

TITLE: Design and Performance Criteria for Acceptance of Ground Wire Monitor Systems

1.0 PURPOSE

- 1.1. This document sets forth Mine Safety and Health Administration (MSHA) design and performance criteria for acceptance of ground wire monitor systems in mine power distribution systems.

2.0 SCOPE

- 2.1. This document applies to all ground wire monitors and their remotely located parts used in mine power distribution systems, as covered by the provisions of the Title 30 Code of Federal Regulations, Sections 18.47(d)(2), 18.50(b), 75.524, 75.803, 75.902, 77.803, and 77.902.

3.0 REFERENCES

- 3.1. This document is related to two Approval and Certification Center's (A&CC) documents:
- 3.1.1. ASTP2134, Standard Test Procedure for Acceptance of Ground Wire Devices and
- 3.1.2. ASTP2135, Standard Test Procedure for Acceptance of Ground Wire Monitor Systems.
- 3.2. Both documents describe the group of tests that MSHA conducts to determine whether an instrument or device meets these criteria. The documents are available by request from the Division of Electrical Safety.

4.0 DEFINITIONS

- 4.1. Broken or Open Grounding Conductor - an impedance/resistance greater than 50 ohms in the ground wire for continuity ground check monitors.
- 4.2. Continuity Ground Wire Monitor - an instrument, apparatus or system that continuously monitors the continuity of a grounding conductor, regardless of the existence of parallel paths, and initiates a tripping signal when the grounding conductor's continuity is broken.
- 4.3. Dropout Resistance - a quantity of resistance that when placed into the monitored circuit causes a ground wire monitor to initiate a tripping function.

- 4.4. Failsafe - means that the failure of any component other than welded relay contacts shall not negate the ability of a ground wire monitor system to perform its intended function, unless the ground wire monitor system is designed to initiate a tripping function when such failure occurs.
- 4.5. Failsafe Ground Check Circuit - an MSHA accepted ground wire monitor system that is installed according to the manufacturer's instructions and specifications and has met all applicable requirements specified in ACRI2003, Design and Performance Criteria for Acceptance of Ground Wire Monitor Systems and ASTP2045, Standard Test Procedure For Acceptance of Ground Wire Monitor Systems.
- 4.6. Hazardous Condition - a condition that can place personnel in contact with potentially harmful voltages. This condition, as applicable to ground wire monitor systems, can be the result of any single component failure internal to the ground wire monitor or its remotely located parts.
- 4.7. Impedance Ground Wire Monitor - an instrument, apparatus or system that measures the impedance or resistance of a designated pilot and ground wire circuit and initiates a tripping signal when the impedance or resistance exceeds an amount necessary to produce a 40-volt (for low and medium voltage systems) or a 100-volt (for high voltage systems) potential, external to the neutral grounding resistor during grounded phase conditions. Note that all permissible equipment applications are limited to 40 volts maximum by 30 CFR 18.50(b).
- 4.8. Parallel Path - an electrically conductive path in addition to the designated ground conductor between pieces of equipment.
- 4.9. Shunt - a device used to exclusively develop a voltage drop for signaling purposes and having an appreciable resistance or impedance. By definition shunts are connected in parallel across other devices or apparatus and divert some (but not all) of the current from it.
- 4.10. Tripping Function - the action occurring when voltage is removed from a ground wire monitor tripping relay coil to cause a set of relay contacts to change from a closed to an open position or from an open to a closed position.

5.0 CRITERIA

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A ground wire monitor system shall meet all applicable design and performance criteria specified in this document and be issued an MSHA acceptance number to be considered failsafe according to 30 CFR Sections 18.47(d)(2), 18.50(b), 75.524, 75.803, 75.902, 77.803, and 77.902.

