EMERGENCY RESPONSE CAPABILITY

FINDINGS FROM THE CONDUCT OF SIMULATED EMERGENCY EXERCISES

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In October of 1998 and September of 1999, full scale emergency exercises were conducted at two Queensland underground mines. These exercises were conducted in response to recommendations contained in the Wardens Inquiry Report on an Accident at Moura No 2 Underground Mine on Sunday, 7th August, 1994 (Windridge:1996). This paper details the key findings on emergency preparedness and response strategies drawn from the conduct of these simulated exercises and closes with a discussion on integrated emergency management systems.

INTRODUCTION

At 5.23pm on Monday 26th October 1998, the unauthorised alteration of a regulator critically altered the ventilation pressures across the face of an operating longwall panel. There resulted a dramatic shrinkage of the fresh-air zone in the goaf, with the explosive fringe now directly behind the chock-line. The reduced air velocities, combined with the normally high CH_4 emission rates, allowed accumulation of a methane gas layer to form along the face line roof - concentrating towards the tailgate.

At 12.05am on Tuesday 27th October 1998, with the shearer adjacent to the tailgate drive, frictional sparking from the roof stone in contact with the shearer's tail drum picks, ignited the gas layer. The flame front traveled like a fuse into the fresh air / explosive fringe behind the chock-line.

A devastating explosion of approximately 2,500 m^3 of methane / air resulted.

The primary percussion wave traveled outbye along the main-gate supply road and homotropal belt road. A lesser percussion wave traveled out the tailgate returns. Coal and coal dust was combusted along all roads, although a coal-dust explosion was NOT propagated.

Coffin seals, overcasts and ventilation control devices were destroyed or damaged, ventilation doors were blown open and all communication systems were disabled. Gas monitoring sensor heads were damaged or "off scale" and the integrity of tube bundle lines was questionable.

By 12.25pm it was apparent that a major fire had developed and that lethal concentrations of carbon monoxide were entering the intake airways.

A total of 36 persons were underground at the time.

At 8.00am on Friday 3rd September 1999, a smoldering mass of accumulated coal under a conveyor return roller at the bottom of the main belt road drift was detected. The loose coal was cleaned up and the area hosed down.

At 3.42pm on Tuesday 7th September 1999, four days after the initial fire was detected, a deep seated spontaneous combustion, triggered in the floor coal by the earlier event, breaks through to top of coal. Fanned by the ventilation velocity, it rapidly develops into a major fire with thick smoke and lethal concentrations of carbon monoxide entering the intakes to all panels in the mine's multi-seam layout.

At 4.04pm, smoke enters the nearest working face and by 4.21pm the stopped conveyor belting is fully ablaze, along with the floor and rib coal. At 5.21pm thick smoke is noticed issuing from the belt road portal.

A total of 22 people were underground.

Coal mining nightmares – undoubtedly. Yet, these were the circumstances confronting the personnel of two of Queensland's modern longwall mines during the recent conduct of that state's first two Level 1 Simulated Emergency Exercises.

KEY FINDINGS

Perhaps the key finding from the conduct of these emergency exercises has been to validate the **Self Escape** philosophy as a robust and effective strategy to enhance the survival of underground personnel. Fundamentally, it provides for all underground personnel to have access to adequate supplies of oxygen to ensure sufficient time to travel along a designated escapeway to a place of safety. It is supported by an **Aided Rescue** strategy, which provides for external assistance to those persons unable of reach a place of safety unaided.

Objective evidence gathered through the exercises conducted to date, has demonstrated what the industry has long suspected – reactive responses through surface management control teams, mines rescue teams and emergency duty card systems have limited impact on survival rates of underground personnel during the first few hours of an emergency. A robust, pro-active, integrated and well-rehearsed self escape strategy is their single best chance for survival. Aided rescue can rarely impact on events within the first critical hours. Its function is the recovery of survivors unable to reach safety unaided. Inherently, such a strategy requires time.

It is the integration of the fundamental aspects of these two strategies that will lead to an effective Emergency Management System. To best address the issue of integration and assess the interactions of the various elements that comprise an emergency response, assessment tools and criteria were developed across process rather than sectional lines. The processes examined were

- Emergency Initiation
- Duty Cards
- Emergency Control
- Emergency Evacuation
- Accounting for Personnel
- De-briefing of Personnel
- Mines Rescue
- Mutual Assistance and External Agencies

Emergency Initiation

Perhaps one of the most critical decisions to be made following an event is the classification of that event to initiate the appropriate level of response. In the case of an ignition such classification would seem simple enough – and yet an emergency was not declared for some hours after an explosion at a mine which took the lives of 12 men (Lynn:1987). Several other events, some resulting in fatalities, were never designated as emergencies thus critically delaying the initiation of appropriate responses (Bird:1999.b).

