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"New Technology provides Effective Communications for Underground Rescue Operations"

by

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New Technology provides Effective Communications for Underground Rescue Operations

This feature describes the introduction of a new underground communication system designed for underground rescue operations. Known as the "m-Comm" system, it employs a light-weight guide wire which can be payed out over considerable distances by the rescue team. A member of the team simply needs to clip on a handset to the wire to talk.

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By its very nature, underground mining can be a hazardous activity. The history of all countries where mining has taken place is unfortunately punctuated by major disasters. Even in recent years there have been numerous incidents world-wide which serve to remind everyone of both the need for continuing assessment of the hazards inherent in mining and the vigilance to identify changes that can, and do, take place in the underground environment. Table I lists just some of the underground mine incidents which have occurred world-wide over the last six years, and which have resulted in multiple deaths.

Table I Examples of mining disasters over the last six years which have resulted in multiple fatalities.

Year	Name of Mine	Incident	Number of Fatalities
1992	Kozlu, Turkey	Explosion	262
1992	Westray, Canada	Explosion	26
1992	South Mountain No 3, USA	Explosion	8
1993	Bilsthorpe, UK	Fall	3
1993	Middelbult, South Africa	Explosion	53
1994	Moura No 2. Australia	Explosion	11
1994	Koorufontein, South Africa	Fire	16
1998	Skochinsky, Ukraine	Explosion	63

The successful initial control of such incidents is crucially dependent on the effectiveness of the mine's immediate emergency response, and the mine's emergency preparedness arrangements which underpin this response. Experience has shown that in many instances of a major fire or explosion occurring underground in mine workings, the primary factor which has ensured the survival of those persons

affected has been the effectiveness of self rescue measures and the quality of training in their application. Thereafter, with every practicable measure taken to ensure self rescue, any further help must come from the mines rescue organisation in place. Inevitably, such tragedies emphasise the continuing requirement for, and the availability of, an adequately resourced mines rescue capability. The mines rescue organisation may be required:

1. To locate and rescue the underground workforce;
2. To locate and seek control of heatings or fires so as to minimise or eliminate their effect on the underground environment, and
3. To permit safe re-entry and subsequent recovery of mine workings.

This short article examines the part that underground communication plays in maximising the effectiveness of a mines rescue team's efforts in carrying out this role, and in ensuring that their activities are undertaken with the lowest possible risk to everyone concerned. Experiences with a new communication system, recently introduced by the UK's Mines Rescue Service and which is seen as having a major impact on performance, is outlined.

The Incident Situation

Time is the most crucial element affecting a successful rescue. In the first instance, the mine emergency plan will kick into action and there will be a rapid switch by the mine's organisation from production duties to incident management and control. The gathering of information and its rapid analysis is of paramount importance from this time onwards. The rescue team, on entering the mine, will need to confirm the location of a fresh air base as close as possible to the incident, consistent with reliable ventilation to the base and a secure means of egress. The fresh air base must have adequate space and communications through to the surface. Under most circumstances, the siting of the fresh air base and the expected location of casualties will be discussed in the team briefing conducted on the surface with the incident management team prior to entering the mine. The first team will want to rapidly progress from the fresh air base in order to locate and attend the casualties. In this phase of the operation, effective communications with the team are essential, both to reduce the risks the team are exposed to, and to brief and prepare the back-up teams for entry.

Maintaining communication with the rescue teams thereafter is imperative. They may be entering an irrespirable atmosphere which may have very high levels of heat, humidity and smoke and the team's own safety is of the highest priority. The rescue team will usually comprise five members, and there is, of necessity, a need to carry a substantial amount of equipment, some of which will be essential and some of which will have been selected to deal with the expected incident situation. This includes the following: Closed circuit breathing apparatus, long duration chemical self-rescuers, gas detection instruments, communications equipment, first-aid kits, resuscitator equipment, stretchers, fire-fighting equipment, safety lines, ropes and other tools. Clearly, savings in equipment weight are paramount. In hot and hostile conditions, the safe wearing period for breathing apparatus will be substantially less than the nominal duration of two to four hours specified for most closed circuit sets. In extreme cases, safe wearing times may be as little as 20-30 min beyond which there is a rapidly increasing likelihood of heat stroke and exhaustion. Under these circumstances, communications between the teams and their fresh air base can almost be as important as the life support equipment that

the teams wear.

There have been numerous incidents recorded where effective communication between the fresh air base and rescue team would have avoided or mitigated potentially dangerous situations. The majority of past underground emergencies have been accompanied by poor visibility, damaged infrastructure including communications, and other unknown dangers resulting from the original incident. One such example is the Michael Colliery fire, Fife, Scotland on 9 September 1967, where rescue teams were sent into smoke-filled roadways with nil visibility to locate missing persons (fig. I)

