INTEGRATION OF SELF AND AIDED RESCUE

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SUMMARY

With the introduction of legislative requirements for management to develop self escape systems which allow underground employees to pass through atmospheres that may not support life, new equipment and systems are to be introduced into the underground coal industry.

Technological developments in self contained self rescuers (SCSR), oxygen generators and carbon dioxide scrubbers has meant that there are a number of different self escape systems and philosophies that can be implemented. Developments in rescue equipment and methods also allows for a change in philosophy, making in-seam rescue and emergency intervention possible.

By integrating these technologies the a more versatile and timely system of emergency preparedness, self escape and aided rescue is developed which greatly increases the probability of underground employees surviving an emergency situation.

INTRODUCTION

The underground coal mining industry in both New South Wales and Queensland are implementing or preparing to implement systems of self escape for underground employees. Although the systems vary in layout, equipment and implementation, all have the basic philosophy of providing a system that allows underground employees to escape through an atmosphere which may not support life.

Once employees have escaped or arrived at a point of safety, self escape may cease and in-seam rescue of missing personnel or other remedial actions may need to be implemented. The Emergency Preparedness and Mines Rescue Guidelines (EP&MRG) allow for in-seam rescue by two man teams, provided suitable safety barriers are maintained.

To provide for aided escape or other intervention measures, breathing apparatus (which is designed for rescue operations) can integrated as part of the self escape system. The change-over stations should be designed and purpose built for the safe storage of self contained self rescuers and rescue equipment whilst providing and maintaining a safe atmosphere for SCSR changeover and for use as a fresh air base (FAB).

A self escape system that integrates rescue and escape resources may provide the only hope of achieving a satisfactory outcome in emergencies requiring the aided escape of people or a timely intervention to contain or control the situation.

LEGISLATIVE CHANGES

NSW - Coal Mines (Underground) Regulation 1997 - DRAFT

PART 5 Emergency provision
Clause 93 - Implementation of underground emergency systems

1. *A mine manager must develop and implement an emergency system to provide general procedures for the underground parts of the mine (an **underground emergency system**).*

2. *Fir this purpose, the mine manager must identify emergencies that may occur at the mine and which could pose a risk to the safety or health of persons.*

3. *In particular, an underground emergency system must cover emergencies such as fire, a fall of roadway, pollution of the mine air or inundation of the mine.*

4. .....

Clause 97 - Escape equipment and self rescuers

1. *A mine manager must provide sufficient escape equipment (including adequate maintained approved types of self rescuers) to allow safe egress of persons from the mine through conditions of reduced visibility and <u>any irrespirable</u> or irritant atmospheres that may be encountered.*

2. *In providing and maintaining self rescuers a mine manager must have regard to any relevant guidance material published by the Chief Inspector.*

3. *A person who is underground at a mine must at all times have attached to him or her an approved type of self rescuer.*

QUEENSLAND - Coal Mines Regulations

Notice of Intention to Withdraw Approval for Filter Self Rescuers - 27th February, 1997.

I hereby notify you of my intention to revoke the approval of all filter type self rescuers as from 31st December 1997 as recommended by the Moura No2 Inquiry which said that any requirements for the use of oxygen self rescuers should be effective at the latest by 3 January 1996.

As from 1 January 1998 only self contained Oxygen supplied self rescuers (SCSR's) will be approved for use in underground coal mines in Queensland.

The approved types shall meet either the requirements of the current European Standard BS/EN 401 for Chemical generated oxygen self rescuers or Australian Standard AS/NZS 1716 for compressed oxygen types.

For those mines that have not already commenced using SCSR's I would bring to your attention, because of the projected demand, the need to take immediate steps to evaluate the requirements at your mine so that the appropriate number of SCSR's can be procured and training programs completed prior to 1 January 1998.

Sufficient SCSR's will need to be provided to allow all persons to escape from the mine, travelling by foot in reduced visibility conditions.

A Standard for the use of SCSR's is currently being developed in conjunction with NSW and should be issued in July 1997, however as an interim guideline the recommendations of Moura task group 4 should be considered (Attach 1).

I also enclose for your information a table showing those models of SCSR's that are capable of being approved or are already approved under BS/EN 401 or AS/NZS 1716. (Attach 2)

Yours Sincerely
B.J.LYNE
Chief Inspector of Coal Mines.

