

THE PROPER USE AND HANDLING OF EXPLOSIVES

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1. Introductions

The power released in a typical production blast is beyond the comprehension of most people. Few people understand the magnitude of the forces released at detonation. In a shot in which all goes well, the muffled sound of the explosives releasing their energy and the gentle rise and fall of the ground which contained the explosives does not give a true indication of the violent forces being released. One 25mmx200mm cartridge of explosives releases about 33 million horsepower of energy in .00004 of a second. The combined horsepower of all the equipment on any mine site pales into insignificance when compared to that of a single small cartridge of explosive. The power of a large production blast I would venture to say is beyond the comprehension of all, including myself. The powers unleashed by explosives are only equalled or bettered by Mother Nature yet with each passing day the respect for the very useful commodity has decreased to a point where many individuals and companies pay scant regard to its hazardous nature.

Studies carried out in the USA have determined that 70 out of 1000 blasting accidents are fatal. If one reads these statistics quickly this may not seem as being a high strike rate, that is until you compare these statistics with that of other activities which we consider as high risk occupations. Excluding explosives, the statistics for other mining operations in the U.S.A is a fatality for 7 out of every 1000 accidents. I do not know the Australian statistics but one could assume that they are similar.

I'm sure that the statistics for injuries and fatalities in recent times are better than they were in the past, but so should they be. Society today expects more.

2. Inherent Dangers

An explosive is essentially a substance that is in a state of metastable equilibrium. That is to say that it is a store of potential energy, which may be converted if given the required stimulation into kinetic energy. In order to manage explosive safety one must first recognise the potential dangers

2.1 Impact Sensitivity

The impact or shock sensitivity of an explosive is the ease with which the explosives can be induced to detonate. All explosives do exhibit a degree of sensitivity. The reason for this is that the atoms which constitutes the explosives, given their freedom of choice, prefer to be in other combinations. This is evident by their heat (energy) output during explosion or decomposition as the atoms reconstitute into more stable forms.

Accidental detonation or deflagration can occur in situations where the explosive is exposed to impact or is squeezed between objects.

The standard test for impact sensitivity is the dropping of a specified weight from varying heights under controlled situation onto a thin section of the tested explosive. Impact test using a 1kg weight has shown that nitroglycerine will explode when the test weight is dropped 2cm. Pentaerythritol tetranitrate (PETN) which is the base charge in detonators and the explosive in detonating cords will explode if the test weight is dropped 31cm.

Explosives technology has come a long way in the past few decades. Packaged gelignite and dynamite have been replaced by less sensitive ANFO, emulsions and watergels. In tests, ANFO, emulsions and watergels have shown that they are significantly less sensitive to impact. The safety virtues of these less sensitive explosives have been sung loud and long for many years. Despite these virtues, one must keep in mind that all explosives are designed to explode and regardless of whether the explosive is of old or modern technology, if given the appropriate stimulus, it will explode. The necessary stimulus need not necessarily be a prepared primer. Despite all the advances in technology, explosives cannot tell the difference between the application of an accidental or deliberate stimulus. Many in the blasting industry as a whole, appear to be ignorant of this cold hard fact.

One also needs to complete the picture. When relative insensitive emulsions and watergel explosives are used in a blast, we have in fact a mixture of old and new technology. In almost every blasting application there is a requirement to use detonators, cast boosters and detonating cords. Detonators by necessity contain powerful sensitive explosives, which are very sensitive to impact and shocks that can easily be applied by inappropriate handling. Detonating cords and cast boosters must be treated with care as these also contain explosives that are highly impact sensitive. When all the explosives come together the entire shot is no less sensitive than its most sensitive component. Just as a chain is as strong as its weakest link, so is it the case with explosives.

When handling explosives one should:

- treat all explosives with respect. No explosive, regardless of their stated degree of safety, should be abused;
- not subject explosives to high impact situations;
- not carry unsecured explosives around in a vehicle;
- not leave explosives where they can be inadvertently run over by vehicles;
- not allow cast boosters to free wheel down blast holes;
- not force explosives that have become stuck in a blasthole; and
- not manoeuvre underground charge vehicles without due care.

