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MSHA/OSRV

STOLAR Research Corporation

Mine Safety and Health Administration
Request for Information (RIN 1219-AB44)

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E. Communications

1. *What types of communications systems can be utilized in an emergency to enhance mine rescue?*

   A radio communications and tracking system must be capable of two-way transmission through the overburden, along conveyors and/or cables, through the coal seam, and in the passageways. The data rate is a few hertz per second through the overburden, thus requiring text messaging. The data rate increases to kilobytes per second along conveyors and/or cables, which enables fast text messages and/or voice communications.

   Most underground mining complexes have adopted pager telephones and/or more advanced multichannel telephone networks for place-to-place communications. Adoption and maintenance of telephone systems has been reinforced by 30 CFR 75.1600. Rescue teams employ a different communication facility for many reasons. Rescue communication networks must be intrinsically safe (IS) because mine ventilation systems are often disrupted in emergency situations. Rescue operations require communications between roving teams and the fresh-air base, as well as from one rescue team member to another.

   Designing an effective underground communications system is an extremely difficult science and engineering challenge. The predominant problem is the transmission distance limitation because transmit power must not exceed methane ignition limits. Although attenuation rates of the signals through natural media are significant, reflection losses occurring at air-media interfaces of contrasting impedance and antenna coupling losses also must be considered.

   A robust transmission network must be created for use in an underground mining complex that has a self-diagnostic and self-healing design similar to that of this nation's terrestrial and satellite communications systems. In these systems, the network control software automatically reroutes traffic when links in the network fail.

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2. *Current systems include permissible hand-held radios using small diameter wires, pager systems, sound powered telephones, leaky feeder systems that "leak" radio signals out of and into special cables, and inductively coupled radios that use mine wires as a carrier for radio signals. Are there other systems?*

   Leaky feeder and thin-wire-paired telephone systems cannot withstand most emergency events. The recent and past tragic history of underground mine disasters demonstrates that miners lose their lives because of a long list of limitations associated with each of these devices. A roving miner must be equipped with a multimode transceiver. The multiple communications modes must operate in a network.

3. *Should a particular system be required over another? If so, what system and why?*

   Radio geophysics adds an entirely new dimension to the surface telecommunications knowledge base. Any attempt to integrate well-established surface telecommunications equipment, any modified design of this equipment or knowledge directly into the underground mining environment will come up short. For example, leaky feeder cables, pair or multipair telephone cables, and 6-gauge wires are not robust conductors and cannot be used successfully as the backbone of a communications network. Communications systems that do not rely on these types of network backbones are required.

4. *What new communication devices or technology may be well suited for day-to-day operations and also assist miners in the event of an emergency?*

   Because of the limited number of electronics technicians employed by the underground coal mining industry, maintaining two different and/or independent communications systems is problematic. A single communications system serving both emergency and operational needs must be required by federal mine regulations. The performance of such a system being continuously tested through daily use in an operational mode is a significant advantage and safety enhancement.

5. *How should information be securely, reliably, and quickly transmitted during emergencies from remote locations to the mine rescue Command Center or from MSHA headquarters to District offices? What technology should be used to quickly and securely transmit information from the mine site to or from MSHA headquarters, to District offices, mining companies, and the media?*

   This problem may be unique to underground mining. The acoustic noise level near feeder breakers and diesel equipment exceeds the threshold of hearing by orders of magnitude. The U.S. Bureau of Mines Pittsburgh Research Center has struggled to solve this problem. Text messaging may well be the solution because prepared messages can convey a message without emotional distortion. These messages can be processed easily in secure code for communication between MSHA headquarters and District offices. The MSHA centers can be connected directly to the underground mining complex network.

6. *How can the number of relay points be minimized in a rescue situation so that communications do not get garbled or misunderstood?*

   Repeater transceivers can be drilled into the roof rock. A communications network can be designed to be self-healing if damaged. The direct result of allowing separate emergency or rescue and operational communications in U.S. underground mining environments is garbled and/or misunderstood messages.

7. *How can communications be improved if a rescuer is wearing a breathing apparatus and talking through a speaking diaphragm in the mask?*

   Adoption of text messaging capability solves this problem. The U.S. Navy has developed new technology for communications with subsurface divers. This technology can be augmented with vocoders to create text messages. Synthetic voice capability also may be a solution.

8. *PEDs are one-way communications devices that transmit messages through the earth to receivers that are carried by miners. PEDs are currently being used in 19 mines throughout the U.S. Should PEDs be used even though they can only transmit signals to miners and are not bi-directional?*

   The PEDs system exceeds the MSHA methane ignition limits by a factor of 300 times per mile of installed number 6 cable. Consequently, a PEDs system must be shut down when ventilation is disrupted in an underground coal mine. Therefore, PEDs systems often cannot function in emergency conditions. The PEDs primary signal illuminates electrical conductors, such as the three-phase power cables, conveyor belt structures, rail lines, and telephone cables, creating secondary electromagnetic waves of the opposite polarity. Interference will occur in roadways causing the PEDs receiver to go below the threshold and stop messaging. Emergency messaging to roving miners is unreliable. The problem is especially severe because the PEDs data rate is 2 Hz/sec and a message cannot be restored.