The management and control of any event, whether involving one or several persons, is always best controlled through an effective and automatic response plan initiated at the earliest possible time. Rapid response depends on four critical aspects

1. A prearranged and tested Action Response Plan
2. Establishment of quantified trigger points that will activate that plan
3. Persons trained, competent and authorised to recognise and act on those trigger points
4. Control room ergonomics and the display of data, status and alarms is clear and unambiguous

Duty Cards

Duty cards are used almost universally as an integral part of a mine's emergency plan. They are essential tools that act as critical memory prompts and provide a valuable recording and reporting function. They serve a vital role in ensuring essential activities are not overlooked and establish a base line of roles, responsibilities and authorities.

What they cannot do, and are not designed to do, is exercise control over the event itself. Belief that an emergency will be controlled by following a set of duty cards is unfounded. Control is exercised by trained, experienced and competent people.

Three issues have emerged on the use and application of duty cards

1. They are being relied upon as a primary control mechanism instead of being an aid to control. They can offer neither interpretation, nor analysis, nor solution and cannot establish objectives or set priorities
2. Duty cards are primarily task focussed and do not allow for the development of options or the input of critical thinking. Many good solutions have been lost through obedience to an unimportant task
3. In an effort to be all things in all circumstances, they can become ponderous and unmanageable. A typical emergency response plan may contain anything up to 24 duty cards – few mines have that Number of personnel available, particularly on back shifts

Emergency Control

It would be impossible to over-emphasise the importance of establishing an authoritative Incident Control Team and a well-equipped base from which it can operate.

There must be clear authorities established, reporting to an undisputed Emergency Leader/Director and a definitive understanding of how and why decisions are to be made and recorded.

Display boards detailing clearly defined goals, objectives and priorities as well as the status of events provide a focus for activities and verifiable communications channels are essential to the accurate and timely flow of information – both on and off-site.

There is a growing body of evidence to suggest that stated group extrinsic objectives such as

- Saving lives
- Protecting property
- Preventing deterioration
- Recovery operations

are naturally influenced by other unstated intrinsic objectives, such as

- Compliance with established protocols and written procedures - at all costs
- Mitigation of legal liabilities
- Desire for favourable judgement of individual performance - by peers, employers, community

What is at question is not the legitimate and valid existence of both sets of objectives, but open recognition of the impacts and interrelations they may hold for each other.

Emergency Evacuation

Many emergency evacuation procedures contain latent flaws due to their algorithmic nature and inflexibility to circumstance. Table I details a typical evacuation procedure and some circumstances of problem solving and decisions that may render the sequential nature of the procedure irrelevant.

ELEMENT	DECISION BRANCH
At the first sign of smoke, don your self rescuer and proceed to your designated assembly point	Diesel exhausts ? Smoke or moisture ? See or smell or detect ?
Wait at the assembly point until you are given an evacuation order	Supervisor not present – Phones out of service Attempt to control the hazard eg. fight the fire ? How to communicate wearing SCSRs Evacuation orders not received
Proceed to the nearest oxygen cache and take a unit with you	Travel into smoke, cannot locate Not enough for whole group
Stay with your group and follow the Primary Escapeway from the mine	Some missing - wait, search or leave ? Too slow, unfit, injured ? Walk or drive ?
If the Primary Escapeway is impassable, proceed via the Secondary Escapeway	Advised to proceed via Secondary Escapeway No oxygen caches along Secondary Escapeway

TABLE I – GENERIC EMERGENCY EVACUATION PROCEDURE

Other aspects of evacuation under duress to be considered include

- Self-rescuers must be fit for purpose AND fit for person. Problems have been identified with vacuum-sealed units that cannot be opened with sweaty hands and nose clips that cannot provide a seal on persons of different ethnic backgrounds
- Purpose designed self rescuer change-over stations limit the chances of CO poisoning
- Signs and arrows pointing to escapeways and oxygen caches or roadways delineated by hanging lanyards are of little use in zero visibility

- In zero visibility, the smallest obstacle can become a major hazard. One evacuee could not force himself to step down off a 4” pallet being akin as it was to stepping off into space and hoping the ground was not too far away
- Persons seem inclined to walk out along belt roads rather than use available transport
- Underground DAC systems can provide a vital communication tool for general broadcasts of information downstream. Methods also need to be devised to pass non-verbal communication up-stream
- Self rescuers do not allow people to attempt control of a hazard e.g. fight the fire, conduct a search or assist the injured

Accounting for Personnel

In both exercises, the accounting for personnel functions were handled well. There still exists research opportunities to develop a reliable personnel location system.