POTENTIAL RISKS IN UNDERGROUND COAL MINES

Reported Dangerous Occurrences in NSW Coal Mines

Table (i)

Category	1994 / 95	1995 / 96	1996 / 97
Arcing in the Hazardous Zone	16	30	24
Outbreaks of Fire	18	31	17
Buried Continuous miners	8	4	4
Ignition of Gas	8	4	3
Surface Fire	0	0	1
Electrical shock / burns	1	0	0
Self Heating	0	1	0
Shaft / Haulage incidents	3	7	0
Outbursts	3	1	1
Discovery of Gas	2	1	0
Insurge of Gas	0	1	1
Inrush of Water / Material	1	1	0
Failure of Transport	5	2	0
TOTALS	**64**	**83**	**51**

As can be seen in Table (i), arcing in the hazardous zone and fire are the most frequently reported Dangerous Occurrences. The ignition of flammable gas accumulations in the hazardous zone, an explosion or an outbreak of fire underground are the most likely risks. All of these types of emergency occurrences effect the mine atmosphere and ventilation and any underground self escape system would at least have to take these occurrences into account.

EQUIPMENT AVAILABLE

Self Contained Escape Equipment

1. 30 minute duration

a) Fenzy Biocell 1 Start - chemical oxygen unit
b) Drager Oxy K - chemical oxygen unit
c) MSA- Auer SSR 30/100 - chemical oxygen unit
d) Drager SR 30 & 45 - compressed oxygen unit

2. **60 minute duration**
a) Drager Oxy K plus - chemical oxygen unit
b) MSA Life-Saver 60 - chemical oxygen unit
c) CSC SR 100 - chemical oxygen unit
d) MSA - Auer SSR 90 - chemical oxygen unit
e) Ocenco EBA 6.5 - compressed oxygen unit

3. **90 minute duration**
a) Fenzy Biocell 90 Start - chemical oxygen unit
b) MSA - Auer SSR 120 - chemical oxygen unit

ESTIMATING DURATION & TRAVELLING DISTANCES FOR SCSR

Table (ii) may be used as a guideline to determine the duration and distance that it can be reasonably expected that a person can travel when using a SCSR. These guidelines have been established from the 1997 ACARP Project- Number C5039.

The duration of SCSR should be estimated at 60% of their rated duration to take into account body mass greater than 80kg with a heart rate greater than 120 beats per minute. Travel distances should be estimated at 60% of the distance of the distance that 95% of personnel could achieve in good visibility to accommodate for conditions of poor visibility. Condition of roadways, gradient and any obstacles will also have to be taken into account in estimating travel distances.

As part of the mine site risk assessment process a trial to determine realistic travelling distances should be undertaken. The assessment needs to consider both the terrain of the mine and the ability and physiology of those underground. An in-seam trial could be conducted by having a person (who is in excess of 100kg) walking the primary and second means of egress wearing a compressed air breathing apparatus (CABA) to establish your 80% bench mark.

Table (ii) - Actual Duration of SCSR's

Conditions	% of Unit Rating	30 min unit	60 min unit	90 min unit
Normal - person under 80kg -heart rate below 120/min	100 %	30 min	60 min	90 min
Normal - person over 100kg - heart rate below 120/min	80 %	24 min	48 min	72 min
95% percentile - unknown weight & heart rate	60 %	18 min	36 min	54 min
95% - Poor visibility - unknown weight & heart rate	36 %	11 min	22 min	33 min

LAYING OUT A SELF ESCAPE SYSTEMS

Figure (i) shows a 'hypothetical mine' layout which has change-over stations at locations 'A' through 'G'. The change-over stations provide additional SCSR units so that escape can continue or may be designated as a refuge station / safe havens, allowing persons who are unable to continue out to remain in them for a given time. In Australian coal mines, the main emphasis is to allow personnel to continue out of the mine. In NSW, it is proposed that you must have a guaranteed system of recovery for any persons who remains in a refuse station / safe haven.

Table (iii) indicates the quantity of SCSR's that would be required when using units of various duration. The system is based on all panel employees having a 30 minute SCSR and all outbye personnel having the same SCSR that is located at the change-over station.

Table (iii) - Number and Location of SCSR

Location	30 min SCSR system	60 min SCSR system	90 min SCSR system
Panel employees	32	32 (30 min units)	32 (30 min units)
Outbye employees	6	6	6
Change-over 'A'	8	12	12
Change-over 'B'	2	Not needed	Not required
Change-over 'C'	2	2	Not required
Change-over 'D'	12	12	12
Change-over 'E'	38	16	18
Change-over 'F'	38	26	Not required
Change-over 'G'	38	16	24
Total SCSR's	**214**	**90 x 60min & 32 x30min**	**72 x 90min & 32 x 30min**

TRAINING REQUIREMENTS FOR SELF CONTAINED SELF ESCAPE SYSTEM

Training and competency assessment must be an integral part of the emergency escape system.

