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An approach to addressing explosive related accidents by implementing strategic training

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AN APPROACH TO ADDRESSING EXPLOSIVE RELATED ACCIDENTS BY IMPLEMENTING STRATEGIC TRAINING

Gour C Sen[1] and Geoff Downs[2]

ABSTRACT: In underground coal mines, the use of explosives is very limited, particularly where the longwall method of mining is practised. However, occasionally the call for the use of explosives does occur in most underground coal mines. Explosive use today is generally confined to shooting a dyke, excavating an overcast in stone, for fault drivage, and for shaft sinking or drifting in cases where use of a road header is considered to be uneconomical. Explosives have also been successfully used in triggering goaf falls to prevent wind-blast or for remote mining through areas where methane gas does not drain below the 'outburst threshold limit' It is therefore essential that among the mine personnel there are employees qualified in the handling of explosives under varying conditions, and these qualifications should be up to date.

This paper proposes that all shotfirers should undergo a refresher course in blasting at intervals of five years, so that up-to-date knowledge is disseminated. The essential modules of such a refresher blasting course should consist of the following: a) Familiarisation with current types of explosives and accessories; b) Types and modes of initiation; c) Blast design and calculation; d) Precautions to be taken before and after firing; e) Consideration of environmental factors; and f) Dealing with misfires. Above all, a safety culture amongst the personnel who handle explosives needs to be established, and strictly adhered to.

INTRODUCTION

In mining and in civil engineering projects, blasting is one of the most potentially hazardous operations. It is recorded (Sen & Hayword, 2007) that blasting related accidents have claimed the lives of more than a thousand people around the world since the turn of the Millennium. Most of these accidents are due to flyrock and an inadequate blast exclusion zone. A number of recent explosive related accidents will be cited and conclusions drawn. Explosives manufacturers are continually developing their product, with improved safety characteristics, and it is fair to comment that most blasting accidents are usually due to human error or ignorance, rather than a faulty product. The impact of increasing safety and environmental legislation as well as the growing explosives security requirements demand that blasting operations should be managed by shot-firers who are competent in all facets of explosives usage. This is particularly pertinent to those shot-firers who get sporadic, often very infrequent calls to undertake blasting operations.

Many European countries (Akhavan et al, 2007) are endeavouring to review explosives regulations and realise that training with respect to the management of blasts needs to be improved. Apart from primary risk associated with the storage, transport and handling of explosives, there are possible operational risks due to flyrock or misfires caused by poor blast design. The major shift is to train the blasting crews so that the new training scheme prepares them for competence-based, rather than knowledge based qualifications.

This paper firstly deals with some explosives related incidents and analyses their causes. This will be followed by instructions in line with the directives of the Australian Forum of Explosives Regulators – a body seeking to harmonise explosives regulation throughout Australia – training with respect to the management of blasts needs to be improved.

EXPLOSIVES RELATED INCIDENTS

Numerous explosives related accidents have occurred, and it is not possible to mention or analyse them here. This paper will endeavour to focus on certain incidents from which conclusions can be drawn.

Porgera Gold Mine, Papua New Guinea Explosion

This explosion totally destroyed the explosives manufacturing facility on the surface in August 1994 with the loss of 11 personnel (Sen and Abrahams, 2005). There were two explosions, about 1 hour 15 minutes apart. The fires on the bulk truck around and underneath the bulk emulsion and process oil tanks subsequently caused the second explosion, which was larger than the previous one. It is estimated that approximately 5½ tonnes of various types of explosives were destroyed during the first explosion, creating a crater of 7 x 5 x 2 m. The second explosion

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produced a crater of approx. 40m in diameter and 15m deep, with the destruction of nearly 90 tonnes of explosives.

After extensive analytical work, it was found that the first explosion occurred in the emulsion explosives packaging line, specifically within the Mono pump. Although the exact mechanism of the initiation of the explosion is not known, it is believed that the initiation point for the first explosion took place inside the rotor boss-head cavity, where the emulsion explosives compound managed to leach pass O-rings and a possibly missing packing gland over a period of time. It is thought that microscopic cracks, flexing of components, heat and possibly back pressure were sufficient to create the right conditions to initiate the explosive compound in the cavity. Some emulsion explosives exhibit strong exothermic reaction above 230° C.

