NEW INTEGRATED PATHWAYS FOR MINE VENTILATION TECHNICAL TRAINING IN AUSTRALIA

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ABSTRACT
Two key issues currently facing the Australian mining industry include the shortage of skilled personnel (at all levels) due to difficulties of either attracting or retaining workers and the difficulties in developing or upgrading skills sets in individuals, particularly as workers change roles, employers, locations and move from residential to FIFO status or vice-versa.

A particular area of concern is the ventilation capability in underground mines. Ventilation-related issues have been at the core of numerous health and safety issues and most disasters in the industry in the past, including disease, outbursts, fires and explosions. This is true for both coal and metalliferous operations. Recent respiratory/ventilation issues affecting other industries include asbestosis and, quite recently, silicosis. In addition, diesel particulate matter (DPM) is now classified by the International Agency for Research on Cancer (IARC) as a Class B carcinogen (known carcinogen in animals and suspected carcinogen in humans) and is the subject of numerous current investigations and enquiries. Official enquiries at both the Moura and Westray disasters were both scathing concerning the design and operation of the mine ventilation system and warning indicators.

This paper describes the factors leading to the current shortage of appropriately trained and competent ventilation professionals in the industry, and new approaches being taken to provide increased and improved pathways for workers to develop these competencies.

INTRODUCTION
One of the most significant "real issues" for the Australian mining industry today is the critical 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 12 months and the recruitment of increasing numbers of overseas-trained mining personnel. This shortage will impact more substantially on those states which have their economic base more heavily dependent on their resource industry, including Queensland. This is reflected in several key Queensland Government initiatives announced over the past 12 months. In turn, this skills shortage has the potential to impact adversely on safety and health in the industry over the next few years due to dilution or downgrading of the existing skills inventory unless a pro-active and coordinated approach is taken to lifting training standards and flexibility of delivery.

The Conference of Chief Inspectors of Mines has also recently drafted the *National Mine Safety Framework Implementation Plan* 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.

The *Resources and Infrastructure Industry Skills Centre* (RIISC) [formerly the *National Mining Industry Training Advisory Board* (NMITAB)] has obtained ministerial approval through the *Australian National Training Authority* (ANTA) 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.

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 competencies are listed in the *National Training Information Service* (NTIS) and under "mutual recognition" legislation enacted by all Australian States and territories are legally recognised throughout Australia providing true "national accreditation" and "national portability".

All these units are *competency* based. This is a different concept to University-style of teaching and assessment, which is largely *knowledge-based* or earlier statutory requirements, which were frequently *experience-based*. Competency-based qualifications have been, over time, resulting in significant changes to the training environment in the industry and, over time, will impact on health and safety outcomes in the industry.

Some regulatory authorities have already linked statutory positions under their authority to some of these qualifications. For example, the Queensland Mining Board of Examiners has nominated 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 in Queensland. 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 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 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.

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.

It is also apparent that some competencies in the Coal training package are identical to competencies in the Metalliferous training package. For example, the metalliferous competency unit, MNMMSM631A *Establish the ventilation management system* in referring to the Coal competency unit MNCU1106A, states:

> "The work described in this (metalliferous) unit is equivalent to (the coal unit) MNCU1106A *Establish the ventilation management plan."*

In addition, there is often some overlap between competency units even within the same training package. For example, the Coal competency unit MNCU1106A refers to the MNCU1109A (the unit required for Coal statutory ventilation officer) in this way:

> "The work described in unit MNCU1109A *Manage, operate and maintain the mine ventilation system*, covers all of the work described in this unit (MNCU1106A)"

And additionally states in the MNCU1109A training package:

> "The work described in this unit (MNCU1109A) covers the work described in the units:
> - MNCU1102A Establish the spontaneous combustion management plan
> - MNCU1106A Establish the ventilation management plan
> - MNCU1111A Establish the gas management plan
> - MNCU1116A Establish the gas drainage plan
> - MNCU1121A Establish the outburst management plan"

In response to industry demands, TAFE Queensland (TQ) Mining Services, in conjunction with ventilation specialists, Mine Ventilation Australia (MVA), has developed Australia's first fully-integrated suite of mine ventilation competencies available through the AQF. Enrolments have already been received from across Australia into a number of these competencies.

TQ Mining Services is also offering the world's first *Advanced Diploma in Mine Ventilation*, which is designed to integrate seamlessly with the AQF ventilation competencies. This Advanced Diploma provides dual-trained ventilation specialists in both coal and metalliferous (hardrock) applications.

