appliance and the testing system are functioning properly (if the testing system is abnormal, the warning unit will alarm). Connect the testing system lines according to the requirements of the test item.
2. Operate the control panel to input control instructions. Close the distribution switchgear and low-voltage protection cabinet. Start the humidity sensor and temperature testing unit B for measuring the test environment parameters. The PLC system collects the temperature and humidity data of the test environment and displays them on the screen.
3. The PLC system adjusts the voltage output of the adjustable voltage test power supply B via voltage converter B to provide control voltage for the transformer of the explosion-proof electrical appliance.
4. Set the parameters of the explosion-proof electrical appliance according to the test item (overload test, short-circuit test, or phase-loss test). The PLC system adjusts the output current of the adjustable voltage test power supply A via voltage converter A (if the current value does not meet the requirement, the switch changes the work circuit of the large current generation device).
5. The PLC system controls the output of the test current, and the timer measures the action time of the explosion-proof electrical appliance. It then feeds back to the PLC system. Based on the test type and collected data, the PLC system determines whether the test is qualified and displays and stores the data via the display screen and industrial computer.
6. The PLC system sends control instructions to disconnect the power supply lines for the intelligent testing system (distribution switchgear, low-voltage protection cabinet, and adjustable voltage test power supply A). The control panel stops the testing system.
7. Clean up the test equipment and complete the testing of the explosion-proof electrical appliance (overload test, short-circuit test, phase-loss test).

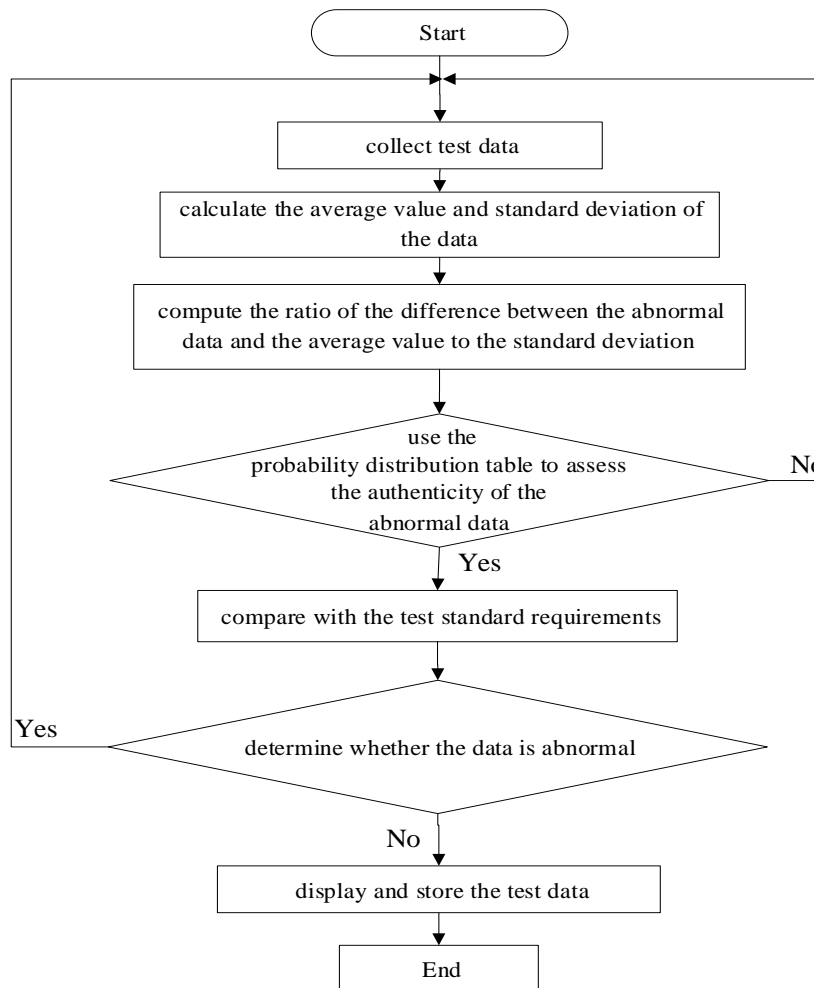


Figure 3: Flowchart for Qualification Determination of Overload, Short-Circuit, and Phase-Loss Tests

The leakage lock and unlock tests for explosion-proof electrical appliances in mines are divided into leakage lock tests and unlock tests. Using the leakage lock test as an example, first, the two ends of the adjustable resistor need to be connected to the ground and the leakage detection terminal of the explosion-proof electrical appliance. The PLC system adjusts the resistance of the adjustable resistor from large to small through the electromagnetic relay. When the explosion-proof electrical appliance detects leakage, it locks (the electrical appliance cannot start). The leakage information is fed back to the PLC system through the leakage signal detection unit. The PLC system collects the resistance value feedback from the resistance testing unit and displays and stores the data through the display screen and industrial computer. The leakage unlock test is similar to the leakage lock test, with the resistance adjustment process going from the leakage lock value to a larger value.

3. Conclusion

Based on the PLC system, the intelligent testing system for the safety parameters of explosion-proof electrical appliances in mines has been designed. This system improves the testing capability for safety parameters, enhances the testing accuracy and technological level, increases the scientific added value of the products, and provides experimental verification and technical support for the material and component selection in the new product development process of explosion-proof electrical appliances. It promotes the continuous and healthy development of testing and inspection, and the field of explosion-proof electrical appliances in mines.

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