RISK ASSESSMENT OF EXPLOSIVES USE IN AN OPEN CUT COAL MINE

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SUMMARY

A system safety risk analysis on all aspects of the use of explosives for blasting has been conducted at Blackwater Mine. The objective is to formulate an Explosives Management Plan for the safe use and handling of explosives on a minesite.

The review was prompted by the occurrence of an incident involving the manufacture of explosives. A major recommendation from the investigation was to carry out a safety risk analysis on all aspects of explosives handling onsite with the view of developing a safety management plan.

The safety risk analysis was facilitated by MineRisk with a team including representation from ICI Explosives, Department of Mines and Energy Inspectorate (Mines, Mechanical and Explosives), and Mine Management, Blast Crew and Miners Officer representatives from Blackwater Mine.

All aspects of the handling of explosives, including procurement, transport, storage, site manufacture, usage and equipment were covered in the review. Also considered were such aspects as maintenance practices and competencies of people.

All hazards identified, and their corresponding risks, were assessed in terms of consequence and probability and ranked in terms of risk profile. This then established a basis to prioritise and identify key areas to review or establish controls to minimise risk and to develop an Explosives Management Plan.

BACKGROUND

Blackwater Mine is an open cut coal mine located some 25km southwest of the town of Blackwater in Central Queensland. It is part of the Central Queensland Coal Associates joint venture, and operated on their behalf by BHP Australia Coal Pty Ltd.

The use of explosives for overburden and coal blasting at Blackwater Mine is as per industry standard. ANFO and water resistant explosives for overburden blasting are manufactured on site by batch loading a bowl truck. The water resistant explosives for coal blasting are provided by ICI Explosives utilising a Mobile Manufacturing Unit (MMU). Historically by way of mine practices, site procedures and legislative controls the main attention to risk control utilising explosives has been directed in the main, toward the preparation and firing of shots, and the handling of misfires.

In May 1995 an incident occurred on site during the manufacture of heavy ANFO which created a potential situation for premature explosion. This occured when a trailer mounted monopump was incorrectly connected for the process of transfering emulsion from a bulk tanker to the bowl truck. The result was, the operation of the pump was in the reverse direction creating a condition known as "dry running". The lack of feed caused the stator to get hot, thus exposing any residual emulsion to heat and pressure. There have been incidences overseas where if this situation is prolonged, it creates an explosive condition.

The subsequent investigation highlighted the need for a focus on safety systems in relation to all activities related to the use of explosives on the minesite.

DEVELOPMENT OF THE EXPLOSIVES SAFETY SYSTEM

A detailed review was undertaken during July and August 1995. It was run as a facilitated exercise, coordinate by MineRisk with a total of seven contact days involving representatives from Blackwater Mine Blast Crev Registered Mine Manager, Miners Officer, production and product experts from ICI Explosives an representatives from both the Coal Mines and Explosives Inspectorates.

The objectives of the review were:

- To identify and assess risks to safety and production loss, and then to identify existing an additional risk management measures to;
  - support the development of an Explosives Management Plan specific to Blackwater Min and
  - provide a framework for a more general Explosives Management plan for BHP Austral Coal.
- To promote an improvement awareness and knowledge of explosives and promote go communication within a review team drawn from various backgrounds and areas of expertise.

The scope of the initial review was primary blasting with the focus of attention on "upstream" activities fr firing. The "tie up" and "firing" process is relatively well documented and controlled and for which existi procedures are available.

At a later period, a separate risk assessment was carried out to review secondary blasting in ROM hoppe crushing/conveying facilities, bins and bottom dump trucks. Whilst the scope is not outlined here, it will included in the Explosives Management Plan.

With primary blasting, a detailed examination of the following activities was undertaken

- Procurement of explosives
- Transport onto and around the minesite
- Storage on site of ingredients and/or explosives
- Manufacture on site (BHP bowl truck)
- Site preparation (for manufacture and loading)
- Loading (charging)
- Maintenance of equipment

A more general review was made of

- Stemming
- Tying up
- Firing
- Post firing inspection
- Treatment of misfires

The interrelationship between these activities is outlined in Figure 1.

