CHAPTER 33

Improving emergency equipment and facilities

Introduction

1. As part of a good emergency management system, a mine should have equipment and facilities available that, in an emergency, can assist both the workers underground and those responding to the event. The first priority in an underground coal mine emergency is for workers to self-escape, that is, escape by their own efforts. Few workers in underground coal mines have been saved by external mines rescue teams following fires or explosions. Rescue teams should not enter a mine without evidence that the atmosphere is safe.

The miners

2. Provision for workers underground to self-escape should include:

    - early warning systems;
    - breathing devices such as self-rescuers and compressed air breathing apparatus (CABA);
    - changeover stations, fresh air bases or refuges;
    - a usable second means of egress;
    - navigation aids such as smoke lines and signage;
    - vehicular or mechanical means of exit; and
    - a communication and personnel location system.

3. What was provided at Pike has been considered earlier in the report. This chapter considers whether the regulatory framework, including other codes and guidance, contains sufficient requirements for self-escape facilities. Queensland's requirement for an emergency management system includes a specification that it provides for self-escape from the mine in an emergency. New South Wales also sets out, in regulations, the minimum contents of the emergency management system. These types of requirements are absent from the New Zealand regulatory framework, which has only a few specific provisions relating to emergency facilities.

Early warning systems

4. Early warning systems should be capable of detecting the first signs of fire or explosion and alerting workers so that they can evacuate through smoke-free escapeways. Underground coal mines need a means of continuously monitoring carbon monoxide and methane levels. Should these gases be detected at levels indicating a risk of fire or explosion, workers should be evacuated. In terms of the risk posed by methane, workers would need to be evacuated well before the concentration of methane reached its explosive range. Waiting until methane levels reach that range (5 to 15% of air) is too late. Gas monitoring systems should be designed to detect trend changes in concentration of gases and to alert workers to those changes. Trigger action response plans (TARPS), which describe actions that must be taken in response to defined events, should be the basis of this system and workers need to understand what to do at particular action points. Workers evacuating during an emergency must be able to monitor the atmosphere as they leave the mine.

5. There is insufficient provision for gas monitoring in underground coal mines in New Zealand. At the very least, there needs to be better guidance about where monitors should be located. The Queensland and New South Wales regulations are much more prescriptive about gas monitoring systems and the location of monitors. The New

Zealand regulations currently only require continuous monitoring at a face when a person is present, whereas the Queensland and New South Wales regulations ensure monitoring at or near a place where coal is being extracted even in the absence of workers. New Zealand should adopt an approach similar to that of Queensland and New South Wales. Underground coal mine atmospheres should be monitored continuously.

Breathing devices

6. If an emergency in an underground coal mine causes the ventilation system to stop functioning or the atmosphere becomes filled with toxic gases following a fire or explosion, all survivors underground need ready access to equipment that will provide oxygen and restrict their exposure to a toxic atmosphere.

7. New Zealand does have requirements relating to the provision and maintenance of, and training in the use of, suitable self-rescue units, but again Queensland's regulations are much more thorough and also include provisions for other breathing apparatus. Queensland expressly prohibits anyone entering an underground mine without a self-rescuer, without having been trained in its use, without having examined the self-rescuer and if not physically capable of using the self-rescuer.[1]

Figure 33.1: Example of a self-contained self-rescuer

8. There should be a mandatory requirement for underground coal mines in New Zealand to include both CABA and self-rescuers in their self-escape equipment. It is best practice to include CABA. They allow for more flexible escape strategies than self-rescuers, including the ability to assist injured personnel and to fight minor fires. Self-rescuers would remain the 'at-hand' breathing device, worn on the belt at all times and immediately available. They can be used during an emergency to enable escape to a safe place, where CABA is stored. Once there, workers would be able to remove their self-rescuers and strap on CABA units. Strategically located compressed air exchange stations should be available to recharge CABA.

Figure 33.2: Man wearing compressed air breathing apparatus (CABA)

Figure 33.3: Recharge station for compressed air breathing apparatus

9. There is a need for better guidance regarding the use and provision of self-rescuers, particularly in terms of training, though it would not necessarily have to be in the form of regulations. New South Wales provides detailed guidance on self-rescuers in Applied Guidelines (MDG 1020), which have the same status as approved codes of practice. Training needs to be conducted under simulated emergency conditions.

Changeover stations, fresh air bases and refuges

10. Changeover stations, fresh air bases (FABs) and refuges are places within a mine where survivors can more safely change from one self-rescuer to another, or to another type of breathing unit. Having a specific location to change

breathing devices minimises the exposure of survivors to a toxic or oxygen-deficient atmosphere where one breath can be fatal. The effectiveness of any of these facilities in an emergency will depend on the standard to which the facility is built and maintained.

