Developments in mine ventilation legislation, statutory qualifications and ventilation training in Australia

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ABSTRACT: Australia has seen substantial changes to its framework of mine ventilation legislation, statutory mining qualifications and ventilation training over the past 15 years. This has been driven by a number of factors including: advances in underground mining technology, shortages of professionals, fly-in, fly-out (FIFO) arrangements on many sites, the ascendancy of the "risk assessment" philosophy to control health and safety risks, increasing cost pressures, globalisation of the mining industry, the changing nature of Federal-State relations, competition policy (anti-trust legislation), the trend towards competency-based qualifications and other factors. Some of these impacts have been discussed in general terms in an earlier paper by Brake & Nixon (2004). This paper reviews more specifically the trends in legislation, statutory mine ventilation qualifications and mine ventilation training and discusses the likely future impacts not just for Australia, but also to other developed or developing mining nations.

1 INTRODUCTION

Australia is a country the same physical size as continental USA, but with only six States and one significantly sized continental territory. Mine safety is currently regulated at the State not Federal level. There is a wide variation in legislative approaches between the States. Some States (Queensland) have specific and separate legislation for coal and metalliferous mining; some (WA) have combined legislation covering both coal and metalliferous mining; some (NSW, SA) use general "OH&S" legislation applicable to all industrial activities with supplementary specific legislation for mines whilst other States use only general OH&S legislation (Tasmania). This leads to wide variations in legislative requirements between the States, and also to wide variations in the industry background of "inspectors" with some States not having mines inspectors at all, relying on workplace health and safety inspectors who may have no mining experience. Some States have certain tasks on the mine site that are statutory appointments (such as ventilation officer); others do not. Some States have boards of examiners that issue statutory qualifications; others do not. Some individuals now have statutory appointments issued by States that have since abolished their Boards of examiners which effectively renders their statutory qualification obsolete.

These changes are exacerbating what is already a critical and growing shortage of skilled personnel at all levels. This has been recognised by the many working groups and conferences on recruitment and retention in the past 2 years and the recruitment of increasing numbers of overseas-trained mining personnel.

As a result of these factors, the role of ventilation officer or engineer is undergoing major changes. This paper reviews particularly the impacts of changing legislative requirements and statutory appointments and the development of Australia's competency-based qualification system for ventilation professionals.

2 THE CHANGING NATURE OF FEDERAL-STATE RELATIONS, COMPETITION POLICY AND GLOBALISATION

Australian States were independent colonies of Britain until 1901 when the States "federated" to form an independent nation, the Commonwealth of Australia. The national (Federal) government was initially involved principally with defence and foreign affairs. However, over the years, and especially in the past 20 years, the Federal government is increasingly to provide nationally consistent legislative frameworks for many activities that were earlier the prerogative of the States. This process has often been taking place with the States approval, although in some instances, the States have been unwilling to cooperate in this increasingly "federal" framework of government.

Key drivers of the increasingly Federal legislative framework in Australia have been the much higher mobility of personnel across States and the demand by both individuals and organisations for a consistent legislative framework to promote business opportunities and to facilitate the "portability" of personal qualifications across State boundaries. The drive for improved national productivity has also meant that the chronic and inefficient duplication of services and government bureaucracies across States is difficult to justify. Competition policy has also meant that "artificial" barriers to trade or business activities across States (e.g. different standards for similar activities) are being struck down by Federal legislation and the courts, leaving the States with little else other than to adopt consistent standards. Globalisation is also a key driver, in that large companies are insisting on more consistent regulatory frameworks across States due to the large costs involved in having different business standards and procedures or different personnel requirements for similar or identical activities in different States. The "terrorist" threat is also making Australians more concerned about the problems of inconsistent or "piecemeal" regulations or approaches providing opportunities for terrorists and, conversely, making Australians more comfortable with national approaches to many issues. For example, it is now widely recognised that the regulations regarding the transport, storage and use of explosives (which was legislated at State level with numerous inconsistencies across the nation) is a flawed approach and a national framework has now been adopted.

It is therefore likely that, in future, the Australian State governments will be left as the key "deliverer" of services, such as police, health, schools, local government and the like, with the Federal government providing a consistent legislative framework for most aspects of most activities.

