ISSN: 2414-1895 DOI: 10.6919/ICJE.202512_11(12).0007

# Analysis and Maintenance Scheme Research on Disassembly Inspection of Mine-used Flameproof Motors and Electromagnetic Starters

Zhifeng Wu*

Xi'an Research Institute of China Coal Technology and Engineering Group Corp, Xi'an, Shaanxi 710077, China

*E-mail: wuzhifeng@cctegxian.com

## Abstract

**Mine-used flameproof three-phase asynchronous motors and flameproof intrinsically safe vacuum electromagnetic starters are core electrical equipment in underground coal mine production systems, and their operational reliability directly affects coal mine production efficiency and operational safety. For 7 mine-used motors (internal numbers 5-8014~5-8019) and 2 electromagnetic starters (internal numbers 5-8020~5-8021) entrusted for maintenance by Xi'an Research Institute of China Coal Technology and Engineering Group, this study systematically analyzed the equipment fault types and causes, designed targeted maintenance schemes, and implemented verification based on standards such as Explosive Atmospheres (GB/T 3836 series) and General Technical Conditions for Electrical Equipment Used in Underground Coal Mines (MT/T 551-1996), combined with equipment disassembly inspection data. The results show that the main faults of the motors are concentrated in shell structure damage (screw hole wear, rust), transmission component failure (bearing wear, end cover dimension out-of-tolerance), and winding performance degradation (moisture, burnout); the faults of electromagnetic starters are mainly mechanical component jamming (inflexible handle), electrical accessory aging (cable entry device), and flameproof surface defects (rust). Through the closed-loop maintenance process of "disassembly inspection - repair/replacement - testing", the insulation performance, flameproof performance, and operating parameters of all equipment after maintenance meet national standards, with a 100% qualification rate in the overall machine test. This research provides a technical reference and practical paradigm for the standardized maintenance of high-voltage grade electrical equipment in mines.**

## Keywords

**Mine-Used Flameproof Equipment; Three-Phase Asynchronous Motor; Vacuum Electromagnetic Starter; Equipment Disassembly Inspection; Maintenance Standardization; Flameproof Performance Verification.**

## 1. Introduction

The underground coal mine environment exhibits complex characteristics with the coexistence of high humidity, dust, impact, and explosive gases [1]. Core electrical equipment operating in such harsh conditions for long periods is prone to failures due to factors such as mechanical wear, insulation aging, and corrosion of explosion-proof surfaces [2]. Among them, flameproof mining motors serve as key power sources, while flameproof and intrinsically safe vacuum electromagnetic starters fulfill core control functions [3]. Once either of these equipment malfunctions and shuts down,

ISSN: 2414-1895 DOI: 10.6919/ICJE.202512_11(12).0007

it will not only directly lead to the complete paralysis of mining and transportation systems but also may induce major safety accidents [4]. According to statistics on coal mine electromechanical equipment failures, motor and starter failures account for a particularly high proportion of all electrical equipment failures, with bearing failure, degradation of winding insulation performance, and damage to explosion-proof structures being the main causes of such failures.

Currently, the maintenance of mining electrical equipment relies heavily on empirical operations, lacking systematic analysis of disassembly and inspection data and in-depth integration with national standards [5]. This leads to unstable maintenance quality and shortened equipment service life. To address this issue, this paper takes 9 mining electrical equipment units as the research objects, and conducts studies on equipment fault type analysis, maintenance scheme design, and quality verification by combining standards such as Explosive Atmospheres-Part 1: Equipment-General Requirements (GB/T 3836.1-2021), Test Methods for Three-Phase Asynchronous Motors (GB/T 1032-2023), and Explosive Atmospheres-Part 4: Equipment Protection by Intrinsic Safety "i" [6-8].

The research aims to establish a "data-driven, standard-oriented, and closed-loop verification" maintenance mode for mining electrical equipment, so as to provide technical support for the safe production of coal mines.

## 2. Equipment Overview and Disassembly Inspection Fault Analysis

### 2.1 Basic Equipment Parameters

This study involves two types of mine-used electrical equipment. The physical object is shown in Figure 1 below. The specific parameters are shown in Table 1. All equipment was submitted by Xi'an Research Institute of China Coal Technology and Engineering Group, with a unified entry time of 45950 (Note: This is an Excel date serial number; the corresponding actual date needs to be converted using the equipment management system).

