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Emergency escape systems

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Emergency Escape Systems

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ABSTRACT

The Inquiry into the 1994 accident at Moura No. 2 Colliery included in it's findings that mine escape and rescue options for persons in underground coal mines were in need of review. The Inquiry recommended the establishment of industry working groups to report to the Queensland Chief Inspector of Coal Mines on matters including escape strategy and life support for escape from mines.

One of these task groups examined issues relevant to self-escape from Australian underground coal mines and formulated recommendations and guidelines in response to the terms of reference and scope.

A similar working group was also established in NSW by the Chief Inspector of Coal Mines to provide guidance notes for underground emergency escape systems.

This paper covers the major points arising from the work of both the Queensland and New South Wales working groups and the results of a study of overseas escape strategies that was undertaken by the NSW working group.

ESCAPE STRATEGY

Evaluation of the various factors involved identified a number of major elements that need to be addressed in the development of an emergency escape system to enable persons to escape safely from a mine following a mine fire or explosion.

Some of these elements are:

- Early Warning
- Self Rescue Apparatus
- Communications
- Guidance Systems / Lifelines
- Escapeways / Transport
- Refuge Chambers / Changeover Stations
- Training of personnel and
- Safety Management Plans for Evacuation

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The escape of persons underground will be enhanced by the use of a planned strategy that has been developed giving due consideration of these elements and recognition of the potentially difficult circumstances a person could encounter following an incident. Importantly the strategy will include the realisation that the mobilisation of rescue personnel could take time or may not be feasible due to the presence of potentially explosive or toxic atmospheres. The initial reactions of persons underground to an incident situation are a significant determinant on their survival. Planning, preparation and training for such emergencies are essential components required to improving the likelihood of survival.

EARLY WARNING

The role of an early warning system is to sense the first signs of fire or explosion and communicate an alarm so that evacuation of the mine or part of the mine can take place. Control measures taken at the earliest possible time would allow egress through reasonably smoke free escapeways and maximise effective escape.

Carbon Monoxide sensors and increasingly, smoke sensing systems, offer considerable potential for early and more reliable fire detection than do other available systems.

A control system must be established to receive and analyse data on the underground environment. The system must include decision making protocols and enable control to be maintained and action coordinated during an emergency.

Consideration should be given to the incorporation of a communication system throughout the mine that can be used to immediately notify underground employees in all areas of the mine of the need to evacuate. The system should have the ability to provide employees with incident details. Principal systems include telephone, traditional two-way radio, ground induction and leaky feeder.

Western Australian, Canadian and Mount Isa Mines metalliferous mines have introduced systems to release stench gas to the ventilation system to initiate emergency procedures.

Computer generated emergency alert systems are available where recorded messages can be transmitted to localities on an at risk basis. The Revmaux (HBL) mine in France utilises such a system with a maximum of 10 localities alerted at one time. An alert immediately triggers the escape procedure. Similar types of system are being used in Australian collieries.

The Personal Emergency device, referred to as "PED" through-the-earth system is capable of sending radio messages from the surface to wearers of receiving units on a mine-wide basis after an incident, but it's utility is limited by an inability to return signals from the wearer to the surface. Medium frequency partially inductive systems (e.g. Rimtech, Taiheiyo) provide increased potential for survival after an incident because of the robust nature of the wave carriers used (pipes, cables etc.). Prototype units for locating trapped miners have been developed overseas but their application is limited to short range, direct line of sight and restrictive circumstances.

SELF RESCUERS

Filter type self rescuers were introduced into the coal mining industry in the 1960's in response to many fatalities that had arisen due to conveyor belt fires (e.g. Creswell Colliery, UK, 1950 - 80 fatalities). They are only effective where sufficient oxygen is present in the atmosphere to support life.

The introduction of fire resistant anti-static conveyor belts, fire resistant oils, lesser use of timber supports and improved environmental monitoring technology has reduced the risk of major mine fires and hence the principal reason for the introduction of filter type self-rescuers.

An explosion occurring in the vicinity of a working face is now the principal hazard that may require the use of a self-rescuer.

