



## Queensland Guidance Note QGN 20 v 3

# Management of oxides of nitrogen in open cut blasting

*Mining and Quarrying Safety and Health Act 1999  
Coal Mining Safety and Health Act 1999  
Explosives Act 1999*

## Guidance Note – QGN 20

### Management of oxides of nitrogen in open cut blasting

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A fume management webpage is available on the DEEDI website at:

<http://mines.industry.qld.gov.au/safety-and-health/631.htm>

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# Section 1 – Introduction and background

## Introduction

1.1. A meeting was called by the Chief Inspector of Coal Mines and Chief Inspector of Explosives on 18 March 2011 to address issues associated with fumes<sup>1</sup>, in particular, oxides of nitrogen (NO<sub>x</sub>). This followed a number of fume events at coal mines in central Queensland that resulted in persons being taken to hospital as a precautionary measure. The workshop was used to identify the key factors in the production of fumes and possible mitigations. The meeting included coal mines, explosives companies and members of the mines and explosives inspectorate. At the end of the meeting a steering group was formed to report back to the meeting on methods to prevent the generation of fumes, manage a fume event and manage exposure to fumes.

1.2. The Guidance Note does not prevent persons with safety obligations using other methods to achieve an acceptable level of risk in the prevention of fume, fume event management and the management of fume exposure. Prevention of fumes is the best approach.

### Disclaimer

1.3. It should be noted that not all matters in the guidance note were always agreed upon by all of the steering group members. The prevailing view has been taken by the Fume Steering Group. Any matters where there has been disagreement have been reviewed from a regulatory point of view and that view will prevail in this document.

## Purpose

1.4. The purpose of this Guidance Note is to:

- Understand the known causes of fume by identifying the contributing causes then mitigating those causes and identifying persons responsible in the different roles.
- To manage a fume event, whether predicted or not, in the context of a prepared blast and the existing meteorological conditions.
- To manage exposure to fumes.

## Scope

1.5. This guidance note is applicable to blasting activities in open cut blasting. This may be in coal or metalliferous mines.

## Definitions

1.6. Appendix A lists definitions and abbreviations used in this guidance note.

## Background

1.7. Blasting explosives predominantly use ammonium nitrate in the form of ammonium nitrate fuel oil (ANFO) or AN emulsions/water gels. In theory, an ideal ammonium nitrate explosive reaction yields the following by-products:

H<sub>2</sub>O in the form of steam

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<sup>1</sup> In this guidance note, fumes refer to the gases belonging to oxides of nitrogen, particularly NO<sub>2</sub>, the most prevalent and harmful.

CO<sub>2</sub> carbon dioxide

N<sub>2</sub> nitrogen.

1.8. The application of blasting explosives in the field, under variable conditions, results in non ideal explosive reactions that can produce three main toxic gases (in order of decreasing toxicity):

NO<sub>2</sub> nitrogen dioxide

NO nitric oxide

CO carbon monoxide

1.9. The most harmful, nitrogen dioxide, is identifiable by the generation of orange/brown clouds. There are many factors that can contribute to the generation of fume which is an outcome of the ammonium nitrate explosives not detonating ideally.

1.10. The mining industry operates in a variety of ground types under varying conditions which means that operating conditions are not ideal and this can affect the efficiency of the explosives product.

1.11. The variables that affect explosives performance are:

- Under or over fuelled ammonium nitrate (AN).
- Poorly mixed fuel AN mixture.
- Density of loaded explosives.
- Degree and confinement of explosives.
- Water damage to explosives.
- Ground conditions e.g. fissures, voids, can result in explosives forming without the critical diameter for an ideal explosives reaction causing fume.
- Manufacture and specification of explosive ingredients including AN, EP etc.

1.12. The Fume Steering Group (FSG) identified two areas that required further examination in order to tackle the prevention of fume. These areas over the full life cycle are:

- Activities associated with blasting.
- Persons/organisations associated with blasting.

1.13. This guidance note is focussed on the management of oxides of nitrogen. The major issues are involved with the quantity of nitrogen dioxide produced, its toxicity and the potential exposure.

1.14. The department has provided other guidance on the management of fumes which is available via the following links:

- [\*\*\*Mining and Quarrying Safety Bulletin 61\*\*\*](#) - Flammable and toxic gases in open cut coal mines
- [\*\*\*Explosives Safety Alert 44\*\*\*](#) - Prevention and management of blast fumes
- [\*\*\*Explosives Safety Alert 28\*\*\*](#) - Post blast gases

## Fume event

1.15. The definition of a fume event is an event that generates the visible nitrogen dioxide that moves outside the standard blast exclusion zone. The standard blast exclusion zone is designed to provide protection from projections and blast overpressure. Refer EIB 72 regarding an incident under the Explosives Act. [Explosives Information Bulletin No 72](#)



# Legislation

1.16. The key sections of the legislation that relate to the management of fumes have been reproduced in Appendix B – Legislation. The three key Acts covering operations on a mine site with explosives are the:

- Mining and Quarrying Safety and Health Act 1999
- Coal Mining Safety and Health Act 1999
- Explosives Act 1999

1.17. All explosives used in Queensland are required to be authorised <sup>2</sup> in accordance with s8 of the Explosives Act. The process for obtaining authorisation for an explosive is outlined in [Explosives Information Bulletin No 10](#).

## Blasting explosives that produce fume

1.18. Explosives that contain nitrogen, normally in the form of ammonium nitrate, can produce oxides of nitrogen, commonly called fume. All blasting explosives produce large volumes of gas in very short time spans (fractions of a millisecond) which is the basis for the energetic work they are used for. Typically the volume of gases released is about 1000 times the original volume. Explosives that include ammonium nitrate as the main ingredient can under non ideal conditions produce fumes which are toxic at particular concentrations.

1.19. In the mining context, the explosives that produce fume are a combination of ammonium nitrate and fuel oil with other additives. These may be in the form of ammonium nitrate fuel oil (ANFO) prills or emulsions and water gel containing ammonium nitrate or combinations of these. The ammonium nitrate prill used is Class 5.1 Dangerous Good UN number 1942 and the emulsions or water gels are also Class 5.1 with UN Number 3375. The emulsions and water gels are generically referred to as matrices. Ammonium nitrate is water soluble and therefore is damaged by water. The emulsions and water gels have more resistance to water damage than ANFO mixtures.

1.20. Explosives formulations can be adjusted to minimise fume within their categories. Formulation changes to ANFO are unlikely to decrease fume as the product has no water resistant characteristics however formulation changes to the water resistant range of products could lead to reductions in fume. Explosives suppliers and mine operators need to work together to determine which product category presents the optimum chance of reducing fume in the prevailing conditions.

1.21. There is an opportunity to further explore formulations that deliver a reduction in the generation of post blast fume. Formulations that are designed and produced to be resistant to the production of fume should be tested in field trials to safely gain optimal results from that formula. Raw materials that are used as precursors for the formulations must conform to specifications called up by the formula. The specifications should also be documented within the suppliers technical and compliance standards for that material.

1.22. Explosives products being used for fume mitigation should be fit for purpose. “Fit for purpose” should be defined in a user need specification. The procurement chain involving both supplier and end user must incorporate the user need specifications into the selection of raw materials to gain compliance for the final product.

## Definition of post blast fume

1.23. Fume is a combination of post blast gases which are predominantly nitrogen dioxide, but may also include small amounts of nitrous oxide, nitric oxide, carbon monoxide and carbon

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<sup>2</sup> An authorised explosive has been accepted to be safe and suitable for service during its life cycle. The technical data sheet includes information on the performance and use of the product and any limitations. The manufacturer has obligations to ensure the product specification and performance remains within its design and authorisation. The user has obligations to use within the advised parameters.

dioxide. Nitrogen dioxide is the only post blast gas that is visible. The two main gases are nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>)

1.24. Nitric oxide in air is unstable and gains an extra oxygen atom from the atmosphere and becomes nitrogen dioxide. Two of the most toxicologically significant compounds are nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>). Other gases belonging to this group are nitrous oxide, N<sub>2</sub>O, and nitrogen pentoxide (NO<sub>5</sub>).

1.25. While oxides of nitrogen are created in varying amounts when blasting they are mainly generated from high temperature combustion such as vehicles. The largest contributor to NO<sub>x</sub> fumes in the atmosphere is the automotive industry. Some cities have a haze that is often coloured brown – this includes NO<sub>x</sub> pollution, predominantly from motor vehicles.

1.26. Some nitrogen dioxide is formed naturally in the atmosphere by lightning and some is produced by plants, soil and water. However, only about 1% of the total amount of nitrogen dioxide found in our cities' air is formed this way. The most important sources of NO<sub>2</sub> are internal combustion engines, thermal power stations and, to a lesser extent, pulp mills. Butane gas heaters and stoves are also sources. The excess air required for complete combustion of fuels in these processes introduces nitrogen into the combustion reactions at high temperatures and produces oxides of nitrogen (NO<sub>x</sub>). Limiting NO<sub>x</sub> production demands the precise control of the amount of oxygen used in combustion. Appendix C details the properties of nitrogen dioxide.

## Toxicology of nitrogen dioxide

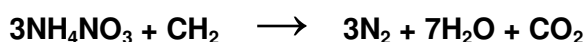
1.27. Nitrogen dioxide is a yellow, orange or brown coloured, acrid smelling gas. It is heavier than air. Details of the toxicology of nitrogen dioxide are contained in Appendix D. This appendix covers the occupational exposure standards and health effects. Throughout this guidance note the objective of the management of fume is to ensure that persons are not exposed to levels of nitrogen dioxide above the Short Term Exposure Limit of 5 parts per million (ppm). A material safety data sheet for nitrogen dioxide is at Appendix E.

## Ideal and non ideal Conditions

1.28. The ideal explosive reaction of ammonium nitrate and fuel oil (ANFO) or ammonium nitrate emulsions including ammonium nitrate, fuel oil and other chemicals does not release NO<sub>x</sub>. This occurs under ideal conditions where an ideal explosive reaction is assured. Conditions encountered during mine blasting are never ideal.

1.29. The ammonium nitrate converts to nitrogen, water and oxygen and the fuel converts to carbon dioxide and water.

The equation for an ideal explosive reaction is as follows:

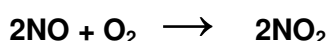


This is an oxygen balanced explosive reaction that does not generate NO<sub>x</sub>.

A non ideal explosive reaction is as follows:

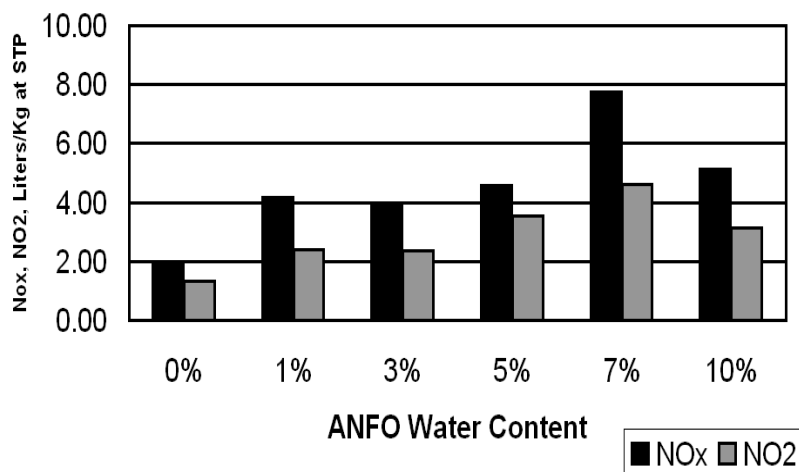


The nitric oxide combines with oxygen in the atmosphere to produce nitrogen dioxide.



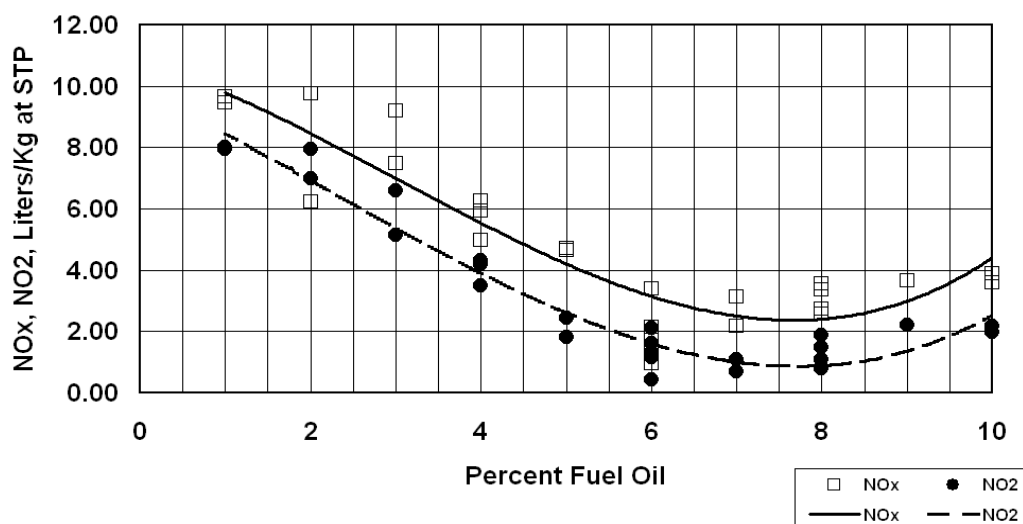
1.30. This is an oxygen unbalanced explosive reaction that will produce NO<sub>x</sub>, given that every other significant parameter is not contributing to NO<sub>x</sub>.

1.31. Figure 1.1 shows the effect of water content on ammonium nitrate fuel oil mixtures in relation to the generation of oxides of nitrogen, the water causes product damage. This demonstrates that a larger quantity of NO<sub>x</sub> would be generated when ANFO has water content.



**Figure 1.1 Effect of 94/6 ANFO water content on NOx production<sup>3</sup>**

1.32. The basic formulation may be a factor in whether the explosive reaction is ideal or not. For instance if the mixture has too little fuel, it will produce more nitrous oxides. If it has too much fuel it will tend to produce more carbon monoxide. Figure 1.2 shows the effect of fuel on the production of oxides of nitrogen in ammonium nitrate fuel oil.



**Figure 1.2 Effect of percentage fuel oil on fume in ANFO<sup>4</sup>**

1.33. Open cut blasting is conducted in conditions where there are variables that result in non ideal explosive reactions which may generate fumes. This guidance note will examine the causes of non ideal explosive reactions in more detail.

## Section 2 – Causes of Fume

### The causes of fume

2.1. Fume is generated as a result of a non ideal explosive reaction. The causes of the non ideal explosive reaction are many and variable. This guidance note groups them into categories

<sup>3</sup> Rowland, J & Mainiero, R, February 1997 'Factors affecting ANFO fumes production' 'Effect of 94/6 ANFO water content on nitrogen oxides and nitrogen dioxide production for 94/6 ANFO and high explosives (cap-sensitive explosives) Figure 9.'

<sup>4</sup> Rowland, J & Mainiero, R, February 1997 'Factors affecting ANFO fumes production' 'Effect of 94/6 ANFO fuel oil content on nitrogen oxides and nitrogen dioxide production Figure 6.'

and further identifies the person or organisation that is best able to control the variable around the cause. The six categories that cause fume are listed below:

**2.2. Cause 1 Explosives blends and precursors chemical design**

- Chemical formulation of the mixed explosives and/or precursors unknowingly inherently designed to generate fume.
- Formulation of explosives mixture and/or precursors having small ranges of optimal sensitivity.
- Formulation of explosives mixture and/or precursor having limited conditions of stability.
- Formulation of explosives mixture and/or precursor insufficiently resistant to conditions it is used in.
- Formulation of explosives mixture and/or precursors not suitable for the prevailing climatic or seasonal conditions.
- Generation of fume not forming part of explosives and its precursors' qualification criteria - Chemical formulation of explosives mixtures and precursors not checked for quantity and make up of fume under varied field conditions before releasing into the industry.

**2.3. Cause 2 Explosives and precursors conformance to specification, adversely impacting on the detonation performance of the explosives.**

- Explosives product delivered down the hole out of specification.
- Precursor delivered to mine site out of specification.

**2.4. Cause 3 Blast design inherently containing aspects increasing the likelihood of fuming.**

- Explosives – rock mass properties mismatch.
- Explosives product selected not suitable for the prevailing ground conditions (water, rock mass strength, etc.)
- Blast design (explosives product selection, initiation design, etc.) not appropriate for blast requirements.
- Insufficient consideration given to blast dynamics.

**2.5. Cause 4 Explosives detonation performance negatively impacted by the adverse effects of blast dynamics.**

- Dynamic shock desensitisation of explosives
- Decoupling of explosives column
- Inappropriate burden relief
- Inappropriate confinement created by poor ground conditions or selection and placement of stemming materials

**2.6. Cause 5 On-bench/site practices leading to explosives not performing optimally.**

- Not adequately sensitising explosive product by addition of gas bubbles or sensitising chemicals.
- Explosives product not suitable for the bench conditions (Not reconsidering product selection after changed bench condition, e.g. change in water conditions)
- Contamination of explosives (bottom of hole, stemming section, etc.)
- Explosives products not to specification when delivered down the hole.
- Explosives precursors not to specification when received on site.

## 2.7. Cause 6 Blasting personnel.

- Lack of an understanding of the possible causes, and prevention techniques, of fume amongst blasting personnel (shotfirers, MMU operators, blast designers)
- Blasting personnel not consistent in defining dry and wet bench conditions
- Blasting personnel not consistent in following explosives supplier's product application guidelines

2.8. These causes are examined in detail at Appendix F - Causes of NO<sub>x</sub> fume and mitigations (adapted and amended by FSG from AEISG data). This is a useful table in developing and reviewing the control of fume within an organisation. It will also be useful in assisting mine operators and regulators in the investigation of a fume event.

## Identification of persons/organisation to prevent fumes

2.9. This section is an indicative list of organisational positions and roles. The table 2.1 identifies the obligations of those parties in relation to the production of fume during blasting activities.

- Senior Site Executive (SSE)
- Production manager
- Procurement manager
- Blast designer
- Geologist
- Drill and Blast Superintendent
- Drilling contractor
- Driller
- Borehole profilers
- Explosives supplier
- Explosives manufacturer
- Blasting contractor
- Shotfirer
- Assistant shotfirer
- Bench assistant
- Mobile Manufacturing Unit (MMU) Operator
- Dewater operator
- Blast controller
- Explosives Inspectorate
- Magazine keeper
- Maintenance personnel for MMU
- Designer of MMU

**Table 2.1 Persons and responsibilities to prevent fume**

Person / Organisation	Role	Responsibilities/Remarks
Geologist	Provide data on ground conditions to assist blast designer in the layout of the shot	Accurate provision of ground data across the proposed shot. Review of data after firing to determine if data was as predicted. Provide soil moisture index data for site
Mine Operations Planner	Plan the mine operations to extract coal overburden removal, plan water removal	Ensure that design of extraction plan is designed to limit where possible mine geometries where blast fume has been known to be produced such as deep wet boxcuts.
Drilling contractor	To provide drilled holes for the loading of explosives for a shot	Accurately drill the shot plan. Report variations Report ground conditions to blast designer.