**Figure 1.** Physical picture of mining explosion-proof motor and electromagnetic starter

ISSN: 2414-1895 DOI: 10.6919/ICJE.202512_11(12).0007

**Table 1.** Basic Parameters of Submitted Equipment

| Equipment Type | Internal Number | Model Specification | Rated Power/Current | Manufacturer | Serial Number |
|---|---|---|---|---|---|
| Mine-used flameproof three-phase asynchronous motor | 5-8014 | YBK2-315S-4 | 110 kW | Jiangsu Xi'an Da Flameproof Electrical Co., Ltd. | 46837302 |
| Mine-used flameproof three-phase asynchronous motor | 5-8015 | YBK2-315S-4 | 110 kW | Jiangsu Xi'an Da Flameproof Electrical Co., Ltd. | 36609301 |
| Mine-used flameproof three-phase asynchronous motor | 5-8016 | YBK3-315M-4 | 132 kW | Jiangsu Xi'an Da Flameproof Electrical Co., Ltd. | 894029201 |
| Mine-used flameproof three-phase asynchronous motor | 5-8017 | YBK3-315M-4 | 132 kW | Jiangsu Xi'an Da Flameproof Electrical Co., Ltd. | Unclear |
| Mine-used flameproof three-phase asynchronous motor | 5-8018 | YBK3-315M-4 | 132 kW | Jiangsu Xi'an Da Flameproof Electrical Co., Ltd. | 863890101 |
| Mine-used flameproof three-phase asynchronous motor | 5-8019 | YBK3-315M-4 | 132 kW | Jiangsu Xi'an Da Flameproof Electrical Co., Ltd. | Unclear |
| Mine-used flameproof intrinsically safe vacuum electromagnetic starter | 5-8020 | QJZ-200/1140(660)Z | 200 A | Huarong Technology Co., Ltd. | 23036003 |
| Mine-used flameproof intrinsically safe vacuum electromagnetic starter | 5-8021 | QJZ-200/1140(660)Z | 200 A | Huarong Technology Co., Ltd. | 23036001 |

## 2.2 Fault Types and Cause Analysis from Disassembly Inspection

Based on the Technical Specification for Disassembly Inspection of Mine-used Electrical Equipment, the equipment was subjected to hierarchical disassembly inspection covering "overall structure - core components - electrical performance - flameproof surface". The fault types and causes are as follows:

a, Mine-used Flameproof Three-phase Asynchronous Motors (5-8014~5-8019)

Disassembly inspection revealed that the faults of the 6 motors are concentrated in 4 categories, as shown in Table 2. The fault differences between motors of different powers are mainly reflected in the degree of winding damage (110 kW motors are mainly affected by moisture, while 132 kW motors have coil burnout).

**Table 2.** Fault Statistics from Disassembly Inspection of Mine-used Flameproof Motors

| Fault Location | Fault Phenomenon | Involved Equipment Numbers | Cause Analysis |
|---|---|---|---|
| Overall shell | Thread wear of screw holes, shell rust, missing oil filler pipe | 5-8014, 5-8016~5-8019 | Thread jamming caused by underground dust accumulation, rust caused by high-humidity environment |
| Rotor transmission system | Bearing wear, out-of-tolerance dimensions of bearing installation positions on end covers, bearing position wear | 5-8014~5-8019 | Bearing lubrication failure due to long-term high-speed operation, accumulated assembly errors |
| Stator winding | Insulation resistance of 30~50 MΩ (moisture), coil burnout | 5-8014~5-8015, 5-8017~5-8019 (moisture); 5-8016 (burnout) | Insulation degradation caused by moisture intrusion, coil burnout caused by overload or short circuit |
| Auxiliary components | No obvious faults | All motors | No damage found in fans and cable sockets, no replacement required |

Note: According to MT/T 551-1996, the standard value of insulation resistance requires that the insulation resistance of the stator winding of mine-used motors should be ≥ 100 MΩ (at room temperature). All insulation resistances of 30~50 MΩ detected in this disassembly inspection are judged as unqualified.

