PART SIX

FIELD UTILIZATION OF SEISMIC SYSTEMS

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PART SIX

FIELD UTILIZATION OF SEISMIC SYSTEMS

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I. SUMMARY

Proper design characteristics for a seismic system to locate miners during a mine disaster are considered in terms of a total system concept. Field hardware, processing equipment, operating personnel, deployment, training, and supportive R and D are necessary elements of the total system. Each of these elements is discussed and an indication given as to the requirements necessitated by each one.

Hardware must be portable, rugged, and fieldworthy. Processing equipment must be simple to operate, expandable for future processing improvements, and ruggedized for field use. A small well-trained team must be available for quick response in times of emergency. Alternative deployment procedures are necessary to allow for a variety of situations including both ground and air delivery. Supportive R and D is used to support training and upgrading of the system.

II. INTRODUCTION

Here we discuss a set of design characteristics that would result in an improved seismic system for miner location following a mine accident. The system, when implemented as proposed, will be an adaptable multi-purpose seismological array packaged in hand-portable sized containers for use under severe field conditions. The system will be capable of monitoring up to 12 individual sensors, recording on magnetic tape, providing visual displays, and accomplishing some data processing and analysis.

In selecting individual items, great emphasis should be placed on the use of equipment which has been design tested and proven under operational field conditions. Special design modifications should be used only as required to meet special needs of remote and severe field operations; for example, the use of modular-type moisture-proof-container packaging for seismometers and field amplifiers.

In order to specify the design of this equipment, it is necessary to assume the following:

1. Optimum location accuracy requires calibrated and timed signals.
2. Power may not be obtainable at the various remote locations where the system will be deployed.
3. Measurements will be made under field conditions where electronic test and repair facilities are not readily available.
4. Emergency conditions will exist at the time of deployment and quick response is absolutely essential.
5. Personnel making the measurements must be able to evaluate the data within a short length of time.
6. The system should be expandable to meet future requirements of improved analysis.
7. Maximum use of off-the-shelf components.

To operate under these assumptions, the system should have the following features:

- The basic system should contain an accurate calibrating device. The calibrator should apply an impulse of known polarity to verify seismometer polarity, and sine waves of known amplitude at any desired frequency to the seismometer calibration coil to obtain a frequency response at a known gain.

- The sensing system should be a vertical seismometer-amplifier combination capable of direct burial. The seismic signals would be fed to a recording and processing system powered by the same source powering the amplifier.
- Monitoring and field analysis will require a playback unit capable of producing the data at either .5mm/ms or 1.0mm/ms on a paper strip recorder. A monitoring oscilloscope should also be provided.
- The tape recorder should be able to record up to 12 channels of data plus time and compensation channels. A time code should be encoded on the tape. Additional design provisions should be made for inserting operational amplifiers, modules, attenuators, and filters as desired.
- The whole system should be as compact and lightweight as possible, and sufficiently rugged to withstand transport under the worst field conditions. Simplicity, mobility, ruggedness, and ease of setup and operation are prime design goals.

III. REQUIREMENTS

To minimize the interference of nearby cultural (man-made) and weather-induced noise, seismic surveys usually employ either seismometer burial or small array techniques. In the mine disaster case, the rescue team will often be hampered by the absence of favorable surface geology at the points where the particular deployment must be made. Of the two possible techniques, seismometer burial appears to be the simpler solution. A seismometer capable of operating at shallow depth will enable the rescue team to pick any desired point for measurement and then drill (possibly with a hand auger) until reaching some suitable foundation materials. Even at the shallow depths reached by hand drilling, the seismometer should have a considerably reduced response (compared to a surface site) to locally induced cultural noise (seismic and acoustic). In addition, if relatively solid foundation material can be reached, some signal attenuation may be avoided.

In many situations, the simplest, most direct method to determine a location will be for the operator analyst to read relative signal arrivals from the individual array elements. Being able to record such signals from each element of the array on an identical, selectable time basis will greatly improve the operator's

response time and the precision of the location. The sought-after objective is the ability to record under any field conditions with a completely independent portable system capable of highly accurate, dependable results.

It is proposed that both the seismometer and amplifier be packaged in the same case. This will result in a single, easily transportable instrument package that can be placed in a constant environment away from molestation.

The time encoder should be a highly accurate digital device capable of providing several different frequency standards in order to broaden the overall capability of the system. Of particular importance is a 100-Hz signal on the compensation trace. This frequency is then used as a reference to obtain an accurate time-based playout in high speed visual reproductions.