The same drivers for more consistent regulatory frameworks are also likely to start to develop across national boundaries. For example, if a mining nation sets up a taskforce to review and make recommendations for new mine safety legislation, it is likely that the global mining companies as key stakeholders would become involved and would set out to recommend what they believe is "best practice" legislation across their portfolio of operating mines transglobally. In the same way that the world is (slowly) moving towards lower trade barriers, it is likely that the world will also move towards a more consistent approach on legal frameworks, including occupational health and safety.

A further example of the impact of globalisation is the fact that major mining houses are developing their own internal standards for key hazards, often including underground ventilation (Anon 2001). It is clearly in their interests for these standards to be able to be used in all their operations.

Benchmarking of legislation is slowly leading to the conclusion that some types of legislation are superior to others. For example, a review commissioned by the NSW Government has found support from several sources that key elements of the NSW legislation should be changed to be similar to that in the Queensland legislation (Anon 2000).

As part of this trend in Australia, the Conference of Chief Inspectors of Mines (a meeting of the Chief Inspectors of Mines of each State) has recently issued the *National Mine Safety Framework Implementation Plan* (Anon 2003a) and implementation of this plan has started in all Australian mining jurisdictions. It is interesting that the first two of the seven strategies in this plan are provision of:

– A nationally consistent legislative framework, and
– Competency support to ensure that workers are competent to do their jobs

This clearly reflects the desire for "harmonisation" of mine safety regulations across the country and the concern from the regulators about ensuring all workers in the industry are actually "competent" to do their jobs.

3 RISK BASED LEGISLATION, APPROVED GUIDELINES OR CODES OF PRACTICE, AUDITS, PROSECUTION POLICIES AND THE CHANGING NATURE OF MINING INSPECTIONS

In the past 10 years, Australia has moved very comprehensively towards the "risk based" duty of care approach to workplace health and safety legislation. More recently, several States are seriously considering adopting the "safety case" style of safety legislation, which is highly regarded by the regulators of other hazardous industries such as the North Sea oil and gas platforms, etc (Heiler 2005, Anon 2005a, Raman undated). This general risk-based duty of care is supplemented by varying amounts of "prescriptive" regulations. In addition, most legislation also requires operators to adopt the "ALARA" principle, i.e. to reduce the risk not only to an acceptable level (defined in the regulations) but also to the lowest that is reasonably achievable. The industry is still struggling to come to grips with just what is meant in practice by "as low as reasonably achievable" and how it should be assessed. In some instances, the legislation defines this. However, it may well be that once this principle is tested in a court, that what was "reasonably achievable" in hindsight after a serious safety accident may be interpreted differently to what operators considered to be "reasonably achievable" before the incident. The way in which risk assessments are to be conducted and the results incorporated into hazard management plans and standard operating procedures is now carefully defined in

law. In many instances, ventilation officers are now involved in these formal risk assessments requiring them to be familiar with these concepts. In some cases, they are required to facilitate these risk assessments, which requires a new set of technical and management skills. For example, in Queensland, all coal ventilation officers are now required by law to have the national competency standard MNCG2 "Facilitate the risk management process" (Anon 2002c).

One of the outcomes of the trend away from prescriptive legislation (and the resulting "void" that it leaves) is that State governments have been developing "Guidelines" or "Approved codes or practice" to supplement the regulations (e.g. Anon 1997, Anon 2003b, Anon 2003c, Anon 2003d). Mine operators do not have to comply with these guidelines or codes, but they are admissible in law, and if an operator has a related incident, then the operator must be able to demonstrate that the level of risk under the operator's own procedure was at least as low as that resulting from the approved guideline or code (Anon 2003c). In addition, new legislation often no longer specifies allowable gas concentrations or noise levels etc, but defers to the most recent national TWA or STEL limits in these areas. A consequence of these changes is that ventilation officers must be familiar with not only the mining "regulations" but also a wide range of other standards and documents.