2.2 Fire

One must also recognise the potential for fire. The sensitivity of explosives increases dramatically when fire and heat is introduced. Detonation by transition from burning to detonation is a very real risk, especially in storage and manufacturing situations. The risks associated with fire are not restricted to explosives of old technology. History has shown that unsensitised emulsions, generally referred to by industry as a class 5.1 Oxidisers, can explode and have exploded in the event of a fire. One also needs to remember that a fire does not need to engulf the explosives themselves for an explosion to occur. Fire in the vicinity of explosives can elevate temperatures enough for explosion to occur. Generally the more confined the explosives, the greater the risk.

Injury and death as a result of fire in or amongst explosives has occurred since explosives were first used and have continued to occur ever since. Those who know something of explosives history may recall the events of April 16, 1947. A ship loaded with about 22000 tonnes of ammonium nitrate caught fire and exploded in Texas City Harbour. 576 people lost their lives as a result of that explosion and many hundreds were injured. This incident would not have occurred had a member of the crew not disregarded the 'no smoking' sign. The so-called experts at the time assured everyone that this product would not explode. Had this advice been different then hundreds of lives may have been saved. The lessons learnt from this tragedy should have ensured that everyone would be continuously vigilant in order to prevent a recurrence, however death and injury caused by fire amongst explosives or explosive precursors has continued. Thankfully the scale of these occurrences have been less significant. In order to reduce the risk of explosion from fire one must first accept that a risk exists, regardless of the type of explosive involved.

Simple steps that one can undertake to minimise the potential for fire include:-

- ensuring that all unnecessary combustibles are moved away from explosives;
- ensuring that explosives are not transported with other flammable material;
- ensuring that serviced firefighting equipment is available and people are trained in their use;
- ensuring that equipment used to handle explosives is fitted with suitable spark protection;
- ensuring that no naked flame is allowed within the vicinity of explosives; and
- ensuring that all employees are aware of the risks that fire amongst explosives presents.

3. Current Concerns

As mentioned earlier explosives by nature are a hazardous material, however explosives alone do not cause accidents. Accidents are caused by people who have carried out a careless or thoughtless act. Sometimes the effect of a careless or thoughtless act is not immediate and the consequences of these actions may be removed from where this act took place. It is often the case that people who carry out careless or thoughtless actions are never aware of the ramifications of those actions

3.1 Explosives Security

Explosives have played an extremely significant role in the development of the modern world. Materials acquired from mining and the development of much of the infrastructure we have in place would not be possible if it were not for explosives. Unfortunately explosives are not always used for the benefit of mankind. The very same explosives that are used every day on mine and construction sites, if allowed to come into the hands of untrained persons or those who use explosives for unlawful activities, present very real dangers to people and property.

Significant quantities of explosives do go missing from mine sites each year. Most of these missing explosives are not reported and in many cases it appears that those in control of these explosives are not aware that they are missing. Unfortunately all too often these explosives are required to be recovered from unauthorised people in unauthorised locations and at times at great danger to those required to recover or neutralise these explosives.

The standards required for surface explosives magazines are high and to gain unauthorised entry, although not impossible, is very difficult. Secure explosives storage is an important measure to prevent explosives falling into the hands of unauthorised persons, however the effectiveness of this control is diminished if it is not accompanied by other controls. The employees who work at a mine are a cross section of the community. We have our honest and our not so honest. Those in charge of explosives must ensure that explosives are under supervision at all times. Explosives should never be left unattended on the back of vehicles or on the bench. Personnel who do not have legitimate reason to come into contact with explosives should not be allowed access to explosives. The efforts to ensure explosives security whilst the explosives are in storage are to a large degree negated if similar efforts are not applied once the explosives leave the storage magazines.

Stocks used during a shot should be reconciled at the end of the day to ensure accountability. If any discrepancies are found the discrepancy should be investigated. Any unexplained explosives discrepancies should be reported to relevant authorities.