b, Mine-used Flameproof Intrinsically Safe Vacuum Electromagnetic Starters (5-8020~5-8021)

The two starters have highly consistent fault types, mainly involving mechanical operating components, electrical accessories, and flameproof structures, as follows:

Mechanical operating components: The handle rotates inflexibly. Disassembly inspection found dust accumulation and slight rust between the handle and the shaft sleeve, leading to transmission jamming;

ISSN: 2414-1895 DOI: 10.6919/ICJE.202512_11(12).0007

Electrical accessories: The cable entry device is aged (hardening of rubber sealing rings), and there is no baffle at the bell mouth, which does not meet the sealing requirements for flameproof entry devices specified in GB 3836.2-2010;

Electrical performance: The contacts of the operating buttons are oxidized, resulting in button jamming and poor contact during power-on testing;

Flameproof surface: There is slight rust on the upper cavity, inner cavity, and top cover, with no deep scratches, but it affects the flameproof gap (the standard requires the flameproof joint gap ≤ 0.2 mm).

## 3. Maintenance Scheme Design and Implementation

Based on the fault analysis from disassembly inspection, combined with the Maintenance Requirements for Motors and Electromagnetic Starters (Document 2) and relevant national standards, standardized schemes were formulated for "motor maintenance" and "starter maintenance". The core idea is "fault location - repair/replacement - standard verification" to ensure that the performance of the equipment after maintenance meets the standards.

### 3.1 Maintenance Scheme for Mine-used Flameproof Three-phase Asynchronous Motors

(1) Insulation Performance Repair

Winding treatment: For motors with excessive moisture (5-8014~5-8015, 5-8017~5-8019), the "vacuum drying - varnish dipping - secondary drying" process was adopted: first, drying in a vacuum environment at 80±5°C for 4 hours to remove moisture inside the windings; then, vacuum pressure varnish dipping with epoxy resin varnish (pressure 0.3 MPa, time 1 hour); finally, drying at 120±5°C for 6 hours to ensure uniform adhesion of the insulation layer;

Coil replacement: For the stator coil burnout of motor 5-8016, the coil was rewound according to the original design parameters (copper wire material, wire diameter 1.5 mm, number of turns 60). After rewinding, an interturn tester was used to detect the interturn insulation to ensure no short circuit;

Insulation component replacement: The insulation seats and terminal posts of all motors were uniformly replaced with insulation materials of 155°C temperature resistance grade that meet GB/T 11021-2014. After replacement, the insulation resistance was tested to be ≥ 150 MΩ (at room temperature).

(2) Maintenance and Replacement of Core Components

a, Rotor transmission system:

Bearing replacement: Bearings of all motors were replaced with three brands (SKF, NSK, FAG) for the party A to choose from, with the model 6319 (suitable for YBK series motors). High-temperature grease (temperature resistance -20~150°C) was applied during replacement;

End cover repair: The bearing installation positions on the end covers with out-of-tolerance dimensions were repaired by electroplating (plating thickness 0.1~0.2 mm). After repair, a micrometer was used to detect the dimensional accuracy, with the tolerance controlled within ±0.02 mm;

Rotor dynamic balance: All rotors underwent dynamic balance testing (in accordance with GB/T 9239.1-2006), with a balance accuracy grade of G2.5 and residual unbalance ≤ 5 g·mm;

b, Shell repair: The worn screw hole parts were treated by "thread tapping - fastener replacement", using high-strength stainless steel bolts (material 304); the rusted parts of the shell were treated with the "sandblasting derusting (Sa2.5 grade) - painting (epoxy resin antirust paint)" process, with the paint film thickness controlled at 80~100 μm.

(3) Flameproof Performance Guarantee

Flameproof surface treatment: The rusted parts of the flameproof surface were polished with fine sandpaper (800#) to ensure the surface finish Ra ≤ 6.3 μm. The flameproof gap was detected with a feeler gauge, and the gap of all parts was ≤ 0.2 mm;

Label supplement: After cleaning the motor surface, nameplates (including model, power, flameproof mark Ex d I), safety warning signs ("No live opening"), and indicator signs were supplemented to ensure clear and firm labels.

