MINE COMMUNICATIONS

An Overview of the Bureau of Mines Communications Research

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ABSTRACT

Since 1969, the Department of Interior, Bureau of Mines, has carried out communications research. Research has been directed toward developing emergency and nonemergency mine communications. This paper gives an overview of the progress made in the last two years. Particular emphasis is given to the overall program, noise and signal measurements, systems studies, guidelines, products, and demonstrations now being carried on in operating mines.

INTRODUCTION

Presently mine communications consists of loudspeaking- or paging-type telephones or alternatively, magneto ringing telephones; in either case all phones are on a common party line with one telephone for each working section and additional phones at other key locations, such as maintenance shops, both underground and on the surface. While a few mines have begun to use dial-type telephones underground, their use to date has been very limited. Additionally, rail transportation systems are typically equipped with carrier current phones to provide communications between vehicles and between vehicles and a central dispatcher.

While there have been qualitative indications that mine communication systems need improvement, the exact nature and the extent of the modifications required have not been precisely defined. The Bureau of Mines has undertaken a program to specifically define the areas where improved technology and techniques can be of benefit to the mining industry, and through a Bureau/contractor team, various mine communications systems are being developed and, with the cooperation of the mining industry, are being evaluated in underground coal mines.

THE RESEARCH PROGRAM

The Bureau has developed an approved mine operating/emergency communications system complete with simple monitoring and a means of communicating with trapped miners. The system is installed in the Bureau's Safety Research Mine at Bruceton, Pennsylvania. Simultaneous with this inhouse program, the Bureau developed a contractor program. The contractor program includes other government agencies, universities, private companies, and mine operators. The contractor program has resulted in reports covering (1) electromagnetic noise and propagation measurements within operating mines; (2) survey of existing mine communications systems; (3) theoretical and analytical studies of particular problems in mine communications; (4) a program for the preparation of guidelines for mine communications; and (5) new products for underground communications. At this seminar we will be reporting on a new mine carrier phone using frequency diversity and a new mine communications system using coaxial cable.

MEASUREMENTS

The experimental in-mine measurements cover the spectrum of interest for electromagnetic communications. As would be expected, the electromagnetic noise follows Murphy's Law: At very low frequencies, where propagation is independent of the mine openings, noise is greatest; and at higher frequencies, where propagation is forced to follow the mine openings, the noise is minimal. It is of interest to note that about 30 years ago when the Bureau of Mines determined the frequency of the trolley wire communications, they selected the area of 100 KHz This frequency is a tradeoff between the electromagnetic noise and the electromagnetic propagation efficiency.

Mine wireless communications are highly desirable. Measurements at the ultra high frequencies indicate the following significant propagation characteristics: (1) Attenuation in db increases linearly with increasing distance; (2) horizontal polarization produces significantly lower transmission loss at a given distance than does vertical polarization; (3) transmission losses decrease significantly at a given distance as the frequency is increased from 200 to 1,000 MHz. As an example, with both transmit and receive antennas vertically polarized, attenuation in db per 100 feet is 25, 6, and 4 for 200, 415, and 1,000 MHz, respectively; (4) signal attenuation immediately around a corner is considerable at all frequencies and is about 25, 17, and 14 db for 200, 415, and 1,000 MHz, respectively; and (5) complete signal depolarization is observed around the corner.

SYSTEM STUDIES

To more specifically define the problems within mine communications systems, surveys have been taken in underground mines to determine the key operational parameters, namely (1) the time to reach key personnel underground; (2) the traffic density or availability of phone lines as a function of time during the working shift; and (3) reliability and/or maintainability of the existing communications equipment. Surveys have consisted of full-shift monitoring of mine telephone lines and carrier current rail haulage communication circuits, followed by detailed analysis of these recordings to ascertain if there are particular problem areas. As an example, the results from a survey of a 4500-ton-per-day mine indicate that the maximum use of the mine telephone was 49 percent of the time during the second hour of the shift. During quarter-hour periods there were times when the system was used 71 percent of the time. With this kind of a system there is a 30 percent chance of finding a busy signal on a given call. This is considerably worse than the one chance in a thousand which is the standard for commercial telephone circuits. It is estimated that a six-channel phone system would be required to bring the system to commercial standards.