Figure 33.4: Strata Worldwide coal refuge chamber

11. The use of refuge chambers in underground coal mines as part of an overall escape strategy was considered by one of the task forces established after the inquiry into the Moura No. 2 explosion. The task force's report noted that workers changing over their self-rescuers 'should be able to do so in a safe manner'.[2] It set out a preference for refuge chambers or changeover stations to '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'. The task force believed the escape system 'should be mainly designed so that miners have a safe place to assemble'. Although it is best to focus on providing assistance to escape, the task force said it must be recognised that there may be injured workers who cannot escape but may be able to reach a place of safety.[3]

12. Queensland subsequently introduced a requirement for underground coal mines to include, in their safety and health management system, provision for self-escape from the mine or a part of it to a place of safety.[4] The system must be developed through a risk assessment, which must consider, among other things, the number and location of changeover stations and refuges.[5] Refuge chambers are not routinely installed in Queensland underground coal mines partly because coal mine fires can burn indefinitely in the presence of very low levels of oxygen, which could prevent rescuers from entering the mine. Refuge chambers are, however, commonly available in metalliferous mines in Australia.

13. The United Kingdom requires the owner of every mine to provide, where necessary, safe havens or facilities for the exchange and recharge of self-rescuers.[6] New South Wales has also included detailed guidance on changeover stations and refuges in MDG 1020. Canada, South Africa, Japan and the United States have also regulated the installation of refuge chambers.[7]

14. In contrast, there is no express legal requirement for underground mines in New Zealand to have a changeover station, an FAB or a refuge. There is also no guidance recommending the use of any of these facilities or the minimum standards to which they should be built and maintained.

15. The variability in any mine's design and state of development means prescriptive requirements governing the provision of changeover stations or refuges are inappropriate. However, there should be a requirement for a mine to consider the need to provide changeover stations or refuges. There should be guidance about when changeover stations or refuges are required, the standards to which they should be built and maintained, and what each should contain. This would assist mine operators to know the minimum standards such facilities should meet in order to be truly considered a changeover station or refuge, and provide a basis for an inspector to assess the adequacy of the facility.

Second means of egress

16. The requirement for a usable second means of egress is a fundamental aspect of underground mining worldwide. Legislation enshrining this requirement in overseas countries followed mining disasters in the United States and United Kingdom, where miners died after their only means of escape became impassable. The need to have at least two outlets separate from each other is also recognised in the Health and Safety in Employment (Mining – Underground) Regulations 1999.

17. Providing truly suitable and sufficient means of egress, and particularly more than one egress, is so important that a mine should know exactly its obligation and the inspectorate should have no qualms about enforcing that requirement. The suitability and sufficiency of a means of egress should be considered against the workers' ability to exit during any possible emergency, as well as during normal conditions. Evacuation through the second means of egress should be tested regularly. At least one of the egresses needs to allow exit by vehicles or other mechanical means.

18. The development of a second means of egress should be a priority for every mine. It should be constructed as soon as the development of the mine permits and should be in place before panel production begins.

Navigation aids

19. In an emergency, there may be reduced visibility in the mine and those underground may be disoriented and under extreme stress. A mine should provide aids that will enable workers underground to reach changeover stations or refuges and leave the mine quickly and easily. These can include smoke lines, walking canes and the use of fluorescent signage and markers. Such aids must be strong enough to survive an emergency.

20. There are no express legal requirements for an underground mine in New Zealand to have smoke lines or life lines, or any other emergency navigational aids. There is at least some, though not entirely sufficient, guidance in the MinEx Health and Safety Council (MinEx)'s *Industry Code of Practice on Underground Mines and Tunnels*. It says that the emergency management system should provide, where practicable, for paths of egress to be marked 'so that persons who are not familiar with a route can safely travel it in conditions of poor visibility'. [8]

21. Queensland requires underground coal mines to consider selecting and marking escape routes;[9] New South Wales requires an underground coal mine's emergency management system to include 'the marking of paths of egress so that people can safely travel on them in conditions of poor visibility'.[10]

22. In the United Kingdom, the Health and Safety Executive (UK HSE) has issued guidance that escape routes out of the mine should be clearly marked and points to the use of emergency way-finder beacons for use in low visibility.[11] The UK HSE has also issued guidance that safe havens should be easy to locate and special 'sensory' measures should be taken to identify them when visibility is limited.[12] It gives, as examples, fluorescent way-finding roadway markers and directional life lines.