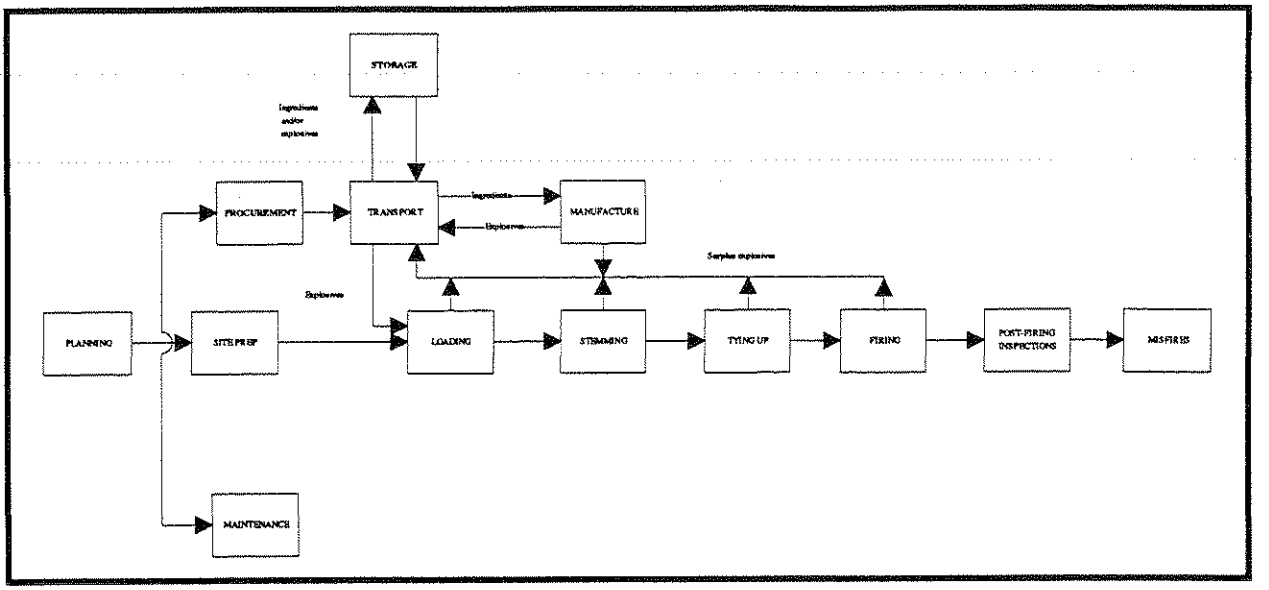

Figure 1. Explosives management process at Blackwater Mine for primary blasting

The risk analysis process used in the exercise is outlined in Appendix A. The process included a description of the steps followed for each of the explosive handling activities and for each of these steps the identification of any potential hazards. These hazards were then reviewed and a risk ranking nominated. The system allows for ratings of 1 - 25 to be nominated and the risks are then ranked into:

High risk (1 - 6)
Medium risk (7 - 15)
Low risk (16 - 25)

The risk rankings or profiles, provide for an indicative priority to review or assess controls already in place and if found to be inadequate to propose potential controls that need to be put into place to minimise the risks to safety and production.

OUTCOME

With consideration given to the hazards identified and ranked, and to existing controls in place, the following general observations are made

- The age and maintenance of key equipment used in explosives handling was a major concern
- Manufacturing includes some high risk issues, but many hazards identified are around the "medium to low risk" range
- Transport and loading represent some areas of significant risk
- Procurement and storage represent few risks

Outlined in Table 1 is a summarised version of an explosives management plan. In addition to the identified hazard and control sets, it is necessary to allocate responsibility to ensure the controls are in fact implemented and incorporated into the "culture" of explosives handling. The consideration to effective controls must include an understanding of the concept of "hard" and "soft" barriers (Appendix B).