- 5.1. To determine whether a ground wire monitor system meets the failsafe requirements of this document, the ground wire monitor and its remotely located parts shall be installed and calibrated in simulated circuits, according to the manufacturer's instructions and specifications, and the following tests performed:
 - 5.1.1. Inductors, transformers, resistors, except resistors used as shunts under 5.2, relay coils, and lamps shall be individually failed in the open mode.
 - 5.1.2. All semiconductor devices, surge suppression devices, and capacitors shall be individually failed in both the open and shorted modes.
 - 5.1.3. Integrated circuits shall be individually failed in both the open and shorted modes according to their design and application in the circuit that they are installed.
 - 5.1.4. To pass the failsafe test, one of the following conditions must be satisfied:
 - 5.1.5. A tripping function must be initiated immediately, or
 - 5.1.6. A continuity monitor must initiate a tripping function when 50 ohms is inserted into the ground wire, or
 - 5.1.7. An impedance or resistance monitor must initiate a tripping function when its specified dropout resistance is inserted into the ground check wire.
 - 5.1.8. Applicants may specifically request that a value less than 50 ohms be used during the failsafe testing of their application.
- 5.2. Shunts and resistors used as shunts internal to the ground wire monitor that meet the following criteria at $22^{\circ}\text{C} \pm 1^{\circ}\text{C}$ shall be exempted from failure during the failsafe test;
 - 5.2.1. The shunt must be used in a shunt type application;

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- 5.2.2. The shunt must withstand a current 10 times the shunt's nominal current for three ten-minute applications, applied at 30-second intervals, without changing its resistance;
- 5.2.3. The resistance of the shunt shall be measured before and after the test, a + 5% tolerance is allowed.
 - 5.2.3.1. Note: Components used for feedback purposes shall not be classified as shunts.
- 5.3. A continuity ground wire monitor system shall initiate a tripping function when a maximum of 50-ohms is inserted in the ground wire. Applicants may specifically request that a value less than 50-ohms be used during the failsafe testing of their application. This feature may provide more flexible attributes to applicants under MSHA's Monitor and Power System program (MAPS).
- 5.4. An impedance or resistance ground wire monitor system shall initiate a tripping function when the impedance of the grounding circuit increases beyond an amount necessary to cause a 40-volt drop in the grounding circuit external to the grounding resistor under grounded-phase conditions (for example, 1.72 ohms for a 1,000 volt, 25-amp system).
- 5.5. Ground wire monitor systems for underground applications will be tested to determine if up to 10 amperes of stray DC current can prevent the systems from initiating a tripping function, when applicable conditions as specified in 5.3 or 5.4 occur.
- 5.6. Tripping relays shall be energized under normal operating conditions and the relay contacts shall change position when power is removed from the relay coil.
- 5.7. The maximum time delay measured from the instant the grounding circuit is opened until the instant the ground wire monitor tripping relay activates shall not exceed 250 milliseconds.
- 5.8. The maximum open circuit voltage used for ground wire monitor signals shall not exceed 40-volts and shall not cause or promote inter-machine arcing.

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- 5.9. When two or more ground wire monitor systems are connected in series or parallel, interference leading to incorrect tripping shall not occur. In order to insure this, ground wire monitor systems shall be tested in each applicable configuration with and without parallel earth returns.
- 5.10. All ground wire monitor systems shall monitor at least 1000 feet of 4/0 AWG SHD-GC cable.
- 5.11. There shall be no internal or external adjustments that will permit:
- 5.11.1. A continuity ground wire monitor system's tripping relay to remain energized when 50-ohms is inserted in the grounding conductor, or
- 5.11.2. An impedance ground wire monitor system's tripping relay to energize on a circuit in excess of 12-ohms or remain energized on a circuit in excess of 15-ohms.
- 5.12. Any device connected in series with the pilot wire shall be rated to withstand 25 amperes from a nominal 1000-volt system for a 2.5-second period without changing its impedance more than 5%. Pilot wire terminating devices shall not have an impedance that restricts available ground fault currents to values less than can be detected by the ground fault tripping apparatus. Pilot wire devices shall not exhibit a 60-hertz impedance greater than 10 ohms, unless the ground wire monitor system will clear a phase to pilot wire fault in less than 200 milliseconds. If a pilot wire terminating device exceeds 10 ohms, a parallel apparatus that effectively reduces the 60-hertz impedance of the device may be acceptable.
- 5.13. Temperature variations from -26°C to 60°C shall not cause a ground wire monitor system to false trip or exhibit component failure. Continuity type ground wire monitors shall not exceed a dropout resistance of 50-ohms and impedance ground wire monitor systems shall not exceed its specified dropout resistance.
- 5.14. Ground wire monitor systems shall operate correctly one thousand times in 96 hours at a temperature of 85°C without component failure.
- 5.15. Ground wire monitor systems shall withstand a line voltage equal to 80% of nominal for one minute without false tripping or component failure.