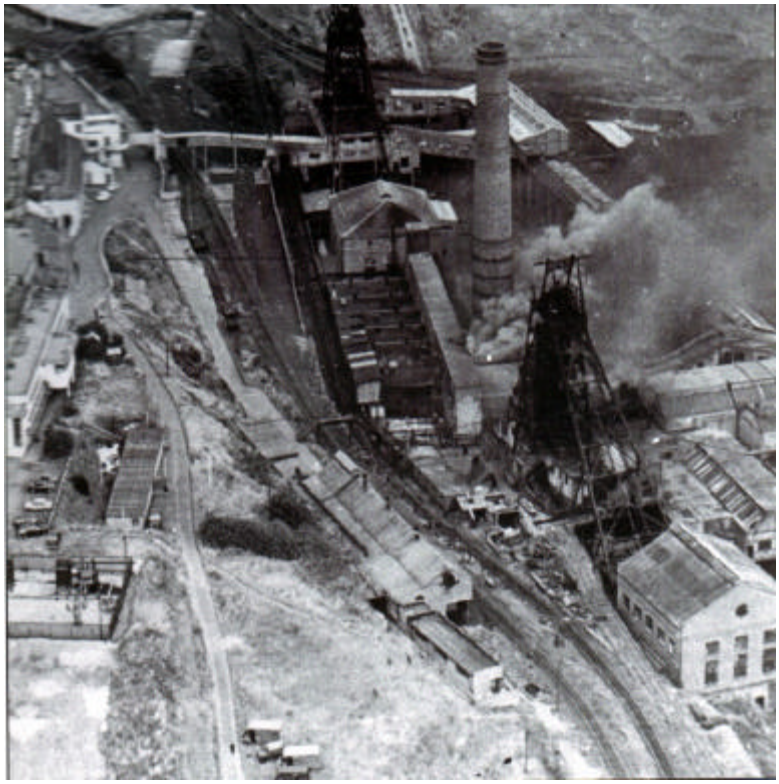

Fig 1

The fire at Michael Colliery in Fife in 1967 caused major problems for the rescue teams who lacked effective communications. The rescue team vehicles are at the bottom left of the illustration. Smoke is to be seen billowing from a ventilation shaft.

The seat of an intense fire was located near the shaft bottom and consequently thick black smoke had filled most of the districts where men were believed to be. At one stage, four to five hours into the operation, conditions had worsened so much that a second rescue team was deployed to recall the first team. The fire had put the telephone exchange, located near the shaft bottom, out of action, and there was no means of communication and hence knowledge of the whereabouts and condition of the first team. Fortunately, both teams returned, but this incident illustrated the requirement for effective rescue team communications.

Other notable UK mining incidents include the Houghton Main (1975) and Lofthouse (1973) disasters in Yorkshire. In the Houghton Main incident, the inbye automatic telephone system was badly damaged by the explosion, and communication between the fresh air base and incident control room was conducted over an unreliable Tannoy system for nearly 12 hours. This impeded the rescue work and was a subject of consideration at the subsequent Inquiry. In the Lofthouse Colliery disaster, seven men were killed due to an inrush of water from old workings (fig. 2).

Fig 2
The aftermath of the inrush of water into Lofthouse Colliery in 1973. The picture shows the blockage in the South 9B District main gate. All the telephones in the large section of the mine involved were on a one-party-line extension which became hopelessly blocked. (Crown Copyright, HMSO, loaned from National Coal Mining Museum for England).

This incident highlighted the limitations of the telephone system, where all the telephones in the large section of the mine involved were on one-party-line extension which became hopelessly blocked. This led to a complete reappraisal of telephone technology used underground in UK mines.

In an extensive or protracted underground incident, there may be a need for several rescue teams with many wearings of breathing apparatus. Hot and stressful conditions greatly reduce wearing times and the total number of wearings teams can have. This makes it essential that logistics and communications are to a high order. Tackling major mine fires or inaccessible heatings inevitably leads to the construction of substantial seals or stoppings to isolate the area affected. These efforts may require many man-hours working under oxygen with logistical problems of distance, materials and equipment transport. In multi-entry workings, the problem may be further exacerbated. There may be high methane levels and possibly hydrogen evolved from the dissociation of steam at extreme temperatures. For any electrical communication system to be used safely under these circumstances, it needs to be certified intrinsically safe to the highest standards.

Communications — Past and Present

There have been many attempts to improve communications between a fresh air base and a rescue team. Before the advent of a full face breathing mask, the mouthpiece in use prevented speech. As a result, surviving telephones along rescue routes could only be answered with coded bleeps or whistles. When full face masks did finally replace the mouthpiece in breathing apparatus, transportable voice communications systems using intrinsically safe field telephone/intercom type equipment were introduced. These utilised large drums of twin-core cable. These systems can perform satisfactorily but have a major problem in that the cable reels are very heavy and can constitute a major part of the weight of equipment that the rescue team must carry. These systems also require slip-ring cable drum connections, and a number of interconnecting plugs and sockets which can compromise operational integrity. For a rapid response rescue team, the systems lacked portability and range. The UK Mines Rescue Service, recognising the less than ideal state of their rescue communications, embarked on a feasibility study and development of a purpose-designed communications system which would not depend on the existing colliery infrastructure, and which would be light-weight and simple to deploy.

An intense three-year development programme, in association with research staff from the IMC Group, resulted in a fundamental re-think in portable underground communications. The new system, 'm-Comm', is a marriage between the convenience of a portable radio and the predictability of a telephone line (fig. 3).