In many explosions reviewed, due to the reduced oxygen content of parts of the mine atmosphere following explosions, the use of a filter type rescuer would not have enabled persons to escape.

For this reason, it is considered essential that all persons underground be equipped with a self-contained self-rescuer (SCSR), i.e. a self-rescuer that provides the wearer with respirable air.

There are many brands and types of SCSR's currently available.

These are mainly manufactured either in Europe, the USA or South Africa with each country having different testing and approval criteria. The only international standard currently available for the testing of chemical type (KO_2) oxygen self-rescuers is EN 401 (BS/1993). The testing of compressed oxygen self-rescuers in Australia is covered by AS/NZ 1716 (DMR, 1996).

Because of the differing test criteria used, and the confusion that this creates when evaluating different brands, EN 401 has been recommended as the standard for testing of chemical oxygen SCSR's until an Australian standard, equivalent to EN 401, is developed

Immediately following an underground mine explosion, visibility can be significantly reduced due to presence of smoke and dust, whilst the smoke and toxic gases present may also irritate the eyes. Disorientation may result from this lack of visibility, and combined with the lack of communication, serious limitations are place on the ability to effect escape.

South African research and experience with chemical oxygen SCSRs has shown that poor visibility and disorientation can reduce the distance travelled to 60% of that expected under normal conditions.

Many cases have been cited where persons have not been able to find their self-contained self-rescuer immediately adjacent to them (DMR, 1996).

Due to this disorientation and lack of visibility, it is essential that all people' underground carry an SCSR with them at all times.

Another factor that can play a major part in the escape of persons using self-rescuers is body mass. This subject is dealt with comprehensively by Paul Mackenzie Wood in his paper "Deployment of Self-Contained Self-Rescuers in Coal Mines"

There is a requirement in all Australian underground coalmines for the use of approved self rescuers. The minimum requirement is currently for filter type self rescuers in NSW and in Queensland self-contained self rescuers have been required since 1 January 1998.

COMMUNICATIONS

There is a need for a communications system that would survive an incident and provide ongoing two-way communications between escaping or trapped miners and rescue personnel on the surface. The system must be compatible with the type of self-rescue apparatus to be used and the likely escape or refuge options available to survivors. As power to the mine is likely to be interrupted during an incident, self-contained battery powered backup should be integral to the system. Whilst voice is the highest priority for transfer, systems which can also transmit data and video signals should be encouraged to assist the rescue process.

The minimum coverage requirement is for a communication system to be established along escape routes

The location and tracking of all persons (and most vehicles) in underground mines should also be considered in any escape system. Effective two-way voice communication will contribute to this requirement but more efficient electronic systems should be pursued.

Formal management plans to support efficient use of communication system should be developed. This control plan should attempt to identify the range of possible incidents, early warning trigger levels and incident response actions. It should also determine who is be to be communicated, with, who communicates messages and what information or instructions are to be given.

ESCAPEWAYS

Rescue response following an incident involves a period of time that, in most circumstances, requires persons underground to attempt an organised escape, rather than await rescue. In Australian collieries, the distance from the working face to the surface can be considerable, and in many cases the seam grade can be quite steep. These escape route difficulties, allied with the expected problems of disorientation and poor visibility, give rise to a requirement for a roadway to be established in each mine that meets the criteria of good trafficability.

This roadway should, as far as practicable, be capable of maintaining a respirable atmosphere that is free from fumes and airborne dust, after an explosion or fire. To achieve this, the escapeway should be an intake airway, protected from damage by being segregated from other roadways, with stoppings capable of withstanding low intensity explosions.

Use of the term "second means of egress" is commonly applied to return airways, with little thought being given to which is the most desirable escape route. In emergency exercises involving different scenarios, employees invariably attempted to escape via the returns, even when this may have been the most inappropriate route. The concept of "second means of egress" as the primary escape route should be replaced by the concept of an "escapeway".

Mine management should carefully consider which airway would make the most suitable escapeway. Because of the need to maintain a respirable atmosphere, the risk of fire in this roadway should be reduced to a minimum. This could be achieved by restricting the use of equipment in this roadway to those items that are either fitted with fire suppression devices, or which incorporate a fail safe system to prevent the outbreak of fire.