Objective

- To achieve an effective response from people in an emergency
- To instil confidence in equipment and procedures
- To ensure skills and knowledge are maintained

Elements

1) Alert communications system (who - when - what)
2) Evacuation plan and accounting for all personnel
3) Recognition of conditions requiring an emergency response
4) Knowledge of environmental conditions in an emergency
5) Familiarity with escape ways
6) Donning and use (operation) of SCSR
7) Refuge procedures
8) Leadership training for supervisors
9) Maintenance of emergency equipment
10) Availability of outside agencies
11) Contractors and visitors
12) Competency of trainers
13) Desktop emergencies for colliery officials
14) Training frequency / refresher -(return after annual leave, change in workplace, 6 monthly - donning SCSR and annually full evacuation)

Studies in the USA have indicated that if there has been no training on donning a SCSR for over two months then there is only a 90% accuracy in properly changing over to a new SCSR in an irrespirable atmosphere. To summarise this finding, one man in ten will breath in instead of out during the change-over process.

LIMITATIONS OF A SELF ESCAPE SYSTEM

These systems are established for escape only and do not allow for any rescue effort to commence. Should a person arrive at a change-over station which is found to be on the fresh air side of the problem then they can not be expected to use the self escape self rescuers to assist others or to try and alleviate the problem. The SCSR units are designed to allow a person to escape and no manufacturer will give any assurances that the units can be used for any rescue or intervention activity.

A major concern is that should a person try to assist another out of the mine there is a high likely hood that both of them will not make it to the next change-over station. This may cause great concern to the thinking of mine workers. In addition, there have been a number of cases where underground personnel have attempted an aided escape or rescue and even fire fighting activity whilst relying on the protection of a filter self rescuer or SCSR. If it is anticipated or expected that mine personnel would or should be involved in these types of actions then the appropriate equipment, systems and training must be provided.

HOW CAN RESCUE/INTERVENTION METHODS BE INTEGRATED?

By integrating rescue breathing apparatus into the self escape system, rescue or other remedial actions can be initiated immediately from in-seam. The EP&MR guidelines allow for two man teams to be dispatched under the following circumstances :-

EMERGENCY PROCEDURES & MINES RESCUE GUIDELINES - Doc No: GDLN 130398 - Revision 2
PROCEDURE 1

Persons trained and accredited in the use of breathing apparatus are required whenever it is necessary to enter into or work in an irrespirable atmosphere (as defined in Reference 6).

*RESPONSE BY LESS THAN 5 PERSONS - **LIFE IN DANGER***

In order to mitigate against a potential disaster or life threatening situation a response team of less than five persons who have been trained and accredited in mines rescue or have received other appropriate training and accreditation may use SCBA to enter an irrespirable atmosphere, provided the following barriers are established:

- *Entry into the irrespirable atmosphere is only permitted for brigades of two or more members;*
- *Each person carries a SCSR and due care is exercised to complete the critical task within the capability and protection afforded by the Self Contained Breathing Apparatus (SCBA) and SCSR;*
- *The brigade members support each other;*
- *They return to the FAB prior to the low warning whistle activating on the Compressed Air Breathing Apparatus (CABA) or with more than 30 Bar oxygen capacity in the BG-174;*
- *They do not travel more than 200 metres distance if the conditions are good and the terrain is level or 60% of the rated duration of their SCSR, whichever is least;*
- *The FAB contains at least one person whose role is to ensure the expected contaminants remain below their statutory limits and to activate the emergency system if a contingency situation develops;*
- *The FAB equipment is at least monitoring equipment to ensure the air remains respirable and an oxygen based escape system to a place of safety for the FAB person and the brigade members;*
- *If more than two brigadesmen are inbye the standby arrangements are as follows:*

Response (No of People)	***FAB Officials***	***Standby (No of People)***	
2 inbye	*1 (minimum)*	*2*	*} OR*
	2 (preferred)		*} Available within half the expected*
3 inbye	*2*	*2*	*} duration of the active brigade's*
4 inbye	*2*	*3*	*} SCSR.*

***Note 1**: A single official at the FAB is allowed in a life saving situation requiring rapid response of short duration with only once active team.*