<b>Person / Organisation</b>	<b>Role</b>	<b>Responsibilities/Remarks</b>
Blast Designer	Design a blast to provide optimum extraction of material and manage blasting hazards such as fume, flyrock, overpressure	Blast design to be cognisant of: Weather conditions Presence of water in ground and dynamic water. Ground conditions. Select explosives product appropriate to conditions and ensure explosives design parameters are met. Review actual loaded condition of blast prior to shot being fired. Ensure that mine contracts in relation to blasting ensure that products and equipment are to specifications and enable the safe effective blasting operations with minimum fume.
Blasting contractor	Provides a blasting service to clients	An effective safety management system that covers the blasting activities
Drill and Blast superintendent	Manage all drill and blast operations for the site.	Investigate blasting incidents Incident advice Implement improvement Competence of blast team Adequate resourcing of blasting activities Authorisation of blast design Setting explosives inventory Storage capacity
Blast Supervisor	Manage day to day blasting operations	Review the use of UN1942 vs UN3375 vs diesel vs chemicals against manufacture and load specification Review the use of gas bags against dip logs Compliance check of bench activity Stock rotation Storage environment management
Drill Supervisor	Supervise drill activities on the bench	Conduit from drill activity to blast designer Bench preparation prior to drilling
Shotfirer	Oversight all explosives activities on bench.	Management of on bench water Compliance with design Variations from design Recording data. On bench explosives quality Supervision of loading technique Calibration of equipment Conduit from bench to blast designer
MMU Designer	Design MMU to produce explosives to specification	Equipment appropriate and produces explosives to specifications

<b>Person / Organisation</b>	<b>Role</b>	<b>Responsibilities/Remarks</b>
MMU Operator	Manufacture blasting explosives On bench activities as directed by the shotfirer	Compliance with load sheets Recording and reporting variations to blast design Calibration Precursor material quality checks Manufacturing equipment compliant Adequate and correct process chemicals Manufacture QC checks Generate delivery/production record
MMU maintainers	Maintenance of MMU	Ensure equipment delivers explosives within calibration Vehicle maintenance conducted to design and operational criteria.
Bench Assistant	Support shotfiring activities On bench activities as directed by the shotfirer	Recording of water conditions down hole Dewatering holes Measuring recharge rates for wet holes Marking of hole data Positioning of primers in Blast holes Accurate placement of gas bags Measuring and recording the depth of holes Hose handling for pumped products QC density checks Stemming Collar protection and hole liners Preventing contamination of the explosive column Identifying hole slumping
SSE	Oversight of all blasting activities. Integration into mine operations	Responsibility rests with the SSE or an appointed delegate. (Legally it remains an obligation of the SSE) Ensure that adequate resources are available to support successful blasting activities
Explosives manufacturer	Provide explosives fit for purpose	Undertake development work on explosives technology to improve products ability to perform in robust conditions. Provision of precursors and formulation to ensure minimum amount of fume. Safety Management System including rigorous change management of formulation to ensure fumes are minimised in product. Design, calibration and operation of explosives manufacturing equipment to deliver consistent explosives within specification. Specification of accessories – detonators and booster to ensure efficient blast

Person / Organisation	Role	Responsibilities/Remarks
Supplier	Provide explosives fit for purpose	Provision of precursors and formulation to ensure minimum amount of fume. Safety Management System including rigorous change management of formulation to ensure fumes are minimised in product. Design, calibration and operation of explosives manufacturing equipment to deliver consistent explosives within specification. Accessories – detonators and boosters to explosives specification.
Procurement managers	Procure blasting explosives	Ensure supplier is providing specified product. Purchase appropriate products fit for task based on technical input. Seek industry solutions to fume problems and other explosives performance issues through contract negotiation, agreement and operation.
Explosives Inspectorate	Authorisation of explosives	Ensuring explosives company have SMS that control the specification, formulation and delivery of explosives within authorisation

2.10. The positions identified in this table have been placed into the causes of fume table at Appendix F - Causes of NO<sub>x</sub> fume and mitigations (adapted and amended by FSG from AEISG data). This column indicates the persons that could contribute to the cause listed in this table. In a review of a fume event it is important that these persons contribute to the identification of issues from their work area that may have contributed to the fume.

## Identification of activities that may contribute to fume

2.11. The activities that are associated with a blast are:

- Explosives research development and innovation of low fume products
- Manufacture of AN prill and emulsion
- Manufacture of gassed sensitised product
- Mixing of final product
- Manufacture of accessories initiating explosives
- Storage of AN prill and emulsion
- Selection of initiating explosives
- Design of the blast
- Drilling of the shot
- Loading of the shot
- Firing of the shot
- Post blast activities (eg. Management of misfires)
- Procurement of explosives
- Mine production planning

2.12. These activities are examined in greater detail in section 3.

## Factors outside the blasting activities that contribute to fume

2.13. This section identifies those areas outside the direct blasting design, preparation and firing that could contribute to a fume event. There are other activities and influences that could impact on a blast producing fume. These other areas are not under the control of persons in the blasting area. Senior management should commit to:

- 2.13.1. Ensuring that the prevention of fume is a stated objective for the organisation.



- 2.13.2. All of the organisations departments recognise and treat the issues under their control that could contribute to fume.
- 2.13.3. Providing adequate and quality resources to ensure fume mitigations can be appropriately managed.
- 2.13.4. Appoint persons with appropriate training, experience and skills to manage factors that contribute to fume.
- 2.13.5. Ensure fume incidents are adequately investigated, the root causes identified, lessons learnt identified, communicated and systems updated in time with change management.
- 2.13.6. Identification of leading indicators and industry trends that lead to unacceptable production of fume.
- 2.14. The factors outside the drill and blast area that could contribute to fume events are:
- 2.14.1. Management not accepting that fume events can unexpectedly breach the exclusion zone.
- 2.14.2. Procurement contracts that are locked into unsuitable products and limits the sourcing of explosives products more suited for mitigation of fume.
- 2.14.3. Poor logistic planning that results in available but unsuitable explosives being substituted for the conditions. Inadequate stocks at the mine site caused by just in time becoming just too late.
- 2.14.4. Poor maintenance, calibration and availability of specialist explosives and support vehicles such as drill rigs, dewater trucks, MMU, stemming vehicles.
- 2.14.5. Inadequate resources to undertake the blasting activities to meet production requirements.
- 2.14.6. Inadequate preparation of bench and support areas handed over to the drill and blast process.
- 2.14.7. Impact of mine schedule (Whole of Mine) pressures and inadequate internal communications that affect the safe, effective and efficient preparation of the blast.
- 2.14.8. Failing to incorporate learning's from previous fume events into the process

## **Section 3 Prevention of fume**

### **Prevention of fume**

3.1. The most effective way to manage fume is to aim to eliminate the possibility of fume being generated. The elimination of fume requires the concerted action by all entities involved in the blasting activity. This section uses the activities that were identified in section 2.9. In reviewing these preventions it is always better to operate at the higher levels in the hierarchy of controls.

#### **Explosives research development and innovation of low fume products**

3.2. The development with Industry of products that are formulated for open cut mines to prevent or minimise fume production is being undertaken. This development should include a User Needs Specification which details the overall parameters that explosive product is required to perform within. From this process, the manufacturing parameters will be delivered and then component specifications can be detailed.

- Be safe and suitable for the range of ground conditions and operational processes found at the mine (sleep time, water, depth, confinement, reactive and or hot ground etc).

- Be able to be supplied in sufficient volume to meet the mines production requirements.
- Formulated for delivery system used at the mine.
- Predictable performance in ground conditions found at the mine.
- Delivery of broken ground suitable for excavating equipment.
- Product has safe and effective characteristics.
- Formulated to produce low fume.

### **Manufacture of AN prill, emulsion, initiating accessories, gassed and sensitised product.**

3.3. The explosives manufacturer/supplier should have documented change management procedures for modification and alterations to explosive and/or precursor formulations. The procedures should provide for:

- Assessing and managing risk associated with the modification/alteration of the formulation Through the use of documented hazard and technical review assessments;
- Recording any modification/alteration and updating relevant authorisations, technical data sheets, material safety data sheets, work procedures, and training programs as and where relevant;
- Ensuring that any modification or alteration does not affect the validity of an authorisation issued by the relevant authority; and
- Notifying the user sites of changes to authorisations, technical data sheets, material safety data sheets or recommendations in relation to proper use of the explosives or precursor products.

3.4. The performance of an explosive in the field is critical to a successful blast. In the fume context this relates to the performance of the explosives in the extraction process and, from a fume perspective, a product that is resistant to water, has the ability to cope with varying levels of ground confinement and performs adequately in deep holes.

3.5. Water resistance can be affected by formulation changes and there is a general obligation on the manufacturer/supplier to ensure that the formulation change does not lead to excessive fume. The manufacture of the explosives on the site must produce a quality consistent product for use in the conditions. The quality control of this aspect is critical to a low fume blast.

3.6. The development of a blasting explosive must consider the generation of fume. There is no standard test for the production of fume from a particular formulation. Tests used to exist for the nitro-glycerine range of products as the sample size was small in weight and could be examined in small scale blasting chambers. Ammonium based nitrates require larger samples and there are no large scale testing facilities that can accommodate this. The field trialling of blast explosives and ongoing performance of explosives is important to ensure there is no tendency to generate fume.

### **Storage of AN prill, ANFO and emulsion**

3.7. AN prill and emulsions are subject to temperature cycling which can lead to the production of fines in AN prill and crystallisation in emulsions. These have an impact on the explosives performance. The creation of fines affects the absorption of fuel and affects the density of the product.

3.8. AN prill should be stored in well ventilated areas under cover from direct sunlight. It should not be stored in bags under tarpaulins without ventilation. Crystallisation is promoted by temperature cycling; the use of shadow roofs on storage location will reduce the temperature cycling and increase the time taken for crystallisation to occur. Crystallisation is not a fume generator however it is an indicator of stability of the product.

3.9. The other factor is to ensure that both prill and emulsion are not stored for long periods of time. These vary with manufacturers and whether the product is a matrix. The manufacturers recommendation on this is specified in the technical data sheet but generally are as follows:

- |              |          |
|--------------|----------|
| • AN prill   | 3 months |
| • Emulsions  | 3 months |
| • Water gels | 3 months |
| • ANFO       | 6 months |
| • Heavy ANFO | 3 months |

3.10. The storage requirements to prevent degeneration of other ingredients such as fuel oil, gasser solution, companion solution, acetic etc should also be considered.

### **Selection of initiating explosives and explosive product**

3.11. Initiating devices must be those recommended by the explosive manufacturer. Detonators, boosters and the main charge must be appropriate to initiate and maintain the detonation wave. An inadequate booster could lead to a less optimum explosive reaction that produces fume.

3.12. The initiating explosives are critical to the blast and must be matched to the product and the conditions they are employed in. In the event of misfires of boosters or product not being given sufficient detonation wave there will be an increased amount of fume or perhaps a misfired column of explosives product to be appropriately dealt with after the blast.

3.13. The blast designer must design and use explosives in accordance with the manufacturers recommendations and establish the suitability of the explosives and accessories for the hole depth, diameter, moisture level, ground hardness and density.

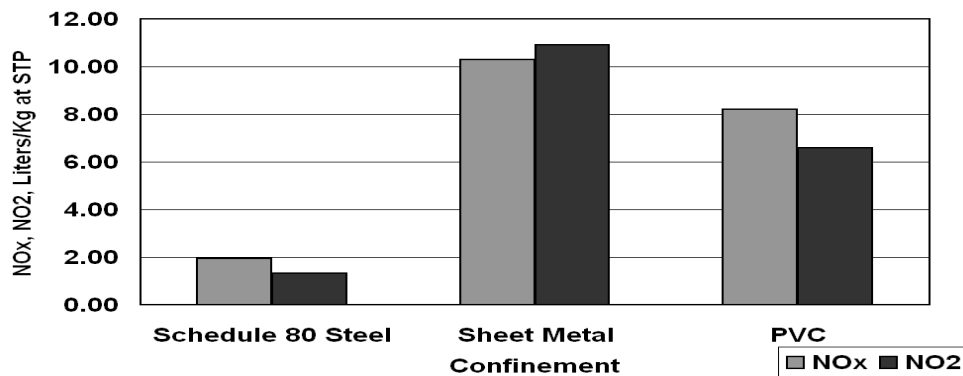
**Ensure that initiating system components are matched to the explosive product.**

### **Design of the mine shot**

3.14. The objectives for a blast design should be to:

- Assure the safety of the public, site personnel and surrounding properties.
- Identify site-specific requirements;
- Identify hazards, risks assessed, controls established and residual risks;
- Introduce blasting as part of the overall task;
- Control the blast process from design to initiation, evaluation and misfire treatment;
- Implement a review process to ensure that the objectives are met.

3.15. Ground conditions and geology influences the confinement of the explosives which is a critical requirement to ensuring the explosive reaction is near ideal. Research using known confinement such as steel, sheet metal and PVC demonstrates the effect of varying confinement. Figure 3.1 clearly shows the effect of confinement on fume generation. The lesser confinement of an explosive column results in higher releases of NOx.



**Figure 3.1 Confinement of explosion effects the release of NOx<sup>5</sup>**

3.16. Understanding of the site geology is important to underpin the blast design so that interhole distance and timing will not contribute to fume. Design of blasts must always take into account the whole rock mass not just the point rock strength (MPa quoted strengths). The blast designer should have in place a system that enables determination of appropriate whole of rock mass strength characteristics. The system should be capable of delivering the suitable blast design parameters suitable for the specific rock mass strength characteristics.

3.17. An important issue is the knowledge gained from previous blasts at the mine site. This will provide vital information about ground conditions and water that will influence the blast design such as.

- Initiation sequence. This should be designed to limit the potential for desensitisation of adjacent explosives product columns as well as allow for adequate confinement to ensure complete detonation of the explosives column and conversion of intermediary explosion gas products to their final form.
- Presence of a free face will in the majority of cases allow for controlled movement and adequate confinement of the rock mass
- Ground conditions – does the type of ground provide adequate confinement for the explosives to detonate well. If the ground too hard it is possible that increased ground shock will desensitise adjacent explosives columns that could result in excess fume generation.

**Match the explosives to the confinement provided by the specific rock mass strength characteristics**

### Drilling of the shot

3.18. Drilling must be to the design with variations recorded and incorporated in all relevant post drilling activities. The drill log can provide data to the blast designer that verifies the rock mass and blastability. Matching an appropriate explosive to the rock mass ensures it is appropriately confined to provide a good blast.

### Loading of the shot

3.19. Loading must reflect the design and variations recorded and reported for inclusion in the pre-blast risk assessment. During the loading of the shot, information is obtained regarding the presence of water e.g. surface or sub surface, incorrectly drilled holes, missing holes, collapsed holes, amount of product loaded, density of product, use of air bags etc. These need to be monitored and dealt with during the loading process. These recorded variations may become important considerations in the prefiring review.

<sup>5</sup> Rowland, J & Mainiero, R, 'Factors affecting ANFO fumes production' 'Effect of Confinement on nitrogen oxides and nitrogen dioxide production for 94/6 ANFO, Figure 11.

## **Firing of the shot**

3.20. Prior to firing or at a point through the blast being loaded a review of the blast should be conducted. The purpose is to determine if there is now an increased chance of fume as a result of the loading activities and the conditions of the shot. A thorough pre firing review is essential. This review is to identify that all appropriate safeguards are in place. It should identify any variation in the design, drilling and loading of the shot that could contribute to fume. This review must include reviewing and adjusting firing plans to weather conditions. Each site should develop its own review process based on their procedures. Factors to be considered at a pre firing review are at Appendix G.

3.21. A thorough pre firing review is essential. The review is to identify that all appropriate safeguards are in place. It should identify any variation in the design, drilling and loading of the shot that could contribute to fume. This review must include reviewing and adjusting firing plans to weather conditions.

## **Post blast activities**

3.22. A post blast review should be carried out to verify that design/operational aspects did contribute to a safe blasting outcome, not just fuming.

3.23. A review should be conducted after any fume event to ensure all records and documents, such as blast pack, video and measurements are available. This should identify issues and provide causation factors to support the investigation.

3.24. Incident reporting: A system is to be in place where the fume level of all blasts, to be recorded. All blast incidents, including fume events that breach blast exclusions zones, must be reported where required. All blast fume levels (0-5) should be reported in the provided format through [fumesurvey@deedi.qld.gov.au](mailto:fumesurvey@deedi.qld.gov.au) to DEEDI until 1 July 2012 regardless of whether the cloud leaves the blast exclusion zone.

## **Procurement of blasting explosives**

3.25. Procurement should be based on sourcing products that are compliant to the User Need Specification (mitigation of fume should be a component of this specification).

3.26. Contracts for the procurement of explosives need to be flexible to deal with the ability to select a variety of products to deal with the variables that product selection is capable of mitigating against. Such examples are:

- Presence of wet holes – product needs to be available on site
- Extreme rain events
- Ground conditions / blastability

3.27. It is essential that the explosives supplier and the user develop an ongoing relationship in regard to product performance that can ensure appropriate products within specification are delivered and used within their design parameters. Either party working alone is unlikely to have the expertise to determine problems relating to performance of explosives.

## **Mine planning**

3.28. This planning process determines the allocation of ground to the blast and drill superintendent. This planning can be fine tuned to deliver the ground containing the materiel to be extracted in sections that are less conducive to fume than others. Other planning considerations include:

- Impact of mine schedules (whole of mine) pressures and inadequate internal communications that affect the safe, effective and efficient preparation of the blast.
- Recognising the soil conditions - will the drilled hole provide adequate confinement for the selected explosive.
- The presence of water in blast holes will degrade the explosive and its performance. Is the explosives product suitable for the water conditions?

- Explosives products are formulated to ensure they meet the User Need Specification.

### Training competency and certification

3.29. All persons should be adequately trained for the role they do. Competency training units, as below (when available) should be used. These are generally in place for shotfirers and assistant shotfirers. For the most recent version of the Shotfirers competencies see: [http://mines.industry.qld.gov.au/assets/explosives/competency\\_requirements\\_for\\_shotfirer\\_licensing](http://mines.industry.qld.gov.au/assets/explosives/competency_requirements_for_shotfirer_licensing).

While trained and competent, persons then need to be trained in the local procedures and systems and mentored in the role. Once a person has the competencies and the appropriate induction training and guidance, the SSE could consider appointing the person into a role such as Blast Designer.

3.30. Persons operating MMUs should receive specific training to ensure explosives loaded are within the manufacturers specifications and blast design parameters.

3.31. The competencies highlighted in the table on the following page are not a licensing requirement for individuals such as shotfirers. It is strongly recommended that persons performing these roles are trained in the individual competencies.

**Table 3.1 Recommended competencies**

<b>Blast Designer</b>	<b>Blasting Supervisor/ Contractor</b>	<b>MMU Operator</b>
↓	↓	↓
RIIBLA601A Design surface blasts	RIIBLA401A Manage blasting operations	RIIBLA203A Conduct mobile mixing of explosives
RIIBLA402A Monitor and control the effects of blasting on the environment	RIIBLA402A Monitor and control the effects of blasting on the environment <sup>1</sup>	
	RIIBLA602A Establish and maintain a blasting system	
	RIIRIS402A Carry out the risk management processes or equivalent	

<sup>1</sup> This is required when a shotfirer is seeking a licence to operate inside a built up area.

3.32. This document is recommended to training providers as a way to improve the level of training given in relation to the prevention, management and treatment of fume exposure. The department intends to work within the training networks to review the training packages that relate to fume generation.

## Section 4 - Management of a fume event

### Management of a fume event

4.1. The systems must be already established, so that, should a fume event occur, will give short term exposure if engulfed. Management of this event will take place. The location of people who could be exposed and the behaviour of the fume plume will be understood so that appropriate actions will be taken without delay. Under certain circumstances if the conditions are not suitable, the blast may need to be rescheduled.

4.2. Prior to firing a blast it may be either evident that a significant fume event is likely to occur or that there may be an unexpected fume event. The mine must take either situation into account whenever conducting a blast.

4.3. A pre firing review is required of any blast to deal with the possible hazards of a blast and ensure that personnel and equipment is protected against flyrock, overpressure, and heat or ground shock – fume must also be considered.