9. *Can PEDs be developed into two-way systems? If so, how long would it take and at what cost?*

   The PEDs system cannot be designed for two-way operation because of the self-jamming nature of the design. The PEDs 400-Hz waveform is highly distorted, producing radio frequency interference (RFI) that far exceeds limits established by the Federal Communications Commission (FCC). The PEDS system jams every sensing receiver in an underground mine.

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H. Developing New Mine Rescue Equipment

1. *What are the technological or economic problems in developing new equipment such as mine communications equipment or other mine rescue technology?*

   A major technological problem is that radio geophysics considerations predominate the development of advanced communications systems. U.S. universities with electrical engineering curricula do not offer a radio geophysics element. Other than West Virginia University and the University of Pittsburgh, radio geophysics is not included in mining engineering curricula. As such, the technical work force in the mining industry does not have the experience needed operate and maintain complex underground communications systems.

   Because mine rescue equipment must operate when the ventilation is disrupted, such equipment must be designed to achieve intrinsically safe (IS) and/or flameproof operation. Congressional pressure as well as the entrepreneurial spirit of equipment manufacturers will cause a deluge of IS applications submitted to the MSHA Triadelphia Certification Center. This surge of requests will further extend the already lengthy approval process, which places a significant financial burden on manufacturers of mine communications and rescue equipment.

   The nation's "easy-to-mine" coal beds are nearing exhaustion. New underground mines will be in deeper, thinner, and more geologically complex areas and will often be near long-abandoned mines. Coal mines are production organizations, not product development organizations. Consequently, manufacturers are likely to encounter extreme difficulty in developing and testing new equipment in realistic underground mine conditions because mine personnel have very little tolerance for experimentation and production interference. The simple approach developing an experimental mine will not significantly change the problem or the outcome.

2. *Do manufacturers of such equipment have problems making the equipment permissible for use?*

   Methods of designing to IS and/or flameproof requirements are not presently taught in mining engineering schools. Therefore, MSHA Triadelphia Certification Center engineers must effectively educate design engineers employed by mining equipment manufacturers. This situation makes the MSHA approval process quite long. The complexity and time required to obtain MSHA approvals translates into a high monetary cost for equipment manufacturers. Because the markets for MSHA-certified equipment are small relative to other telecommunications markets, there is an inherent disincentive for developing innovative, new products for the underground mining industry.

3. *What are the specific problems?*

   The main problem is the time, and thus expenditures, required to obtain MSHA approval for new equipment. A recent example is 37 months to obtain approval for a current tip circuit for use with a battery-powered instrument.

4. *Should the approval process for such equipment be streamlined or otherwise changed? Do current approval standards allow the flexibility for developing new technology?*

   The approval process should be fast tracked for key mine safety equipment that is selected by an MSHA technology review team. The IS requirement cannot be changed.

5. *How can equipment manufacturers be encouraged to invest in new technologies for mine rescue equipment?*

   Congressional action and/or promulgation of regulations mandating the functionality of certain mine safety products would encourage manufacturers to invest in developing technology to address such a market. Mature manufacturers recognize that legal liability is extreme for mine safety equipment. Communications or lack thereof during a mine emergency can easily become the focal point of a liability claim. MSHA should follow the U.S. Department of Defense procurement specifications, whereby manufacturers supply a product to meet certain specifications and, as such, are indemnified with respect to product liability. Governmental limitations on product liability as is done in the nuclear power and general aviation industries could remove some of the risk of manufacturing safety products for the underground mining industry.

I. Mine Rescue Teams

1. *What equipment should an effective team have?*

   Mine rescue teams need technology that enables them to determine the location of trapped miners from the surface as well as from within the mining complex under emergency conditions. Robust, two-way communications systems able to be operated in the absence of normal mine ventilation need to be available to rescue teams.

8. *Should any new technology be used to assist mine rescue teams at mine emergencies?*

   Mine rescue team members need communications systems that allow them to communicate with each other while in the underground mining complex.

J. Government Role

1. *What equipment and technology should be promoted to improve mine rescue?*

   Tracking systems for locating trapped miners from the surface and from within the underground mining complex should be promoted. Deployment of robust and redundant two-way communications systems operable in instances when a mine ventilation system is disrupted during an emergency should be encouraged. Intrinsically safe and/or flameproof-compliant equipment can improve mine rescue operations. Communications equipment that operates within the RFI limits established by the FCC is important so that clear messages can be sent and received.

3. *How could our standards and implementation regarding mine equipment and technology be improved?*

   Radio frequency interference levels should be regulated. Wireless communications and tracking systems need to be mandated in place of the current 30 CFR 75.1600 and 30 CFR 49 requirements.

5. *What non-regulatory initiatives should we explore?*

   Financial incentives (e.g., tax credits) for the mining industry for the purchase of qualified mine safety and rescue equipment, installation of such equipment, and training of appropriate maintenance personnel. Research and development (R&D) tax credits to encourage the development of innovative mine safety and rescue equipment. Financial incentives for mining companies to allow in-mine testing of newly developed mine safety and rescue equipment.

6. *What further steps should we take to improve the capability, availability, and effective use of mine rescue equipment and technology?*

   Maintaining communications and/or tracking equipment that has very limited range in an ever-changing underground mining environment is a major challenge. Most maintenance personnel will have difficulty maintaining two separate operational and emergency systems. All of the communication assets of the rescue team must communicate with roving miners during the first few minutes of an emergency event. There is insufficient time to deploy separate mine rescue equipment in most instances.