

A Passive Means To Detect Hot Trolley Insulators

Objective

To devise a passive means to detect overheating insulators on mine trolley/track haulageways.

Background

Electrical trolley systems are used for both mineral haulage and movement of personnel and supplies in nearly 50 U.S. mines, mostly in southwestern Pennsylvania and West Virginia. These systems use a trolley wire, energized at 300- or 600-V dc, to power vehicles constrained to run on a network of permanently installed steel track. The bare copper trolley wire along with a feeder wire are suspended about every 6 m from insulators that are anchored into the roof by bolts. The insulators prevent current from flowing to the grounded return track via the overlying strata.

Coal and rock dust accumulations, as well as acidic drainage and condensation, may jeopardize insulator integrity. Leakage currents from the trolley wire into the roof strata can heat the insulator, as well as the immediate area in which the suspended bolt is anchored. If not detected and corrected, this may result in ignition of roof coal and a catastrophic mine fire.

An insulator and surrounding strata that are subject to leakage currents may be discolored, have an odor, or exhibit no physical evidence of deterioration. Leakage can be confirmed through voltage measurements across the insulator. However, this can be a time-consuming, tedious task considering the thousands of insulators distributed over miles of haulageway. A portable infrared detector can be used to scan for heat on the insulators and in the roof from a slow-moving vehicle. This can be effective when done regularly, but this method cannot detect impending failures between examinations. An insulator, integrally designed to give some indication of the presence of leakage currents, could be detected and replaced promptly.

Approach

Trolley systems in underground coal mines are diminishing in number as new mines opt for belt haulage and diesel power. Consequently, those mines still employing trolley and track for haulage tend to be older with a limited operational life. The haulageways in these mines must still be maintained, but there is little incentive from mine management's view for improvement. Wholesale replacement of system components such as insulators is simply not justified economically. Accordingly, any thermal indicating means for trolley insulators must be easily retrofitted on existing insulators. Also, it must be inexpensive compared to the cost of a new insulator.

To be effective in preventing fires, a thermal indicator must activate in the presence of leakage currents at the lowest practical temperatures. However, it must not react to other sources of heat, such as idling mine locomotives. Reliability dictates that it be simple in both design and function. Ideally, it should be a passive device that requires no external power to operate.

How It Works

The National Institute for Occupational Safety and Health (NIOSH), Pittsburgh Research Laboratory, designed a passive device to detect overheating insulators on mine trolley/track haulageways (figure 1). The hot insulator detector features a cartridge containing a spring-loaded streamer, which is brazed to an adjustable hose clamp. The clamp is installed around the insulator housing. When leakage currents cause the insulator to become elevated in temperature, heat is transferred via the clamp to the cartridge. Temperature-sensitive wax seals hold the spooled streamer in place. At the melt temperature specified for the wax, the spring ejects the spooled streamer out of the cartridge. Gravity pulls the nonconductive streamer downward, where air currents along the haulageway cause it to flutter noticeably. This design is



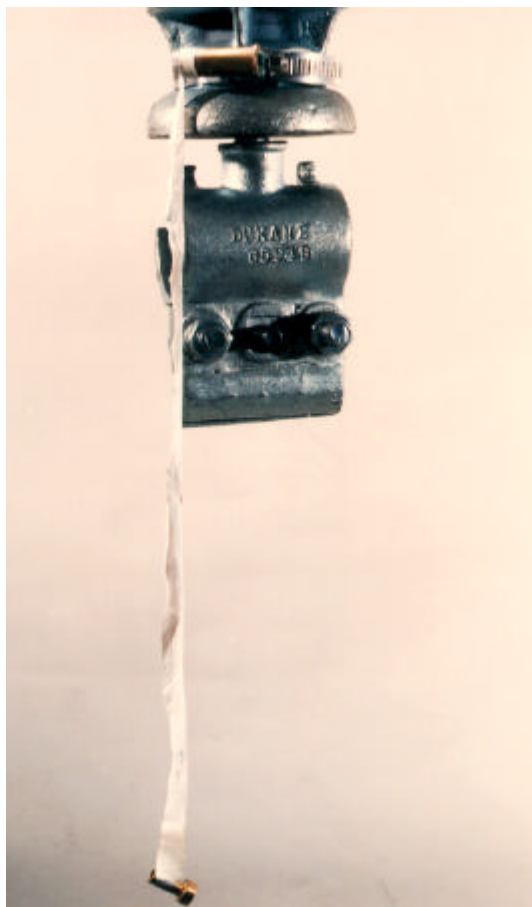


Figure 1.C Activated detector installed on trolley insulator.

simple and is easy to install on insulators in service. It has the potential to be inexpensive, while providing a recognizable warning signal to vehicles traveling the haulageway.

Test Results

The thermal indicator must react before heat generated by leakage currents through resistive paths can ignite nearby combustibles. These paths may be present on the surface of the insulator in the form of moisture and dirt. In the case of a cracked insulator, the resistive path for leakage current may be internal. In addition, heat may be generated in the roof as the current seeks to return to the grounded rail. To preclude ignition of coal dust accumulations on external surfaces of mechanical or electrical components, Title 30 of the Code of Federal Regulations imposes a 150 °C limitation. In addition, some dc trolley insulator manufacturers specify a maximum operating temperature of 121 °C. Due to thermal resistance, an indicator brazed to a clamp wrapped around the insulator housing will lag in temperature rise. Consequently, the temperature at which the device activates must be less than limitations imposed on the insulator housing.

Laboratory tests with heat sources above and below the insulator quantified this temperature gradient as 35 °C. For maximum sensitivity, the device activation temperature (the rating of the wax pellet) was chosen at 65 °C.

Additional tests gauged the reliability of the design. One hundred wax-sealed cartridges were mounted on an aluminum panel and inserted into an air oven. The temperature in the oven was gradually increased from ambient. Ninety-seven of the cartridges successfully ejected the Teflon streamer within ± 5 °C of the target temperature of the wax. An examination of the three that failed to activate revealed deformities in the brass cartridges that hindered spool ejection. Careful packaging and handling of the device should preclude this damage in storage and transit.

Condensation may form on underground surfaces during the summer months when warm, humid air is drawn into the mine. This moisture may cause sudden arcing across trolley insulators, especially on 600-V systems. Laboratory tests were conducted to determine if the thermal indicator would activate in the presence of an electrical arc and if the indicator would be damaged by the arc. The rapidly escalating heat of the test arcs activated the insulator detector nearly instantaneously. In some cases, the Teflon streamer remained intact after arc interruption. However, most of the time the arc energy severed the streamer and it fell to the ground. Consequently, the insulator detector is not effective in the case of an arcing trolley insulator.

Patent Status

An application for a patent on this device has been filed.

For More Information

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