23. New Zealand's lack of legal requirements or guidance on navigational aids issued or approved by the regulator is not consistent with best practice. Underground coal mine operators should be required to mark the paths to self-escape facilities and equipment, including exits and changeover stations or refuges. The markers must be easily seen in low visibility conditions.

Vehicular means of exit

24. During an emergency, it is critical that workers are able to make their way out of the mine as quickly as possible. The most efficient way to do so is in personnel transport vehicles, provided they are available and can be started. The use of motorised transport was a 'significant factor' in the survivors of the first explosion at Moura No. 2 managing to escape from the mine.[13] Vehicles also allow for quick evacuation of injured workers.

25. There are no express legal requirements for underground mines in New Zealand to have vehicles available for use in an emergency evacuation, except that at least one outlet must have a 'mechanical means of entry and exit'.[14] The MinEx *Industry Code of Practice for Underground Mines and Tunnels* does state that a fire and general emergency

system, where practicable, should provide for '[s]ufficient types and numbers of transport or alternate escape means, in combination with escape equipment, to allow the safe evacuation of persons.'[15]

26. In New South Wales, a coal mine's emergency management system is required to have provisions for the treatment and transport of sick or injured people and, in respect of the underground parts of the mine, sufficient transport or alternative means of escape to allow safe evacuation.[16] MDG 1020 sets out detailed guidance regarding transport: '[p]rovision of high speed vehicular escape or equivalent must always be a primary object of any emergency escape system.'[17] MDG 1020 also advises that systems relying on long walks through difficult conditions should be remedied.

27. It is best practice for underground coal mines to have personnel transport vehicles available to evacuate a mine during an emergency. In general, all mines should be expected to have vehicles available, although they may not be needed in small mines where leaving on foot is easier and quicker.

28. The Moura No. 2 inquiry recommended the formation of a group to examine and report on various emergency escape facilities, including the role of motorised transport.[18] Following extensive research and trials in Queensland, a standard flameproof diesel personnel carrier has been modified so that it can operate in compromised visibility, and in an atmosphere deficient in oxygen and rich in methane. The vehicle's special features include proximity sensors, a navigation system for operating in zero visibility and a medical breathing system. Queensland's Safety in Mines Testing and Research Station (SIMTARS) and the National Institute of Occupational Health and Safety (NIOSH) in the United States are collaborating to refine the self-rescue features so that such features can be built into all personnel transport vehicles at a mine. As soon as self-rescue capable personnel transport vehicles are commercially available, mines should be required to provide enough to rapidly remove workers from an underground mine in the event of a fire or explosion.

Communication and personnel location system

29. The provision of adequate communication devices, capable of surviving emergency events such as explosions, ensures that workers underground can raise the alarm with the surface and with other workers, and can advise surface personnel of the status of workers underground and their planned escape route. A communication system allows those on the surface to guide workers underground towards the best way out of the mine. This is especially important if a particular route could lead workers into danger. Communication and personnel location devices are also beneficial when workers cannot get out of the mine on their own. In such situations, surface rescue teams can be directed straight to the survivors without having to undertake a time-consuming search of the mine.

30. In New Zealand there are no express legal requirements for the provision of communications systems in underground mines, either during an emergency or in normal operating conditions. There is guidance in the MinEx code for suitable means of communication to be provided and maintained in specified areas.[19]

31. Queensland, by way of contrast, does have express legal requirements for the provision of a telephonic communication system in underground coal mines, including that it have an adequate back-up power supply. It also specifies where the communication devices must be located in the mine.[20] Queensland's Recognised Standard 08: Conduct of mine emergency exercises includes the requirement for mines to have an effective means of communication with surface control, and specifies their locations. The United Kingdom also requires mines to establish and maintain 'communication systems to enable assistance escape and rescue operations to be launched'.[21]

32. The technology for communications and personnel location devices is improving. Most Queensland underground coal mines have installed certified PED systems developed by Mine Site Technologies. They provide wireless through-the-earth communication and can be used both as an emergency and as a day-to-day system.[22] Three of Queensland's underground coal mines use the Northern Light Technologies wireless messenger system, which provides for two-way communication between workers underground and the surface and includes a built-in personnel tracking system.

Figure 33.5: Northern Light Technologies two-way messenger system[23]

33. Alternative communications systems include leaky feeders. Leaky feeders are not wireless and so require cables to be hung from the roof throughout the mine. Underground workers are provided with intrinsically safe walkie-talkies, which allow for two-way communication.