4.4. The mine must have in place an assessment at prefiring that includes the identification of factors during the shot preparation that could contribute to fume. Factors to be considered in the prefiring review are provided at Appendix G.

4.5. Management must be clear that the review is mandatory and any specifically identified risks and proposed mitigations should have the approval of the SSE prior to firing.

**A pre firing review must be conducted to ensure blast hazards – blast overpressure, flyrock, ground shock and fume – can be managed safely with appropriate precautions in place.**

### **Meteorological conditions**

4.6. The actual meteorological conditions at the time of firing the blast will have a significant impact on the fume plume and its local effect.

4.7. If significant issues including wet-holes etc have been identified in the preparation of the shot that indicate that a fume event is likely, an examination of the likely local weather conditions need to be made in relation to potentially exposed sites prior to firing the shot. These principles need to be developed by specialists and embedded into the standard operating procedures. It should take into account the following matters:

- Potential blasting areas and potentially exposed sites
- Meteorological conditions
  - inversion
  - wind direction and speed
  - atmospheric stability
  - cloud cover
  - time of day
  - temperature
  - humidity

### **Time of firing**

4.8. When considering a time to initiate the blast – weather conditions must be assessed. Generally the atmosphere is most stable early morning and late afternoon due to the absence of direct ground heating from the sun. If a fume event occurs at these times and the wind conditions are light it is likely to have a greater impact in terms of size, distance travelled, stability of cloud and slow dissipation.

### **Potential fume exposure sites**

4.9. A master fume map such as Figures 4.2 should be developed and maintained for each blast site. The purpose of this map is to identify internal and external potentially exposed sites and the number of persons at that site. Examples are:

- Internal potential exposure sites
  - Offices
  - Car parks
  - Workshops
  - Administrative areas
  - Explosives storage area

- Benches
- Underground mine entrances and ventilation shafts
- External potential exposure sites
  - Houses and farms
  - Towns
  - Industrial Sites
  - Public Roads
  - Railways
  - Underground mine entrances and ventilation shafts

4.10. This map should be used to identify potential monitoring sites either of a permanent or temporary nature when firings are to occur.

### Modelling to support fume map

4.11. This section includes some model prediction data in relation to a fume event generating NO<sub>x</sub>. The modelling has significant assumptions and is based on the limited measurements conducted. Absence of measurements indicates the need for blasting operators to ensure a monitoring plan is in place for all blasts. Once reliable additional data becomes available the quality of the predictions will improve.

4.12. Preliminary modelling of nitrogen dioxide dispersion has been undertaken using the modelling tool SLAB with a range of representative meteorological conditions. Exclusion zones in Table 4.1 below have been estimated based on nitrogen dioxide concentration of less than 5 ppm. The table provides indicative downwind exclusion distances for fume events of varying levels (0-5) and the four stability conditions.

**Table 4.1: Length of potential exclusion distance downwind (m) with several different wind conditions covering the daytime stability classes.**

Fume category Subjective ranking	Initial NO <sub>2</sub> (ppm) <sup>1</sup>	Downwind exclusion distance (m) required to maintain NO <sub>2</sub> concentration below 5ppm				Potential extent of 0.12 ppm (m) (odour threshold)	Cross-wind exclusion distance (m)
		Stability class and wind speed					
		A (very unstable) high temp, windy, no cloud	B (unstable)	C (slightly unstable)	D (neutral)		(from blast cloud centre line)
		Wind speed 6.8 – 12.6 kmph	Wind speed 2.9 – 10 kmph	Wind speed 1.4 – 4.32 kmph	Wind speed 1.4 – 2.2 kmph		
0	2	100	100	100	100	1,200	100
1	4	130	140	150	150	3,000	150
2	7	400	500	500	500	4,000	500
3	17	600	1000	1200	1200	8,000	1000
4	70	900	1600	3000	3000	13,000	1500
5	500	1600	3000	5000	5000	20,000	2000

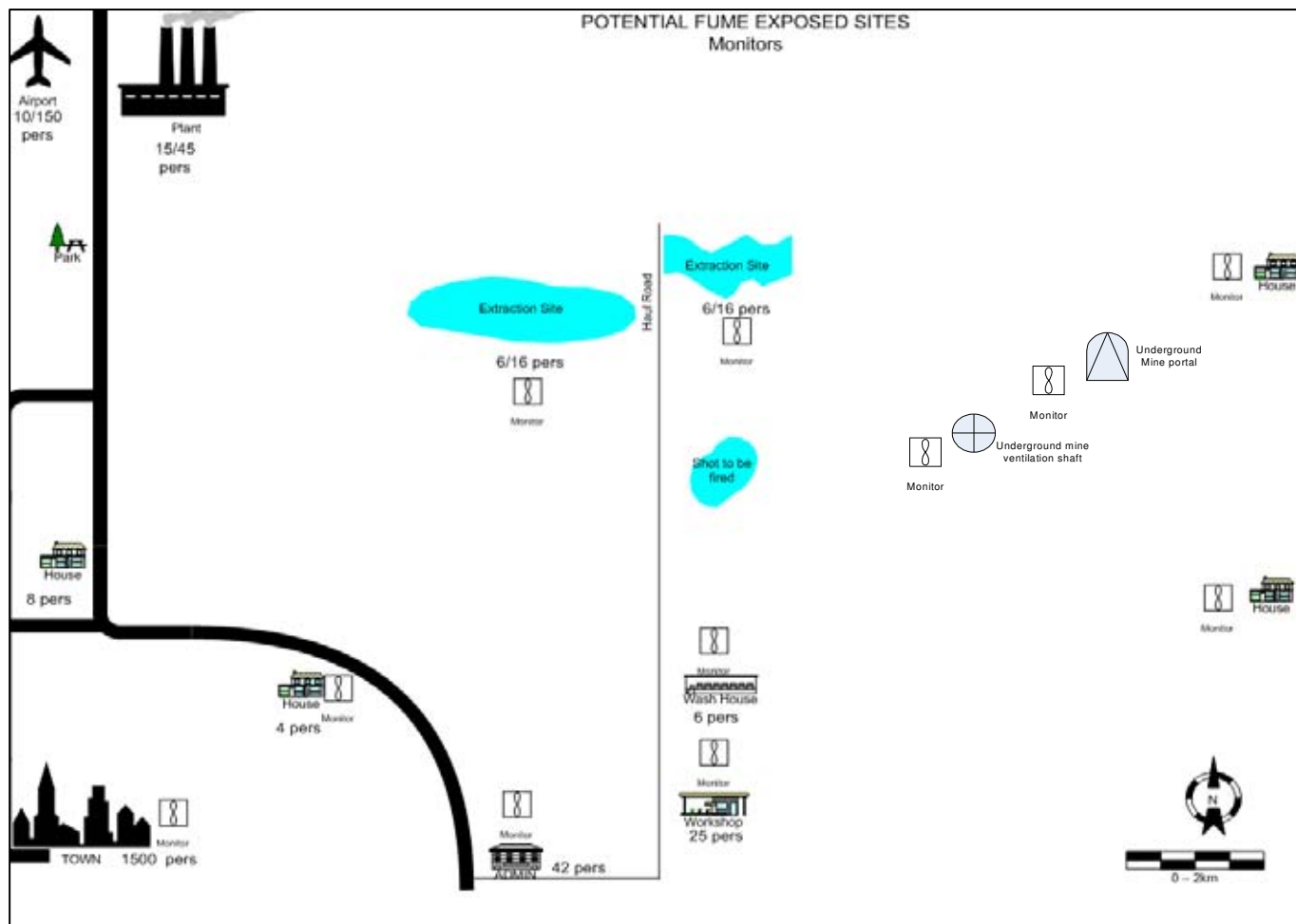
Notes: 1. Initial NO<sub>2</sub> concentrations are estimates based on a small number of measurements. These concentrations will vary greatly depending on depth of fumes, angle of sunlight, and subjective nature of ranking.



Other assumptions in the use of this table are:

- Blasting can only be undertaken in daylight hours.
- Initial cloud dimensions 100 m x 100 m from ground level up to 150 m high
- Surface roughness of 0.05 m (grassland).
- NO<sub>2</sub> may factor up 5 times due to NO to NO<sub>2</sub> conversion in the presence of definition.  
This warrants further investigation.

**Note: The table has been developed as a guide and is regarded as being indicative only.**



The standard map without the fume prediction should identify potentially exposed sites under all possible conditions where monitors should be placed either permanently or temporarily for each firing.

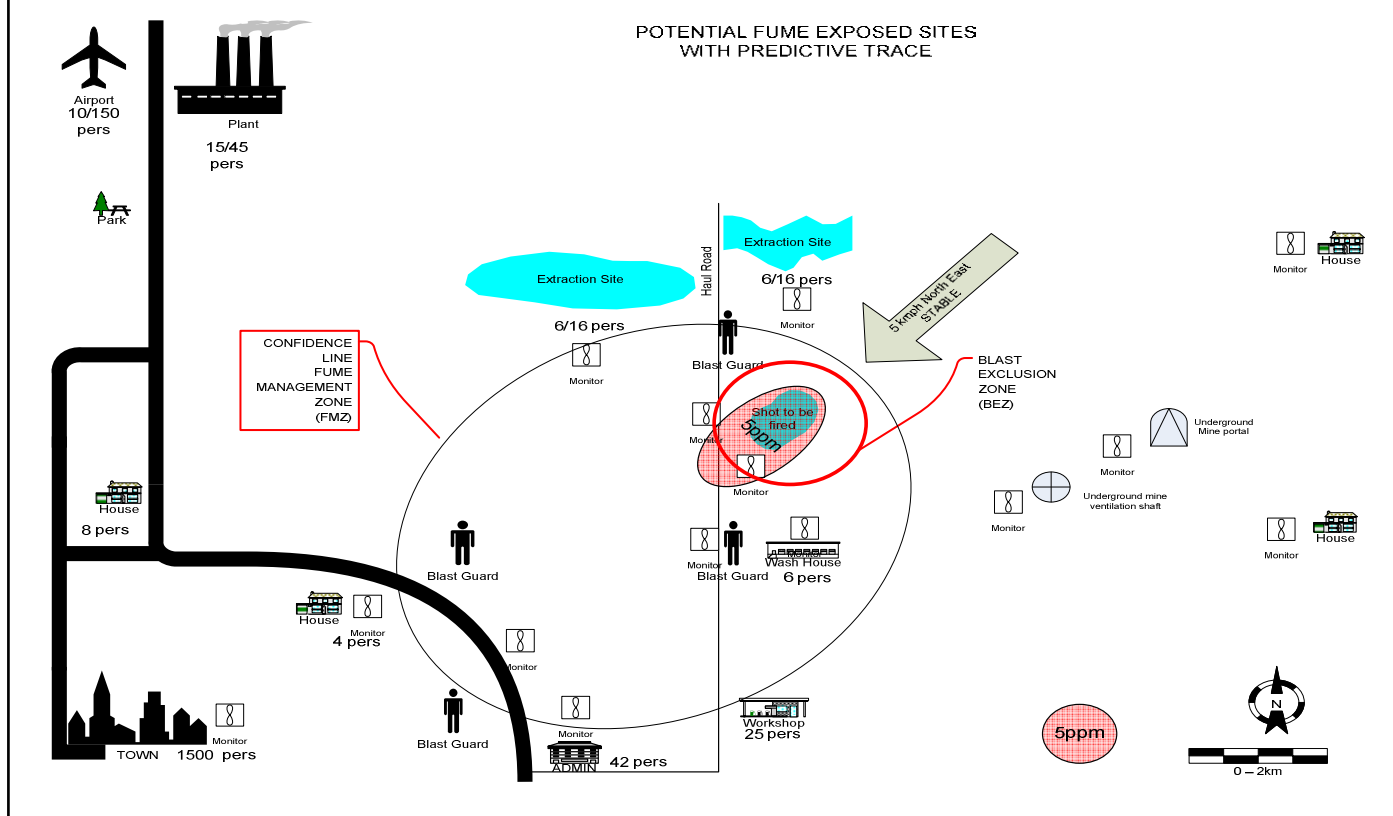
**Figure 4.1 - Master fume map without fume prediction**

### Fume Management Zone (FMZ)

4.13. When the pre firing review is conducted the map should have the standard exclusion zone indicated on it to cover flyrock, overpressure and ground shock. It should also have an indicated plume event trace that becomes the fume management zone (FMZ) where the blast controller has to ensure that persons will not be exposed to the plume. The background calculation of the plume should have been developed for the site by competent persons. A schematic of this fume map is shown below.

4.14. The key data to determine this zone is based on

- Estimated level of fume event 1-5
- Expected wind speed and direction and actual observations
- Atmospheric stability class for the time of the firing.



**Figure 4.2 - Master fume map with fume prediction**

Example workings to calculate expected fume management zone (FMZ) level e.g. 4 stability conditions, temperature, cloud cover and timing of cloud to travel at ground level.

#### **Notes**

1. Consider evacuation of wash house.
2. Advise admin, farmhouse and workshop of possible low level exposure - small only.
3. Smell may take up to 30-40 minutes to reach main roads depending on wind conditions.
4. Extraction sites to the north could continue working. Consider PPE for persons who cannot evacuate – dragline operator

4.15. This map should be used to identify additional temporary monitoring sites for fumes for a particular blast with the predicted trace of fumes. The identification of the FMZ is an important tool for identifying and managing potentially exposed sites.

**A fume cloud generally presents short term exposure unless the conditions are stable**

#### **Monitoring of NOx**

4.16. Monitoring NOx levels before and after a fume event is important to:

- enable background levels to be established for particular locations
- take action to safe guard personnel
- increase the information available to investigators determining the amount of fume generated.
- provide indication to treating medical staff of the possible level of exposure.
- record exposure to persons and sites that may become the basis of legal claims – this should be identified in a review.
- identify exposure levels at particular sites

**Persons should not enter a fume cloud that is yellow, orange or brown. Such fume clouds will be visible and have an acrid smell.**

### **Monitoring equipment**

4.17. Monitoring equipment (personal or fixed) varies depending on its purpose which could include personal monitoring, site or area monitoring, potentially exposed site monitoring. Specific monitors can be hired or purchased outright. When purchasing monitors specify the target gases to ensure the monitors are able to monitor the target gases.

4.18. All monitors must remain in calibration and be challenged regularly with the gases they are meant to detect. Monitors may provide a basic warning of a gas with an alert and may also log data by ppm recorded over time.

4.19. All monitor positions must be accurately recorded with GPS co-ordinates to enable later analysis.

4.20. Monitors are capable of multiple gas detection and should be capable of detecting NO<sub>2</sub>, NO and CO.

### **Monitoring plan**

4.21. The SHMS should develop, operate and maintain a monitoring plan in place appropriate to the site and identify potentially exposed sites. The monitoring plan should be risk based. The monitoring plan should consider but is not limited to:

- Internal potentially exposed sites under the control of the mine site such as
  - Shotfirers and blast crew
  - Blast guards
  - Mine facilities such as wash ports, offices, workshops, pits etc.
- External potentially exposed sites not under the control of the mine site such as:
  - Schools, health care facilities
  - Mines
  - Mine Ventilation shaft
  - Farms
  - Roads, railways, airports
  - Towns

4.22. Monitoring requires the following principles to be of value:

- Monitors shall be tested, challenged and calibrated
- Monitoring data is recorded and maintained.
- GPS location of monitor is accurately recorded
- Monitors need to be time synchronised with each other and other recording equipment such as videos.
- Data analysis should be undertaken to verify modelling.

4.23. The monitoring is important for the reasons above. The data to be recorded needs to be done in a similar manner to be of value for further analysis. The pre-firing review is used to refine the standard monitoring plan. It should identify the persons who are most likely to be close to the blast and/or within the determined exclusion zone and hence more likely to be exposed. These persons should be evacuated or placed on evacuation standby if appropriate.

4.24. This may include and be obvious based on the proposed exclusion zone based on the weather conditions.

4.25. Personal Protective Equipment (PPE). PPE is always regarded as a last resort and is very low on the hierarchy of controls. The exposures associated with a blast will usually be brief as the cloud moves over an area. It would be unusual to have a number of blasts per day that generate fume into the same locations. PPE is very low on the hierarchy of controls, however the use of PPE (gas masks) should be considered in the mine procedures. There may be persons in a location that have a low likelihood of exposure however could be exposed at short notice e.g. an excavator operator outside the exclusion zone that is subject to a sudden wind change and exposure. The widespread use of PPE is generally not appropriate and it is best to ensure that prevention to exposure is in place.

**Measuring NOx site measurements in ppm, duration and recording the location in relation to a blast will provide data to improve the management of fume events, and demonstrate if appropriate exposure levels are met.**

### Documentation and records

4.26. The documentation and records required for the preparation and firing of a blast is important to ensure the following:

- Information is available to the blast superintendent or SSE to support the pre firing decision
- If a fume event occurs there is sufficient information available to enable the investigation to find the variable or variables that contributed to the fume event.
- Each blast is to include the following documentation:
  - Site Data Sheet
  - TDS
  - Blast mudmap
  - Tonnage calculation
  - Blast markout report
  - Face hole profiles
  - Load sheets
  - Tie up plan
  - Firing sequence
  - Timing contours map
  - Explosives quantities
  - Delivery dockets
  - Issues log
  - Blast design
  - Vibration
  - Air blast printouts
  - NOx monitor records
  - Prefiring
  - Post firing reviews

# Section 5 - Management of a fume exposure

## Management of a fume exposure

### Initial first aid

5.1. Get out of the cloud. Seek fresh air. Use water to reduce the amount of exposure to wash out eyes and clear nose and throat. Any person exposed to fumes should be sent to be checked by medical staff. This is a precautionary measure that must be undertaken. It can be difficult to determine the level of exposure and if certain symptoms are obvious on presentation to a treating doctor – the person may need to remain under observation for at least 4-6 hours to monitor for pulmonary oedema.

5.2. If there is monitoring information available, this information should be passed to the treating medical staff. For example if there is a monitor in the area the data of exposure level in parts per million (ppm) and duration of the exposure is useful information for the treating doctor and also provides information to inform future planning of dealing with fume exposures.

### Advice to medical staff

5.3. The treating medical staff must be aware of what the person has been exposed to. A standard letter for persons exposed to oxides of nitrogen is at Appendix H.

5.4. The treating medical staff should provide the patient with feedback on the signs and symptoms observed when the patient was presented.

## Incident reporting

5.5. There are obligations in regard to reporting incidents under the applicable legislation. If a fume cloud travels outside the designated blast exclusion zone (BEZ) must be reported to the Explosives Inspectorate and the Mines Inspectorate. The information to be provided for reporting a fume event is:

- Time of event
- Fume strength rating 0-5. A NO<sub>x</sub> rating scale can be found at Appendix I. Determine the rating when the cloud is at its highest concentration
- Percentage of blast area emitting fume (0% - 100% in 10% increments) or use A to C rating from AEISG.
- Size of NO<sub>x</sub> cloud in metres referring to width, length and height.
- Wind speed and direction
- Stability class of atmosphere
- Temperature
- Cloud cover
- Persons exposed
- Treatment provided
- Pre firing review summary – add to incident report
- Post firing review summary – add to incident report

5.6. The routine blast fume survey requirements whether an incident or not were mentioned at 3.24. Further details on fume survey reporting requirements are at Appendix L.

# **Section 6 - Investigation of fume events and ongoing audit and review**

## **Investigation to isolate key causes**

6.1. It is important that all fume events are thoroughly investigated to determine as accurately as possible the causes of the fume. The investigation relies heavily on the availability of accurate records from a blast. If the investigation cannot identify causes for the fume it is most likely the result of inadequate record keeping. When the investigation team finds this situation it must ensure that all future blasts are conducted with the appropriate records in place.