Typical "hard" barriers include

- various upgrades to ingredient transfer systems
- improved preventative maintenance systems
- replacement of equipment (eg proposal to replace bowl truck with a bowl/mobile manufacturing unit (MMU) to improve availability and also eliminate many of the identified hazards associated with manufacture and transport of bulk explosives (manufactured as loaded)

Typical "soft" barriers include

- Schemes and work instructions (30 in total)
- Effective system of signage and naming systems
- Training and competencies of persons supervising, handling and generally associated with explosives

ACTIVITY	PRINCIPLE HAZARDS	PRINCIPLE CONTROLS
Procurement	Quality, quantity	Quality control, supplier performance, good planning procedures
Transport	Less than adequate transport equipment and operations - premature initiation during transport	Equipment complies to standards and statutes (maintenance) Minimal exposure to mine workforce/facilities to prevent premature initiation Competent personnel
Storage	Less than adequate storage, security	Storage facilities good state of repair and comply to AS and CMA Procedures providing for effective and secure storage
Manufacture on site	Uncontrolled initiation - Diesel spillage during transfer - Mono transfer pump failure, incorrect operation - External or internal source initiated fire	All equipment well maintained Follow fuel spillage procedure Fail safe mechanisms Trained/competent personnel Favour low ignition temperature explosives (eg EP300) Emergency Response procedure in place if fire
Site preparation	Less than adequate site preparation - Depth of holes not measured/recorded accurately - Hot holes undetected	Well prepared timely plan; communication to drillers, blast crew Competent personnel Need to record anomalies (hot holes, water)
Loading	Less than adequate operations with explosives - potential to cause premature initiation, fly rock and misfires	Adequate handling, and loading procedures Adequate equipment to accurately load Well maintained equipment Systems to deal with hot, wet, damaged and overloading of holes Adequate and safe priming procedures Adequate loading plan, record system System to ensure good communication between shifts
Stemming	Misfires - loss of downline	Secure attachment system Correct stemming method
Tying up	Less than adequate tie up leading to misfire	Tie up system, simple Competent personnel
Firing	Fly rock, fume, dust, fireball - injury to persons, equipment damage	Procedure for communication, distance of block offs, firing Competent persons System to ensure transfer of information from load records (eg presence of overcharged holes, inadequate overburden) Adequate post firing inspection system
Misfires	Premature initiation - immediately after firing - from hot ground - hit by excavation machinery	Time interval - post firing inspections Accurate marking of inaccessible misfires and correct procedure deal with during excavation Operational personnel competent to identify misfired explosives during excavation
Maintenance of equipment	Defective, unreliable equipment affecting safety and scheduling of explosives handling operations Premature initiation in workshop or while maintenance being carried out	Program to replace/overhaul old equipment All equipment to be regularly serviced/maintained subject to a planned maintenance program Pre use inspection procedure Cleansing/inspection/certification system prior to carrying out a maintenance activity (minor, cold and hot work certifications)

Table 1 Principle hazards identified and proposed controls

EXPLOSIVES MANAGEMENT PLAN

The plan outlines the control and responsibilities for risks associated with the handling of explosives and explosives ingredients at Blackwater Mine. The scope of the plan includes

- Procurement
- Storage and transport,
- Manufacture and use,

of explosives associated with primary and secondary blasting.

Included are maintenance standards for equipment/plant and emergency responses for identified event scenarios (also incorporated in the mine emergency response plan for contingency control and responsibility).

The purpose of the plan is to communicate requirements and standards to all people involved in the handling of explosives and associated activities on site, and used as a basis for an audit process to ensure continuing effectiveness and promote continuous improvement.

ACHIEVEMENT OF OBJECTIVE

To effectively manage risk with an activity such as explosives handling, particularly in a large organisation, requires several steps to be followed -

(1) Review the process
(2) What hazards and associated risks can be identified with the process
(3) Rank these, and propose controls and responsibilities to minimise the risk
(4) Develop a management plan for the safe operation of the process

To achieve the objective of implementing an effective process for the safe use of explosives, the criteria of input, throughput and output need to be satisfied.

The **input** is what is outlined above; the development of the system to control the process of handling explosives.

Throughput is the most important aspect of the successful implementation of any system. This measures the degree of success of the implementation and follow through of the standards, rules and procedures in the workplace. To successfully do this, requires input and commitment from all levels within the organisation. The senior management people deal with the macro issues, and the workplace operators are responsible for the micro controls on the job. Supervisors, middle management have duties and responsibilities in between.

A lot of care and attention is required from all levels (most importantly at the workplace level) that people are competent, they have the correct rules and procedures in place and use them on an ongoing basis and that the equipment and facilities for the job are in a well maintained condition. Involvement of all stakeholders is the key to achieving this.