The traditional role of mines inspectors has been auditing against detailed regulations and investigating incidents "after the fact". The approach now in vogue focuses more the "systems design", i.e. the inspector (often in a team) conducts an audit of the operators risk assessments, procedures and outcomes, and then issues binding and/or non-binding improvement or non-compliance notices. Most of these audit template documents are publicly available and are quantitative (i.e. give a point score), so that self-auditing is possible and desirable (Anon 2003e). Ventilation officers have always had an important auditing role, but this is now becoming much more formalized and also more focused on "systems" as well as the minutiae of the regulations.

Finally, most States have issued "compliance policies" or "enforcement and prosecution policies" for their safety legislation (Anon undated, Anon 1999, Anon 2004). These clearly set out the factors that the inspectorate will take into account when determining whether to launch a prosecution against a company or an individual. Typical factors that regulators might take into account when determining whether action should be taken against an organisation or individual, or the severity of the action include:

- The sufficiency of safety management plans at the operation
- The implementation of safety management plans at the operation
- Training of personnel in terms of:
  - Content
  - Accreditation, and
  - Understanding of the safety management plans
- Communications in the organisation in terms of:
  - Internal
  - External and
  - Retention of knowledge base (corporate memory)
- Previous history of incidents in this organisation
- The risk assessment process, especially controls put in place as a result of the risk assessments
- Good practice across the industry
- What other risk control options were considered, if any
- Audit systems in place

Taken together, these factors mean that the breadth and depth of knowledge required by the ventilation officer has increased significantly. The technical knowledge and skills are increasing in complexity but in addition, the ventilation officer must manage technical issues in the light of "duty of care" and "as low as reasonably achievable" legislation. The potential shortfall in competency due to the growing skill set requirement is aggravated by the reduction in middle management positions (who in the past had both the time and skills to provide an important mentoring role for new ventilation officers or engineers), leaving today's ventilation officer with a substantial exposure to prosecution if an error of judgement or any negligence were to occur and an incident resulted.

4 CHANGING TECHNOLOGY

Changing technology is having a significant impact on the nature of the ventilation officer's role. For example, gas monitors are now available that can analyse four or even five gases using the one belt-worn (handheld) instrument. The relative ease of use of these devices has meant that legislators and managers expect more extensive gas testing to be undertaken than in the past, where "stain tubes" were the only practical method of gas testing for spot samples. However, the ventilation officer may now also be responsible for ensuring these devices are calibrated, or even doing site calibration, requiring specialised training.

Mining equipment is getting larger and has much more powerful engines or motors.

Longwall machines are much more powerful so that the width of a longwall face can be much longer than before, and the length of the panel can be much longer. Gas management is more complex as the higher cutting rates and longer face width and panel

depth mean that dilution with intake air is not always sufficient, giving rise to a much stronger reliance on gas drainage and goaf management. The greater seam heights and wider faces also increase the risks from windblast.

Development heading sizes are increasing. Duct and fan technology is resulting in longer distances being run on auxiliary ventilation. The advent of remote-controlled machines has meant that mining methods are changing, sometimes resulting in mine design or operational requirements that conflict with ventilation good practice. The higher productivity of these machines and methods, combined with better metallurgical processing, is making lower grade orebodies economic, creating a more general trend towards "caving" methods for hardrock mines.

5 TRAINING AND QUALIFICATIONS

In the past, mine ventilation training in Australia was at two levels:

- Mining engineers obtained some ventilation knowledge during their undergraduate program. However, this was often not started until third year and was seen as a follow-on to fluid mechanics taught in first or second years. It was taught from a substantially theoretical base, with practical experiments depending on the quality of the local laboratory. This is not a criticism, but it certainly wasn't the intention of most programs for students to be able to finish their course and immediately practice as a confident and competent ventilation officer in a modern mine.
- Mining engineers or non-professional persons could attend ventilation "courses" offered by private individuals. Often these courses were really a re-hash of a university course, but perhaps covering additional material. In all cases, these courses were not assessed (required no assignments, examinations or practical tests), so that neither the knowledge nor the competence of those attending was known at the end of the course.

This approach was typical not just of mine ventilation training, but also of much of the training in the industry. Training was not assessed and the resulting competence of the individuals was left to the subjective opinion of peers or management. This leaves the manager very exposed in the event of a safety issue occurring in the mine, given the manager's "duty of care". Just how does the manager prove that he has discharged his "duty of care" when sending a young engineer to a non-assessed ventilation course?