A planned inspection programme covering critical plant and equipment, parts and items could have avoided this massive destruction.

Incident during demolition of buildings, Canberra, Australia

This incident happened in July 1997 in the course of the demolition of a tower block constructed of reinforced concrete with steel columns. The building, to be demolished by implosion, was situated on the edge of a lake. An estimated 30, – 40,000 spectators were gathered around the lake on the far side of the building. A young girl, who was standing about 430 m from the explosion site watching the demolition, was hit by a flying projectile and died instantly. Her death was caused by a fragment of steel expelled from one of the corner columns of the building. This steel projectile, which weighed nearly 1 kg, struck the girl's head. This impact caused the girl's scalp and skullcap to sever from her head.

The impact velocity of the steel fragment was estimated to be 128 – 130 m^{-1}, with an associated energy of around 8.172 kJ. A piece of fractured steel from another backing plate was embedded in the grounds of a house about 400 m from the blast site. The plate was warm to the touch. Other metal debris, recovered from the surrounding area after the blast showed the same qualitative characteristics that generally occur when steel is intimately exposed to a sudden explosive impact.

Subsequent enquiry revealed that there were a large number of weaknesses in executing the project, the prominent ones being: a) the blasting contractor did not have sufficient experience in imploding a large building; b) there was a lack of pre-weakening of some pertinent structure of the building; c) the quantities of explosives used were clearly excessive; d) the protective measures were inadequate; e) there was an inappropriate exclusion zone to ensure the safety of the crowd and f) the height of the bund erected for containing projectiles was insufficient.

Truck explosion, Hunter Valley, Australia

A utility truck, used for carrying explosives in a open cut coal mine, exploded in February 2003. After loading 97 holes with boosters and detonators for the blast of the day there remained a surplus of one box containing 23 detonators, two full boxes of boosters and one box containing 38 boosters. The detonator box and the partly filled booster box were placed at the rear right of the truck, and two full booster boxes on left side of the tray.

The shotfirer then had liquid refreshment and smoke, after which he went to the 'crib hut' and took a packet of cigarettes and placed it in the cabin of the truck. Then he drove the vehicle to the magazine gate, which he stopped to open. After getting out of the truck, the shotfirer noticed smoke coming from the driver's side of the rear tray. He ran to the passenger side at the front of the truck and crouched down, when the vehicle exploded. The shotfirer was hit by flying gravel and knocked over, clear of the moving truck.

The locked gate restricted forward movement of the truck, but was smashed open by the post-exploded vehicle. The dazed shotfirer regained his feet and wandered around the compound in the direction of the 'crib hut'. Subsequently he was found lying on the ground outside the hut.

The injured shotfirer was taken to the hospital to be examined, but apart from small cuts, abrasions, bruises to arms and legs he was not seriously injured. The shotfirer must have been shielded from the explosive force by the cabin, and his injuries were caused by the shock waves from under the truck. Eardrum damage would have normally occurred within 15m of the explosion and although he was actually within a 10m limit, because of the shielding effect of his actual position, he sustained no increased injuries. If the shotfirer had been in a standing position in front of the truck, the windscreen would have decapitated him.

It was clear that the cause of the whole incident was that the shotfirer flicked a burning cigarette out of his window whilst driving, and it landed on a detonator box. The movement of the air over the cigarette caused the box to ignite, which in turn ignited the foil and finally the detonators. The detonators then set off the open box of boosters, which in turn set off two unopened boxes of boosters almost immediately.

Some snapshots of incidents around the World (Anon)

Unplanned detonation of seismic detonators, South America
This incident, involving electric seismic detonators, occurred in South America and resulted in the death of one operator and the amazing survival of another. The survivor has been able to give a complete description of the events leading up to the accident. From this it has been possible to eliminate the obvious causes, such as radios and batteries etc.

The essential details are that a primer charge of Pentolite was being prepared by taping the wires of the detonators to the outside of the charge, when it detonated. The primer charge was a typical plastic seismic cartridge, and two cartridges were joined together, each with a detonator in the detonator well. The detonator leads were shorted and the bared wires insulated. The weather was about 20° C and not particularly conducive to static generation. The operator was wearing light clothing and was kneeling on a wooden platform taping up the primer when it exploded.