Fig 3
The m-Comm equipment comes housed in a compact carrying case.
(Photo courtesy of Dr R. Jozefowicz)

The simplicity and flexibility of the final system is readily appreciated from the schematic diagram shown in Fig. 4. The results from tests at a variety of mine and surface rescue simulations involving rescue teams wearing full breathing apparatus confirmed that the new system offered significant benefits over the traditional system. The use of advanced low frequency inductive communications technology offers the possibility of communications at any point along the guide wire between the base station and the hand portables. Of particular benefit, is the lightness and compactness of the system and its ease of use, and the range, typically five kilometres or more (the equipment has been used recently to provide communications over a distance of 8 km).

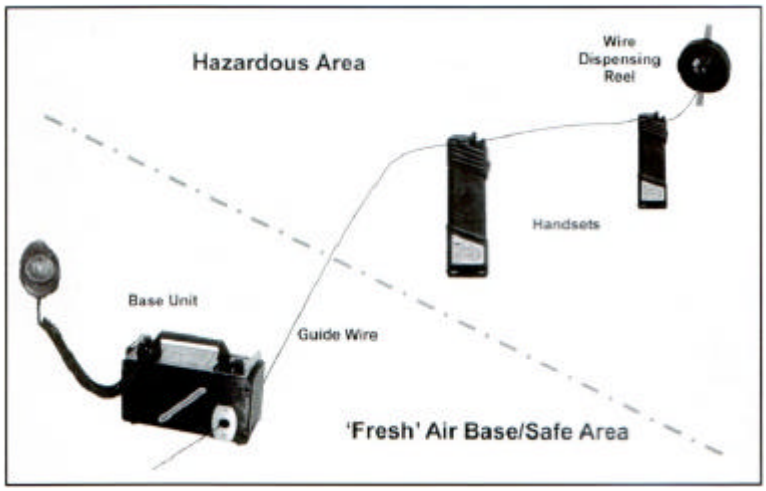

Fig 4
This schematic diagram shows the arrangement of the m-Comm equipment in an underground rescue situation.

The m-Comm equipment is simple to use and can be set up anywhere in minutes. To deploy the equipment, the rescue team simply pays out the guide wire as it advances and clips on the handset to the guide wire to talk (fig. 5 and 6). The base station unit has a number of additional built-in features compared with the smaller, robust handset, such as the generation of a link integrity checking signal every 15 sec, which provides a reassuring comfort bleep to the rescue team, confirming that the line back to the fresh air base is intact. The equipment fully complies with the certification and approvals required for use in UK coal mines under emergency conditions. The base station has been certified to methane standard and the handheld units, used by the rescue team, are certified to hydrogen standard. Sets of this new equipment have now been supplied to each of the six Mines Rescue Stations in the UK. Each set comprises a base station, three handsets, a reel dispenser, reels and wire, providing a fully self-contained communication system suitable for use in a wide variety of circumstances.

Fig 5
Members of a rescue team demonstrate how the m-Comm handset is clipped to the guide wire.
(Photo courtesy of Dr R. Jozefowicz)

The m-Comm handsets only weigh 700 gm and achieve voice communications via a life line weighing no more than 6 kg per km. The one PP3 type battery in the handset lasts for over eight hours, which is matched by the base-station battery life.

With the introduction of reliable, flexible underground rescue communications and the logistical advantages which this provides, it raises a number of interesting questions over the rescue practices which may now be considered. For example, it may now be feasible for a team member to stay with a casualty where communications with the fresh air base and other team members can be maintained. Similarly, it is possible to anticipate more than one team being dispatched from the fresh air base, with communications being used to manage their interaction and ensure that effective coverage is maintained at the site of the incident. Its range is sufficient so as to enable it to be "reeled out" from the surface in the case of mines with drift access, with the base station in the surface incident control room.

This new communication system has already been used in two recent extended underground incidents following an explosion of methane gas at one mine, and a serious spontaneous combustion/heating problem at another. In both instances, the system proved reliable, flexible and robust when used in conjunction with remote cement pumping stations during the construction of roadway stoppings. It has also been utilised in underground sewers and water tunnels and in hazardous surface confined space working environments.

Fig 6
Speaking into the handset.
(Photo courtesy of Dr R. Jozefowicz)

Conclusion

Voice communication between individual members of a rescue team and between the team and its "fresh air base" became possible with the technical advances made which enabled a full facemask to be used. The development and successful introduction of the m-Comm portable radio/telephone has been yet another significant step forward in the application of modern technology to the difficult and hazardous tasks often faced by mines rescue teams. Its introduction will invariably result in improved safety for the team and improve their own ability to carry out their intended role.

It should be remembered, however, that the human factor in communication needs to be addressed as well as that of a technical nature. The rescue training discipline instilled into mines rescue teams is recognised and widely admired by everyone involved in underground mining.

Care must be taken to ensure that this is not jeopardised by decisions made by others, based on the misunderstanding of reports and instructions conveyed by the rescue team itself. As ever, frequent practices involving liaison with rescue and mine incident management teams will go some way towards preparing everyone concerned for such an experience should it ever occur.

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