34. All underground mines should have an adequate communications system that allows effective contact between miners underground and the surface during an emergency. New Zealand should keep abreast of the development of effective personnel location systems. As reliable and suitable systems become available, mine operators should also be required to install these.

Conclusions

35. There is inadequate coverage of self-rescue facilities in the mining health and safety regulations. Only four aspects are addressed and even those are not entirely satisfactory.[24] Many self-rescue requirements are not covered by regulations or other guidance material.

36. A fresh start is required. New regulations requiring underground coal mines to develop a health and safety management system should include a requirement that the system contain a comprehensive emergency response management plan. That plan should cover the facilities and training required to support self-rescue.

The emergency responders

37. While providing self-escape facilities should be the priority, an underground coal mine should also be able to assist the rescue operation. That includes being able to measure the atmospheric and physical conditions underground and, once it is established that there are no survivors, to promptly seal the mine and prevent further explosions.

Understanding the atmospheric conditions

38. No mines rescue team will enter an underground coal mine without adequate knowledge of the atmospheric conditions so that they can accurately predict when and for how long they can safely go underground. Although there are legal requirements in New Zealand relating to gas monitoring in underground mines during normal operating conditions, there are no express requirements for mines to have facilities or equipment that will help to establish atmospheric conditions during an emergency. There are also no relevant guidelines.

39. An underground coal mine's emergency management system should consider how the atmospheric conditions of the mine will be monitored and understood after an emergency such as a fire or explosion. This means installing a tube bundle system as well as the real-time monitoring system. Following the Moura No. 2 explosion, the use of tube bundle systems became the norm in Queensland and now all underground coal mines in the state have both systems.

40. A tube bundle system can be more useful than real-time monitoring devices after an explosion or fire, as the analysis components on the surface remain intact and can continue analysing the mine atmosphere. This is because if the

tube bundle equipment in the mine is damaged, tubes can be connected to the surface infrastructure and lowered down boreholes into the mine. Gas drawn from the mine through the tube bundle system can also be subjected to further analysis and interpretation, using gas chromatography.

41. A gas chromatograph from the Mines Rescue Service (MRS) rescue station in Rapahoe and the two chromatographs brought over by SIMTARS were used to analyse gas samples obtained from the mine during the search and rescue operation. Having more than one chromatograph available provided a degree of comfort in the accuracy of results. It would also have been convenient to have had a mobile laboratory available to assist with analysis of results on site. The inquiry into the explosion at the Kianga No. 1 mine in Central Queensland in 1975 recommended: 'All mines have available at short notice the means of analysing the air samples obtained while dealing with an out-break of fire below ground. This end may be accomplished by either mobile laboratories or laboratories established in each mining locality.'[25] The regulator and the MRS should consider obtaining and maintaining a mobile gas laboratory that could be available at short notice.

Understanding the physical conditions

42. It is also important during a search and rescue operation to understand the physical condition of the strata in the mine. Fires and explosions can weaken bolts put in place to hold up the roof, leading to roof falls in the mine. Much time and effort was expended at Pike obtaining robot cameras to examine the mine's drift, only for these to experience difficulties. Equipment suitable for use in assessing the physical environment underground should be identified and trialled before another mine emergency occurs.

Inertisation and sealing facilities

43. Following a fire or explosion, it may become necessary to seal the whole mine. Early inertisation can prevent further explosions and loss of the whole mine. It can also make any recovery operations easier and more likely.

44. There are no express legal requirements for underground mines to provide facilities that will ensure efficient and safe inertisation and sealing in an emergency. The MinEx *Industry Code of Practice on Underground Mines and Tunnels* does recommend that a mine's fire control and general emergency system cover rapid and effective sealing of the mine or a section of the mine if the fire or other emergency conditions cannot be controlled by other means.[26]

45. Queensland requires the underground coal mine site senior executive to ensure that each entrance from the surface to the underground mine is capable of being rapidly sealed. At least one of the entrances must have an airlock and the mine, when sealed, must have facilities that allow safe use of inertisation equipment.[27] The inquiry into the Moura No. 2 explosion highlighted the need to be able to inertise a mine following an explosion. Its recommendations led the Queensland Mines Rescue Service to obtain an inertising system and train a team to use it.

Figure 33.6: Inertisation connection facilities

46. New South Wales also requires coal operations to include, in the emergency management system, provision for 'the rapid and effective sealing of the mine (while at the same time allowing for re-entry to the mine).'[28]

47. New Zealand's underground coal mines should be required to make sufficient provision for emergency mine sealing and inertisation. This includes constructing airlocks and docking stations.