The opinion is that an electrostatic discharge must have caused the incident. Technically, the plastic tape being unwound generated a voltage, so that a charge was induced on the detonator. It is postulated that a spark occurred between the shell of the detonator and the fusehead assembly and leadwires.

Explosion while burning empty explosive boxes
After loading a face of a quarry with explosives and initiating devices, a shot-firer collected the empty boxes ready for disposal by burning, and liberally sprinkled diesel fuel to aid combustion. As it was a cold day, he decided to warm himself by the fire. Suddenly there was an explosion, and the man was fatally injured by the blast.

The subsequent investigation revealed that during the shot loading operation, someone had placed an off-cut of heavy duty detonating cord into one of the boxes for later disposal and failed to warn anyone of this fact. The burning of the empty cases, aided by the diesel oil, led to the explosion of the detonating cord. Further, the shotfirer had been standing too close to the fire. Had the shotfirer obeyed basic rules for burning discarded explosives packaging, this accident could have been avoided.

Lightning initiated an explosion in a surface mine, Australia
In 1968 lightning hit a totally non-electric blasting work area in a surface mine in Western Australia. All the blastholes were loaded and were to be initiated with detonating cord downlines and mainlines, and then to be fired with a capped safety fuse.

A rain-storm with associated lightning moved into the area. Because it was hot, the blast crew decided to stay out in the rain to cool off and continued to charge the holes with gelignite. The reel of detonating cord was located on a vertical stake at one end of the blast site. Downlines for each hole were cut off this reel as the blast-crew moved along the row, and eventually the detonating cord lay over the tops of a number of charged holes.

The lightning got close and finally hit the blast site, when the gelignite detonated. This initiated the detonating cord back to the reel, which promptly exploded violently. The two men who were charging were killed. Random holes along the face were initiated where the cord lay over the ends of the downlines.

Safe practice dictates that all shot firing operations should cease in the vicinity of an electrical storm. Moreover, a mainline detonating cord should never be casually run over the downlines. The reel should be taken to each hole and then cut leaving an adequate length secured at the collar. When all the holes are charged, only then is the reel run out to form a mainline. This practice minimises the time that the mainline cord is actually connected to the holes.

Explosion in a truck carrying detonators, China
A truck carrying 285,000 blasting caps exploded in the southwest city of Chongqing, killing 14 persons and injuring 48. Explosions from this blast lasted almost half an hour, blowing out windows in a 50m radius. The driver of the truck and a passenger were killed, while other victims were nearby pedestrians.

It is suspected that a burning cigarette came in contact with the cardboard detonator box, which caused a small fire, followed by the explosion.

Explosion in an underwater blasting operation, Newcastle, Australia, 1978 (Apel, 2005)
The aim of this blasting operation was to deepen the harbour channel to allow larger vessels to berth. The work involved drilling and blasting from a barge where the water depth was between 15 to 20 m. Nitroglycerine based explosives (AN60) with detonating cord were used. Occasionally, drilling rods were used as a tamping rod to push the explosive cartridges into the blasthole.

One day, two lengths of drilling rods were being mechanically joined on the barge surface and caused an explosion in which two workmen were killed.

Subsequent investigation revealed the cause of the accident. Since drilling rods were used to tamp the explosive cartridges, some parts of the explosive cartridge accumulated in the rod threads as well as in the hollow section of

the rods. This explosive residue was not visible, as the rods were partially covered with mud. The pressure created by the mechanical joining of the rods initiated the explosion.
This is a salutary example of the consequences of using an inappropriate tool.

Incidents with trucks carrying explosives, Spain
Two incidents are quoted here. The first one happened in Castellon, Spain, when a lorry carrying ammonium nitrate collided head-on with two cars, killing two persons and injuring three. The damaged heavy goods vehicle overturned and left the road. The diesel fuel from the broken tank came in contact with the load of ammonium nitrate, which initiated an explosion half an hour after the vehicle overturned. The resulting explosion could be heard in villages more than 15 kilometres away. The lorry was totally destroyed, leaving a crater several metres across. The fireballs generated travelled for a radius of up to one kilometre around the area of the accident, leading to 15 small fires. After this accident, the Special Risk Plan for the Carriage of Dangerous Goods was introduced.