De-briefing of Personnel

The de-briefing of personnel and the accurate recording and passing on of information is vital to any effective incident control. It is important that de-briefing officers seek to obtain **objective** evidence as well as the subjective and be aware that the survivor will not be aware of what, if any, information the de-briefing officers or the Incident Management Team currently hold. Procedures for the analysis, quarantining and storage of evidence – such as downloadable data from hand-held gas detectors – should also be developed.

Catering for re-hydration is paramount and first-aid treatment should not be limited to obvious injury.

Mines Rescue

In evaluating the performance of the Queensland Mines Rescue Service (QMRS), it must be stated that all mines rescue service personnel, team captains and team members performed admirably and should be commended for their ability to perform in difficult and trying circumstances.

Excellent, high quality and comprehensive mines rescue protocols and guidelines have been developed in both New South Wales and Queensland. The findings from these exercises indicate that it may be timely to extend the coverage of these documents to include details on the policies of team sizes, minimum equipment, stand-by team protocols and the use of available transport / communication systems. Such a review would seek to integrate the change from traditional aided rescue to the current strategy of self-escape, better enabling mines rescue services to achieve its primary objectives of search and rescue.

Mutual Assistance and External Agencies

All mutual assistance schemes met their design intent, even to the extent that neighbouring mines committed personnel and resources to the conduct of these exercises at cost to their own production.

The involvement of external agencies included police, ambulance, doctors, hospitals, State Emergency Services, SIMTARS, Department of Mines and Energy inspectors, district union check inspectors, community liaison officers and local and state media outlets. Their involvement was considerable and it remains only to be said that timely and accurate two-way information flow is essential to the coordinated conduct of these exercises.

INTEGRATED EMERGENCY MANAGEMENT SYSTEMS

Numerous reference materials are available as aids to the development of emergency response plans, management systems and control strategies for the mining industry. Similar research data and publications are available from other industries, most notably the military, nuclear, petro-chemical and aviation industries, as well as from numerous civil emergency response agencies. All are highly authoritative, substantial and founded on extensive experience in dealing with the management and consequences of catastrophic failure. Although it is not within the scope of this paper to analyse this material in detail, what is apparent is that whilst differences may exist in the detail, several elements are common to effective control and mitigation of emergency situations across all industries. Broadly speaking these critical aspects (Sikich:1993) are shown in Table II.

ASPECT	ELEMENT
PREPARATION and PREVENTION	risk assessment planning and design maintenance training etc
DETECTION and CLASSIFICATION	control room protocols inspection, recording and reporting regimes gas monitoring, sampling trigger points/alarms etc
RESPONSE and MITIGATION	incident control teams and duty card systems action response plans, evacuation plans mutual assistance schemes self rescuers, safe havens and refuge chambers etc
RE-ENTRY and RECOVERY	hazard analysis loss mitigating decommissioning

TABLE II GENERIC ELEMENTS OF EMERGENCY MANAGEMENT PLANS

Research has tended to focus on the elements of these strategies – evacuation procedures, designated escape routes, mutual assistance schemes, call-out procedures etc and the technologies used to support them – guidance systems, self-rescuers, personal locating devices, early warning systems, communications and the like.

One aspect of the systemic approach that has received less attention requires an appreciation of how the system will interact with its people. Again, detailed research and publications are available on how people may be expected to react in different circumstances (Reason:1990) and how inherent design flaws contribute to disasters (Kletz:1994). In compiling an integrated emergency response system, consideration must be given to two often-overlooked principles. Firstly, that “human error” is increasingly being more accurately identified as “design-induced error” (Casey:1998) and secondly, that every action, whether by an individual at the working face or a member of the incident control team, will be predicated by some form of decision making process. Many emergency control systems ignore these relationships and tend to initiate/recover control through a series of algorithmic procedures that do not allow for vital evaluations to be made and decisions enacted. As a consequence, strategies and procedures can often fall apart at the first decision branch (Cole, Vaught, Wiehagan, Haley & Brnich:1998).

Control mechanisms and procedures need to be constructed with the facility, and flexibility, to cope with the decision making process. In emergency situations, people are often confronted with misleading, incomplete and/or conflicting information. They make decisions without knowledge of their ultimate consequences (a constraint not suffered by those who sit in post-event review of those decisions) and such decisions are often irreversible. No protocol or set of procedures can cover every eventuality. No amount of training can prepare for all circumstances – people will always have to make judgements and enact decisions – and people are fallible. Recognition of this inevitability, can assist in the development of “friendly” integrated control mechanisms to limit the possible negative impacts of such events.