The legal and moral obligations of a blasting contractor or mine manager in relation to explosives does not necessarily stop at the mine exit. Those in control of explosives must ensure the accountability of their explosives.

3.2 Complacent Attitudes

The absence of frequent death or injury associated with explosives use in recent years has definitely lead to a complacent attitude by many in regards to the very real hazards that explosives bring. This is in some ways highlighted by the tendency to skirt around using the word explosives these days. Less alarming terms such as blasting agents, IE and accessories have become everyday definitions. If those who come into contact with this product are aware of what this product is it doesn't matter what you call it, but to many if you don't call a spade a spade, it ain't a spade.

Blasting manuals at Mine Sites mention things such as 'presents no hazard under normal handling' but then do not go on to clarify normal. Some of the practices that are occurring at some of the sites which use explosives could hardly be called normal.

Comments such as 'a truckload of these explosives could fall down the mine and nothing would happen' have been witnessed being given by a person who held a position that could influence explosive safety. It is not too hard to guess what the overriding attitude towards explosives are within this organisation. Another presentation given by a member of industry referred to modern explosives as 'play dough'. Unfortunately this type of message is eagerly consumed by many users who see the opportunity to save costs by not following the rigorous safeguards of the past.

People do abuse explosives everyday and get away with it. Every time explosives are mishandled without incident complacency inevitably follows. Australian Army statistics of about 20 years ago showed that army personnel who were most likely to be injured by explosion were soldiers who had

many years experience with explosives. They had become complacent with the potential. New recruits rarely had any mishaps. One would venture to say that the same might well hold true in our industry.

If one were to spend a few moments trying to comprehend the magnitude of the powers possessed by explosives as mentioned in the introduction of this paper, surely one's appreciation of this product potential cannot be anything but enhanced.

3.3 Practices

The flow-on effect of complacency is that practices involving the manufacture, storage, handling and use of explosives deteriorate. Poor practices that go unpunished lead to further complacency that begets even poorer practices. If this cycle is allowed to continue its downward spiral, an incident is eventually inevitable.

More than once have operators been found to be driving over a shot that has been loaded or in the process of being loaded. Some operators have been found to continue this practice even after being made aware of the hazards that this type of action can bring. Do such operators fail to be convinced of the hazards despite accident reports to the contrary, do they believe that it is worth the risk to facilitate shorter loading times or are these people just so irresponsible that they don't care about the risks to others and themselves?

Shots are not always checked after tying in and at times those who design the shot spend little time surveying the work site. Flyrock in many cases is considered as an inevitable by-product of blasting and hence accepted. Many sites introduce the detonators to the explosive being used as a primer long before required, thereby littering the site with pre-made bombs. Explosives have been thrown off vehicles onto the bench, allowed to free-fall down blast holes and have been run over by loaders in dark conditions underground. Any of these, and many other poor practices, have the potential to end in tragedy.

Often explosives are used in environments that are extremely challenging such as areas of high temperature, highly reactive grounds, geologically unsound ground or water affected ground. The importation of poor practices that have been carried out in competent mining conditions to these more challenging environments increases the potential for an incident to occur.

4 Corrective Actions

4.1 Training

Of all the occupations that are available, one cannot think of many that would have a greater demand for high levels of training than those who use explosives, however this is not always the case. Qualifications and skills of many using explosives, I'm sorry to say, on the whole is not high. The first position too many occupy when they start at a mine is that of the blast engineer or as part of the blast crew.

Poor practices have been passed from trainer to student and therefore become the 'norm'. Checks on the competencies of those using explosives have been all too infrequent and, when undertaken, are more often than not, too shallow.

The person in charge of the blast crew should be well experienced and his/her primary task should be the management of blasting operations. When new personnel are appointed to a blast crew these employees should be under direct supervision until competence is assured. Even if new employees have had previous experience with explosives, it must be recognised that technology and blasting practices change rapidly that the new employees skills may well be out of date and hence the previous experience amounts to little. The safety of any blasting operation depends upon qualified, competent personnel using the proper equipment and materials, observing correct blasting procedures and working in accordance with a well formulated plan. Strong communication between the designer of the shot and the drill and blast crew is a must.