***Note 2**: A person wearing a SCSR while at rest may achieve three times the rated duration compared to a person escaping. This may allow an active team to leave such a person inbye for a recovery by a standby team.*

*RESPONSE BY LESS THAN 5 PERSONS - **NO LIFE IN DANGER***

This procedure allows for the re-entry of a response team of less than five persons who have been trained and accredited in mines rescue or have received other appropriate training and accreditation may use SCBA to enter an irrespirable atmosphere to mitigate, control or contain an emergency situation provided the following barriers are established:

- *Entry into the irrespirable atmosphere is only permitted for brigades of two or more members;*
- *Each person carries a SCSR and due care is exercised to complete the critical task within the capability and protection afforded by the Self Contained Breathing Apparatus (SCBA) and SCSR; The brigade members support each other;*
- *They return to the FAB prior to the low warning whistle activating on the Compressed Air Breathing Apparatus (CABA) or with more than 30 Bar oxygen capacity in the BG-174;*
- *The FAB is fully equipped and manned (Procedure 4);*
- *If communication is unavailable, they do not travel more than 500 metres if the conditions are good and the terrain is level or 60% of the rated duration of their SCSR, whichever is least;*
- *If communications are available, they do not travel more than 1,000 metres if the visibility is good and the terrain is level or 60% of the rated duration of their SCSR, whichever is least;*
- *If a team is to go active, the standby arrangements are as follows:*

Response (No of People)	*FAB Officials*	*Standby (No of People)*
2 Inbye	*2*	*2*
3 Inbye	*2*	*2*
4 Inbye	*2*	*3*

In applying this Procedure, a mine could have four or more CABA or other rescue breathing apparatus of at least 60 minutes duration stored at the change-over stations. This would allow a rescue attempt to be instigated in-seam up to a distance of 500 meters from Fresh Air Base (FAB) with no communications available. In addition, fire fighting or other intervention methods could be under taken quiet safely and more promptly.

EQUIPMENT AVAILABLE

Compressed Air Breathing Apparatus

1) **Type of Back packs**
   a) Drager PA 92 series
   b) MSA DP series
   c) Sabre Centurion series
   d) Siebe Gorman series

2) **Size, capacity and duration of cylinders based on AS measure - 40 litre/min**
   a) 4 litre x 200 bar cylinder
      - 20 minutes
      - - two cylinder backpacks available
   b) 6 litre x 300 bar cylinder
      - 45 minutes
      - two cylinder backpacks available
   c) 6.8 litre x 300 bar cylinder
      - 51 minutes
      - two cylinder backpacks available
   d) 9 litre x 200 bar cylinder
      - 45 minutes
   e) 9 litre x 300 bar cylinder
      - 67 minutes
   f) 11 litre x 300 bar cylinder
      - 82 minutes
      - two cylinder backpacks available

REQUIREMENTS FOR AN INTEGRATED SYSTEM

Equipment

- Four, automatic positive pressure CABA units placed in all change over stations which have a minimum of 60 minutes duration - these should have a duration at least compatible with the SCSR's used in the system and would repalce SCSR's one one-to-one basis.
- Gas monitoring equipment for FAB would be supplied by the mine deputy.
- Fresh Air Base (FAB) would logically be located in a change-over station because of the equipment, communications and escaping personnel are trying to arrive there.

Training

- Initial training course on SCSR, CABA, gases, fire fighting, searching, life support and mines

rescue procedures and guidelines over 5 days

- Refresher training consisting of fours hours, four times per year

Note 1: This training would more than cover all of the requirements of the 'Self Escape' training system.

Note 2: Medical and training requirements for the use of CABA are not the same as for BG-174 units due to the shorter duration of the CABA, cooler air temperature and automatic positive pressure characteristics of the unit.

Who should be trained

This is dependant on the system that the mine instigates and the risks that have been identified for the mine and can cover :-

- To obtain the best coverage for a mine, all employees would be trained which would cover all of their self escape and emergency system / procedures training requirements
- Shift officials, who are expected to take a leading role during an emergency situation should be trained .
- Mines rescue brigades
- Mine fire teams
- Any employees in a high risk zone like an outburst area.

AN EXAMPLE OF APPLICATION

Using Figure (I) and a self escape system consisting of 30 minute SCSR's on all panel personnel with 60 minute SCSR's for outbye personnel. Change-over stations to contain 60 minute SCSR's in addition to 4 x 60 minute CABA units.