Drilling into a charged hole, Denmark, 1995
Two men had been drilling in a rock excavation operation. After drilling a few holes and charging them with nitro-glycerine based explosives with electric detonators, they found the remainder of a previous blasthole, which is often termed a 'butt'. They started drilling into this 'butt' until an explosion occurred, which injured both men.

Subsequent investigation concluded that the men were drilling into un-detonated explosives. Fortunately, the firing circuit with all charged blastholes had not been joined. Of greater concern is that neither of the men had attended a blasting course and that they were using a 12V battery to initiate the shot.

Explosives truck blown up by candles, China, 1996
A truck carrying one tonne of explosives, 5,000 detonators and 500 metres of detonating cord blew up in Sichuan Province. The explosives were accidentally ignited by workers when they lit candles to provide light while unloading the truck.

At least 14 people were killed, more than 30 seriously injured and an unknown number of people missing. All houses were totally destroyed within a radius of 100 metres of the blast, which occurred in an agricultural machinery station in Yunyang County, Sichuan Province.

Premature explosion of detonating cord reel
At a large open pit operation, low energy cord was being used to link-up down lines of standard cord protruding from blastholes. The surface lines were deployed from off the reel from the back of a moving truck when suddenly one of the lines become snagged and snapped. There was an explosion and the remaining detonating cord in the reel exploded into the back of the truck, seriously injuring the operators.

At the enquiry following this accident, it was concluded that the practice of unreeling the detonating cord from a moving truck had the potential to cause a serious accident if the cord becomes entangled or snagged. When this occurs, tension and friction created at the surface connection, when used, is believed to heat the priming element making it much more sensitive to initiation by friction or shock. Premature detonation can occur when the cord is under tension.

Collision of a truck loaded with ANFO, Mexico, 2007 (Abrahams, 2007)
A truck, loaded with 25 tonnes of ANFO, crashed into a pickup on a two-lane highway, and then burst into flame. It took about ¾ of an hour for the cargo to explode after the accident, and created a huge hole in the road. This accident took place near a small farming village and an aquatic recreation centre packed with families on weekend outings. The questions arose about why authorities did not evacuate the scene.
The chief of police investigations in Monclova, a steel city a few miles from the accident site, said the driver of the truck and a co-driver had survived the explosion and were wanted for questioning.

STRATEGIC TRAINING PROGRAM

Introduction

This section describes the Queensland Explosives Inspectorate approach to managing explosives' safety and security, shotfirer licensing, and reviews the proposed directions of the Australian Forum of Explosives Regulators, the work of Skills DMC: National Industry Skills Council in developing uniform national shotfirer competencies. It evaluates the need for skills maintenance of shotfirer competencies and a general evaluation of training and competencies of others in the explosives' life cycle.

Explosives are an essential tool to the mining and some other industries. The management and control of explosives in its life cycle is essential to the health, safety, security and well being of all those involved in its lifecycle. The lifecycle includes all those activities involved in the import, export, sale, use, transport, storage, manufacture and disposal of explosives. These activities are generally licensed under explosives legislation. On a mine site, the people with a role in explosives and blasting may include -

- Drill and blast superintendent;
- Blast designer;
- Driller;
- Blasting contractor;
- Shotfirer;
- Shotfirer assistants;
- Magazine keeper;
- Vehicle drivers;
- Transporters; and
- Explosives manufacturers including mobile manufacturing units and ANFO blow loaders. Of these people, the shotfirer is one of the few people who must have mandatory competencies for an accompanying licence or equivalent.

Queensland Explosives Inspectorate Approach

The Queensland Explosives Inspectorate administers the *Explosives Act 1999* and Explosives Regulation 2003. The approach of the inspectorate is governed by the legislation and the vision and mission. The vision of the inspectorate is *Our community safe and secure from explosives* and the mission is *To protect our community from the adverse impact of explosives*.

The approach of the Explosives Inspectorate is based on the approach of Professor James Reason and the Swiss Cheese Model and is summarised in Figure1.