### 3.2 Maintenance Scheme for Mine-used Flameproof Intrinsically Safe Vacuum Electromagnetic Starters

(1) Maintenance of Flameproof Enclosure and Mechanical Components

Flameproof surface repair: The rusted flameproof surfaces of the upper cavity, inner cavity, and top cover were treated with the "polishing - phosphating" process, with a phosphating film thickness of 5~10 μm. After treatment, the width of the flameproof joint (≥15 mm) and gap (≤0.2 mm) were detected, meeting the requirements of GB 3836.2-2010;

Mechanical component treatment: The handle was disassembled and the shaft sleeve was polished to remove dust and rust. After applying grease, it was reassembled to ensure flexible rotation without jamming; the bell mouth baffle (brass material) was supplemented, and the aged cable entry device was replaced (nitrile rubber was used for the rubber sealing ring, which is oil-resistant and temperature-resistant).

(2) Repair and Testing of Electrical Performance

a, Electrical component replacement: The oxidized operating buttons (model LA10-2H) were replaced. Three brands (Schneider, ABB, Siemens) were provided for all purchased components for the party A to choose from; the wires inside the cabinet were inspected, and the aged control wires (cross-sectional area 1.5 $mm^2$, color consistent with the original design: red for phase wires, blue for neutral wires, yellow-green for ground wires) were replaced;

b, Power-on testing: Power-on tests were conducted in accordance with GB/T 10233-2019:

No-load test: Rated voltage was applied, and the voltage deviation of the control circuit was tested to be ≤ ±5% with normal display;

Load test: A simulated load (200 A) was connected, and the protection functions (overcurrent, short-circuit protection) were tested to act reliably with a response time ≤ 0.1 s;

Intrinsically safe circuit test: The intrinsically safe parameters ($U_o$ ≤ 12.5 VDC, $I_o$ ≤ 1300 mADC) were detected, meeting the requirements of the equipment technical manual.

(3) Label and Document Delivery

After cleaning the starter surface, nameplates (including flameproof certificate number CMExC22.0758, safety certificate number MAD120472), flameproof marks (Ex db [ib] Mb I), and safety warnings were supplemented; maintenance records (including disassembly inspection reports, replacement parts lists, and test data) were organized and delivered to the party A together with the equipment.

## 4. Maintenance Quality Verification

### 4.1 Verification Standards and Methods

In accordance with the Acceptance Specification for Maintenance Quality of Mine-used Electrical Equipment, the "special inspection + overall machine test" method was adopted to verify the maintenance quality. The core verification items and standards are shown in Table 3.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202512_11(12).0007

**Table 3.** Maintenance Quality Verification Items and Standards

| Equipment Type | Verification Item | Standard Requirement | Testing Method |
|---|---|---|---|
| Mine-used motor | Stator winding insulation resistance | ≥100 MΩ (at room temperature) | Megohmmeter (500 V) |
| Mine-used motor | Rotor dynamic balance accuracy | Grade G2.5, residual unbalance ≤ 5 g·mm | Dynamic balance testing machine |
| Mine-used motor | Overall machine flameproof performance | Flameproof gap ≤ 0.2 mm, complete labels | Feeler gauge + visual inspection |
| Mine-used motor | Rated load operating current | Deviation ≤ ±5% (rated current 200 A/245 A) | Clamp ammeter |
| Electromagnetic starter | Control circuit voltage | Deviation ≤ ±5% (rated voltage 1140 V/660 V) | Multimeter |
| Electromagnetic starter | Flameproof surface phosphating treatment | Film thickness 5~10 μm, no missing coating | Coating thickness gauge + visual inspection |
| Electromagnetic starter | Protection function action time | ≤ 0.1 s (overcurrent, short-circuit protection) | Oscilloscope |

### 4.2 Verification Results

All 9 sets of equipment passed the quality verification after maintenance. The test results of core indicators are as follows:

Mine-used motors: The insulation resistance of the stator windings was 120~180 MΩ (at room temperature), the residual unbalance of the rotor dynamic balance was 2~4 g·mm, the deviation of the overall machine load operating current was 3%~4%, and the flameproof gap was 0.1~0.15 mm, all meeting the standards;

Electromagnetic starters: The control circuit voltage deviation was 2%~3%, the thickness of the flameproof surface phosphating film was 6~8 μm, the action time of the protection function was 0.06~0.08 s, the operating buttons were sensitive without jamming, and the cable entry device had good sealing performance.

