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MULTIPLE FIRE SENSORS FOR MINE FIRE DETECTION AND NUISANCE DISCRIMINATION

Objective

To determine the effectiveness of multiple types of fire sensors for early and reliable mine fire detection.

Background

The National Institute for Occupational Safety and Health (NIOSH) has evaluated the effectiveness of multiple types of fire sensors for early mine fire detection and nuisance signal discrimination. Reliable early fire detection in underground mines can be hindered by false fire alarms produced by carbon monoxide (CO) and smoke particulate emissions from diesel equipment, welding, and metal-burning activities. Another false fire alarm source is the cross-interference of hydrogen (H_2) produced by battery-charging operations with a CO sensor's chemical cell. Workers can learn to ignore repetitious "false" alarms associated with these emissions. This jeopardizes their safety in the event of a mine fire.

Approach

An experimental mine fire detection program was begun at the NIOSH Pittsburgh Research Laboratory (PRL) to determine the effectiveness of combinations of multiple types of fire sensors for early mine fire detection and nuisance signal discrimination. Optical and ionization smoke sensors, CO sensors, and metal oxide semiconductor (MOS) sensors were used to collectively differentiate fire products-of-combustion (POC) signatures from nuisance emissions produced by diesel equipment, metal flame cutting, and the charging of battery-operated mine equipment. As part of this research program, coal, conveyor belt, electrical cable insulation, and diesel fuel mine fire detection experiments were done in PRL's Safety Research Coal Mine (SRCM) (see figures 1 and 2). An in-mine evaluation of the sensors in an operating coal mine complemented the research. Fire sensor alarm values for the smoke and MOS sensors were defined as a 10-standard-deviation change in the sensor's signal from its ambient value. The CO sensor alarm value was defined to be a 5-ppm increase above ambient. Systematic interpretation of the results was accomplished with the application of a neural network analysis program.

Results

Experimental results showed the clear advantage of smoke sensors over CO sensors for early mine fire detection. It was shown that smoke sensors could detect smoldering belt combustion smoke particulates long before alarm levels of 5-ppm CO were detected. In the presence of diesel emissions, an MOS sensor, which is sensitive to nitric oxides (NO_x), responded to smoldering coal and belt POC with a signal output indicative of a decrease in the sensor element resistance in contrast with an increase in the sensor element resistance associated with the presence of NO_x from diesels. It was shown in an operating coal mine that the MOS sensor can detect nuisance emissions associated with diesel equipment and acetylene torch cutting. Without the MOS sensor signal, the CO and ionization smoke sensor would identify these nuisance emissions as a fire. At a battery-charging station, several hundred ppm of H_2 produced a false indicated CO alarm value because of chemical cross interference in the CO sensor's chemical cell. Without the smoke sensor signal, the battery-charging activity would be considered a fire. A neural network was developed that was able to predict for the in-mine SRCM fire detection experiments the occurrence of a coal or conveyor belt fire in the presence of steady-state diesel emissions based on CO, MOS, and optical smoke sensor responses.

Recommendations

Multiple types of fire sensors, such as smoke, CO, and MOS sensors, should be implemented whenever possible to reduce the risk of nuisance fire alarms and provide early mine fire warning capability based on the expected fire and nuisance emissions sources. A rule-based system derived from the expected sensor responses could be implemented into a mine atmospheric warning system. To enhance miner safety, a smoke sensor should be used in a conveyor belt entry for early fire detection and at a battery-charging station to

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eliminate false chemical cell CO alarms. With the operation of diesel equip-ment in underground mines, a NO_x-sensitive MOS sensor can be used to discriminate diesel emissions and provide a positive indication of a fire. A combination of a CO sensor, smoke sensor, and MOS NO_x-sensitive sensor is one possible sensor combination for early mine fire detection and nuisance signal discrimination.

For More Information

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To receive additional information about occupational safety and health problems, call **1-800-35-NIOSH (1-800-356-4674)**, or visit the NIOSH Web site at www.cdc.gov/niosh

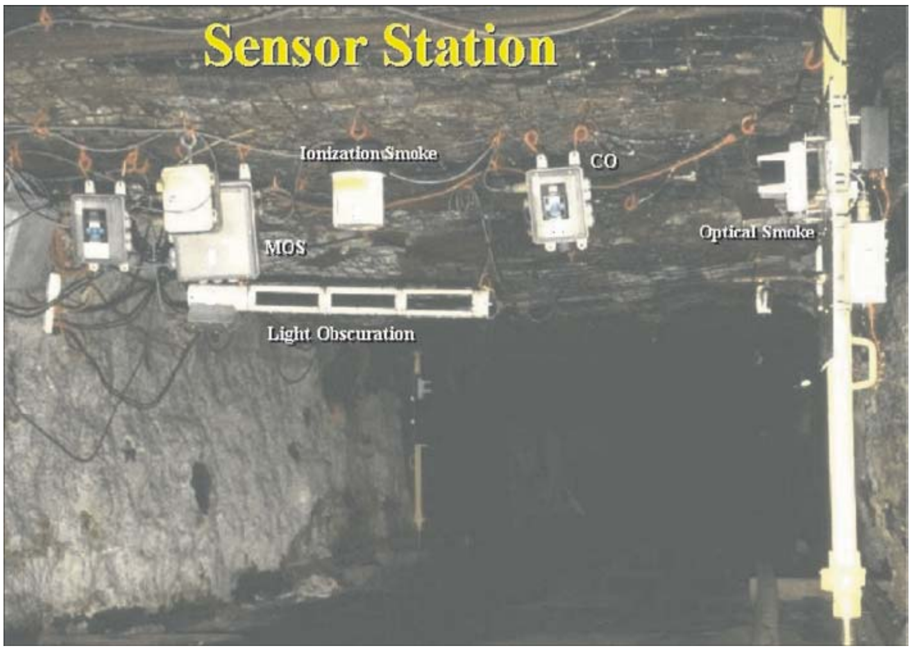

Figure 1.—Sensor station in the Safety Research Coal Mine.

Figure 2.—Smoldering coal fire test in the Safety Research Coal Mine.