New explosives legislation will require shottirer's qualifications to be of a higher standard than they have generally been in the past, however those using explosives and those in charge of such operations have a professional and moral duty to ensure that:

- only blasting activities that are within their competence are undertaken;
- professional skills are maintained and improved;
- codes and standards are strictly observed and
- the selection process for employment of those who undertake explosives activities endeavour to ensure that these people are sensible and responsible people.

4.2 Safety Systems

Even the most diligent and safety conscious person who is employed in the manufacture, handling or use of explosives is subject, to some degree, to the same failing and distractions as the rest of society. Every routine action undertaken by an employee will not be a well thought out conscious act. Well developed safety systems will minimise the potential for an accident even during brief attention lapses of employees. Safety systems need to be rigidly enforced to ensure that good safe work practices are developed through repetition. Repetition of good practices will in time become habit and only through habit are actions reasonably predictable.

Safety systems at a minimum should consider the following where applicable:

- supervision of visitors and contractors in explosives areas;
- maintenance of buildings, plant and equipment;
- restrictions on smoking, alcohol and other factors affecting explosives safety;
- chemicals register and availability of MSDS;
- preparation of operating procedures, eg who, authority?;
- selection, maintenance and use of PPE;
- lock out/tag out, confined space entry and hot work permits;
- disposal of waste explosives and ingredients, including burning ground procedures;
- modification of process equipment, formulations, materials, packaging or procedures;
- testing of trips, alarms and other protection systems;
- emergency response plan including an evacuation plan, appropriate fire fighting controls, consequence minimisation steps, control of spills;
- transport of explosives;
- security of explosives;
- storage of explosives;
- materials handling;
- receipt of explosives to site;
- explosives and personnel limits in buildings or locations;
- use of explosives;
- adverse weather conditions eg lighting;
- restrictions on sources of ignition;
- segregation of incompatible materials;
- competence of personnel for tasks;
- explosives manufacture;
- explosives operations or activities with particular emphasis on hazards, housekeeping and accident prevention;
- incident reporting and response;
- non-conforming materials and product;
- records to be maintained;
- safety meetings;
- complaints and response;
- operations of plant and equipment use with explosives and
- self auditing of systems and procedures.

5. Summary

A relevant analogy of the potential hazards explosives bring in relation to mining operations would be that of a very large boulder balancing on top of a mine wall or drive. At the beginning everyone is concerned and aware of the potential dangers this rock brings. After a couple of years this boulder has not moved and everyone now pays it no attention. Stability checks are no longer taken and safeguards relaxed. This boulder may rest there for years until someone inadvertently gives it a bump causing it to topple from its resting place destroying all in its path.

Skills are not as good as they should be. If the skill levels of those using explosives were to improve not only would the potential for mishaps to occur diminish, the mine would also benefit as increased skill will mean saving in production as the ability to optimise blasting increases. The explosives industry is constantly changing with new products and techniques. Only a skilled blast crew can quickly and safely come to grips with changing products and techniques.

Many of the explosives on the market today are more stable and less sensitive to impact than they were a few years ago, however just by using modern explosives and equipment does not eliminate the potential for an explosives accident. Modern motor vehicles are safer than motor vehicles of the past but people driving these vehicles are still killed or injured every day. Using modern explosives does not eliminate the potential for an explosive accident.

We do have a good safety record for the use of commercial explosives in Queensland and the manufacturers, users and regulatory authorities can all take some credit for this good record. There have however been many documented very near misses and if luck had not played its part our statistics would not be so flattering. We need to take advantage of modern technology to increase the level of safety, not view these explosives as an opportunity to relax practices for convenience or economic purposes..

REFERENCES

International Society of Explosives Engineers
Queensland Explosives Inspectorate

Blaster's Handbook
Draft Explosives Regulations