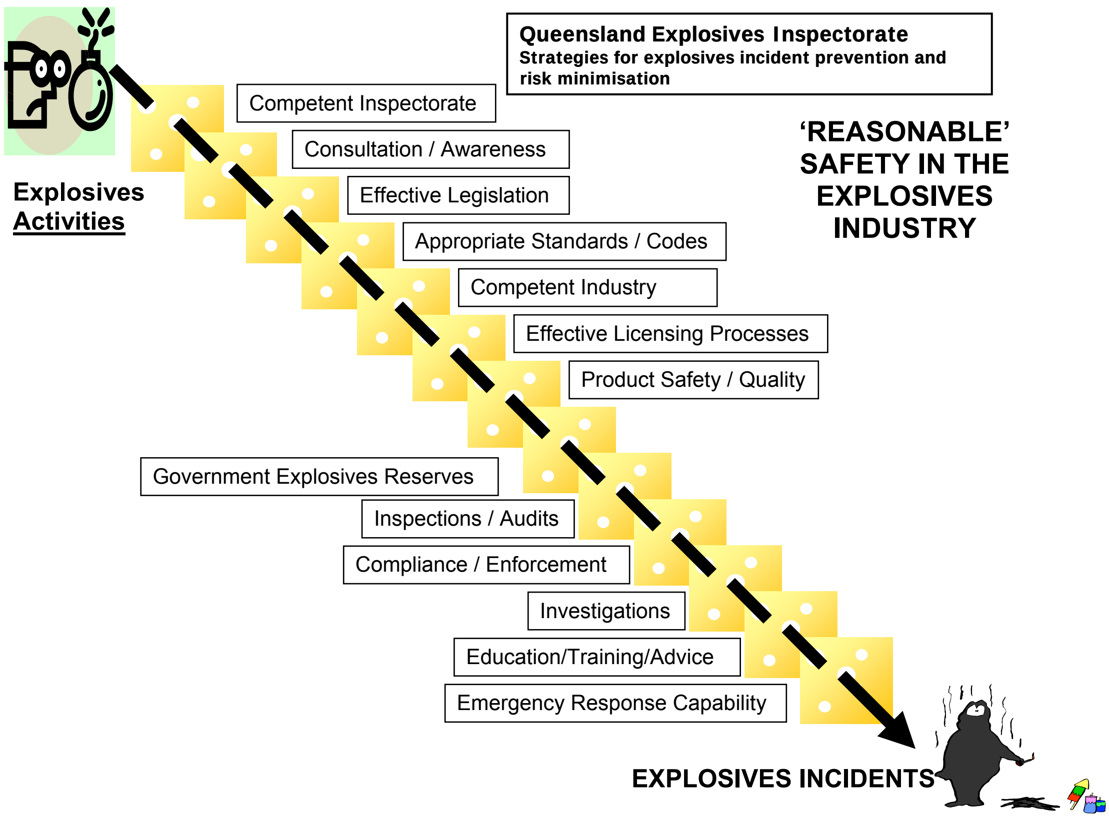

Figure 1 - Queensland Explosives Inspectorate Strategies for explosives incident prevention and risk minimisation

Briefly, in the "Swiss Cheese" model, a series of barriers and defences are put in place to prevent incidents. Each barrier and defence is not entirely 100% effective and hence there is an opening in that barrier and defence and hence the hole. The hole may open and close due to the changing circumstances altering its effectiveness. The more barriers and defences that are effective are put in place, the more reliable and effective the strategy and system will be. When the holes in the "Swiss Cheese" line up, an incident will occur.

From Figure 1, a competent industry together with suitable education and training are important barriers and defences in the strategy to prevent explosives incidents and minimise risk. Effective training and competencies are essential strategies. Training is a combination of formal training and on-the-job training. A similar type of model could be developed by a workplace for the development of their own strategies to prevent accidents and minimise risk.

Shotfirers

Now specifically looking at shotfirers in Queensland, a shotfirer for underground or above ground coal activities must be licensed under the Explosives Act 1999 or appointed as a shotfirer by the Site senior Executive under the Coal Mining Safety and Health Act 1999. A shotfirer licence is issued for a one or five year period. For a new shotfirer licence to be issued or renewed, a current Statement of Attainment from an accredited Registered Training Organisation (RTO) under the Australian Quality Training Framework (AQTF) must be provided with the application. The Statement of Attainment must be dated within the last three years and must have the required national competency units from a national training package. Table 1 in the Appendix is used by the Queensland Explosives Inspectorate to determine if the requisite competencies from the agricultural, metalliferous, construction industry, quarry or coal packages have been obtained. The columns in Table 1 provide a list of alternative competencies that can be obtained to achieve the desired category of licence, Category 1 being agricultural, seismic and small scale blasting, Category 2 is quarrying, open cut and construction and Category 3 is tunnelling and underground mining. As seen from the table, the selection of competencies is quite complex considering the competencies options from the agricultural, metalliferous, quarry or coal packages, which have equivalent competencies.