6.2. Appendix J is a guideline in relation to fume investigations that should be used by the mine site, Explosives Company or the regulator. The use of Appendix F outlining the possible causes of fume will be a valuable aid and in identifying issues that contributed to the causes of fume.

## **Investigation template**

6.3. A template for the investigation of fume events is also included at Appendix J. The use of this template by mines, explosives companies and the regulator will ensure that there is a common approach to the conduct and outcome of investigations.

6.4. A previous review of fume investigations and the follow up indicates that many investigations are unable to attribute an exact cause and generally list a range of causal factors. This is understandable because of the variables associated with blasting but it is important that lessons learnt are translated into procedures and practices to eliminate those identified causes. Mines and explosives companies must ensure that poor practices, inadequate procedures are corrected within their SHMS to prevent future occurrences.

6.5. Appendix K includes a bow tie diagram developed around the six causes identified in relation to fume. This has been based on the AEISG causes and are in preliminary stage only. There is some additional work to be completed on the controls associated with the management of the consequences side of the bowtie. These will be updated in a later version of the document.

## **Audit and review**

6.6. Regular audits of the activities need to be undertaken to ensure that all parties involved in blasting are ensuring that their part of the blast activity is well controlled. This continuous verification is essential in an activity that has significant variables to be controlled. Audit results by supervisors, superintendents and SSE should be recorded and retained.

6.7. Audits must review previous incidents regarding fume and ensure that the SHMS has implemented procedures that ensure that the explosives, application, procedures will not lead to a repeat situation. If the SHMS has not been corrected after such events' and monitored for ongoing compliance there has been no safety gain from the incident and it is likely to be repeated. A repeat fume occurrence is an indication that the system for the safe management of fume is out of control.

6.8. Review of a fume event should be comprehensive and must pinpoint which particular variables were the main contributors to the fume event. The use of effective documentation and records outlined above is critical to accurately reviewing an event.

# **Section 7 - Conclusions**

## **Conclusion**

7.1. The focus of this Guidance Note is to prevent a fume event, and is important to insure that appropriate plans to manage a fume event and a fume exposure are in place.

7.2. There are many factors to be managed well to minimise fumes across the life cycle of blasting explosives and the preparation, drilling, loading and firing of blasts. Changes to the plan and in conditions during the preparation phase of a blast may become critical items to manage in the blast itself.

7.3. A prefiring review is essential to ensure that a fume event can be managed safely. It must take into account the meteorological conditions and adjust the standard exclusion zone and determine an appropriate fume management zone.

7.4. The monitoring of blasts is an important issue to obtain actual data to improve modelling and understanding of plume behaviour. It is also an important issue to enable mines to verify that exposures are within the appropriate guidelines.

7.5. Exposures must be treated with a precautionary approach and medical facilities advised of the type of exposure. If there is monitoring data to support the exposure this information should also be provided to the medical facility.

7.6. Investigations of fume events must be thorough and determine the most prominent causes of an incident. Thorough investigations will ensure that appropriate controls can be developed to reduce the future occurrence of fumes. For investigations to be effective all sites must keep good blast records.

7.7. As the causes of fume events are variable, it is essential that controls put in place to control fume are vigorously applied. All persons, supervisors and managers must ensure that their controls are firmly embedded and maintained for blasting operations.

## References and further reading

1. Queensland Government, *Mining and Quarrying Safety and Health Act 1999*
2. *Coal Mining Safety and Health Act 1999*
3. *Explosives Act 1999*
4. Explosives Inspectorate Safety Alert No 44 – Prevention and management of blast fumes
5. Explosives Inspectorate Safety Alert No 28 – Post blast gases
6. Monitoring and removal of CO in blasting operations by Harris, M L (Marcia) Mainiero, R J (Richard); 2008; p.1393-1405.
7. Behavior of Nitrogen Oxides in the Product Gases from Explosive Detonations by Richard J. Mainiero, James H. Rowland III, Marcia L. Harris, and Michael J. Sapko.; Conference on Explosives and Blasting Technique ( 2006; 10P. IN: Proceedings Of The Annual Conference On Explosives And Blasting Technique, Volume 2.- Cleveland: Int Soc Explosives Engineers;
8. TOXIC FUMES ON THE ROCKS by MICHAEL S. WIELAND.; Conference on Explosives and Blasting Technique (28th: 2002: Las Vegas, Nev.) 2005; 14p. IN: Proceedings Of The Twenty-Eighth Annual Conference On Explosives And Blasting Technique, Volume 2.- Cleveland: Int Soc Explosives Engineers
9. Quarry management; Feb. 2004 After-blast fumes from ANFO mixtures: the effect of prill type and mixing technique by Farnfield, R (Rob) Wetherelt, A (Andy); 2004; p.11-19.
10. Propellants, Explosives, Pyrotechnics; v.29, no.4. Work-Principle Model For Predicting Toxic Fumes Of Non Ideal Explosives /by Wieland, M S (Michael); 2004; p.236-243.
11. Toxic fume comparison of a few explosives used in trench blasting by Harris, M L (Marcia) Sapko, M J (Michael) Mainiero, R J (Richard); 2003; p.319-336. IN: Proceedings of the Twenty-Ninth Conference on Explosives and Blasting Technique, Feb 2-5 2003.- International Society of Explosives Engineers;
12. Chemical and physical factors that influence NOx production during blasting: exploratory study by Sapko, M (Michael) Rowland, J (James) Mainiero, R (Richard) Zlochower, I (Isaac); Conference on Explosives and Blasting Technique ( 28th: 2002: Las Vegas, Nev.) 2002; p.317-330. IN: Proceedings Of The Twenty-Eighth Annual Conference On Explosives And Blasting Technique, Volume 2.- Cleveland: Int Soc Explosives Engineers;

13. Factors affecting fume production in surface coal blasting operations by Turcotte, R Yang, R Lee, M-C Short, B Shomaker, R.; Conference on Explosives and Blasting Technique ( 28th: 2002: Las Vegas, Nev.) 2002; p.307-316. IN: Proceedings Of The Twenty-Eighth Annual Conference On Explosives And Blasting Technique, Volume 2.- Cleveland: Int Soc Explosives Engineers;
14. Emissions from Explosives by Wetzig, V.; Conference on Explosives and Blasting Technique; 2001; p.371- IN: Proceedings of the 27th Annual Conference on Explosives and Blasting Technique. Volume 2.- Orlando, FL: International Society of Explosives Engineers;
15. Fumes from Blasting Operations. Institute of Makers of Explosives; 2001;
16. Undergraduate thesis, University of Queensland. The effects of mixing different fuel oil types into ammonium nitrate fuel oil (ANFO) formulation on post detonation fume production by Marriott, B.; University of Queensland; 2000;
17. Factors affecting ANFO fumes production by Rowland, J H Mainiero, R J.; 2000; p. 63-174. IN: Proceedings of the 26th Annual Conference on Explosives and Blasting Technique.- Anaheim, CA: International Society of Explosives Engineers;
18. Emission Estimation Technique Manual for Explosives Detonation and Firing Ranges by National Pollution Inventory; Australia. Department of Environment and Heritage; Canberra: Department of Environment and Heritage, 1999; 12p.
19. Work principle for predicting explosive toxic fumes by Wieland, M S (Michael); 1998; p.121- IN: Proceedings of the Annual Symposium on Explosives and Blasting Research;
20. Journal of cleaner production; v.5, no.3 Method of reducing nitrogen oxide fumes in blasting by Granholm, Richard H Lawrence, Lawrence D.; 1997; p.244-244. (JOCP.5.3.244-244.63)
21. A technique for measuring toxic gases produced by blasting agents /by Mainiero, R J.; 23rd annual conference on explosives and blasting technique (1997: Las Vegas, NV (USA)) 1997; p.595-604. IN: Proceedings of the 23rd Annual Conference on Explosives and Blasting Technique. Cleveland, OH: International Society of Explosives Engineers, 1997 Jan; :595-604;
22. Canadian Patent Application; Method of reducing nitrogen oxide fumes in blasting by Granholm, R H Lawrence, L D.; 1996;
23. A study on post blast generation of nitrogen oxide by Lawrence, L D.; 22. Annual conference on explosives and blasting technique (1996: Orlando, FL (USA)) 1996; p.89-100. IN: Proceedings of the twenty-second annual conference on explosives and blasting technique. Volume 2.- Cleveland, OH (USA): International Society of Explosives Engineers;
24. The large chamber test for toxic fumes analysis of permissible explosives by Santis, L D (Lon) Rowland, J H (James) Viscusi, D J Dennis) Weslowski, M H (Mark); 21. Annual conference on explosives and blasting technique (1995: Nashville, TN (USA)) 1995; p.341-355. IN: Proceedings of the twenty-first annual conference on explosives and blasting technique. Volume 1.- Cleveland, OH (USA): International Society of Explosives Engineers;
25. Experimental investigation of the fumes produced by modern commercial explosives by Roberts, W Katsbanis, P D de Souza, E M.; 1992; p.53-62. IN: Proceedings of the 8th Annual Symposium on Explosives and Blasting Research, Orlando, FL, January 22- 23, 1992;
26. Journal of Mining Science; v.17, no.5 Study of the development and dispersion of a dust and gas cloud during rock blasting in iron-ore open-cast mines by P. V. Beresnevich I. V. Fursa.; 1981; p.437-440.
27. National Pollutant Inventory Website.



## Appendix A - Definitions

AEISG:	Australian Explosives Industry Safety Group – a group of explosives company working in a collaborative manner to improve explosives safety in Australia.
ANE:	Ammonium nitrate emulsions classed as UN No 3375. These include both emulsions and water gels.
ANFO:	A mixture of ammonium nitrate and fuel oil with or without a dye colouring agent (Definition from AS2187.0).
Bench Assistant:	A person assisting the shotfirer on the bench in blasting activities.
BEZ:	Blast Exclusion Zone
Blast Designer:	The person with direct management responsibility for the design of blasting practices in any mining situation, including the selection of explosive products.
Blasting Supervisor/Contractor	The person supervising blasting activities of the shotfirer and shot crew. My also be the lead shotfirer.
Burden relief:	A measure of the time delay, provided by the initiation design, between two consecutive burdens, measured in ms/m
Confinement:	A measure of the effort required from detonation gasses to displace the fractured rock.
Deep hole:	A blast hole of greater than 30 metres.
Desensitisation:	The process of reducing or removing the sensitivity of an explosives, whether temporarily or permanent
Dewatered hole:	A blast hole which has had rain or surface water removed using an in-hole pump or other mechanical means.
Drill and blast superintendent:	The nominated Drill and Blast Person accountable for the performance, safety as well as meeting production requirements of the Department of some mines
Drill and blast Supervisor:	The person supervising blasting activities of the shotfirer and shot crew. He/She may be the lead shotfirer.
Dry hole:	A blast hole which contains no detectable water.
Driller:	The contractor or individual responsible for drilling the blast pattern to the blast design specification. Data and information on actual conditions encountered and variations to the pattern are to be recorded and advised to the blast designer and shotfirer.
Dust:	Airborne particulate matter ranging in diameter from 10 to 50 microns.
Dynamic water:	Water that's in motion (i.e. flowing water)
FMP:	Fume Management Plan
FMZ:	Fume Management Zone. A predicted zone where fume is likely to be present after a blast. The FMZ is managed to ensure that persons are not exposed to fume in this area.
Fumes:	Refers in the context of this QGN to the gases belonging to oxides of nitrogen, particularly NO <sub>2</sub> , the most prevalent and harmful. Fume is a combination of post blast gases, which are predominately nitrogen dioxide but may also include nitrous oxide, nitric oxide, carbon monoxide and carbon dioxide. Nitrogen dioxide is the only one of the post blast gases that is visible.

Gas bag:	An inflatable bladder used to block off a blast hole and support explosives or stemming.
Gassing:	Chemical reaction creating small gas bubbles in explosives blends with the addition of chemical gassing agents. This process increases the sensitivity of the explosives.
Hole liner:	A flexible plastic tube which is placed into a blast hole before product is loaded into the tube, providing some protection from water or broken ground
Hole saver:	A plastic funnel which is placed in the collar of a hole, allowing product to be loaded, but preventing fallback of dirt or water ingress.
Ideal explosion:	A chemical reaction that produces products (solids, liquids, gasses) at volumes, concentrations and of type in accordance with conventional theoretical reaction equations.
IDLH:	Immediate danger to life and health.
MMU:	Mobile Manufacturing Unit. A vehicle built to strict specifications to manufacture and deliver explosives onto a bench.
MMU Operator:	Person trained, assessed and found competent to operate an MMU, and who is authorised and appointed as the MMU operator by the company or mine site.
NOx:	A multiple combinations of oxides of nitrogen ( $N_2O$ , NO, $NO_2$ , $N_2O_4$ , $N_2O_3$ , $N_2O_5$ ) with nitrogen dioxide ( $NO_2$ ) being the principle hazardous nitrous fume.
Non ideal explosion:	A chemical reaction that does not produce products (solids, liquids, gasses) at volumes, concentrations and of type in accordance with conventional theoretical reaction equations.
NPI:	National Pollutant Inventory – provides data on pollutant emissions from inventory.
Oxides of Nitrogen:	Nitrogen bases gases such as nitric oxide, nitrogen oxide, nitrogen dioxide, nitrogen monoxide and mononitrogen monoxide
Post-blast fume:	Gases generated by the explosive reaction during blasting.
Potentially Exposed Site:	A site that is potentially exposed to the effect of a hazard. In this case ‘fume’
Precursor:	A material resulting from a chemical or physical change when two or more substances consisting of fuels and oxidisers are mixed and where the material is intended to be used exclusively in the production of an explosive. (Definition from AEMSC Code of good practice precursors for explosives.)
Recharge:	A term used to describe the re-entry of water back into a blast hole after it has been dewatered.
SDS:	Site Data Sheet
Sensitivity:	A measure on how easily an explosive can be initiated. Highly sensitive = easily initiated.
Shotfirer:	This is a statutory appointment directly responsible for the safety, security and outcomes of a blast
Sleep time:	The time between explosives being loaded into a blasthole and their initiation (Definition from AS2187.0).
SMS:	Safety and health Management System required by legislation for a site to operate under the Coal Mining, Quarrying and Metals Mine or Explosives Act.
Stemming:	The material used to plug a blast hole.

STEL:	Short term exposure limit
Senior Site Executive:	The person appointed as the Senior Site executive under mining legislation
TDS:	Technical Data Sheets
TWA:	Time Weighted Average
User Needs Specifications:	A clear and simply defined set of desired deliverables and characteristics of an explosives product, set by the user of explosives, required to suite the user's operational requirements.
Wet hole:	A blast hole that contains any amount of detectable water
Wet sides:	A description of a section of blasthole that is not filled with water, but is, however wet at the sides.

## Appendix B: Legislation

Statutory requirements under Coal Mining Safety and Health Act 1999 and Coal Mining Safety and Health Regulation 2001 and Mining and Quarrying Safety and Health Act 1999 and Mining and Quarrying Safety and Health Regulation 2001 in relation to risk of exposure from blast fume.

- **Section 6 of both CMSH Act 1999 and MQSH Act 1999** requires compliance of the basic objective of the Act to **protect the safety and health** of persons at mines and persons who may be affected by mining operations and the **risk** of injury or illness to any person resulting from mining operations are at an **acceptable level**. There is significant risk of exposure of blast fume to the mine workers of the mine conducting the blast and to mine workers of adjacent mines as well as persons living in the surrounding community. Obligation under the Act is to ensure the risk from such exposure is at an acceptable level as defined in **Section 26 of the MQSH Act 1999 and Section 29 of CMSH Act 1999**.
- **Section 30 of CMSH Act 1999** provides how to achieve an acceptable level of risk through risk management and operating procedures.  
To deal with the hazard of exposure from blast fume, SHMS of the mine should incorporate
  - appropriate measures to **avoid / remove** unacceptable risk;
  - **monitoring** levels of risk and adverse consequences of retained residual risk;
  - reviewing **effectiveness of risk control** measures;
  - taking appropriate **corrective and preventive** action; and
  - **mitigating** the potential adverse effects arising from **residual risk**
- **Section 28 of MQSH Act 1999 and Section 31 of CMSH Act 1999** requires evacuation of persons to safe location and taking action to reduce the risk to an acceptable level.
- **Section 30 of MQSH Act 1999 and Section 33 of CMSH Act 1999** provides for **safety and health obligations** of mine workers, operator, site senior executive, contractor, manufacturer, importer or supplier of substance for use at a mine and service provider
- **Section 31 of MQSH Act 1999 and Section 34 of CMSH Act 1999** provides for discharge of obligation and **Section 34 and 35 of MQSH Act 1999 and Section 37 and 38 of CMSH Act 1999** provides for how obligation can be discharged if regulation or recognised standard made or not made.

**Section 35(3) of MQSH Act 1999 and Section 38(3) of CMSH Act 1999** provides that the person discharges the person's safety and health obligation in relation to the risk only if the person takes **reasonable precautions**, and **exercises proper diligence, to ensure the obligation is discharged**

- **Section 36, 38, 39, 40, 43 and 44 of MQSH Act 1999 and Section 39, 41, 42, 43, 46 and 47 of CMSH Act 1999** respectively provides for **safety and health obligations** of
  - **Mine workers** to comply with this Act;
  - **Mine operator** to ensure the risk to mine workers while at the operator's mine is at an acceptable level;
  - **Site senior executive** to ensure the **risk** to persons from mining operations / from any plant or substance provided/ is at an **acceptable level**; and to provide for adequate **supervision** and control of mining operations, regular **monitoring** and assessment of the **working environment** and appropriate inspection
  - **Contractor** to comply with the provisions of the act to the extent that they relate to the work undertaken
  - **Manufacturer, importer or supplier** of substance for use at a mine to ensure the **substance is safe** so that, when used properly, the risk to persons from the use of the

substance is at an acceptable level and conducting appropriate levels of testing and examination of the substance to ensure the above and also other obligations like ensuring appropriate information about the safe use, storage and disposal of the substance is provided with the substance; taking required action by the chief inspector to prevent use of an unsafe substance at a coal mine.

- Exposure of blast fume may result into serious accident causing death or serious illness or HPI with potentiality to cause a significant adverse effect on the safety or health of a person as defined in **Section 16 and 17 of both MQSH Act 1999 and CMSH Act 1999** respectively. Hence, as provided in **Section 195 of the MQSH Act 1999 and Section 198 of CMSH Act 1999**, there is a requirement of notification by notice or orally to an inspector and an district workers' representative / industry safety and health representative, as soon as possible, about any serious accident, high potential incident or a death at a coal mine resulting from a blasting event.
- **Section 198 of MQSH Act 1999 and Section 201 of CMSH Act 1999** also provides for an investigation into such serious accident or HPI resulting from blasting event.
- **Section 69 of MQSH Regulation 2001** requires the site senior executive to ensure that, before explosives are used at the mine, a risk management process is carried out to identify the hazards that may arise or interact from the use.
- **Section 116 of CMSH Regulation 2001** requires all surface coal mine to provide a SOP for identifying and controlling hazards during charging and firing explosives having regard to proximity of unrelated activities to charging and firing
- **Similarly Section 70 of MQSH Regulation 2001** requires the SSE of a mine to provide a written Blasting Procedure including warning and guarding persons against entering an unsafe area during a blast; removing persons who may be injured by a blast to a safe place before firing takes place; ability for each person involved in firing the blast to reach a safe position, by walking at normal walking pace, before the blasting happens; firing a blast from a position that is safe from the effects of the blast; deciding when it is safe to re-enter the blasted area etc and also recording the results of blast monitoring at the mine.
- The product of blast in a surface mine like Oxides of Nitrogen or CO may be highly toxic in nature. **Section 142 of CMSH Regulation 2001** requires a surface mine's SHMS to provide for protecting persons from risk of flammable and **toxic gas** and to have a SOP for Flammable and Toxic gas incorporating provisions for
  - identifying and monitoring parts of the mine where the gas might accumulate and create a hazard;
  - fixing flammable gas concentration limits for the work environment;
  - testing for flammable or toxic gas in the work environment, before, during and after carrying out work;
  - recording information about flammable or toxic gas detected in the work environment;
  - controlling flammable or toxic gas in the work environment;
  - establishing emergency procedures for flammable or toxic gas in the work environment.
- If Risk assessment identifies PPE as a control measure for a person against the hazard of being exposed to toxic blast fume, the mine operator has an obligation under **Section 140 of MQSH Regulation 2001 and Section 64 of CMSH Regulation 2001** to provide appropriate and sufficient PPE readily available for use by the workers.
- The coal mine must have a SOP for using the PPE for a task as provided in **Section 65 of CMSH Regulation 2001**
- Further, as explosive is a hazardous substance, SSE has an obligation of maintaining a Hazardous substance register and record of quantity, location, use, disposal, deterioration of the hazardous substance as provided in Section 61, 62 & 63 of MQSH Regulation 2001.