Occurrence and Sequence of Events

A belt fire occurs at the drivehead of Panel 3 then the sequence of events could be :-

- Smoke in the ventilation would be spread through Panels 3, 2 and 1
- Mine emergency procedures are implemented
- Employees escaping from each of these panels would progress to change-over station 'E' using either the SCSR or the CABA located at the inbye change-over stations.

Only a Self Escape System Available

- Any personnel not accounted for at change-over station 'E' would have a maximum of a 60 minute oxygen supply unless they are positioned in a refuge station. Should any of these persons be injured or need assistance to escape whilst between change-over stations then this would need to be implemented immediately.
- Personnel on the outbye side of the fire could commence fire fighting actions but would not have any breathing protection from the smoke. This will hamper fire fighting operations as it is very difficult to quickly get to the base of a fire without using breathing apparatus.
- Mine emergency procedures (which have been implemented) should have emergency equipment, personnel and mines rescue service in transit. Arrival times for all of these are variable.

An Integrated System Available

- Any person escaping wearing a CABA unit can offer aided escape to any injured persons whilst in transit due to the greater rating of the unit (40 litres /min) and they have a known cylinder pressure.
- A FAB can be established at change-over station 'E' and the four CABA units used to either quickly fight the fire or to instigate assistance to escaping personnel.
- The additional CABA units held at outbye change-over stations can be brought inbye for use whilst additional resources are being obtained from the surface.

NEXT GENERATION SYSTEM

Currently, the NSW Mines Rescue Service is conducting research and development on the use of quick fill systems for use with CABA units. These systems allow personnel to quickly tap into a large compressed air cylinder bank or high pressure feed line to fill their CABA cylinders.

Currently, this technology is being used in a number of industries for their tunnels or confined spaces whilst inspection or rescue activities are conducted. As the person conducts their inspection

or search they can top up their CABA cylinders at different points along the passageway. This allows a short duration cylinder which is small and light weight to be used to cover a large area over an extended period of time.

In the future, a bottle bank of high pressure compressed air may be maintain at FAB for rescue or fire fighting teams to return to for refills. The same bottle bank can be used to maintain a positive pressure atmosphere at FAB so that contaminated atmospheres can not migrate in.

In a mine self escape system, it is possible that the change-over stations contain a bottle bank or high pressure surface supplied feed line that allows any escaping person to refill their cylinders. In this type of system, CABA backpacks and cylinders would be maintained at the panel change-over stations for face personnel and others units dispersed for outbye personnel. All change-over stations would have a quick fill system with multiple outlets to allow persons escaping to fill their cylinders. Should somebody need to use the change-over station as a refuge station, then the compressed air can be used to supply them air or even pressurise the station.

This type of application would negate the peril of escaping personnel taking more than one escape unit from the change-over station as well as the risks involved in exchanging escape units in a contaminated atmosphere.

CONCLUSION

The concept of introducing self escape systems and self contained self rescuers is to increase the likelihood of underground mine workers escaping from a section or the mine following a fire, outburst, inundation or explosion. Should one of these incidents occur, there are three initial thrusts:-

1. self escape by the individuals caught in contaminated atmospheres

2. aided escape for those who require assistance

3. intervention from a third party outside the contaminated atmosphere to contain or control the situation.

With an escape system based on SCSR only the first thrust is being addressed and underground employees are given a limited time frame of oxygen to self escape. Actions to mitigate the cause may be commenced but are likely to be restricted due to inappropriate protective equipment and rescue reserves. Rescue actions to search and assist missing, disorientated, exhausted or injured personnel can not be commenced until much later and would probably be outside the oxygen time of the persons SCSR. Persons who elect to remain in a refuge station, due to injury or other condition, would be relying on assistance coming from the surface and / or the mines rescue service, both of which may not be timely.

By providing in-seam rescue capabilities at change-over stations, there is an opportunity to under take actions within this limited time frame providing an increased chance of survival and a satisfactory outcome.

Rescue operations come in a number of phases :-

1. self escape

2. added escape - in seam

3. added escape - from the surface

4. alternative intervention techniques - in seam

5. alternative intervention techniques - from the surface

6. recovery (mine / body)

The quicker that any of these stages can be addressed the more likely a satisfactory outcome can be attained.

ACKNOWLEDGMENTS

The assistance of Mr Paul Mackenzie-Wood, Manager Coal Mines Technical Services (Mines Rescue Service NSW) in the critique of this paper is gratefully acknowledged.

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