The origins of the current blasting competencies are set within a number of nationally accredited training packages under the Australian Quality Training Framework. These training packages can be found on the National Training Information Service (NTIS) website www.ntis.gov.au. These include military, transport, coal mining, quarrying, metalliferous mining, civil construction and agricultural training packages. For blasting, the three nationally accredited mining training packages referred above each contain units, which outline competency requirements for topics from magazine keeping to blast design.

Skills DMC: National Industry Skills Council

Currently the Skills DMC: National Industry Skills Council is managing a consolidation project aimed at rationalising duplication of similar competency units within several closely allied training packages. The common units should be released in late 2008, for use in metalliferous and coal mining, quarrying and construction industries. The proposed consolidation of the shotfiring units will simplify the complexity of competencies across the three nationally accredited mining training packages and this work has been the subject of consultation and review with stakeholders from government, industry and the unions who are in agreement with the proposed changes. The Skills DMC: National Industry Skills Council has kept the members of the Australian Forum of Explosives Regulators (AFER) briefed on the progress and development of the work.

Skills DMC: National Industry Skills Council is a national organisation with the primary role of facilitating the Vocational and Education Training needs of all stakeholders within the Coal, Civil Construction, Construction Materials, Drilling and Metalliferous industry sectors.

Australian Forum of Explosives Regulators

In addition to the consolidation of the shotfirer units by the Skills DMC: National Industry Skills Council, all States explosives regulators who are representatives at Australian Forum of Explosives Regulators (AFER) have agreed to adopt and transition towards using these nationally accredited competency units as a basis for their respective shotfirer licensing regimes.

Through the activities of the AFER, all States explosives regulators have also committed to consistent licensing and licensing criteria for all explosives related activities including shotfirers. Not only has it been agreed, but it is currently under active review. All States explosives regulators have agreed to adopt the national competencies as the basis for licensing.

To date, there has not been discussion or agreement at AFER regarding the refreshing of competencies at regular intervals e.g. every five years.

National competencies for shotfirers have existed for many years now. Not all jurisdictions require evidence of the national competencies for licensing purposes. Even though this position exists, all jurisdictions at AFER have committed to their adoption.

The AFER is the forum of government authorities responsible for administering explosives safety and security legislation in Australia. The AFER reports to the Workplace Relations Ministers' Council (WRMC) on the development of nationally consistent explosives regulation, through the Australian Safety and Compensation Council (ASCC). Membership of AFER consists of two representatives from each Australian state and territory, Australian Government including Defence, Civil Aviation Safety Authority (CASA), and Australian Maritime Safety Authority (AMSA).

AFER's terms of reference include but are not limited to:

- acting as the lead body to provide recommendations to governments through the WRMC on nationally consistent explosives regulation;
- promote the development and implementation of nationally consistent legislation and safety and security standards to Ministers, heads of agencies and associated parties.

Maintenance of competencies

In Queensland, a person applying for a new or renewed shotfirer licence must provide a Statement of Attainment dated within the last three years for the required national competencies provided by an approved Registered Training Organisation. This position is at variance with the State and Territory bodies administering the AQTF. Their assertion is that a person who is deemed competent will remain competent and that competency does not expire.

The approach of ensuring that a Statement of attainment is dated within a certain period of time e.g. three or five years was introduced in the Explosives Regulation 2003 in Queensland. A review of training and competencies was undertaken as a part of the investigation into the fireworks tragedy at Bray Park Brisbane in May 2000. Franklin (Franklin 2001) in his Training and Competencies Report recommended that a program should be developed that states requirements for skills maintenance of all licence holders to the initial standards. Franklin (Franklin 2001) also recommended that legislation must be developed that requires both formal and on-the-job training as an initial licensing requirement, and on-going refresher training as a condition of licence holding.