- Similarly for coal mines, SSE has an obligation of maintaining a Hazardous substance register and a standard operating procedure for using hazardous substances at the mine including purchasing, selecting, storing, using, moving, decanting and disposing of hazardous substances; and appropriate first aid for a person affected by a hazardous substance as provided in **Section 55 & 56 of CMSH Regulation 2001**.

## **ANNEXURE 1: Provisions of Coal Mining Safety and Health Act 1999 and Coal Mining Safety and Health Regulation 2001**

### **Section 6 of CMSH Act 1999: Objects of Act**

The objects of this Act are—

- (a) to protect the safety and health of persons at coal mines and persons who may be affected by coal mining operations; and
- (b) to require that the risk of injury or illness to any person resulting from coal mining operations be at an acceptable level.

### **Section 29 of CMSH Act 1999: What is an acceptable level of risk?**

- (1) For risk to a person from coal mining operations to be at an ***acceptable level***, the operations must be carried out so that the level of risk from the operations is—
  - (a) within acceptable limits; and
  - (b) as low as reasonably achievable.
- (2) To decide whether risk is within acceptable limits and as low as reasonably achievable regard must be had to—
  - (a) the likelihood of injury or illness to a person arising out of the risk; and
  - (b) the severity of the injury or illness.

### **Section 30 of CMSH Act 1999: How is an acceptable level of risk achieved?**

- (1) To achieve an acceptable level of risk, this Act requires that management and operating systems must be put in place for each coal mine.
- (2) This Act provides that the systems must incorporate risk management elements and practices appropriate for each coal mine to—
  - (a) identify, analyse, and assess risk; and
  - (b) avoid or remove unacceptable risk; and
  - (c) monitor levels of risk and the adverse consequences of retained residual risk; and

.....

  - (e) review the effectiveness of risk control measures, and take appropriate corrective and preventive action; and
  - (f) mitigate the potential adverse effects arising from residual risk.
- (3) Also, the way an acceptable level of risk of injury or illness may be achieved may be prescribed under a regulation.

### **Section 31 of CMSH Act 1999: What happens if the level of risk is unacceptable?**

- (1) If there is an unacceptable level of risk to persons at a coal mine, this Act requires that—
  - (a) persons be evacuated to a safe location; and
  - (b) action be taken to reduce the risk to an acceptable level.
- (2) Action to reduce the risk to an acceptable level may include stopping the use of specified plant or substances.

### **Section 33 of CMSH Act 1999: Obligations for safety and health**

(1) Coal mine workers or other persons at coal mines or persons who may affect safety and health at coal mines or as a result of coal mining operations, have obligations under division 2 (**safety and health obligations**).

(2) The following persons have obligations under division 3 (also **safety and health obligations**)—

- (a) a holder;
- (b) a coal mine operator;
- (c) a site senior executive;
- (d) a contractor;

.....

- (g) a manufacturer, importer or supplier of substances for use at a coal mine;
- (h) a person who supplies a service at a coal mine.

### **Section 34 of CMSH Act 1999: Discharge of obligations**

A person on whom a safety and health obligation is imposed must discharge the obligation.

### **Section 37 of CMSH Act 1999: How obligation can be discharged if regulation or recognised standard made**

(1) If a regulation prescribes a way of achieving an acceptable level of risk, a person may discharge the person's safety and health obligation in relation to the risk only by following the prescribed way.

(2) If a regulation prohibits exposure to a risk, a person may discharge the person's safety and health obligation in relation to the risk only by ensuring the prohibition is not contravened.

(3) Subject to subsections (1) and (2), if a recognised standard states a way or ways of achieving an acceptable level of risk, a person discharges the person's safety and health obligation in relation to the risk only by—

- (a) adopting and following a stated way; or
- (b) adopting and following another way that achieves a level of risk that is equal to or better than the acceptable level.

### **Section 38 of CMSH Act 1999: How obligations can be discharged if no regulation or recognised standard made**

(1) This section applies if there is no regulation or recognised standard prescribing or stating a way to discharge the person's safety and health obligation in relation to a risk.

(2) The person may choose an appropriate way to discharge the person's safety and health obligation in relation to the risk.

(3) However, the person discharges the person's safety and health obligation in relation to the risk only if the person takes reasonable precautions, and exercises proper diligence, to ensure the obligation is discharged.

### **Section 198 of CMSH Act 1999: Notice of accidents, incidents, deaths or diseases**

(1) Subject to subsections (2) and (3), as soon as practicable after becoming aware of a serious accident, high potential incident or a death at a coal mine, the site senior executive for the coal mine must notify an inspector and an industry safety and health representative about the accident, incident or death either orally or by notice.

(2) Subsection (3) applies to—

.....

- (b) a high potential incident at a coal mine of a type prescribed under a regulation; or

(3) The site senior executive must, as soon as possible after becoming aware of the accident, incident or death, by notice or orally notify an inspector and an industry safety and health representative about the accident, incident or death in terms that include the information (the **primary information**) stated in subsection (3A).

(3A) for subsection (3), the primary information is all of the following—

- (a) the precise location where the accident, incident or death happened;
- (b) when the accident, incident or death happened;
- (c) the number of persons involved in the accident, incident or death;

.....

(e) if the notification is about a serious accident or high potential incident—

- (i) the name of any person who saw the accident or incident, or who was present when the accident or incident happened; and
- (ii) the name of any person who was injured as a result of the accident or incident;
- (f) if no one was present when the person mentioned in paragraph (d) died or the person mentioned in paragraph (e)(ii) was injured—the name of the person who found the deceased or injured person;
- (g) a brief description of how the accident, incident or death happened.

#### **Section 16 of CSMH Act 1999: Meaning of *serious accident***

A ***serious accident*** at a coal mine is an accident at a coal mine that causes—

- (a) the death of a person; or
- (b) a person to be admitted to a hospital as an in-patient for treatment for the injury.

#### **Section 17 of CSMH Act 1999: Meaning of *high potential incident***

A ***high potential incident*** at a coal mine is an event, or a series of events, that causes or has the potential to cause a significant adverse effect on the safety or health of a person.

#### **Schedule 1 Types of high potential incidents for section 198 of the Act**

##### **Section 13 of CSMH Regulation 2001**

#### **Prescribed types of high potential incidents—Act, s 198**

A type of high potential incident mentioned in schedule 1 is prescribed for section 198(2)(b) of the Act

.....

.....

9 An incident involving an explosive

#### **Section 39 of CSMH Act 1999: Obligations of persons generally**

(1) A coal mine worker or other person at a coal mine or a person who may affect the safety and health of others at a coal mine or as a result of coal mining operations has the following obligations—

- (a) to comply with this Act and procedures applying to the worker or person that are part of a safety and health management system for the mine;
- (b) if the coal mine worker or other person has information that other persons need to know to fulfil their obligations or duties under this Act, or to protect themselves from the risk of injury or illness, to give the information to the other persons;
- © to take any other reasonable and necessary course of action to ensure anyone is not exposed to an unacceptable level of risk.

#### **Section 41 of CSMH Act 1999: Obligations of coal mine operators**

(1) A coal mine operator for a coal mine has the following obligations—

- (a) to ensure the risk to coal mine workers while at the operator's mine is at an acceptable level, including, for example, by providing and maintaining a place of work and plant in a safe state;
- (b) to ensure the operator's own safety and health and the safety and health of others is not affected by the way the operator conducts coal mining operations;

#### **Section 42 of CSMH Act 1999: Obligations of site senior executive for coal mine**

A site senior executive for a coal mine has the following obligations in relation to the safety and health of persons who may be affected by coal mining operations—

- (a) to ensure the risk to persons from coal mining operations is at an acceptable level;



(b) to ensure the risk to persons from any plant or substance provided by the site senior executive for the performance of work by someone other than the site senior executive's coal mine workers is at an acceptable level;

.....

(f) to provide for—

.....

(iii) adequate supervision and control of coal mining operations on each shift at the mine; and  
(iv) regular monitoring and assessment of the working environment, work procedures, equipment, and installations at the mine; and  
(v) appropriate inspection of each workplace at the mine including, where necessary, pre-shift inspections.

### **Section 43 of CMSH Act 1999: Obligations of contractors**

A contractor at a coal mine has an obligation to ensure, to the extent that they relate to the work undertaken by the contractor that provisions of this Act and any applicable safety and health management system are complied with.

### **Section 46 of CMSH Act 1999: Obligations of manufacturers, importers and suppliers of substances for use at coal mines**

(1) A manufacturer or importer of a substance for use at a coal mine has the following obligations—

(a) to ensure the substance is safe so that, when used properly, the risk to persons from the use of the substance is at an acceptable level;

(b) to ensure the substance undergoes appropriate levels of testing and examination to ensure compliance with the obligation imposed by paragraph (a).

(2) Also, a manufacturer, importer or supplier of a substance for use at a coal mine has the following obligations—

(a) to ensure appropriate information about the safe use, storage and disposal of the substance is provided with the substance;

(b) to take the action the chief inspector reasonably requires to prevent the use of an unsafe substance at a coal mine.

(3) For subsection (2)(a), information is **appropriate** if the information clearly identifies the substance and states—

(a) the precautions, if any, to be taken for the safe use, storage or disposal of the substance; and

(b) the risks, if any, associated with the use, storage or disposal of the substance.

### **Section 201 of CMSH Act 1999: Action to be taken in relation to site of accident or incident**

(1) If there is a serious accident or high potential incident, the site senior executive must—

(a) carry out an investigation to decide the causes of the accident or incident and

(b) prepare a report about the accident or incident that includes recommendations to prevent the accident or incident happening again

### **Section 273 of CMSH Act 1999: Withdrawal of persons in case of danger**

(1) If a coal mine is dangerous, all persons exposed to the danger must withdraw to a place of safety.

### **Section 274 of CMSH Act 1999: Where coal mine worker exposed to immediate personal danger**

(1) Subject to section 273(2) and (3), if a coal mine worker (the **original worker**) believes that there is immediate personal danger, the worker has the right—

(a) to remove himself or herself to a position of safety; and

(b) to refuse to undertake a task allocated to the worker that may place the worker in immediate personal danger.

(2) The coal mine operator for the coal mine or the coal mine operator's representative must not disadvantage the coal mine worker for exercising the worker's rights under subsection (1).

(3) Subsection (4) applies if the coal mine operator or the operator's representative subsequently asks or directs another coal mine worker (the **subsequent worker**) to place himself or herself in the position from which the original worker has removed himself or herself, or to undertake a task that the original worker has refused to undertake.

(4) The operator or the operator's representative must advise the subsequent worker that the original worker exercised rights under subsection (1) because the original worker believed that there was a serious danger to the original worker's safety or health.

## **CMSH Regulation 2001**

### **Section 64 of CSMH Regulation 2001 providing personal protective equipment**

A coal mine operator must—

- (a) provide, for the mine's coal mine workers, personal protective equipment that is—
  - (i) appropriate for the hazards associated with the workers' tasks; and
  - (ii) sufficient for the number of workers carrying out the tasks; and
- (b) ensure the equipment is readily available for use by the workers

### **Section 65 of CSMH Regulation 2001 Standard operating procedure**

(1) A coal mine must have a standard operating procedure for using personal protective equipment for a task at the mine.

(2) The procedure must include provision for the following—

- (a) training workers in—
  - (i) selecting appropriate personal protective equipment for the task; and
  - (ii) using the equipment;
- (b) instructions on using, maintaining and disposing of the equipment.

### **Section 67 of CSMH Regulation 2001 Plans of coal mine workings**

(1) A site senior executive for a coal mine must keep at the mine—

.....

- (c) information likely to be required to evaluate the effect of the mine on—
  - (i) the safety of adjoining coal mines; and
  - (ii) any potential uncontrolled flow of material into the mine workings; and
- (d) information likely to be required to evaluate the effect of any adjoining mine on the safety of the mine.

### **Section 55 of CSMH Regulation 2001: Hazardous substance register**

(1) The site senior executive must ensure the mine has a register of hazardous substances used at the mine.

(2) The register must—

- (a) contain the material safety data sheet for each hazardous substance; and
  - (b) be kept at the mine in a location that is easily accessible by each coal mine worker at the mine.
- (3) The material safety data sheet must comply with NOHSC's document entitled 'National Code of Practice for the Preparation of Material Safety Data Sheets [NOHSC: 2011]'.

### **Section 56 of CSMH Regulation 2001: Using hazardous substances**

(1) A coal mine must have a standard operating procedure for using hazardous substances at the mine.

(2) The procedure must include provision for—

- (a) purchasing, selecting, storing, using, moving, decanting and disposing of hazardous substances; and
- (b) appropriate first aid for a person affected by a hazardous substance.

### **Section 116 of CSMH Regulation 2001 Safety and health management system**

(1) A surface mine must have a standard operating procedure for

the following—

- .....
- (g) identifying and controlling hazards—
  - (i) during the charging and firing of explosives; and

- .....
- (3) The procedure for identifying and controlling hazards during the charging and firing of explosives must—
- (a) have regard to the following—
    - (i) the proximity of unrelated activities to the charging and firing;
    - (ii) ground conditions; and
  - (b) state the allowable period for the explosives to remain in the ground before being detonated.

#### **Section 142 of CMSH Regulation 2001 Flammable or toxic gas**

- (1) A surface mine's safety and health management system must provide for protecting persons from risks from flammable or toxic gas at the mine.
- (2) The system must include a standard operating procedure that provides for the following—
- (a) identifying and monitoring parts of the mine where the gas might accumulate and create a hazard;
  - (b) fixing flammable gas concentration limits for the work environment;
  - (c) testing for flammable or toxic gas in the work environment, before, during and after carrying out work;
  - (d) recording information about flammable or toxic gas detected in the work environment;
  - (e) controlling flammable or toxic gas in the work environment;
  - (f) establishing emergency procedures for flammable or toxic gas in the work environment.

### **APPENDIX B: Provisions of Mining and Quarrying Safety and Health Act 1999 and Mining and Quarrying Safety and Health Regulation 2001**

#### **MQSH Act 1999**

##### **Section 6 of MQSH Act 1999: Objects of Act**

The objects of this Act are—

- (a) to protect the safety and health of persons at mines and persons who may be affected by operations; and
- (b) to require that the risk of injury or illness to any person resulting from operations is at an acceptable level.

##### **Section 28 of MQSH Act 1999: What happens if the level of risk is unacceptable?**

- (1) If there is an unacceptable level of risk to persons at a mine, this Act requires that—
- (a) persons be evacuated to a safe location; and
  - (b) action be taken to reduce the risk to an acceptable level.
- (2) Action to reduce the risk to an acceptable level may include stopping the use of specified plant or substances.
- (3) The action may be taken by the operator for the mine, the site senior executive for the mine, district workers' representatives, site safety and health representatives, workers, inspectors or inspection officers.

##### **Section 30 of MQSH Act 1999: Obligations for safety and health**

- (1) Workers or other persons at mines or persons who may affect safety and health at mines or as a result of operations, have obligations under division 2 (***safety and health obligations***).
- (2) The following persons have obligations under division 3 (also ***safety and health obligations***)—
- (a) holder;
  - (b) operator;
  - (c) site senior executive;
  - (d) contractor;

- (e) designer, manufacturer, importer and supplier of plant for use at a mine;
- (f) erector and installer of plant at a mine;
- (g) manufacturer, importer and supplier of substances for use at a mine;
- (h) person who supplies a service at a mine.

### **Section 31 of MQSH Act 1999: Discharge of obligations**

A person on whom a safety and health obligation is imposed must discharge the obligation.

### **Section 34 of MQSH Act 1999: How obligation can be discharged if regulation or guideline made**

- (1) If a regulation prescribes a way of achieving an acceptable level of risk, a person may discharge the person's safety and health obligation in relation to the risk only by following the prescribed way.
- (2) If a regulation prohibits exposure to a risk, a person may discharge the person's safety and health obligation in relation to the risk only by ensuring that the prohibition is not contravened.
- (3) Subject to subsections (1) and (2), if a guideline states a way or ways of achieving an acceptable level of risk, a person discharges the person's safety and health obligation in relation to the risk only by—
  - (a) adopting and following a stated way; or
  - (b) adopting and following another way that achieves a level of risk that is equal to or better than the acceptable level.

### **Section 35 of MQSH Act 1999: How obligations can be discharged if no regulation or guideline made**

- (1) This section applies if there is no regulation or guideline prescribing or stating a way to discharge the person's safety and health obligation in relation to a risk.
- (2) The person may choose an appropriate way to discharge the person's safety and health obligation in relation to the risk.
- (3) However, the person discharges the person's safety and health obligation in relation to the risk only if the person takes reasonable precautions, and exercises proper diligence, to ensure the obligation is discharged.

### **Section 36 of MQSH Act 1999: Obligations of persons generally**

- (1) A worker or other person at a mine or a person who may affect safety and health of persons at a mine or as a result of operations, has the following obligations—
  - (a) to comply with this Act, standard work instructions, and procedures applying to the worker or person that form part of a safety and health management system for the mine;
  - (b) if the worker or other person has information that other persons need to know to fulfil their obligations or duties under this Act, or to protect themselves from the risk of injury or illness—to give the information to the other persons;
  - (c) to take any other reasonable and necessary course of action to ensure that persons are not exposed to unacceptable levels of risk.

### **Section 38 of MQSH Act 1999: Obligations of operators**

- (1) An operator for a mine has the following obligations—
  - (a) to ensure the risk to workers while at the operator's mine is at an acceptable level, including, for example, by—
    - (i) providing a safe place of work and safe plant; and
    - (ii) maintaining plant in a safe state;
  - (b) to ensure the operator's own safety and health and the safety and health of others is not affected by the way the operator conducts operations;

### **Section 39 of MQSH Act 1999: Obligations of site senior executive for mine**

- (1) A site senior executive for a mine has the following obligations in relation to the safety and health of persons who may be affected by operations—
  - (a) to ensure the risk to persons from operations is at an acceptable level;

(b) to ensure the risk to persons from any plant or substance provided by the site senior executive for the performance of work by someone other than the site senior executive's workers is at an acceptable level;

.....

(f) to provide for—

.....

(iii) adequate supervision and control of operations on each shift at the mine; and

(iv) regular monitoring and assessment of the working environment, work procedures, equipment, and installations at the mine; and

(v) appropriate inspection of each workplace at the mine including, where necessary, pre-shift inspections.