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- 5.16. Ground wire monitor systems shall operate correctly while subjected to 115% nominal line voltage in a temperature chamber of $85^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for 24 hours without component failure.
- 5.17. Ground wire monitor systems shall be subjected to transient voltage 10 times the nominal input voltage applied between the input terminals and 2,400-volts applied between the input and the ground wire terminal and the input and case. The pulse width shall be at least 10 microseconds. The impedance of the pulse source shall not be less than 50-ohms. Twenty pulses will be applied between a time range of 50 to 60 seconds. The ground wire monitor system shall not exhibit component failure or false tripping. This test may be waived if the manufacturer provides transient protection in the areas indicated.
- 5.18. Ground wire monitor systems shall withstand a minimum of 50-volts induced 60-hertz voltage applied between pilot and ground terminals without component failure or false tripping.
- 5.19. All ground wire monitor components installed in the pilot or ground conductor shall be rated at least for the system line-to-line voltage.
- 5.20. Phase couplers and filters shall not impose a hazardous condition during normal operation or in the presence of an open or faulted conductor.
- 5.21. All phase coupler filters installed on "approved" equipment shall be mounted inside explosion-proof enclosures.
- 5.22. Capacitors used in phase couplers and filters shall meet the following minimum requirements:
- 5.22.1. Shall have a minimum rating of at least 1,000-volts RMS at 60-hertz and be rated for the nominal system voltage of the circuit.
- 5.22.2. Shall meet all requirements of IEEE Standard 18-1980, Part 5, excluding paragraph 5.4 (Voltage and Reactive Power Ratings) and shall be subject to the following limitations of paragraph 5.2.3 of a maximum continuous voltage of 2,400VAC total RMS voltage.
- 5.22.3. Each capacitor shall be tested according to Section 7 of IEEE Standard Number 18-1980.

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- 5.23. Phase coupler and filter capacitors shall be equipped with internal discharge devices that reduce the residual voltage to 50-volts or less in one minute or less after the coupler is disconnected from rated nominal voltage.
- 5.24. Plug interlock capability must be provided by all ground wire monitor systems.
- 5.25. Ground wire monitor systems shall pass a 3KV, 60-hertz hypot test without exceeding a maximum current flow of 0.1 milliamperes between the following points:
- 5.25.1. Ground wire terminal and case.
 - 5.25.2. Pilot wire terminal and case.
 - 5.25.3. Input voltage terminals and ground wire terminal.
 - 5.25.4. Input voltage terminals and pilot wire terminal.
 - 5.25.5. Trip relay contacts and ground wire terminal.
 - 5.25.6. Trip relay contacts and pilot wire terminal.
- 5.26. MSHA reserves the right to impose other requirements or require additional evaluations on unique designs not anticipated. Since all possible designs, circuits, arrangements, or combinations of components and materials cannot be foreseen, MSHA reserves the right to modify these design and performance criteria to obtain the same degree of protection as provided by this document and the tests described in ASTP2135, Standard Test Procedures for Acceptance of Ground Wire Monitor Systems.