It is recognised that fireworks operators had similarities to underground coal shotfirers to the extent that they conduct their explosives activities on an infrequent basis.

In addition, from reviewing explosive incidents and complaints undertaken by the Queensland Explosives Inspectorate, the knowledge and skills of shotfirers has been contributing factors. Within the last 15 years, there have been great changes in most areas within the explosives life cycle. There had been the implementation and adoption of new legislation, Explosives Act 1999 and Explosives Regulation 2003, changes for control and security of security sensitive ammonium nitrate, new and updated Australian Standards AS2187 Parts 1 and 2 for the storage and use of explosives, new code for the transport of explosives by road and rail, new industry codes for the explosives precursors, mobile processing plants and hot and reactive grounds. The *Explosives Act 1999,* like the *Coal Mining Safety and Health Act 1999* is performance based adopting a risk management approach to the management of health and safety.

During these periods, technology has advanced with the implementation of new initiation systems, explosives companies introducing changed products including safer explosives and with the growth of the industry, shots are being larger. With these changes have also come new challenges such as hot and reactive ground in areas where they were unknown for the new products being used. In general, there was considerable change. This has driven the mechanism to be in place for the shotfirer to upgrade their skills. This mechanism is the refreshing of the competencies though possessing a current Statement of Attainment. The issue date should be within the last three years.

During this period, the world security crisis has resulted in the upgraded focus on security of explosives, ammonium nitrate and explosives precursors and the appropriateness of people having supervised and unsupervised access.
In addition to these technical changes, the mining industries are facing huge challenges with skill shortages, high staff turnover rates and loss of corporate memory. In the Australian Mining Journal Nov/Dec 2005, the Newcrest Managing Director reported that 41% of the employees of that company had been with the company for less than one year.

All shotfirers must have and maintain a desirable level of competence. To achieve this, shotfirers must be initially well trained. There is sufficient data (Franklin 2001) to suggest this can be achieved in a structured training course, which includes sufficient task skills development. There is also sufficient evidence (Franklin 2001) to suggest this is more likely to occur in a formal training environment than by potentially ad hoc on-the-job training. Data (Franklin 2001) has shown that initial competence can be lost over time and/or replaced with alternative approaches. This indicates that competency can be lost over time. One explanation is the loss of theoretical knowledge in relation to safety matters. Other explanations are that practical skills were never gained, such as with limited practical training or were lost by lack of use due to limited numbers of blasts. A combination of the two approaches is another obvious explanation.

Under legislation, a person must be trained and competent for the role and tasks that they will be undertaking. In addition to the identification of formal training needs, all workplaces managing explosives must develop operate and maintain a safety management system and security plans. These activities require, in addition to formal training to national competencies, on the job training and for this training to be refreshed.

There is a combination of formal training and on the job training for all jobs. The greater the reliance and use of national competencies is well recognised and supported. The relative timing of formal training and on-the-job requirement is important.

The essential modules of such a refresher blasting course should consist of the following :

- Familiarisation with current types of explosives and accessories;
- Types and modes of initiation;
- Blast design and calculation;
- Precautions to be taken before and after firing; and
- Consideration of environmental factors; and
- Dealing with misfires.

This is essentially renewing the national competency which can be done by a combination of course work and recognition of prior learning. The addition of reviewing accidents and incidents such as those identified earlier in this paper would be most useful.

As seen above, national competencies exist for shotfirers and these are being rationalised by the Skills DMC: National Industry Skills Council. It is also noticed that not all states explosives regulators require that shotfirers must be competent under these national competencies. Because shotfirers must hold licences or equivalents based on these competencies in Queensland, there are eight Registered Training Organisations in Queensland approved to deliver training and refresher for shotfirers to these national mining competencies covering explosives. This training covers shotfirers, assistant shotfirers and magazine keepers. This is a very effective and satisfactory outcome.

European developments

A recent paper (Akhavan et al, 2007) describes developments in the European Qualification for Workers in the Explosives Sector. Over the past three years, the UK, Sweden, Norway, Finland and Italy have taken part in a program under the EU funded Leonardo Da Vinci program. The UK has developed National Occupational Standards for the civil and defence sectors. The National Vocational Qualifications define the knowledge and skills and how these form the basis of vocational education. Currently there are 440 National Occupational Standards and competencies, 24 National Vocational Qualifications within 12 key roles. These can be found on http://www.qca.org.uk/610.html under explosives substance and articles. People have the ability to subscribe to some of these competencies over the web for a fee.