#### **Section 40 of MQSH Act 1999: Obligations of contractors**

A contractor at a mine has an obligation to ensure, to the extent that they relate to the work undertaken by the contractor that provisions of this Act and any applicable safety and health management system are complied with.

#### **Section 43 of MQSH Act 1999: Obligations of manufacturers, importers and suppliers of substances for use at mines**

(1) A manufacturer or importer of a substance for use at a mine has the following obligations—

(a) to ensure the substance is safe so that, when used properly, the risk to persons from the use of the substance is at an acceptable level;

(b) to ensure the substance undergoes appropriate levels of testing and examination to ensure compliance with the obligation imposed by paragraph (a).

(2) Also, a manufacturer, importer or supplier of a substance for use at a mine has the following obligations—

(a) to ensure appropriate information about the safe use, storage and disposal of the substance is provided with the substance;

(b) to take the action the chief inspector reasonably requires to prevent the use of an unsafe substance at a mine.

(3) For subsection (2)(a), information is **appropriate** if the information clearly identifies the substance and states—

(a) the precautions, if any, to be taken for the safe use, storage or disposal of the substance; and

(b) the risks, if any, associated with the use, storage or disposal of the substance.

#### **Section 195 of MQSH Act 1999: Notice of accidents, incidents, deaths or diseases**

(1) Subject to subsections (2) and (3), as soon as practicable after becoming aware of a serious accident, high potential incident or a death at a mine, the site senior executive for the mine must notify an inspector and a district workers' representative about the accident, incident or death either orally or by notice.

(2) Subsection (3) applies to—

(a) a serious accident at a mine resulting in a person receiving—

(i) a bodily injury endangering, or likely to endanger, the person's life; or

(ii) an injury causing, or likely to cause, a permanent injury to the person's health; or

(b) a high potential incident at a mine of a type prescribed under a regulation; or

(c) a death at a mine, whether or not caused by an accident at the mine.

(3) The site senior executive must, as soon as possible after becoming aware of the accident, incident or death, by notice or orally notify an inspector and a district workers' representative about the accident, incident or death in terms that include the information (the **primary information**) stated in subsection (3A).

(3A) For subsection (3), the primary information is all of the following—

(a) the precise location where the accident, incident or death happened;

(b) when the accident, incident or death happened;

(c) the number of persons involved in the accident, incident or death;

.....

(e) if the notification is about a serious accident or high potential incident—

- (i) the name of any person who saw the accident or incident, or who was present when the accident or incident happened; and
- (ii) the name of any person who was injured as a result of the accident or incident;
- (f) if no one was present when the person mentioned in paragraph (d) died or the person mentioned in paragraph (e)(ii) was injured—the name of the person who found the deceased or injured person;
- (g) a brief description of how the accident, incident or death happened.

**Schedule 1 Types of high potential incidents for section 195(2)(b) of MQH Act 1999**  
**Section 12A of MQSH Regulation 2001**

**Prescribed types of high potential incidents—Act, s 195**

A type of high potential incident mentioned in schedule 1 is prescribed for section 195(2)(b) of the Act

.....

10(k) the exposure of a person to a hazardous substance;

**MQSH Regulation 2001**

**Section 61 of MQSH Regulation 2001:                      Register of hazardous substances and dangerous goods**

- (1) The site senior executive must ensure the mine has a register containing—
  - (a) a list of all hazardous substances, and a list of all dangerous goods, used or produced at the mine; and
  - (b) the current MSDS for each substance or good.
- (2) The site senior executive must ensure the register is readily accessible by each worker required to use the substances or goods at the mine.

**Section 62 of MQSH Regulation 2001:                      Resources for complying with MSDS**

The site senior executive must ensure the mine has the first aid supplies and facilities and personal protective equipment recommended in the relevant MSDS for each hazardous substance and dangerous good used at the mine.

**Section 63 of MQSH Regulation 2001:                      Records**

- (1) The site senior executive must ensure a record of the following is kept at the mine for each hazardous substance and dangerous good at the mine—
  - (a) its quantity and location on site;
  - (b) when it was received, or produced, on site;
  - (c) its use, sale or disposal;
  - (d) any deterioration or product failure;
  - (e) any leak, spill, unintended emission, misuse, theft or other loss.
- (2) The site senior executive must ensure the record about the disposal of hazardous substances and dangerous goods on site—
  - (a) is kept at the mine until the mine's operations stop; and
  - (b) after operations stop, is given to the chief executive.
- (3) The site senior executive must ensure a record about another matter mentioned in subsection (1) is kept at the mine until the substance or good to which the record relates has been used, disposed of, or removed from site.

**Section 69 of MQSH Regulation 2001: Identifying interaction hazards before explosives are used**

- (1) The site senior executive must ensure that, before explosives are used at the mine, a risk management process is carried out to identify the hazards that may arise or interact from the use.

### **Section 70 of MQSH Regulation:        Blasting procedures**

- (1) If blasting is carried out at a mine, the site senior executive must ensure the mine has written procedures for the blasting.
- (2) The procedures must provide for the following—
  - (a) ensuring equipment used for charging and firing is maintained in a good operating condition;
  - (b) cleaning blast holes before charging;
  - (c) blast times;
  - (d) warning and guarding persons against entering an unsafe area during a blast;
  - (e) removing persons who may be injured by a blast to a safe place before firing takes place;
  - (f) the ability for each person involved in firing the blast to reach a safe position, by walking at normal walking pace, before the blasting happens;
  - (g) firing a blast from a position that is safe from the effects of the blast;
  - (h) deciding when it is safe to re-enter the blasted area;
  - (i) examining the blasted area and blast hole remnants safely;
  - (j) communicating, from 1 shift to another, information about charging and blasted locations.
- (3) The procedures must provide for the following additional matters, as are appropriate, having regard to the nature, size and complexity of the blasting—
  - (a) keeping air blast, air overpressure, dust generation, flyrock, ground vibration and noise within acceptable limits;
  - (b) keeping the effect on ground stability to as low as practicable;
  - (c) keeping blast times within worker and community expectations for blasting;
  - (d) finalising blast design and firing sequence;
  - (e) recording the results of blast monitoring at the mine, including the monitoring of ground vibration.

### **Section 140 of MQSH Regulation 2001: Using personal protective equipment**

- (1) This section applies if a person's exposure to a hazard at a mine can not be prevented or reduced other than by using personal protective equipment.
- (2) The site senior executive must ensure—
  - (a) the person is given suitable and effective personal protective equipment; and
  - (b) the person is competent in using the equipment; and
  - (c) the person's work load and work cycles are reduced to allow for the increased physical load of the equipment.
- (3) A person who is given personal protective equipment under subsection (2) must use the equipment when the person's level of risk from the hazard is unacceptable.

## ***Explosives Act 1999***

### **8 Authorised explosives**

- (1) The chief inspector may declare an explosive to be an authorised explosive for this Act.
- (2) Before making a declaration under subsection (1), the chief inspector must—
  - (a) define the composition, quality and character of the explosive; and
  - (b) classify the explosive in a way prescribed under a regulation.
- (3) If the composition, quality or character of an authorised explosive changes, the explosive stops being an authorised explosive.

### **11 Offence in relation to unauthorised and prohibited explosives**

- (1) A person must not manufacture, possess, sell, store, transport or use an unauthorised or prohibited explosive.

Maximum penalty — 400 penalty units or six months imprisonment.

- (2) Subsection (1) does not apply to an act done under an explosives trial approval.

### **32 General duty of care**

- (1) A person who is doing an act involving explosives must take reasonable precautions and use reasonable care to avoid endangering any person's safety, health or property.

Maximum penalty—

- (a) if the contravention causes multiple deaths and serious harm to property or the environment—3000 penalty units or 3 years imprisonment; or
- (b) if the contravention causes multiple deaths—2000 penalty units or 3 years imprisonment; or
- (c) if the contravention causes death or grievous bodily harm—1000 penalty units or 2 years imprisonment; or
- (d) if the contravention involves exposure to a substance likely to cause death or grievous bodily harm—750 penalty units or 1 year's imprisonment; or
- (e) if the contravention causes bodily harm—750 penalty units or 1 year's imprisonment; or
- (f) if the contravention causes serious harm to property or the environment—750 penalty units or 1 year's imprisonment; or
- (g) otherwise—500 penalty units or 6 months imprisonment.

(2) In this section—

***bodily harm*** see the Criminal Code, section 1.

***grievous bodily harm*** see the Criminal Code, section 1.

### **33 Employer's obligation about employees**

- (1) Before an employer employs someone to do something allowing the employee to have access to explosives, the employer must ensure, as far as practicable, the person is an appropriate person.
- (2) A regulation may prescribe the minimum steps an employer must take to satisfy subsection (1).
- (3) Failure to comply with this section may be a ground for suspending or cancelling an authority holder's authority.

### **38 Explosive to be manufactured under authority**

- (1) A person must not manufacture an explosive unless the person holds an authority that authorises the person to manufacture the explosive.

Maximum penalty—400 penalty units or 6 months imprisonment.

- (2) Subsection (1) does not prevent a person—

- (a) manufacturing, not more than 500g of an explosive, or a smaller amount prescribed under a regulation, under direct adult supervision, for use by the person manufacturing it in a chemical experiment; or
- (b) reconditioning an explosive at a government magazine or under an inspector's supervision; or
- (c) if the person is licensed or otherwise authorised to use a weapon under the Weapons Act 1990—filling ammunition for the weapon for use by the person.

- (3) Also, subsection (1) does not prevent the holder of an authority to use an explosive manufacturing an explosive prescribed under a regulation for this section (***a prescribed explosive***), by a manual operation performed under conditions prescribed under a regulation, for the holder's immediate use.
- (4) In addition, subsection (1) does not prevent an inspector manufacturing a prescribed explosive, by a manual operation performed under conditions prescribed under a regulation, for the inspector's immediate use.

### **55 Notice of explosives incident**

The authority holder whose explosives are involved in an explosives incident must immediately give the chief inspector written notice of the incident and any loss of life, personal injury or property damage caused by the incident.

Maximum penalty—170 penalty units.

### **57 Site not to be interfered with without inspector's permission**

- (1) A person must not interfere with the site of an explosives incident without the permission of an inspector.

Maximum penalty—200 penalty units.

- (2) Permission under subsection (1) must not be unreasonably withheld.



- (3) For this division, action taken to save life or prevent further injury at a place is not interference with the site.

### **59 Person must answer question about explosives incident**

- (1) This section applies if an inspector asks a person a question about an explosives incident.  
(2) The person must answer the question unless the person has a reasonable excuse.

Maximum penalty—40 penalty units.

- (3) It is a reasonable excuse for an individual to not answer the question that answering the question might tend to incriminate the individual or make the individual liable to a penalty.

### **39 Employees of particular authority holders taken to be holders of authority**

- (1) This section applies to an employee of a holder of a prescribed authority if the employee is—  
(a) acting within the scope of the employee's employment;  
and

- (2) The employee is taken to be a holder of the prescribed authority.

- (3) In this section—

**prescribed authority** means a following authority—

- (c) a licence to manufacture explosives;

### **42 Requirement to have and give effect to safety management system**

- (1) This section applies to the holder of a prescribed authority if 1 or more employees of the holder carry out activities under the authority.

- (2) The holder must have and give effect to a safety management system for—

- (a) if a place is stated in the authority as a place where an activity may be carried out under the authority—the place; or

Examples for paragraph (a)—

- 1 an explosives factory 2 premises where explosives are stored

- (b) if an activity is carried out under the authority other than at a place mentioned in paragraph (a)—the activity.

Examples for paragraph (b)—

- 1 blasting activities carried out under an authority at various locations 2 transporting explosives

Maximum penalty — 50 penalty units.

- (3) The safety management system is a system that incorporates risk management elements and practices that ensure the safety and health of persons who may be affected by activities carried out under the authority.

- (4) The safety management system must—

- (a) be an auditable written system that complies with section 43; and

- (b) provide for ongoing consultation with employees and contractors of the holder who are engaged in carrying out activities under the authority, at least once a month, about safety in relation to the activities.

- (5) The safety management system may be part of a safety management system (however called) required under another Act.

Example—

The safety management system may be part of a safety and health management system for a coal mine required under the Coal Mining Safety and Health Act 1999.

- (6) In this section—

**prescribed authority** means any of the following authorities—

- (a) a licence to import explosives;  
(b) a licence to export explosives;  
(c) a licence to manufacture explosives;  
(d) a licence to sell explosives;  
(e) a licence to store explosives;  
(f) a licence to transport explosives;  
(g) a licence to use explosives;  
(h) a shotfirer licence;  
(i) a fireworks contractor licence.

### **43 Contents of safety management system**

A safety management system must contain each of the following—

- (a) a description of the holder's safety policy;
- (b) details of the organisational structure of the holder's operations, including details of the personnel responsible for performing all the functions provided for under the system;
- (c) a system procedure for each matter stated in schedule 3, part 1;
- (d) an operational procedure for each matter stated in schedule 3, part 2 that is applicable to the place or activity to which the system applies.

### **68 Manufacture of explosives**

A relevant holder must—

- (a) ensure an explosive manufactured under the licence is manufactured in a safe condition; and
- (b) ensure the explosive is correctly classified; and
- (c) ensure the packaging of the explosive is marked with the correct classification code for the explosive; and
- (d) take reasonable steps to ensure the explosive will function as it was designed to function; and
- (e) for an explosive that is a mixture of ammonium nitrate and fuel oil, with or without other substances—ensure the explosive is manufactured as required under AS 2187, part 2 or alternative safety measures for the standard; and
- (f) for an explosive that is or includes precursors—ensure the explosive is manufactured as required under the precursor code or alternative safety measures for the code; and
- (g) for an explosive manufactured in a mobile manufacturing unit—ensure the explosive is manufactured as required under the mobile manufacturing code or alternative safety measures for the code.

Maximum penalty—50 penalty units.

### **123 Particular blasting explosives prescribed for s 53(2) of Act**

For section 53(2) of the Act, a blasting explosive used by a following person is prescribed—

- (a) a person who is appointed as a shotfirer for a mine by the site senior executive or underground mine manager of the mine;
- (b) a person who is in the presence and under the direct supervision of a prescribed shotfirer.

### **124 Persons who may be appointed as shotfirer for a mine**

The site senior executive or an underground mine manager of a mine must not appoint a person as a shotfirer for the mine unless the site senior executive or underground mine manager is reasonably satisfied the person meets the criteria stated in section 35(1)(a) to (e).

Maximum penalty—50 penalty units.

### **125 Persons who may use blasting explosives under supervision**

- (1) A person (a *supervised person*) who does not hold an authority authorising the person to use blasting explosives may use a blasting explosive in the presence and under the direct supervision of a prescribed shotfirer.
- (2) However, the prescribed person must not allow the supervised person to use the explosive unless the prescribed person is satisfied the supervised person—
  - (a) is an adult; and
  - (b) is physically able to carry out blasting activities; and
  - (c) has satisfactory knowledge of—
    - (i) the requirements under the Act about storage, transport, manufacture, sale and use of explosives; and
    - (ii) the hazards associated with each type of blasting explosive, its blasting characteristics, safe handling procedures and methods of use.

Maximum penalty—50 penalty units.

- (3) In this section—  
***prescribed person*** means—  
(a) if the prescribed shotfirer is the holder of a shotfirer licence—the holder; or  
(b) if the prescribed shotfirer is a person appointed as a shotfirer for a mine—the site senior executive or underground mine manager of the mine.

## **126 Use of blasting explosives**

- (1) A prescribed shotfirer must—  
(a) use a blasting explosive as required under—  
(i) AS 2187, part 2; or  
(ii) alternative safety measures for the standard; and  
(b) take all reasonable steps to—  
(i) prevent misfires; and  
(ii) minimise the risk associated with material projected by a blast; and  
(iii) minimise the adverse effects of ground vibration and shock waves caused by a blast; and  
(iv) ensure the security of an explosive used in blasting activities; and  
(c) not use an explosive after the expiry of the manufacturer's recommended shelf life for the explosive unless the explosive was sold to the shotfirer after the expiry under section 76(2)(b)(ii).  
Maximum penalty—100 penalty units.

## **127 Records**

- A prescribed shotfirer must—  
(a) keep a record of the amount and type of explosives purchased and used by the shotfirer; and  
(b) keep, as required under AS 2187, part 2, a record of each blast carried out by the shotfirer.  
Maximum penalty—50 penalty units.

## Appendix C - Properties of Nitrogen Dioxide

Nitrogen dioxide is produced for the manufacture of nitric acid. Most nitric acid is used in the manufacture of fertilisers, while some is used in the production of explosives for both military and mining uses.

### Substance details

Substance name: Oxides of nitrogen

CASR number: N/A

Molecular formula: NO, NO<sub>2</sub>, N<sub>2</sub>O and N<sub>2</sub>O<sub>5</sub>

Synonyms: NO: nitric oxide, nitrogen oxide, nitrogen monoxide, mononitrogen monoxide

NO<sub>2</sub>: nitrogen dioxide

### Physical properties

NO: sharp, sweet-smelling, colourless gas

Melting point: -163.6°C

Boiling point: -151.8°C

Relative Density: 1.6 (air = 1) – It is more dense than air and it will fill hollows, holes and cuttings

NO<sub>2</sub>: reddish-brown gas with irritating odour.

Melting point: -9.3°C

Boiling point: 21.15°C

Vapour Density: 1.58

### Chemical properties

NO only burns when heated with hydrogen, and forms nitric acid (a strong acid) when dissolved in water.

NO<sub>2</sub> is sparingly soluble in water to form nitrous acid (a weak acid).

Australian National Pollutant Inventory - 'Oxides of Nitrogen' overview

## Appendix D – Occupational exposure standards and health effects for Nitrogen Dioxide (NO<sub>2</sub>)

### Occupational Exposure Standards

Occupational exposure standards represent airborne concentrations of individual chemical substances which, according to current knowledge, should neither impair the health of nor cause undue discomfort to nearly all workers. Additionally, the exposure standards are believed to guard against narcosis or irritation which could precipitate industrial accidents. These exposure standards are guides to be used in the control of occupational health hazards. They should not be used as fine dividing lines between safe and dangerous concentrations of chemicals. (NHSC 1995)

A full list of all occupational exposure standards and the relative documentation behind them are made available from Safework Australia at the following link.

<http://hsis.ascc.gov.au/SearchES.aspx>

Table C-1 lists the current occupational exposure standards and IDLH value for NO<sub>2</sub>.

Exposure Standards	Percentage by Volume (Parts per million)
TWA (Time Weighted Average)	3ppm (0.0003%)
STEL (Short Term Exposure Limit)	5ppm (0.0005%)
IDLH (Immediately Dangerous to Life and Health)*	20 ppm (0.002%)

### Irritant Effects

Many of the gases generated in an explosive reaction are unstable and of low toxicity. The main gases to consider are nitric oxide and nitrogen dioxide. Nitrogen dioxide is formed when nitric oxide combines with the oxygen in the atmosphere. Nitrogen dioxide is one of the irritant asphyxiant gases. At sufficient concentrations these gases cause intense irritation to the eyes, mucous membranes and respiratory passages.

Nitrogen dioxide has a very strong acrid odour that is easily detectable by smell at concentrations that are much lower than the current exposure standards (up to 40 times lower). In addition concentrations from 4 ppm may anaesthetize the nose, thus creating a potential for overexposure if smell is used as an indicator of exposure.