A properly equipped field analysis and processing center is essential if rapid response and adaptability are to be provided to what will surely be a fluid situation. During the course of a location attempt, it will frequently be necessary to make judgments regarding seismometer emplacement and coupling, noise characteristics in the area, transmission quality, and signal reception. Thus, it may be necessary to vary bandpass filters and apply other processing techniques. For this reason, inclusion of a playback unit in addition to a monitoring oscilloscope is necessary.

The package for the filters, attenuators, and operational amplifiers should be designed with plug-in cards to provide for rapid changes in the data circuits.

Power will be provided by public power facilities when available; however, battery backup should be provided to maintain system operation if the primary power source fails or if a primary source is not used. The battery pack should have sufficient capacity to maintain operation for at least twelve hours. A battery charger should be included to recharge a fully discharged battery bank within two hours.

All interconnecting cables should be prefabricated. Connections should be waterproof and should be designed so that improper connections cannot be made. System cabling should be designed for maximum portability.

Sufficient accessory items like hand tools, test equipment, and spare parts should be carried to and from the field by operating personnel. The accessory kit would possibly include its own power supply so that the operation of this equipment would not use power from the principal source.

A well-coordinated field exercise is impossible without reliable communications. This factor is paramount where time is a critical factor during an emergency. To meet this need, special radio communications can be provided as part of the total system to assure efficient operation of the crew.

Major attributes of a field system which have to be emphasized are ruggedness, simplicity, portability, and reliability. While there need not be a one-to-one correspondence, useful guidelines for the criteria to be placed on a field system can be obtained from Military Specifications for field equipment. The cost of a field system is likely to be on the order of $100,000.

The crew required to operate the seismic detection and location equipment must be considered a part of the total system. As much care and attention must be given to the selection and training of the team as to the design and construction of the equipment.

IV. OPERATIONAL PERSONNEL

To successfully perform under emergency conditions, the seismic detection and location equipment (SDLE) must be manned by a team trained and experienced with its deployment and use. As a minimum requirement, a three-man cadre trained to work together who are completely familiar with all phases of the equipment and its operation should be available to deploy the SDLE in the event of an emergency. Additional men needed to expedite the setup and calibration of the equipment could be provided by the mine company involved in the disaster.

The three-man cadre would consist of the following:

- An operator/analyst (team chief)
- An electronic technician(second in command)
- A field technician

The team chief should be a geophysical engineer or someone with an equivalent background whose responsibility includes interfacing with the disaster/rescuer coordinators (mining and/or Government officials), deploying the SDLE, and making final processing and location decisions. He should be a mature individual who is thoroughly familiar with mining operations and practices. The overall success of the mission will depend on his ability to preserve the integrity of the whole team and to direct its operation in a confused situation.

The electronic technician should be qualified and trained to set up and operate the entire field system. He must be able to troubleshoot and repair most system electrical and mechanical malfunctions or failures. In the absence of the team chief, he will substitute as data analyst.

The field technician should be experienced in geophysical field work and capable of directing the efforts of temporary field workers acquired on site. He must be familiar with the use of hand portable and light drilling equipment. His principal responsibility will be to install the seismometers, lay cables, and assist in setting up the analysis center.

Training and practical experience in the use of the seismic equipment are the keys to successful field operations under emergency conditions. Selected personnel should be trained to operate as a team and, as such, be deployed on "operational" missions several times a year. As many of the pressures associated with a real disaster as possible should be simulated during these training excercises.

V. DEPLOYMENT OF SYSTEM

Transportation from the staging area to the field presents special problems. Emergencies may occur at any time and in the most remote areas. Several different contingency plans are necessary to meet the demand for rapid deployment. For use near the staging areas, a suitable four-wheel-drive truck should be available. The truck should be outfitted with appropriate racks and accessory gear such that the field equipment could be installed within one-half hour and dispatched to the field. In addition, the field equipment should be so packaged that it could also be hand portable or cart portable for air movement by either commercial or private aircraft. Consideration should be given to the use of contract or military helicopter for direct delivery to the field site. On delivery to the field, a truck might be made available or the packing crates used to form the analysis center enclosure.

VI. SUPPORTIVE R AND D

Field R and D should serve two purposes. Each R and D field trip could start as a training exercise to improve the performance of the team and to expose areas of weakness or deficiency in the operating procedures. The second objective would be to test a new procedure or possibly gather data to evaluate some point of theory. Certain ideas suggested elsewhere in this report need clarification and evaluation. For example, more data are needed to estimate the calibration range and absolute location accuracy associated with the reference event technique, signal attenuation through various media, calibrated noise measurement for optimization of signal passband, and efficiency of signal generators.