Recognising the shortcomings of these approaches, Australia has, over the past 10 years, developed or greatly expanded its range of vocational qualifications. These were developed at the national level by industry groups or advisory boards but have been subject to rigorous consultation and peer-review before being given Federal and State ministerial endorsement and official legislative backing. All competencies are now listed in the National Training Inventory Service (NTIS http://www.ntis.gov.au/) and under "mutual recognition" legislation enacted by all Australian States and territories are legally recognised throughout Australia providing both true "national accreditation" across Australia and "national portability" of individual qualifications between States.

The *Resources and Infrastructure Industry Skills Centre* (RIISC http://www.riisc.com.au/) [formerly the *National Mining Industry Training Advisory Board* (NMITAB)] has obtained Federal and State government approval through the *Australian National Training Authority* (ANTA http://www.anta.gov.au/) for new industry training packages for both the Black Coal and Metalliferous mining industries. These new packages are designated MNC04 and MNM05 and replace the earlier (and "first run") packages MNC98 and MNM99 endorsed in 1998/1999. The training packages are not meant to replace academic qualifications, such as degrees, but they are meant to actually equip mine personnel to the point of actually being "competent" in a practical sense to do a task such as manage the ventilation in the mine, rather than just understand ventilation principles and theory.

These training packages provide a list of competencies and career paths for the industry at worker, supervisor and manager level. Completion of specific competency units can lead to qualifications such as the *Advanced Diploma in Coal Mining Management* or the *Advanced Diploma in Metalliferous Mining*.

All these units are *competency based*. This is a different concept to University-style of teaching and assessment, which is largely *knowledge-based* (passing a knowledge-based exam) or earlier statutory requirements, which were frequently *experience-based* ("must have three years practical experience", etc). The adoption of competency-based qualifications is, over time, resulting in significant changes to the training environment in the industry and will, in the future, impact very substantially on health and safety outcomes. Note that in both Queensland and NSW, a graduate mining engineer no longer automatically qualifies for a ventilation officer's "ticket", even after obtaining suitable industry experience. For example, the Queensland Mining Board of Examiners has nominated the national qualification MNCU1109A *Manage, operate and maintain the mine ventilation system* as being the key requirement for the statutory position of Ventilation Officer in underground coal mines rather than an undergraduate mining engineering degree. It is likely that other regulatory authorities will follow in the future. Similarly, Queensland has linked the statutory positions

of Deputy, Open Cut Examiner and First Class Mine Manager into the national vocational qualifications and not into academic or experience-based qualifications.

An emerging problem for the industry is that, where local State legislation requires specific mine appointments (such as ventilation officers) to be statutory positions, the same local legislation also sets up a Board of Examiners to accredit such personnel. The Board of Examiners maintains a supervisory role regarding the Certificates issued under its jurisdiction so that, if subsequent events require, the Board will suspend or cancel such accreditation for an individual.

It is now the case that Certificates of Competency issued under mining legislation that has since been revoked may not be recognised by other regulators. For example, Tasmanian mine safety legislation for many years provided for a Board of Examiners to issues First Class Mine Manager's Certificates of Competency. Many current Australian professionals have obtained Tasmanian accreditation. Under mutual recognition legislation, this Tasmanian Certificate has been recognised in another State if the individual transfers to another Australian jurisdiction and obtains an "endorsement" of the Certificate in that State. However, Tasmania no longer has specific mining legislation and has disbanded its Board of Examiners. This means there is now no authority that supervises and, if necessary, suspends or revokes a Certificate issued by the Tasmanian Board. Therefore there is the potential for all past Certificates issued by the Tasmanian Board of examiners to become effectively worthless. It is possible that other States may follow Tasmania's lead and abandon their mining OH&S legislation, relying instead on general OH&S legislation. If this were the case, then it could be argued that linking statutory appointments into AQF qualifications (with re-accreditation if necessary as required) would provide a more robust and enduring solution to this problem. This is particularly true since new legislation often requires "refresher training" to be completed to an accredited standard every five years. Therefore, if a ventilation officer does not practice in the area of ventilation and is not re-certified, then his/her "ticket" will effectively be cancelled after five years.