Recommendation 16:

To support effective emergency management, operators of underground coal mines should be required to have modern equipment and facilities.

- Operators should be required to have equipment and facilities to support self-rescue by workers during an emergency.
- Operators should be required to include, in their emergency management plans, provisions for continued monitoring of underground atmospheric conditions during an emergency.
- Operators should be required to install facilities that will support emergency mine sealing and inertisation.

ENDNOTES

[1] Coal Mining Safety and Health Regulation 2001 (Qld), cl 159.
[2] M. Jakeman, 'Developments in Self Escape and Aided Rescue Arising for the Moura No. 2 Wardens Inquiry: A Special Report by the Joint Coal Industry Committee from Queensland and New South Wales', in N. Aziz (Ed.), Coal 1998: Coal Operators' Conference, University of Wollongong & the Australian Institute of Mining and Metallurgy, 1998, p. 735, http://ro.uow.edu.au/cgi/viewcontent.cgi?article=1228&context=coal
[3] Ibid., p. 736.
[4] Coal Mining Safety and Health Regulation 2001 (Qld), cl 168(1).
[5] Ibid., cl 168(2)(d).
[6] Escape and Rescue from Mines Regulations 1995 (UK), reg 10(1)(b).
[7] Industry & Investment NSW, Mines Rescue Working Group and Mine Safety Operations Division, Guideline: MDG 1020 Guidelines for Underground Emergency Escape Systems and the Provision of Self Rescuers, MDG 1022 Guidelines for Determining Withdrawal Conditions from Underground Coal Mines, Guidelines for In-seam Response Using CABA for Events When Life is at Risk, October 2010, p. 27, http://www.resources.nsw.gov.au/__data/assets/pdf_file/0005/419522/MDG-1020.pdf
[8] MinEx Health and Safety Council, Industry Code of Practice: Underground Mining and Tunnelling, October 2009, MINEX0005/39.
[9] Coal Mining Safety and Health Regulation 2001 (Qld), reg 168(2)(e).
[10] Coal Mine Health and Safety Regulation 2006 (NSW), reg 45(b)(vii).
[11] United Kingdom Health and Safety Executive, Guidance and Information on Escape from Mines, 2001, p. 13. http://www.hse.gov.uk/pubns/priced/escape-mines.pdf
[12] United Kingdom Health and Safety Executive, Guidance and Information on the Role and Design of Safe Havens in Arrangements for Escape from Mines, 2007, p. 5, http://www.hse.gov.uk/pubns/mines08.pdf
[13] Queensland Warden's Court, Wardens Inquiry: Report on an Accident at Moura No 2 Underground Mine on Sunday, 7 August 1994, 1996, CAC0152/67.
[14] Health and Safety in Employment (Mining – Underground) Regulations 1999, reg 23(2)(d).
[15] MinEx Health and Safety Council, Industry Code of Practice, MINEX0005/39.
[16] Coal Mine Health and Safety Regulation 2006 (NSW), regs 45(a)(ii), 45(b)(viii).
[17] Industry & Investment NSW, Mines Rescue Working Group and Mine Safety Operations Division, Guideline, p. 25.
[18] Queensland Warden's Court, Wardens Inquiry: Report on an Accident at Moura No 2, CAC0152/67.
[19] MinEx Health and Safety Council, Industry Code of Practice, MINEX0005/12–13.
[20] Coal Mining Safety and Health Regulation 2001 (Qld), reg 176.
[21] Escape and Rescue from Mines Regulations 1995 (UK), reg 8(1).
[22] Mine Site Technologies Pty Ltd, Mine Site Technologies - Mining Communication Solutions, 2012, http://www.mining-technology.com/contractors/communications/mine-site
[23] Northern Light Technologies, Messenger: Not Just a Cap Lamp!, http://www.nltinc.com/cap-lamp-systems/messenger/
[24] Health and Safety in Employment (Mining – Underground) Regulations 1999, regs 15, 22–24.
[25] Queensland Warden's Court, Warden's Inquiry: Report on an Accident at Kianga No. 1. Underground Mine on Saturday, 20th September, 1975, p. 18, http://mines.industry.qld.gov.au/assets/inspectorate/kianga.pdf
[26] MinEx Health and Safety Council, Industry Code of Practice, MINEX0005/39.
[27] Coal Mining Safety and Health Regulation 2001 (Qld), reg 156.
[28] Coal Mine Health and Safety Regulation 2006 (NSW), reg 45(b)(x).