CONCLUSION

The developments in consolidating and rationalising the current blasting competencies by the Skills DMC: National Industry Skills Council is positive step forward for the training and competencies of shotfirers.

The commitment of the state explosives regulators to move to adopt these competencies for licensing is a positive step forward together with the step toward consistent licensing and licensing criteria.

The maintenance of the knowledge and skills of shotfirers should be refreshed at a minimum of every 5 years and this should be done through the maintaining of the national competency standard. This follows a period of rapid change in technology, legislation, standards, codes and security awareness.

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REFERENCES

Abrahams, D.H., Personal communication, 2007.

Apel, D., Personal communication, 2005.

Akhavan, J. et al, "European explosives qualifications – the EUExcert Project, Proc. 4th EFEEWorld Conf. Explosives and Blasting, Sept. 2007, Vienna, Austria, pp 417 – 424.

Akhavan J. et al "Developments in the European Qualification for Workers in the Explosives Sector" Proc Parari 2007, 8th Australian Explosive Ordnance Symposium, Melbourne, Australia, November 2007.

Anon, "Explosives Engineering", Journal of the Institute of Explosives Engineers, UK, information extracted from several issues.

Franklin P.D. "A Report on the Training and Competencies of Queensland Fireworks Shotfirers and Related Matters For the Investigation Into The Bray Park Fireworks Tragedy on 20 May 2000" Department of Natural Resources and Mines 21 June 2001 – Volume 4 Attachment 4.5 of Investigation Rep Bray Park Fireworks Tragedy 20 May 2000 - Report prepared by G Downs, 27 June 2001 – Department of Natural Resources and Mines.

Sen, G. and Hayward, M., "Blasting operations: training strategies", Proc.4th EFEE World Conf. on Explosives and Blasting, Sept. 2007, Vienna, Austria, pp 395 – 400.

Sen, G.C. and Abrahams, D.H., "An analysis of some explosives related accidents", Proc. 3rd EFEE World Conf. Explosives and Blasting, Sept.2005, Brighton, UK, pp 45 –54.

Competency Units	Training Package	A	B	C	D	E	F	G	H	I	J	
		Category 1 Agricultural, Seismic, Small Scale Blasting					**Category 2** Quarrying, Open cut (metalliferous and coal), Construction			**Category 3** Tunnelling and underground mining		
MNMG 352A - Apply Blasting Activities #; (or QEC110, 111, 112, 113, 114)	MNM 05 (or 39023QLD)	x	X	x	x	x	x	x	x	x	x	*Metalliferous*
RTD 3709A - Handle and Store Explosives	RTD02	x										*Agricultural*
RTD 3710A - Identify and Select Explosives	RTD02	x										
RTD 3711A - Prepare and Use explosives	RTD02	x										
MNMG 313A - Charge Blast Holes (UG); (or MNMG 321A & MNMG 323A)*	MNM 05		X							x		*Metalliferous*
MNMG 412A - Initiate blasts (UG)	MNM 05		X							x		
MNMG 353A - Fire Surface Blasts	MNM 05			x			x					
MNMG 210A - Store, handle and transport explosives	MNM 05						x			x		
MNMG 311A - Conduct secondary blasting	MNM 05				x							
MNMG 349 - Conduct accretion firing	MNM 05					x						
*MNQOPS 313A – Handle and transport explosives** (or MNMG 210A)*	MNQ03 (or MNM 05)							x				*Quarry*
MNQOPS 413A - Conduct Shotfiring	MNQ03							x				
MNCO 1040A - Conduct Shotfiring operations	MNC04								x			*Coal*
MNCU 1048A - Conduct Shotfiring (UG)	MNC04										x	
Conditions		1,5	2,6	2,5	2,3	2,4	2,5	2,5	2,5	2,6,7	2,8	
		□	□	□	□	□	□	□	□	□	□	

APPENDIX - Table 1 – Shotfirer Competency Requirements – Queensland December 2007