THE VENTILATION COMPETENCIES

The ventilation competencies and their links to the industry training packages are shown in Figure 1. 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 topical issues in Australian mines at present.

Completion of the Advanced Diploma in Mine Ventilation will therefore provide successful students with a single qualification comprising 12 individual nationally-recognised mine ventilation related competencies (Table 2) covering both coal and metalliferous industries.

Identify, analyse and evaluate psychrometric heating and cooling processes and climate	AMV100	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)
Establish the heat stress management plan	AMV101	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
Establish the thermal environment management plan	AMV102	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
Establish the mine ventilation model and conduct network analyses	AMV103	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
Establish the ventilation emergencies (egress and entrapment) management plan	AMV104	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

Table 1 - New ventilation-related competencies in the Advanced Diploma in Mine Ventilation.

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

Table 2 - Complete list of AQF-ventilation competencies provided to students completing the Advanced Diploma in Mine Ventilation.

ADVANTAGES OF UNDERTAKING ACCREDITED VENTILATION TRAINING

Even where an appointment is not "statutory" or does not require a formal qualification, there are numerous advantages to students in obtaining an accredited qualification rather than just attending an unaccredited (and unassessed) course, including:

- The qualification is listed on the national register.
- 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 can 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 student 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, will benefit from obtaining a formal accreditation rather than merely attending an unassessed course.
- As accredited courses do not attract Australian GST, the additional cost for the fully-accredited course is often competitive with the cost for the non-accredited version.

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.

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 operations), many of these international mining houses will 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 or measuring airflow or pressure across a ventilation control, designing a drop-board regulator, or establishing a fan pressure/flow specification.

It is often considered that hardrock operations do not have problems with gas, or explosions, or outbursts, or spontaneous combustion. However, gas is produced in mines from the following sources.

- Sedimentary orebodies with carbonaceous material can produce CH_4 or other hydrocarbon gases. Other sedimentary orebodies (e.g. evaporites) can produce CO_2 or N_2 gases.
- Carbonate orebodies can produce CH_4 or CO_2.
- Sulphide orebodies can produce SO_2 or H_2S.
- Uranium orebodies (and others) can produce radon gas.
- Introduced gases, principally diesel gases, but can also include gases from introduced chemicals or other substances.
- Fires and/or spontaneous combustion.

Clearly, there are many opportunities for hardrock mines to have gas issues.

Year	Day	Mine	Mineral	Location	Type	Deaths
1972	2 May	Sunshine Mine	Silver	Kellogg, Idaho	Fire	91
1971	12 Apr	Barnett Complex, Ozark-Mahoning Co.	Fluorspar	Pope Co., Rosiclair, Illinois	Hydrogen sulfide gas	7
1968	6 Mar	Belle Isle Mine	Salt	Franklin, Louisiana	Fire	21
1963	28 Aug	Cane Creek Mine	Potash	Moab, Utah	Explosion	18
1943	5 Jan	Boyd Mine	Copper	Ducktown, Tennessee	Explosion	9
1942	26 Mar	Sandts Eddy Quarry	Limestone	Allentown, Pennsylvania	Explosion (surface)	31
1926	3 Nov	Barnes Hecker Mine	Iron	Ishpeming, Michigan	Flood	51
1917	8 Jun	Granite Mountain Shaft	Copper	Butte, Montana	Fire	163

Table 3 - Selected major US hardrock mining disasters.

In addition, note that most of the significant US hardrock mining disasters were "ventilation related" (see Table 3). Finally, consider the following gas-related issues in hardrock mines:

- One Australian hardrock mine currently has problems with hydrogen as strata gas. SIMTARS has been on site and 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.

- Several Australian hardrock mines currently have methanometers installed in diamond drilling recesses. Special ventilation is set up in these sites. Drillers are trained to recognise telltale signs of methane gas in the drill water. Other operations have had similar problems with H_2S gas.

- Another Australian hardrock operation has significant issues with radon gas and radon daughter products. A number of ventilation strategies applicable to gassy coal mines have relevance to this operation.

- 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 0C. Large quantities of SO_2 and CO_2 were also produced. LHD tyres would catch on fire. The orebody remains unmined to this day. There have also been more recent instances of spontaneous combustion in the pyritic shales at both Tom Price and Mt Newman in WA.

- Several hardrock operations have had problems with SO_2 and H_2S strata gas.

- 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. In some instances, entire levels of the mine have been seriously damaged.

- 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.