### Pulmonary oedema

The irritant asphyxiant gases which are less water soluble, such as nitrogen dioxide, may allow a full inhalation before their irritant nature is revealed, giving them access to the delicate membranes of the lower respiratory passages and alveoli, where they can cause severe damage. At higher concentrations nitrogen dioxide can cause severe bronchospasm (asthma) and an out-pouring of tissue fluid into the air passages, called pulmonary oedema and which, if severe, can lead to drowning due to fluid filled blisters bursting in the lungs. This reaction can be immediate or may be delayed for some hours. Since this happens rapidly when it does occur, it can be dangerous to

allow people who have had significant exposure to go home before a suitable period has elapsed. Even those with minor exposure should be warned of the possibility of lung complications and directed to seek urgent attention if they become short of breath in the subsequent 24 hour period.

### **Other respiratory effects**

Inhalation of raised levels of nitrogen dioxide can increase the likelihood of respiratory problems. Nitrogen dioxide inflames the lining of the lungs, and it can reduce immunity to lung infections. This can cause problems such as wheezing, coughing, colds, flu and bronchitis. Increased levels of nitrogen dioxide can have significant impacts on people with asthma because it can cause more frequent and more intense attacks. Children with asthma and older people with heart disease are most at risk.

### **Long term outcomes resulting from acute exposures**

The long term outcome for a person, who survives the initial exposure to a significant high dose of nitrogen dioxide, can vary. Some recover with no subsequent health problems. Some continue to have a form of asthma known as RADS – (Reactive Airways Dysfunction Syndrome). This is a form of occupational asthma, that is, asthma (in a previously non-asthmatic person) caused by exposure to some substance at work. However, RADS exhibits some differences to classic occupational asthmas. For one, symptoms occur immediately after the exposure, whereas most occupational asthmas follow a variable latent period, where the person is exposed but suffers no symptoms. With RADS, symptoms may persist for a variable period of weeks or months or may be permanent. The sufferer may find that many things such as solvent vapours, cigarette smoke and even cold air, may trigger symptoms.

The most serious long term condition caused by nitrogen dioxide exposure is a condition called obliterative bronchiolitis, which is a severe inflammatory condition in which the bronchioles (very small air passages) become severely scarred and the person may become progressively shorter of breath over time. The condition may eventually lead to a fatal outcome.

### **Medical assessment to confirm exposure**

Because NO<sub>2</sub> is a simple compound that acts locally within the lungs, there is no current useful blood test that can determine if a person was exposed. Reliance must be placed on the history (details of what happened), the person's symptoms (what they are experiencing) and signs (what the doctor finds on examination of the affected person). So for NO<sub>x</sub> it's likely to be a story of an orange cloud passing over, followed by eye irritation and coughing. The doctor will notice red eyes that may be watering, the person may cough. Listening to the person's chest may reveal squeaks and crackles which indicate constricted air passages and the presence of excess fluid.

### **Treatment**

The medical treatment of persons exposed to NO<sub>2</sub> is detailed in Appendix H. Essentially this involves treating the symptoms and signs as they arise, but for significantly exposed people, retain them for observation in cases of delayed pulmonary oedema affects, which may develop too rapid for persons at remote distances to reach medical attention. A summary of the physical/chemical properties, health effects and emergency handling procedures are attached at Appendix H.

**Time Weighted Average (TWA):** are expressed as average airborne concentrations averaged over an 8 hour period.

**Short Term Exposure Limit (STEL):** are expressed as airborne concentrations of substances, averaged over a period of 15 minutes. Workers should not be exposed at the STEL concentration continuously for longer than 15 minutes, or for more than four such periods per working day. A minimum of 60 minutes should be allowed between successive exposures at the STEL concentration.

**Immediately dangerous to life and health (IDLH):** is defined as exposure to airborne contaminants that are likely to cause death or immediate or delayed adverse health effects, or prevent escape from such an environment.

\*The IDLH value is not an occupational exposure standard.

With regard to exposure to NO<sub>2</sub> during blasting operations the STEL is the most appropriate exposure standard to apply as the characteristics of the exposures are likely to be infrequent and brief in duration and result. Adverse health outcomes are likely to be due to high intensity exposure with acute effects.

TWA is generally applied to those contaminants that are encountered over the duration of a working shift on a frequent basis (often daily) and result in chronic health outcomes, for example exposure to dust.

### **Typical NO<sub>2</sub> levels recorded from blasting**

Limited monitoring and measurements have been made from blasts at mine sites. The measurements have generally shown that the concentration of NO<sub>2</sub> up to the normal exclusion zone is less than the 5 ppm. The measured values are low and well beneath the threshold to cause both short term and long term harm. The concentrations that cause harm would require a person to be very close to the blast where other hazards are more likely to cause harm, such as projections or overpressures.

NO<sub>2</sub> has previously been recorded and sighted at up to 8km from a blast. This information has been largely anecdotal and not recorded with any scientific accuracy.

### **Environmental exposure to nitrogen dioxide (NO<sub>2</sub>)**

Most people are exposed to oxides of nitrogen by breathing in polluted air. People who live near combustion sources such as coal burning power plants or areas of high motor vehicle usage, or live in households that burn a lot of wood or use kerosene heaters or gas stoves may be exposed to higher levels of nitrogen oxides. Nitrogen dioxide and nitric oxide are also found in tobacco smoke.

# Appendix E–Material Safety Data Sheet–Nitrogen Dioxide

**NITROGEN DIOXIDE**  
**Nitrogen oxide**  
**Nitrogen peroxide**  
**(cylinder)**  
**NO<sub>2</sub>**  
**Molecular mass: 46.01**

**CAS # 10102-44-0**  
**RTECS # QW9800000**  
**ICSC # 0930**  
**UN # 1067**  
**EC # 007-002-00-0**

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/ SYMPTOMS	PREVENTION	FIRST AID/ FIRE FIGHTING
• FIRE	Not combustible but enhances combustion of other substances.	NO contact with combustibles.	In case of fire in the surroundings: all extinguishing agents allowed.
• EXPLOSION			In case of fire: keep cylinder cool by spraying with water.
• EXPOSURE		STRICT HYGIENE!	IN ALL CASES CONSULT A DOCTOR!
• INHALATION	Cough. Dizziness. Headache. Sweating. Laboured breathing. Nausea. Shortness of breath. Sore throat. Vomiting. Weakness. Wheezing. Symptoms may be delayed (see Notes).	Ventilation, local exhaust, or breathing protection.	Fresh air, rest. Half-upright position. Artificial respiration if indicated. Refer for medical attention.
• SKIN	Redness. Pain.	Protective gloves. Protective clothing.	First rinse with plenty of water, then remove contaminated clothes and rinse again. Refer for medical attention.
• EYES	Redness. Pain.	Safety goggles or eye protection in combination with breathing protection.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
• INGESTION	(See Inhalation).	Do not eat, drink, or smoke during work.	Rinse mouth. Refer for medical attention.

SPILLAGE DISPOSAL	STORAGE	PACKAGING & LABELLING
Evacuate danger area! Consult an expert! Ventilation. Do NOT absorb in saw-dust or other combustible absorbents. Remove vapour with fine water spray. Neutralize	Ventilation along the floor.	T+ symbol R: 26-37 S: (1/2-)7/9-26-45



used water with chalk or soda (extra personal protection: complete protective clothing including self-contained breathing apparatus).

UN Hazard Class: 2.3  
UN Subsidiary Risks: 5.1 and 8

**ICSC: 0930**

Prepared in the context of cooperation between the International Programme on Chemical Safety & the Commission of the European Communities © IPCS CEC 1993

I M P O R T A N T  D A T A	<p><b>PHYSICAL STATE; APPEARANCE:</b> REDDISH-BROWN GAS OR YELLOW LIQUID , WITH PUNGENT ODOUR.</p> <p><b>PHYSICAL DANGERS:</b> The gas is heavier than air.</p> <p><b>CHEMICAL DANGERS:</b> The substance is a strong oxidant and reacts violently with combustible and reducing materials. Reacts with water to form nitric acid and nitric oxide. Attacks steel in the presence of moisture.</p> <p><b>OCCUPATIONAL EXPOSURE LIMITS (OELs):</b> TLV (as TWA): 3 ppm; 5.6 mg/m<sup>3</sup>; (as STEL): 5 ppm; 9.4 mg/m<sup>3</sup> (ACGIH 1996).</p>	<p><b>ROUTES OF EXPOSURE:</b> The substance can be absorbed into the body by inhalation and by ingestion.</p> <p><b>INHALATION RISK:</b> A harmful concentration of this gas in the air will be reached very quickly on loss of containment.</p> <p><b>EFFECTS OF SHORT-TERM EXPOSURE:</b> The substance and the vapour irritate the eyes, the skin and the respiratory tract. Inhalation of the gas or the vapour may cause lung oedema (see Notes). Exposure at high level may result in death. The effects may be delayed. Medical observation is indicated.</p> <p><b>EFFECTS OF LONG-TERM OR REPEATED EXPOSURE:</b> The substance may have effects on the immune system and lungs , resulting in decrease in resistance to infection. May cause genetic damage in humans. Animal tests show that this substance possibly causes toxic effects upon human reproduction.</p>
	<p><b>PHYSICAL PROPERTIES</b></p>	<p>Boiling point: 21.2°C Melting point: -9.3°C Relative density (water = 1): 1.45 (liquid)</p> <p>Solubility in water: reaction Vapour pressure, kPa at 20 °C: 96 Relative vapour density (air = 1): 1.58</p>
	<p><b>ENVIRONMENTAL DATA</b></p>	
	<p><b>NOTES</b></p>	

The commercial brown liquid under pressure is an equilibrium mixture of nitrogen dioxide and the colourless nitrogen tetroxide. Non irritant concentration may cause lung oedema. The symptoms of lung oedema often do not become manifest until a few hours have passed and they are aggravated by physical effort. Rest and medical observation are therefore essential. Immediate administration of an appropriate spray, by a doctor or a person authorized by him/her, should be considered. Do NOT take working clothes home. Rinse contaminated clothes (fire hazard) with plenty of water. Turn leaking cylinder with the leak up to prevent escape of gas in liquid state.

Transport Emergency Card: TEC (R)-109  
NFPA Code: H3; F0; R0; OX

## Appendix F – Causes of NOx fume and mitigations (adapted from AEISG data)

Primary Cause 1: Explosive blends and precursors chemical design (pre site delivery)			
Potential Cause	Likely indicators	Control measures	Responsibilities
Chemical formulation of the mixed explosives and/or precursors unknowingly inherently designed to generate fume	<ul style="list-style-type: none"> <li>• NOx fume</li> </ul>	Reformulate explosive to meet User Needs Specification	Explosive supplier Explosives Manufacturer
		Change product to one that meets User needs Specification	Site Procurement Senior Site Executive
Formulation of explosives mixture and/or precursors marginal with regards to sensitivity	<ul style="list-style-type: none"> <li>• Intermittent NOx fume</li> <li>• Inconsistent blast performance</li> </ul>	Reformulate explosive to meet User Needs Specification	Explosive supplier
		Change product to one with more sensitivity	Site Procurement Explosive supplier
Formulation of explosives mixture and/or precursor marginal with regards to chemical stability	<ul style="list-style-type: none"> <li>• Intermittent NOx fume</li> <li>• Inconsistent blast performance</li> </ul>	Reformulate explosive to meet User Needs Specification	Explosive supplier
		Change product which has chemical stability	Site Procurement Explosive supplier
Formulation of explosives mixture and/or precursor insufficiently resistant to conditions it is used in	<ul style="list-style-type: none"> <li>• Intermittent NOx fume</li> <li>• Inconsistent blast performance</li> </ul>	Reformulate explosive to meet User Needs Specification	Explosive supplier
		Change product to one that meets User needs Specification	Site Procurement Explosive supplier
Formulation of explosives mixture and/or precursors not suitable for the prevailing climatic or seasonal conditions	<ul style="list-style-type: none"> <li>• Intermittent NOx fume</li> </ul>	Reformulate explosive with suitable precursors	Explosive supplier
		Change raw materials	
		Change product to one that meets User needs Specification	Site Procurement Blast Designer Senior Site Executive

Primary Cause 2: Explosives and precursors' conformance to specification post formulation and pre use			
Potential Cause	Likely indicators	Control measures	Responsibilities
Precursor delivered to mine site out of specification	<ul style="list-style-type: none"> <li>Intermittent NOx fume</li> <li>Traceable to a precursor which has degraded between manufacture and use</li> <li>Poor blast performance</li> </ul>	Investigate with supplier of explosive precursors	Explosive Supplier Site Procurement Manager
Precursor degradation during transport and storage	<ul style="list-style-type: none"> <li>Frequent NOx fume</li> <li>All blasts and locations utilising explosive product(s) that incorporate a specific raw material</li> <li>Poor blast performance</li> </ul>	Appropriate storage location, conditions and stock rotation management (i.e. First In First out)	Site Procurement Manager Explosive Supplier Magazine Keeper
		Appropriate transport and transfer of precursors	Drill and Blast Superintendent Blast Designer Explosive Supplier MMU Operator
		Inspection and/or testing of precursors prior to use in accordance with manufacturer's recommendations	Drill and Blast Superintendent Explosive Supplier Shotfirer
Raw material changes	<ul style="list-style-type: none"> <li>Frequent NOx fume</li> <li>All areas associated with loading from a specific delivery system</li> <li>Product appearance abnormal</li> </ul>	Change management procedures in place by suppliers	Drill and Blast Superintendent Explosive Supplier Shotfirer
		Prior notification to suppliers from site change management systems where precursors are supplied by sites, for example customer-supplied fuels	Drill and Blast Superintendent Explosive Supplier Shotfirer
Product past use by date	<ul style="list-style-type: none"> <li>Difficulty achieving final density</li> <li>Separation</li> <li>Crystallising</li> <li>Fines</li> <li>Colour variation</li> <li>Poor blast performance</li> </ul>	Testing to ensure the product is within the manufacturers specification <ul style="list-style-type: none"> <li>pH,</li> <li>Density, Viscosity</li> </ul>	Drill and Blast Superintendent Site Procurement Manager Explosive Supplier Magazine Keeper
Failure to conduct quality tests	<ul style="list-style-type: none"> <li>Incomplete documentation</li> </ul>	<ul style="list-style-type: none"> <li>Conduct Safe Task Observations to ensure compliance with procedures.</li> <li>All blast crew to be</li> </ul>	

<b>Primary Cause 2: Explosives and precursors' conformance to specification post formulation and pre use</b>			
<b>Potential Cause</b>	<b>Likely indicators</b>	<b>Control measures</b>	<b>Responsibilities</b>
		trained in the potential consequences of failing to ensure the quality of the product loaded	

<b>Primary Cause 3: Blast design leading to fume events</b>			
<b>Potential Cause</b>	<b>Likely indicators</b>	<b>Control measures</b>	<b>Responsibilities</b>
Explosives – rock mass properties mismatch	<ul style="list-style-type: none"> <li>• Intermittent NOx fume</li> <li>• Unexpected blast results</li> <li>• Flyrock</li> </ul>	Follow manufacturer's recommendations on explosive product application	Drill and Blast Superintendent Shotfirer Explosive Supplier
		Review of the site approved technical design.	Site Senior Executive Production Manager Drill and Blast Superintendent Blast Designer
Explosives product selected not suitable for the prevailing ground conditions (water, rock mass strength, etc.)	<ul style="list-style-type: none"> <li>• Frequent NOx fume</li> <li>• Poor blast performance</li> </ul>	Follow manufacturer's recommendations on explosive product application	Drill and Blast Superintendent Shotfirer Explosive Supplier
		Review of the site approved technical design.	Site Senior Executive Production Manager Drill and Blast Superintendent Blast Designer
Insufficient consideration given to blast dynamics	<ul style="list-style-type: none"> <li>• Intermittent NOx fume</li> <li>• Unexpected blast results</li> <li>• Misfire product</li> </ul>	Follow manufacturer's recommendations on explosive product application	Drill and Blast Superintendent Shotfirer Explosive Supplier
		Review of the site approved technical design.	Site Senior Executive Production Manager Drill and Blast Superintendent Blast Designer
Failure to identify potential causes of fume generation	<ul style="list-style-type: none"> <li>• Inexperienced designers</li> <li>• Inadequate analysis or records for past blasts</li> </ul>	Use of a Pre-Design Checklist	Drill and Blast Superintendent Shotfirer Blast Designer

#### Primary Cause 4: Explosives detonation performance impacted by blast dynamics

Potential Cause	Likely indicators	Control measures	Responsibilities
Inter-hole explosive desensitisation	<ul style="list-style-type: none"> <li>Frequent NOx fume</li> <li>Blast holes drilled too close together</li> <li>Blast hole deviation</li> <li>Inconsistent blast performance</li> </ul>	Change design	Drill and Blast Superintendent Blast Designer
		Product selection	Drill and Blast Superintendent Blast Designer
		Increased control on drilling with deeper designs	Drill and Blast Superintendent Blast Designer Driller
Intra-hole explosive desensitisation in decked blast holes	<ul style="list-style-type: none"> <li>Frequent NOx fume</li> <li>When using decks only</li> <li>Inconsistent blast performance</li> </ul>	Appropriate separation of explosive decks. Initiator timing.	Drill and Blast Superintendent Blast Designer Explosive supplier
Explosive desensitisation due to the blast hole depth	<ul style="list-style-type: none"> <li>Frequent NOx fume</li> <li>Poor blast performance</li> </ul>	Reduce bench height	Site Senior Executive Production Manager Drill and Blast Superintendent Blast Designer
		Ensure adequate relief in deep holes	Drill and Blast Superintendent Blast Designer
		Follow manufacturer's recommendations on explosive product selection and blast design for deep holes, for example decking where appropriate.	Drill and Blast Superintendent Blast Designer Explosive Supplier
Inappropriate priming and/or placement	<ul style="list-style-type: none"> <li>Intermittent NOx fume</li> <li>Residue product</li> <li>Inconsistent blast performance</li> </ul>	Follow manufacturer's recommendations on explosive product initiation.	Drill and Blast Superintendent Shotfirer Explosive Supplier
		Review of the site approved technical design.	Site Senior Executive Production Manager Drill and Blast Superintendent Blast Designer
Initiation of significant explosive quantities in a single blast event	<ul style="list-style-type: none"> <li>Intensity of post-blast fume proportional to explosives quantity used</li> </ul>	Reduce blast size in order to reduce total explosive quantity being initiated in the one blast event	Site Senior Executive Production Manager Drill and Blast Superintendent Blast Designer
		Reduce powder factor	Drill and Blast Superintendent Blast Designer

#### Primary Cause 4: Explosives detonation performance impacted by blast dynamics

Potential Cause	Likely indicators	Control measures	Responsibilities
Desensitisation of explosive column from in-hole detonating cord initiation	<ul style="list-style-type: none"> <li>Frequent NOx fume</li> <li>Only in areas where in-hole cord initiation is used</li> <li>Inconsistent blast performance</li> </ul>	Follow manufacturer's recommendations on compatibility of initiating systems with explosives	Drill and Blast Superintendent Blast Designer
Primer of insufficient strength to initiate explosive column	<ul style="list-style-type: none"> <li>Frequent NOx fume</li> <li>All blasts using a particular primer type / size</li> <li>Poor blast performance</li> </ul>	Follow manufacturer's recommendations on compatibility of initiating systems with explosives	Drill and Blast Superintendent Blast Designer

#### Primary Cause 5: On-bench/site practices

Potential Cause	Likely indicators	Control measures	Responsibilities
Use of out of specification manufactured bulk explosives	<ul style="list-style-type: none"> <li>Intermittent NOx fume</li> <li>No column rise</li> <li>Stock take of raw materials use out of line with manufacturing requirements</li> <li>No MPU calibration records</li> <li>No QC records on pumpable explosive</li> <li>Poor blast performance</li> </ul>	Review quality process controls during the loading and through post blast audits	Drill and Blast Superintendent Blast Designer Explosive Supplier MMU Operator
Inadequate mixing of raw materials	<ul style="list-style-type: none"> <li>Frequent NOx fume in all areas associated with loading from a specific delivery system</li> <li>Product appearance abnormal</li> </ul>	Visual check	Shotfirer Bench Assistant MMU Operator
		Density check	MMU Operator
Delivery system metering incorrectly (on bench incorrect manufacture of product)	<ul style="list-style-type: none"> <li>Increased frequency of NOx</li> <li>All blasts and all locations utilising</li> </ul>	Regular calibration of metering systems	MMU Operator Equipment owner