At a more general level, linking statutory appointments into industry-recognised, competency-based qualifications is also a more "transparent" accreditation process with very carefully defined outcomes and should ensure more consistent and reliable results for the industry as a whole. It should also make it even easier than is currently the case for individuals to be able to work within different jurisdictions.

In response to industry demands, another national competency-based ventilation qualification has been introduced, the *Advanced Diploma in Mine Ventilation,* which is designed to integrate seamlessly with the existing AQF ventilation competencies. This Advanced Diploma provides dual-trained ventilation specialists in both coal and metalliferous (hardrock) applications.

The ventilation competencies and their links to the industry training packages are shown in Table 2. Note that five new ventilation-related competencies (Table 1) have been introduced into the AQF, all at Level 6 (Advanced Diploma). These were selected on the basis of key ventilation-related issues in Australian mines.

Table 1. New ventilation-related competencies in the Advanced Diploma in Mine Ventilation. For a complete list of competencies, see Table 3

AMV100-Identify, analyse and evaluate psychrometric heating and cooling processes and climate	Be able to identify, analyse and evaluate problems involving mine air and increasing or decreasing amounts of humidity, and to assess surface or underground mine workplace climate (temperatures, humidity, etc)
AMV101-Establish the heat stress management plan	Be able to understand heat illness, assess the thermal environment for heat stress in terms of recognised Australian and international standards, and develop and manage an appropriate heat stress management plan
AMV102-Establish the thermal environment management plan	Be able to assess heat loads in the mine and determine the need for refrigeration and the advantages and disadvantages of the various types of mine refrigeration and delivery methods
AMV103-Establish the mine ventilation model and conduct network analyses	Be able to create computer-based ventilation models, audit these models against measured underground data, and then use the models for fault-finding, network analysis and future mine planning or fan duty
AMV104-Establish the ventilation emergencies (egress and entrapment) management plan	Be able to understand the various types of mine emergencies that may impact on the mine ventilation system, the likely disruptions to the mine ventilation system and the consequential impacts on egress and entrapment, and to be able to select and design egress and appropriate entrapment options

Completion of the Advanced Diploma in Mine Ventilation provides successful students with a single qualification comprising 12 individual nationally-recognised mine ventilation competencies (Table 3) covering both coal and metalliferous industries.

Table 2. AQF mine ventilation competencies and links to other AQF and Queensland statutory mining qualifications

Name of unit	Black Coal/ Metalliferous AQF designation	Coal Statutory VO competency*	Metalliferous Statutory VO competency**	Adv Dipl Mine Vent	Adv Dipl Coal Mining Mgt	Adv Dipl Metall Mining (underground)	1st class Coal Mine Mgr Certif Competency (Qld)	1st class Metalliferous Mine Mgr Certif Competency (Qld)
AQF designator		MNCU1109A	MNMMSM631A	39139QLD	MNC60204	MNM60104	n/a	n/a
Establish the ventilation management plan/system (5-day workshop)	MNCU 1106A (coal) MNMMSM631A (metall)	Mandatory	Mandatory	Mandatory	Mandatory	Mandatory	Mandatory	Mandatory
Establish the spontaneous combustion management plan	MNCU 1102A	Mandatory		Mandatory	Mandatory		Mandatory	
Establish the gas management system	MNCU 1111A	Mandatory		Mandatory	Mandatory		Mandatory	
Establish the outburst management plan	MNCU 1121A	Mandatory		Mandatory	Elective		Mandatory	
Establish the gas drainage management plan	MNCU 1116A			Mandatory	Elective		Mandatory	
Establish the mine ventilation model and conduct network analyses	AMV103			Mandatory				
Identify, analyse and evaluate psychrometric heating and cooling processes and climate	AMV100			Mandatory				
Establish the thermal environment management plan	AMV102			Mandatory				
Establish the heat stress management plan	AMV101			Mandatory				
Establish the ventilation emergencies (egress and entrapment) management plan	AMV104			Mandatory				

Table 3. Complete list of AQF-ventilation competencies provided to students completing the Advanced Diploma in Mine Ventilation