As described by Smith & du Plessis (1999), a systematic approach to emergency planning means

- Recognising that problems WILL arise from the interaction of different elements within a system
- Planning for contingencies WHEN these problems arise
- Incident managers / controllers must understand the integration of these diverse components to understand the whole
- Focus must be given to the underlying structure of these interactions when devising solutions
- Understanding clearly that actions taken to achieve a specific result in one area can have unintended and undesirable consequences in another
- Appreciating that the relationship of such cause and effect is often obscure

CONCLUSIONS

The findings and discussion topics included in this paper are component parts of an overall assessment and continuous improvement program aimed at increasing the emergency response capabilities of our underground mines.

Considerable learnings have emerged from these exercises and there is little doubt that industry preparedness has improved as a result. While the focus of this paper has been on the statewide Level 1 Exercises, there are four levels of emergency exercise conducted annually at Queensland mines – see Table III (Qld DME:1999). As the findings from each are disseminated to industry, this preparedness can only be further enhanced.

In closing it must be stated that these exercises are a most rigorous examination of the procedures, people and expertise in place at a mine. They have provided invaluable data to the whole of industry that would not have been gained but for the commitment and support of the people and organisations concerned. They are to be congratulated and commended for their wholehearted assistance and I am confident that those who have participated share a similar belief - *no matter how well you may have prepared, if you have not practiced, you are not ready.*

	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
TYPE	**STATE LEVEL EXERCISE.** One mine selected for the State each year, rotated annually.	**MAJOR MINESITE EXERCISE.** Whole of Mine.	**MINOR MINESITE EXERCISES** Part Mine or system.	**SUPPORTING EXERCISES**
<u>FREQUENCY</u>	Once per year – selected mine	Once per year - All Mines	Once per year for each crew.	Annually/Periodically

SCOPE	Practical exercise to test the Emergency Response System AND the ability of External Services to administer assistance.
	Involves :-
	♦ Whole mine Evacuation AND
	♦ **Mobilisation** of :-
	  ♦ QMRS – rescue team response to MR Agreement standard – Teams to be deployed U/G where practicable
	  ♦ QMRS Inertisation Unit
	    ♦ Couple to mine infrastructure
	    ♦ Run (uncoupled)
	  ♦ SIMTARS
	  ♦ External assistance per exercise plan.
	****Replaces Level 2 Exercise****
		Practical exercise to test the Emergency Response System including effective communication with External Services and periodic mobilisation of the QMRS Inertisation Unit.
		Involves :-
		♦ Whole mine evacuation
		♦ Mines rescue stations and other external providers to contact stage only – "Can you respond ?"
		♦ Mobilisation of QMRS inertisation unit every 5th. year at each mine – *Inclusive of QMRS scheduled training.*
		
		Each year the day of the week, the time of day and personnel involved is to be varied. The scenario is to be varied each year in order to test all aspects of the Mine Emergency Procedures Plan.
			Practical test to ensure all personnel are familiar with the Mine Emergency Evacuation Plan.
			Involves :-
			♦ Part mine evacuation
			♦ All crews; All shifts including weekends.
			♦ Whenever a crews workplace changes significantly
			Participation in Levels 1 & 2
			qualifies for this exercise.
				Desktop/semi practical to test ability to :-
				♦ respond to a medical emergency
				♦ search & rescue
				
				At least annually ensure the ability to activate surface emergency seals

CONTROL	**Chief Inspector** must ensure the exercise is organised each year. **State Emergency Exercise Management Committee** to include :- ♦ 1 Inspectorate representative (Chair) ♦ 1 manager/representative from each District ♦ 1 host mine representative ♦ 1 QMRS representative ♦ 1 District Union Inspector Others…(may include invitees from external assistance providers or other expertise). COMMITTEE MAKEUP TO BE REVIEWED AFTER FIRST EXERCISE	**Mine manager** must ensure the exercise is organised. Organising Committee to include:- ♦ QMRS representative ♦ Miners Officer	**Mine manager** must ensure these exercises are organised. Organising Committee to include:- ♦ QMRS representative ♦ Miners Officer	**Mine manager** must ensure these exercises are organised.
AUDIT/REPORT	State wide	District/Mine	Mine	

TABLE III: EMERGENCY EXERCISES – STANDARD SUMMARY

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