The **output** is the results. It measures the effectiveness of the input and throughput. The objective of the "explosive handling" risk assessment exercise, and the development and implementation of the Explosives Management System is to ensure a satisfactory "output"; being minesite explosive handling operations that are considered as a low risk operation.

CONCLUSIONS

The risk assessment process is the first (but a most important), step in setting up safe operating systems. It is the process where most of the new data is gathered. This is most effectively done utilising a facilitated session with the facilitator not necessarily having a skill in the process but in conducting, in a structured manner, the collation of relevant information to the process and any associated hazards, risks and corrective actions for control.

It is important, particularly for high risk processes, that persons from outside the workgroup be included in the assessment; particularly technical and general field "experts" who can see "some of the forest through the trees".

The system safety risk analysis on explosives use, conducted at Blackwater, has improved people's awareness of blasting hazards and control in particular; but for a broader sphere, the usefulness of such techneques for hazard recognition and control.

ACKNOWLEDGMENTS

Acknowledgment is given to Mr Peter Walton (Queensland Manager, MineRisk) and Mr Mel Bell (ACIRL who have assisted Blackwater Mine with the development of the Explosives Risk Assessment and Management Plan. Also to those persons from ICI Explosives, DME (Mines and Explosives Inspectorate) and Blackwater Mine who contributed to the risk assessment exercise.

REFERENCES

Documents used as background to this paper include

1) "*A system safety review of primary blasting to support the development of a Blasting Management Plan*"; (MineRisk report)
2) "*Blackwater Mine, Explosives Management Plan*" (Draft MineRisk report)

Appendix A

THE RISK ANALYSIS PROCESS

The method used by MineRisk considers five stages in the hazard awareness and rating process; being

- Identification of steps in the process (eg from procurement to firing)
- Identification of hazards associated with each step, assessing:
  - if energies are under control, and
  - if the work process is correct by assessing the interaction between people, work practices and equipment within the work environment
- Determine the seriousness of any identified hazards by assessing the probability of the event occurring along with the consequence to safety and production. This is assessment using a system as shown in Table A-2 where a risk ranking system is developed in order to provide a priority system for allocating controls.
- Review what controls are already in place to minimise the risk and proposal of additional controls if necessary.
- Propose action plans and responsibilities to implement the controls.

Stages 1 to 4 can be documented in a format similar to that outlined in Table A-1.

RISK ANALYSIS FOR EXPLOSIVES

Area/Process _____ Page _____ of _____

No	Step	Identified Hazard/Loss Scenario	Consequences		Probability	Rating	Existing Controls	Potential Controls
			Cs	Cp	P	R		

Table A-1 Typical documentation format for recording a risk analysis exercise

RISK RANKING TABLE

PROBABILITY

CONSEQUENCE	A	B	C	D	E
1	1	2	4	7	11
2	3	5	8	12	16
3	6	9	13	17	20
4	10	14	18	21	23
5	15	19	22	24	25

Assessment of Risk Ranking

1 - 6	High Priority
7 - 15	Medium Priority
16 - 25	Low Priority

PROBABILITY (of nominated event occuring)

A	Very common/regular	(daily)
B	Common	(weekly)
C	Occasionally	(3 - 6 months)
D	Not likely/rare	(1 - 5 years)
E	Extremely unlikely	(has not been known to occur)

CONSEQUENCES (of effects on safety, property damage or production)

	Safety	**Production**
1	Catastrophic (multi fatality)	Significant loss to business activities
2	Single fatality/permanent disability	Impact on activity over multiple shifts
3	Serious injury (1 - 6 months lost time)	Production affected for one shift
4	LTI/medical treatment	Production affected 2 hours
5	First Aid	Insignificant (minor inconvenience)

Table A-2 Determination of the seriousness of a potential event

Appendix B

EFFECTIVE RISK CONTROLS

HARD BARRIERS

1. ELIMINATE (the hazard - not always feasible)
2. MINIMISE (the energies released)
3. PHYSICAL BARRIERS & ENGINEERING SAFETY SYSTEMS

SOFT BARRIERS

4. SIGNS AND WARNINGS
5. STANDARD WORK PROCEDURES
6. SKILLS AND TRAINING