- 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 (including silica dust), diesel particulates and egress and entrapment.

WHO WILL BE INTERESTED IN OBTAINING AN ADVANCED DIPLOMA IN MINE VENTILATION?

It is expected that the following individuals would 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.

FEATURES OF MINE VENTILATION TRAINING

The TQ Mining Services program has been carefully designed to meet the flexibility requirements of students as they change roles, employers and locations, and as their personal situations change.

- Can start or finish at anytime
- Substantially self-paced
- Multiple workshops per year
- "Full-time" (block release) intensive course option
- Convenient locations around Australia
- Flexible fit with business and personal needs
- Support via web-based tutorial assistance
- Comprehensive high-quality resource materials including CDs, spreadsheets and specialist software

- ¬ Principal resource materials updated at least twice-yearly to reflect current Australian good practice
- ¬ Enables individual AQF statements of attainment in all Units, so provides fully-recognised competencies even if the Advanced Diploma is never finished
- ¬ Provides competencies not just towards VO, but also statutory 1st class Mine Managers' tickets and Adv Dipl Coal Op Mgt or Adv Dipl Met Mining (depending on jurisdiction)
- ¬ Provides "dual trained" ventilation specialists (coal and hardrock) (Adv Dipl Mine Vent only)
- ¬ Suitable for Australian and international students
- ¬ Reasonable and flexible cost
- ¬ Both upfront and "Pay as you go" (PAYG) payment options.

OPPORTUNITIES FOR EXPORT OF AUSTRALIAN TECHNICAL SPECIALISATION VIA TAFE TRAINING

The introduction of these new pathways and qualifications will improve Australia's ability to export its educational services.

Firstly, Australia is a recognised world leader in mining technology and "know-how". There is a good "fit" in leveraging this expertise via education of overseas students. Australia is a 1st world mining country surrounded by developing nations with dramatically growing mining industries. There is a very substantial demand for mining training in many overseas countries, especially as these countries move up the technology curve and need to develop a more sophisticated approach to mine design and operations.

Organisations such as the World Bank and its funding arm, the IFC, want new projects involving IFC funding (e.g. China) to meet Australian "good practice" standards. The development of these ventilation competencies helps to "codify" Australian good practice.

The problems of ventilation are believed by the South Africans to be the "ultimate" limiting factor on the depth of mining operations. Therefore improved ventilation design and operation is critical to the longer-term success of the Australian mining industry particularly as more mines develop underground operations and existing underground operations become deeper.

SUMMARY AND CONCLUSIONS

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) is essential 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. TQ Mining Services, in conjunction with Mine Ventilation Australia, has developed new integrated pathways for ventilation training that are designed to facilitate recognition of competencies throughout Australian jurisdictions and provide maximum flexibility to meet both student and employer requirements.

Name of unit AQT designation Establish the ventilation management plan/system (3 day workshop)	Black Coal Metalliferous ADF designation MNCU 1109A (coal) MNMMSMM531A (metal)	Coal Statutory VO competency* MNCU1109A Mandatory	Metalliferous Statutory VO competency** MNMMSMM31A Mandatory	Adv Dipl Mine Vent TBA Mandatory	Adv Dipl Coal Mining Mgt MNC[illegible] Mandatory	Adv Dipl Metal Mining (underground) MNM[illegible] Mandatory	1st class Coal Mine Mg Certf Competency (Old) n/a Mandatory	1st class Metalliferous Mine Mg Certf Competency (Old) n/a Mandatory
Establish the spontaneous combustion management plan	MNCU 1102A	Mandatory		Mandatory	Mandatory		Mandatory	
Operate 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	
Operate the mine ventilation model and conduct network analyses	AMV101			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	AMV101			Mandatory				

Figure 1 - TAFE/MVA ventilation competencies and links to other AQF and statutory mining qualifications.

** Technically, the Coal VO statutory competency requirement varies from state to state. In addition, the MNC U1109A competency does not necessarily require U1102, U1111 or U1121 competencies as elements of these three specialist competencies are described in U1109. However, in practice, TQ has taken the view that students wishing to obtain the U1109 competency will be required to study for and obtain the other three competencies as well as the "core" U1109 elements. The Gas drainage competency (U1116) is not required in the TQ "VO" qualification as there is very substantial overlap between U1116 and the other three specialist competencies. Note that the Coal VO qualification in Queensland also requires MNCG1002 Implement and apply the risk management processes.*
*** Technically, the metalliferous VO statutory requirement varies from state to state.*