MNCU1106A	Establish the ventilation management plan
MNMMSM631A	Establish the ventilation management system
MNCU1102A	Establish the spontaneous combustion management plan
MNCU1111A	Establish the gas management system
MNCU1121A	Establish the outburst management plan
MNCU1116A	Establish the gas drainage management plan
MNCU1109A	Manage, operate and maintain the mine ventilation system
AMV100	Identify, analyse and evaluate psychrometric heating and cooling processes and climate
AMV101	Establish the heat stress management plan
AMV102	Establish the thermal environment management plan
AMV103	Establish the mine ventilation model and conduct network analyses
AMV104	Establish the ventilation emergencies (egress and entrapment) management plan

6 ADVANTAGES OF UNDERTAKING ACCREDITED VENTILATION TRAINING

Even where an appointment is not "statutory" or does not require a formal qualification, there are important advantages in obtaining an accredited qualification rather than attending an unaccredited course such as traditionally occurred in the past, including:

- An AQF qualification is nationally recognised and "portable" across States and Territories under the "mutual recognition" section of the Australian Quality Training Framework (AQTF).
- The student has been assessed to a consistently applied national competency "standard". Unlike non-assessed courses, the mine manager should be able to be confident that the student can actually understand and apply the knowledge given at the course in a practical way. This can be particularly important in assisting the manager to demonstrate that he/she has met the company's "Duty of Care" in this important technical area, especially in the event of a subsequent ventilation-related accident or incident.
- The student him/herself can also be confident that he/she meets an assessment standard used across Australia for that course. The student will have used their new skills in achieving competency in a situation away from both the training environment and the course presenters. This independent assessment helps the students to develop confidence in their own abilities.
- Students intending to take up a role as Ventilation officer, Planning Engineer or the like, or a longer-term career as a ventilation specialist, benefit from obtaining a formal accreditation rather than merely attending an unassessed course.

As accredited training courses do not attract Australian GST (10% goods and services tax), the additional cost for the fully accredited course is often competitive with the cost for the non-accredited version.

7 WHY PROVIDE FOR DUAL TRAINING (COAL AND METALLIFEROUS)?

It is not uncommon to see hardrock-trained mine surveyors working in coal mines, or coal-trained electricians working in hardrock mines, or any of a variety of other situations occurring in which workers in one industry move their skills and employment across to the other industry. There have been recent examples of mine managers and ventilation officers transferring from coal to metalliferous and vice versa. It makes sense to be able to draw on workers in one sector to meet skills shortages in another sector. In addition, it improves career prospects and may have other advantages to individual workers in terms of better meeting their personal requirements (e.g. for a residential mine rather than FIFO), which may avoid their loss to the industry entirely. Often, the system of "qualifications" in the past resulted in restraints on trade in personal services and, effectively, "closed shops".

Transferring staff between coal and hardrock also results in "cross-fertilisation" of ideas and helps with technology transfer and has other related benefits to both sectors.

With the rationalisation of Australian mining companies and the growth of global mining houses (many of which have both coal and metalliferous portfolios), many of these international mining groups see the benefit of engineers and other staff having exposure to a wider range of minerals produced by the mining house.

Finally, whilst some of the operational details of mine ventilation are clearly different between a metalliferous mine and a coal mine, the basic principles and many of the fundamental competencies remain the same. For example, checking a gas reading, measuring airflow or pressure across a ventilation control, designing a drop-board regulator, establishing a fan pressure/flow specification or investigating the direction and volume of leakage.

It is often a widely held view that hardrock operations do not have problems with gas, or explosions, or outbursts, or spontaneous combustion. However, the following examples indicate that this is not necessarily the case.