Vehicular escape would, in most circumstances, afford the best chance of persons making a rapid escape from the mine, and escapeways should be designed to maximise the likelihood of facilitating vehicular escape, without precluding or endangering passage by foot.

GUIDANCE SYSTEMS

To assist in gaining access to escapeways, and in guiding persons along escapeways in conditions of low visibility, clear guidance systems that will survive an incident are required. Knotted ropes with directional cones fitted (lifelines) have been developed for this purpose. More recently, battery-powered guidance systems, such as the "MOSES" system used in South Africa incorporating directionally discriminating audible pitches and flashing LED's have been developed to provide clearer guidance.

CHANGE-OVER STATIONS

Dependant upon the distance of the working areas from the surface and the duration of any self contained self-rescuers (SCSRs) to be carried, the provision of underground caches of SCSRs must be considered to facilitate the escape of persons to the surface. The number and separation distance between caches should be based on the assumption that the mine atmosphere is irrespirable all of the way to the surface, and that visibility throughout the mine will be very poor.

Caches installed throughout a mine should be constructed so that they are protected from the effects of low intensity explosions. Persons exchanging SCSR's should be able to do so in a safe manner. This could be accomplished by being able to exchange SCSR's in irrespirable atmospheres with minimal risk to persons or by the provision of changeover stations equipped with respirable air. Consideration should also be given to equipping changeover stations with communication facilities, capable of surviving an incident, to facilitate escape co-ordination.

In addition to designated caches located at strategic locations in the mine, consideration should be given to the provision of either a cache of SCSR's or some other system of respirable air, on board personnel vehicles. Compressed air systems are now available, comprising a storage cylinders and a number of face masks connected to a common supply regulator, that could meet this need.

Refuge chambers

Refuge chambers have an accepted place in rescue strategies in South African coal mines where workers are instructed to make their way to the section refuge chamber. This is mainly due to the large area extent of the mine workings, the generally shallow depth of workings (enabling borehole recovery in the event of a disaster) and the differing cultural backgrounds and experience of the mine workers.

The majority of opinions sought on the use of refuge chambers in Australian coal mines indicates that Australian coal miners, in the absence of incident information or training, would attempt to reach the mine surface rather than stay underground in a Refuge Chamber.

In the first instance, escape systems should be provided to enable persons to escape to the surface of the mine or alternative place of safety. Operators should, however, examine their own circumstances and possible scenarios to ascertain whether or not there is a place for refuge chambers in their Self Escape Management Plan.

Current thinking indicates that it is very unlikely that rescue teams will be sent into a mine where explosive or toxic concentrations of gas are present. Miners will generally need to effect their own rescue.

For this reason it is believed that regardless of whether a Refuge Chamber or a Change Over Station is used, the system should be mainly designed so that miners have a safe place to assemble.

The Refuge Chamber or Change Over Station should preferably be supplied with a respirable atmosphere and means of communication to the surface so that people can plan their escape and change from one self rescuer to another in safety.

When designing the system it should also be recognised that some persons may not be able to escape due to injuries sustained, or health and fitness factors. Consequently, consideration should be given for the provision of arrangements to enable these persons to be safely refuged whilst facilitating the timely escape of uninjured and fit individuals.

Training

Provision of oxygen self rescuers, early warning systems and escapeways will be of limited value unless the people attempting escape can make the appropriate decisions when confronted with an emergency situation. It is essential that all mineworkers be given adequate and regular training in all aspects of the mine escape system.

Training exercises should entail more than just travelling through the second means of egress or escapeway.

A feature of both USA and South African mineworker training is participation in regular evacuation exercises, often under simulated conditions of disorientation or low visibility.

EVACUATION MANAGEMENT PLAN

Consideration of all the various aspects of the mine when examined in the light of the previously enumerated factors should be incorporated into a mine evacuation or Self Escape Management Plan.

The plan should be developed using the criteria established in guidelines for Queensland Safety Management Plans or the New South Wales Risk Management handbook for the Mining Industry MDG 1010.

When properly implemented this would provide all persons underground with the capability to reach a place of safety, recognising the difficult environmental conditions likely to be encountered following an underground incident.

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