Further examination of data reveals that the duration of a given call or an attempted call is very short. For many mines of this size the survey shows that the average time to reach key personnel underground is about 30 minutes. In case of emergency this time may be invaluable. In terms of operational efficiency the cost of a high-production section may be $700 an hour; hence, if a maintenance foreman is needed, his value to the total operation can be rather significant and the need to reach him promptly cannot be overstated.

In the same mine the carrier current phones, which are used primarily for dispatching of vehicles on the haulageway, were found to have a probability of being busy approximately 10 percent of the time. However, because these phones serve as a safety control system for the traffic on the haulageway, it is not deemed advisable to provide additional channels.

Existing equipment was found to be operational; however, the quality of the audio was often less than desirable for intelligible communications. In one particular system the lack of intelligibility was traced to improper alignment of the trolley wire phones. In another case the trouble was traced to phone line grounding which was causing extensive hum on the mine phone system.

GUIDELINES

The Bureau in the past has mostly restricted itself to the approval of communications equipment on the basis of permissibility. Other industries have developed standards relative to communications equipment, design, operation, and maintenance. The mining industry needs similar communications guidelines, and the Bureau is presently developing guidelines for the mine telephone system. Guidelines will be established for the installation , maintenance, and tests of wired mine communcation systems using the magneto- and pager-type mine telepnone equipment The guidelines will cover such aspects of the system as the mounting of phones, the hanging of cable, selecting wire and cable, care and service of handsets and hook switches, checking of batteries, measuring of signals, and instructions for inspectors to be used in the examination of an operating system.

Consideration will be given to the test equipment required to check battery status, phone line impedance characteristic, phone line and/or equipment grounding, signaling, message handling capabilities and other system and equipment characteristics that need to be checked to ascertain that the phone system is operational and can be depended upon in the case of an emergency.

After completing guidelines for the mine telephone system, additional guidelines will be prepared for the trolley wire phone system.

NEW PRODUCTS

During the past two years the Bureau has had developed the following new communication products for the mining industry: (1) Trapped miner locator transmitter; (2) trapped miner portable receiver; (3) trapped miner helicopter-borne receiver; (4) call alert paging transmitter; (5) call alert paging receiver; (6) belt box page phone; (7) frequency diversity trolley wire and hoist rope phone; (8) mine telephone to public phone interconnect; (9) carrier phone to wireless radio interconnect; and (10) mine communications and monitoring phone for coaxial cable. A contract is now underway to develop a wireless radio system capable of communicating 1350 feet between two roving miners. A portable transceiver and a repeater are being developed.

DEMONSTRATIONS

New phone systems are being installed, not only by the Bureau of Mines but by mine operators. During this seminar, papers will be presented on (1) new communications center for Ohio Valley Division, by Randy Fizer, Ohio Valley Division, Consolidation Coal Company; (2) a permissive dial/page telephone for coal mining communications by Ken Betch, Gaitronics Corporation, George Trace, Southern Ohio Coal Company, and Paul B. Day, Gaitronics Corporation; and (3) a

new whole-mine communications system by John Combellick, Collins Radio Company. As indicated in the Bureau systems study, each of these systems has multiple channels. The paper by John Combellick describes the system the Bureau of Mines will be demonstrating at U.S. Steel's Robena complex. This is a whole-mine communications and monitoring system. The phone line is a 7/8-inch coaxial cable. The phones are novel--there is a pushbutton dial and a private-line capacity for 100 simultaneous phone conversations. The phones are designed to reach individuals. When the phone is rung, an electromagnetic call alert signal is transmitted to the individual being called. Each key person has his own call alert receiver. Special haulageway phones have CO monitoring, and section phones have CO, methane, and air ventilation monitoring. Air split phones have extensive monitoring in the fresh air and the return air. You will learn about the system from John Combellick.

The Bureau, in the coming year, will also be demonstrating a mine communications system for mines producing less than 400,000 tons per year.

CONCLUSIONS

Techniques and technology are available to overcome many of the operational problems of underground mine communications. These techniques are being reduced to hardware that will be usable for the mining industry. The problems of underground mine communications can be solved; this paper presents a variety of concepts that have been developed and experimentally evaluated in mines. No single concept provides a universal solution, but hybrid systems which address all problems can be and are being implemented. In the course of this seminar, this section and the section to follow, you will learn more of the details of the advances in mine communications.