- One Australian hardrock mine currently has problems with hydrogen as strata gas. A coal based gas drainage specialist has been engaged to advise on options. There is regular "popping and banging" due to minor ignitions.
- Another Australian hardrock mine currently has problems with CO_2 accumulations in the mine. The surrounding strata are carbonates and CO_2 builds up in poorly ventilated areas. This operation has had several instances with miners becoming affected by CO_2, even losing consciousness. They have CO_2 sensors and a telemetric system installed on major return airways.
- Many Australian hardrock mines have methane as a strata gas.
- Uranium mines have significant issues with radon gas and radon daughter products. A number of ventilation strategies applicable to gassy coal mines have relevance to uranium operations.
- The Isa mine in Queensland has a large high-grade orebody that was subject to spontaneous combustion when attempts were made to extract it in the 1960s. The ore was so susceptible to spontaneous combustion that broken ore would increase its temperature to over 1000 ^{0}C. Large quantities of SO_2 and CO_2 were also produced. LHD tyres would catch on fire. The orebody remains unmined to this day.
- At least three mines in Western Australia have had more recent problems with spontaneous heatings in ores with high pyrite contents.
- Several hardrock operations have had problems with SO_2 and H_2S strata gas. One WA mine had an "outgassing" of CH_4 that contaminated the return airway for two full weeks.
- Many hardrock mines have reported problems with NH_3 (ammonia gas) being produced when ANFO (the most common underground explosive) dissolves in water and comes into contact with lime from cement (also dissolved in water), which results in an exothermic reaction producing ammonia.
- Many hardrock operations have had significant incidents with sulphide dust explosions, which have had serious cost and safety implications.
- Potash, Trona and other evaporite mines overseas have had serious gas management/dilution issues with several strata gases and outbursts of CO_2 and N_2.
- Steam outbursts resulting in multiple fatalities have been reported in a Japanese gold mine.
- A number of hardrock mines in Australia have had problems with windblast, with the Parkes mine in NSW suffering from a major windblast in the past 5 years that resulted in a multiple fatality.
- Almost all gold and platinum mines in South Africa experience problems with flammable gas and several have had problems with gas outbursts. Between 1989 and 1999, there were 25 fatalities and 36 serious injuries due to flammable gas issues in South African hardrock mines. The average gas concentration across all mines was 66% methane and 26% hydrogen.

Therefore even on just the basis of gas management, hardrock mines as a group have the potential for significant safety and cost consequences. To these can be added the issues of dust, diesel particulates and egress and entrapment.

In addition, note that most of the significant US hardrock mining disasters (multiple fatalities) were "ventilation related" (see Table 4).

Table 4. Selected major US hardrock mining disasters

Year	Mine	Mineral	Type	Deaths
1972	Sunshine Mine	Silver	Fire	91
1971	Barnett Complex, Ozark-Mahoning Co.	Fluorspar	Hydrogen sulfide gas	7
1968	Belle Isle Mine	Salt	Fire	21
1963	Cane Creek Mine	Potash	Explosion	18
1943	Boyd Mine	Copper	Explosion	9
1942	Sandts Eddy Quarry	Limestone	Explosion (surface)	31
1926	Barnes Hecker Mine	Iron	Flood	51
1917	Granite Mountain Shaft	Copper	Fire	163

The following groups of individuals are likely to be interested in and benefit from completing the Advanced Diploma in Mine Ventilation.

- A "career" senior ventilation technical person in a mine
- A ventilation superintendent responsible for a ventilation department in a mine
- A corporate (group) mining engineer responsible for oversight of ventilation across several mines
- A ventilation consultant
- A regulator (e.g. Inspector) with a key "brief" in the area of ventilation

Fundamentally, any person looking to develop a career in mine ventilation or with strong supervisory/technical role mine ventilation.

8 SUMMARY AND CONCLUSIONS

The nature of mine safety legislation is changing in Australia to a "duty of care" and "as low as reasonably achievable" approach. There is also a strong trend towards harmonisation of safety legislation across the country. The shortage of skilled personnel in both the coal and hardrock mining industries at present is likely to persist. A much stronger focus on skilling the workforce and providing improved opportunities for movement of personnel between mines, employers and between industries, along with methods of delivery that fit in with the multiple requirements of workers (personal situations, residential and FIFO, varying rosters, etc) will be required if the industry is to develop a strong base of competent personnel. Well-trained, competent personnel are also a key factor in developing and maintaining a sustainably safe industry. New competency-based ventilation training has been developed to facilitate recognition of ventilation qualifications throughout Australian jurisdictions and provide maximum flexibility to meet both student and employer requirements.

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