In addition, all equipment labels were complete and clear, and the maintenance record documents were complete, meeting the requirements of the party A's equipment management and coal mine safety production.

## 5. Conclusion and Prospects

### 5.1 Conclusion

The faults of the mine-used motors and electromagnetic starters submitted this time have obvious "environmental correlation": motor faults are mainly caused by insulation degradation due to high humidity and mechanical wear caused by dust, while starter faults are concentrated in operating component jamming and flameproof surface rust. Targeted maintenance measures for "moisture prevention - dust prevention - flameproof protection" need to be strengthened;

ISSN: 2414-1895 DOI: 10.6919/ICJE.202512_11(12).0007

The maintenance scheme based on the "disassembly inspection data - standard requirements - closed-loop verification" can effectively ensure equipment performance: through processes such as vacuum drying of windings, standardized replacement of bearings, and phosphating treatment of flameproof surfaces, the key indicators of all equipment after maintenance are better than national standards, with a 100% overall machine qualification rate;

The brand selection of purchased parts and label supplement are important links in maintenance standardization: providing multiple brand options can meet the personalized needs of the party A, and complete labels can reduce the operational risks at the coal mine site, complying with the requirements of the Coal Mine Safety Regulations.

### 5.2 Prospects

Introduce predictive maintenance technology: Establish an equipment fault database based on the disassembly inspection data this time, and combine vibration sensors (for monitoring motor bearings) and temperature-humidity sensors (for monitoring the inner cavity environment of starters) to realize early fault warning;

Optimize maintenance process automation: Develop automatic equipment for motor winding winding and laser repair systems for flameproof surfaces to reduce manual errors and improve maintenance efficiency;

Establish a full-life cycle management system: Link maintenance records with equipment factory information and underground operation data to form a full-process data chain of "manufacturing - use - maintenance - scrapping", providing data support for improving the reliability of mine-used electrical equipment.

## References

[1] Coal Mine Safety Regulations[J]. Gazette of the State Council of the People's Republic of China, 2025, (28): 6-153.

[2] Haqberdiev A, Toshov J. Analysis of the control system of electric motors of the running gear of self-propelled mine cars used in complex mining and technological conditions[C]//E3S Web of Conferences. EDP Sciences, 2020, 216: 01135. https://doi.org/10.1051/e3sconf/202021601135.

[3] Fotău D, Rad M, Sălăşan D. Considerations regarding the specific tests applicable to electric motors with type of protection flameproof enclosure "d" and type of protection increased safety[C]//MATEC Web of Conferences. EDP Sciences, 2020, 305: 00021. https://doi.org/10.1051/matecconf/202030500021

[4] State Council of the People's Republic of China. Coal Mine Safety Regulations[J]. Gazette of the State Council of the People's Republic of China, 2025, 28: 6-153

[5] S. Spoerhase, F. M. Brombach, F. Eckhardt, et al., "Research on the comparability of static and dynamic overpressure testing of flameproof enclosures," FORSCHUNG IM INGENIEURWESEN-ENGINEERING RESEARCH, vol. 87, no. 2, pp. 605-616, 2023, doi: 10.1007/s10010-022-00604-z..

[6] State Administration for Market Regulation, Standardization Administration of the People's Republic of China. GB/T 3836.1-2021 Explosive Atmospheres-Part 1: Equipment-General Requirements [S]. Beijing: China Standards Press, 2021.

[7] State Administration for Market Regulation, Standardization Administration of the People's Republic of China. GB/T 1032-2023 Test Methods for Three-Phase Asynchronous Motors [S]. Beijing: China Standards Press, 2023.

[8] State Administration for Market Regulation, Standardization Administration of the People's Republic of China. GB/T 3836.4-2021 Explosive Atmospheres-Part 4: Equipment Protection by Intrinsic Safety "i" [S]. Beijing: China Standards Press, 2021.