### Primary Cause 5: On-bench/site practices

Potential Cause	Likely indicators	Control measures	Responsibilities
	explosive product(s) that incorporate a specific precursor <ul style="list-style-type: none"> <li>Inconsistent blast performance</li> </ul>	Quality control of explosive products conducted in accordance with manufacturer's recommendations	Explosive Supplier MMU Operator
Delivery system settings for explosive product delivery overridden		Do not override calibration settings on manufacturing systems	Drill and Blast Superintendent Equipment Owner MMU Operator
Explosive product incorrectly loaded into blast hole	<ul style="list-style-type: none"> <li>Intermittent NOx fume</li> <li>Poor blast performance</li> </ul>	All blast crew to be trained in the correct method of delivery of all products	Shotfirer Bench Assistant MMU Operator
Incorrect product used wet/dry	<ul style="list-style-type: none"> <li>Intermittent NOx fume</li> <li>Poor blast performance</li> <li>Misfires</li> </ul>	All blast crew to be trained in the potential consequences of incorrect product usage	Shotfirer Bench Assistant MMU Operator
MMU operator not yet competent	<ul style="list-style-type: none"> <li>Intermittent NOx fume</li> <li>Misfires</li> <li>Inconsistent blast performance</li> </ul>	<ul style="list-style-type: none"> <li>Unsure only competent personnel operate MPU's unsupervised</li> <li>Conduct Safe Task Observations to ensure compliance with procedures</li> </ul>	Drill and Blast Superintendent Equipment Owner MMU Operator
Excess product loaded	<ul style="list-style-type: none"> <li>Intermittent NOx fume</li> </ul>	All blast crew to be trained in the potential consequences of failing to ensure the correct quantity of product is loaded	Drill and Blast Superintendent MMU Operator
Rainfall on a sleeping shot.	<ul style="list-style-type: none"> <li>Slumping of holes</li> <li>Poor blast performance</li> </ul>	Review rainfall forecasts for planned sleep time of shot and select explosive products according to manufacturer's recommendations.	Production Manager Drill and Blast Superintendent Blast Designer Shotfirer Explosive Supplier
		Minimise sleep time for dry blast hole explosive products if rain is predicted. Consider early firing of blast.	Production Manager Drill and Blast Superintendent Shotfirer

### Primary Cause 5: On-bench/site practices

Potential Cause	Likely indicators	Control measures	Responsibilities
		Bench design for water runoff	Drill and Blast Superintendent Blast Designer Production Manager
		Seal top of blast holes to prevent water ingress e.g. with gas bag	Drill and Blast Superintendent Blast Designer Shotfirer
		Consider removing water affected product	Production Manager Drill and Blast Superintendent Blast Designer Shotfirer Explosive Supplier
Explosive product seeping into cracks	<ul style="list-style-type: none"> <li>Slumping</li> <li>Intermittent NOx fume</li> <li>In specific areas known to contain a high incidence of faulted/fractured ground only</li> <li>Unexpected blast performance</li> </ul>	Follow manufacturer's recommendations on explosive product selection	Drill and Blast Superintendent Shotfirer MMU Operator
	Hole loading larger than planned	Use blast hole liners	Drill and Blast Superintendent Blast Designer Shotfirer Geologist
		Maintenance of accurate drill records which are used to map geological conditions	Driller Drill and Blast Superintendent Geologist Blast Designer
		Record and monitor blast holes which have slumped or require excessive explosive product to reach stemming height, but where water is not present	Shotfirer MMU Operator Bench Assistant
Dynamic water in holes	<ul style="list-style-type: none"> <li>Intermittent NOx fume</li> <li>Slumped blast holes</li> <li>Usually when using non water-resistant explosive products</li> </ul>	Minimise sleep time of shot	Production Manager Drill and Blast Superintendent Blast Designer Shotfirer



### Primary Cause 5: On-bench/site practices

Potential Cause	Likely indicators	Control measures	Responsibilities
	<ul style="list-style-type: none"> <li>Poor blast performance</li> </ul>	Follow manufacturer's recommendations on explosive product selection	Drill and Blast Superintendent Blast Designer Shotfirer
		Measure recharge rates if dewatering, and choose explosive products according to manufacturer's recommendations	Drill and Blast Superintendent Blast Designer Shotfirer MMU Operator Bench Assistant / Dewaterer Operator
		Record slumped holes and use this information to build understanding of pit hydrology	Blast Designer Shotfirer MMU Operator Bench Assistant / Dewaterer Operator
		Understand hydrology of pit and plan blasting to avoid interaction between explosives and dynamic water (either natural or from other pit operations)	Drill and Blast Superintendent Blast Designer Shotfirer Geologist
		Use hole liners	Drill and Blast Superintendent Blast Designer Shotfirer Geologist
Moisture in clay	<ul style="list-style-type: none"> <li>Frequent NOx fume</li> <li>In clay strata only</li> </ul>	Consider water resistant explosive products and how this may impact sleep time.	Drill and Blast Superintendent Blast Designer Shotfirer Geologist
		Hole liners may be required for ANFO.	Drill and Blast Superintendent Blast Designer Shotfirer Geologist
Blast hole deterioration between drilling and loading	<ul style="list-style-type: none"> <li>Intermittent NOx fume</li> <li>Traceable to specific geological areas</li> <li>Inconsistent column rise while loading</li> </ul>	Minimise time between drilling and loading	Drill and Blast Superintendent Blast Designer
		Use blast hole cameras to ascertain hole condition in critical	Explosive Supplier Geologist

### Primary Cause 5: On-bench/site practices

Potential Cause	Likely indicators	Control measures	Responsibilities
		areas	
		Use hole savers	Drill and Blast Superintendent Blast Designer Shotfirer Geologist
		Mine planning to ensure benches are unaffected by backbreak from earlier blasts, for example presplits, buffers etc.	Production Manager Drill and Blast Superintendent Blast Designer
		Optimise drilling practices to minimise hole damage though rock cracking etc.	Drill and Blast Superintendent Driller

### Primary Cause 5: On-bench/site practices

Potential Cause	Likely indicators	Control measures	Responsibilities
Contamination of explosives (bottom of hole, stemming section, etc.)	<ul style="list-style-type: none"> <li>Intermittent NOx fume</li> <li>Blasts containing wet/dewatered blast holes only</li> <li>Dynamic water</li> </ul>	Load wet blast holes first and dip remaining holes prior to loading. Adjust explosive product selection according to manufacturer's recommendations.	Drill and Blast Superintendent Blast Designer Shotfirer Bench Assistant
		Eliminate top loading into wet blast holes	Shotfirer Bench Assistant
		Ensure all primers are positioned in undiluted explosive product	Shotfirer Bench Assistant
		Use of gas bags in dewatered blast holes	Drill and Blast Superintendent Blast Designer Shotfirer Bench Assistant
		Seal top of explosives column to prevent water ingress	Drill and Blast Superintendent Blast Designer Shotfirer Bench Assistant
		Use hole liners	Drill and Blast Superintendent Blast Designer Shotfirer Bench Assistant
		Reduce excessive hose lubrication during charging	Operator Bench Assistant
		Measure water recharge rate after dewatering.	Shotfirer Bench Assistant
		Adjust explosive product selection according to manufacturer's recommendations for wet environment.	Drill and Blast Superintendent Blast Designer Shotfirer Bench Assistant MMU Operator
		Decking to eliminate contact with known dynamic water	Drill and Blast Superintendent Blast Designer Shotfirer Bench Assistant
		Select explosive products for wet blast holes according to manufacturer's	Drill and Blast Superintendent Explosive Supplier Blast Designer

### Primary Cause 5: On-bench/site practices

Potential Cause	Likely indicators	Control measures	Responsibilities
		recommendations.	Senior Site Executive
		Verify correct hose handling practices are in place	Shotfirer MMU Operator Bench Assistant Explosives Supplier
		Load low blast holes last where practical	Shotfirer Bench Assistant
		Use suitable, safe dewatering techniques	Shotfirer Bench Assistant
		Minimize sleep time	Production Manager Drill and Blast Superintendent Blast Designer Shotfirer

### Primary Cause 6: Blasting Personnel (Technical and Operational)

Potential Cause	Likely indicators	Control measures	Responsibilities
Blasting personnel (Technical and Operational)	NOx Fume while primary causes 1, 2, 3, 4 and 5 have been ruled out as possible contributing factors	As below	
Lack of an understanding of the possible causes, and prevention techniques, of fume amongst blasting personnel (shotfirers, MMU operators, blast designers)	<ul style="list-style-type: none"> <li>Frequent NOx fume</li> </ul>	All blasting personnel to be trained in the potential consequences of incorrect product usage	Drill and Blast Superintendent Blast Designer Shotfirer MMU Operator
Blasting personnel not consistent in defining dry and wet bench conditions	<ul style="list-style-type: none"> <li>Frequent NOx fume</li> </ul>	All blasting personnel to be trained in the potential consequences of incorrect product usage	Drill and Blast Superintendent Blast Designer Shotfirer MMU Operator
Blasting personnel not following site SOPs	NOx Fume		

# Appendix G – Pre firing Review

## (Fume specific requirement)

Prior to the firing of any blast a review must be conducted to determine if there are likely to be adverse fume effects as a result of deviations from the blast plan and other issues encountered during the preparation and loading of the shot. A blaster has to account for a number of hazards such as flyrock, overpressure, and ground shock and must also include fumes such as oxides of nitrogen and carbon monoxide. This section relates to fume especially NOx.

This review is conducted just prior to the firing of the blast. It assumes that persons involved in the loading activity have kept accurate and effective records to assist in this pre firing review. The person who conducted the loading needs to be present to speak about problems encountered and records made in relation to those issues so that a reasonable deduction can be made on the likelihood of fume occurring.

These factors must be considered and recorded and mitigations planned where appropriate prior to a shot being undertaken.

- presence of ground water in the holes
- moist borehole sides
- dynamic water (was the water in motion/flowing?)
- excessive sleep time for the product concerned (if a dry product has any exposure to water it will likely fume)
- rock and ground type, including stemming material that gives the explosives poor confinement
- blast design potential for inadvertent dynamic desensitization of surrounding holes
- potential that product has been damaged by water
- loading took place in wet conditions
- poor drainage on the bench exposing product to water.
- substituted product unable to manage water conditions or hole conditions
- product specification and calibration issues on the MMU
- product top loaded from auger into wet hole
- blast design not followed insufficient use of gas bags, primers, decks etc.
- MMU gross ingredient usage check indicates an imbalance in the manufacture process e.g. under fuelled.
- Record the blast design deviations.

Identify potential level of fume

Review of weather conditions

Pre firing outcome should not be used to replace the Blast Fume Management Plan.

- BEZ – Blast Exclusion Zone
- FMZ – Fume Management Zone
  - Location of monitor
  - Evacuations

## Appendix H – Information for treating medical staff

This is a sample of the information that should be provided to a treating doctor. Organisation should ensure that regular meetings are held with the local medical doctors that would be treating their personnel for exposures to oxides of nitrogen and other typical injuries or exposures that could be expected from their employees.

### INFORMATION FOR TREATING DOCTOR

Dear Doctor

This patient has been exposed to NO<sub>x</sub>. This is a gas usually produced on mines after the use of explosives. NO<sub>x</sub> consists of multiple combinations of nitrogen and oxygen (N<sub>2</sub>O, NO, NO<sub>2</sub>, N<sub>2</sub>O<sub>4</sub>, N<sub>2</sub>O<sub>3</sub>, N<sub>2</sub>O<sub>5</sub>). Nitrogen Dioxide (NO<sub>2</sub>) is the principal hazardous nitrous fume.

NO<sub>x</sub> irritates the eyes and mucous membranes primarily by dissolving on contact with moisture and forming a mixture of nitric and nitrous acids. But this is not the only way injury can occur.

Inhalation results in both respiratory tract irritation and pulmonary oedema. High-level exposure can cause methhaemoglobinaemia. Some people, particularly asthmatics, can experience significant broncospasm at very low concentrations.

The following effects are commonly encountered after NO<sub>x</sub> exposure:

#### ACUTE

- cough
- shortness of breath
- irritations of the mucous membranes of the eyes, nose and throat

#### SHORT TERM

- pulmonary oedema, **which may be delayed from 4 to 12 hours**

#### MEDIUM TERM

- RADS (Reactive Airways Dysfunction Syndrome)
- in rare cases, bronchiolitis obliterans, which may take from two to six weeks to appear

#### LONG TERM

- chronic respiratory insufficiency

High-level exposure, particularly associated with methhaemoglobinaemia, can cause chest pain, cyanosis and shortness of breath, tachypnoea and tachycardia. Deaths have been reported after exposure and are usually delayed. Even non-irritant concentrations of NO<sub>x</sub> may cause pulmonary oedema. Symptoms of pulmonary oedema often show until a few hours after exposure and are aggravated by physical effort.

Before transfer to you, the patient should have been advised to rest and, if any respiratory symptoms were present, should have been administered oxygen.

The patient will need to be treated symptomatically, but as a base line it is suggested that the following may be required:







- spirometry
- chest x-ray
- methhaemoglobin estimation.

Because of the risk of delayed onset pulmonary oedema, it is recommended that as a precaution the patient be observed for up to 12 hours. As no specific antidote for NO<sub>x</sub> exists, symptoms will have to be treated on their merits.

Information provided by Dr Vern Madden, Health Advantage Toowoomba

## Appendix I – NOx Rating Scale

The following table together with the Field Colour Chart on the next page details how NOx fumes from a surface blast can be assessed. (Provided by AEISG)

Level	Typical Appearance
<p>Level 0</p> <p>No fume</p>	
<p>Level 1</p> <p>Fume</p>	
<p>Level 2</p> <p>Minor yellow/orange fume</p>	
<p>Level 3</p> <p>Moderate orange fume</p>	
<p>Level 4</p> <p>Significant orange fume</p>	
<p>Level 5</p> <p>Major red/purple fume</p>	

## Field Colour Chart

Assessing the amount of NO<sub>x</sub> produced from a blast will depend on the distance the observer is from the blast and the prevailing weather conditions. The Field Colour Chart can be used to assess the level of NO<sub>x</sub> that is produced in a surface blast.

Pantone colour numbers have been included in the Field Colour Chart to ensure colours will always be produced correctly thereby ensuring a reasonable level of standardisation in reporting fume events across the mining industry.

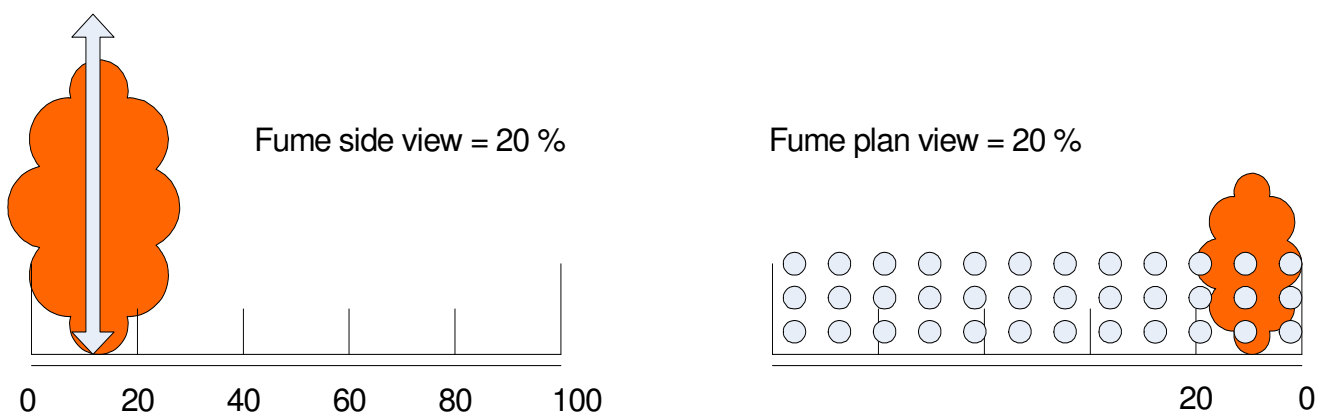
Level	Colour	Pantone Number
Level 0 No Fume		Warm Grey 1C (RGB 244, 222, 217)
Level 1 Fume		Pantone 155C (RGB 244, 219, 170)
Level 2 Minor yellow/orange fume		Pantone 157C (RGB 237, 160, 79)
Level 3 Moderate orange fume		Pantone 158C (RGB 232, 117, 17)
Level 4 Significant orange fume		Pantone 1525C (RGB 181, 84, 0)
Level 5 Major red/purple fume		Pantone 161C (RGB 99, 58, 17)

## Observation Issues

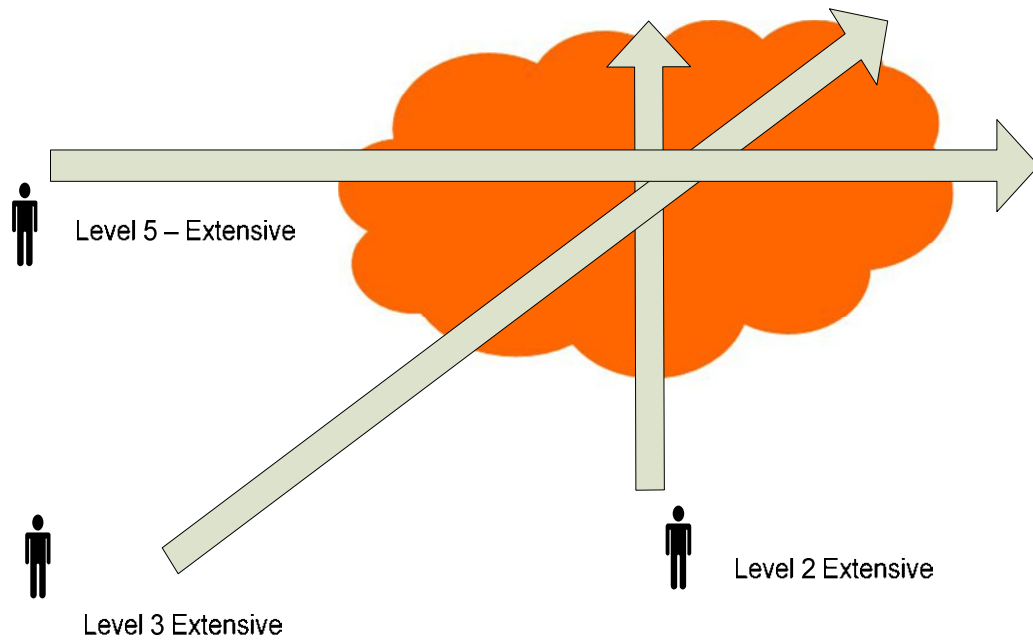
The category should be determined when the fume cloud is at its greatest concentration.

The angle of the person to the fume event will influence the assessment. Where possible and without placing persons in the path of a fume cloud there should be a number of observers to record the level. This can be moderated to give a more accurate indication of the cloud.

The issue is that the observer position and fume cloud orientation may influence the rating given.







- Assessment can also be affected by light conditions as this will vary appearance of fume cloud
- Significant temperature variations can also affect fume cloud colour.

## EFFECT OF ANGLE TO FUME CLOUD AFFECTING ASSESSMENT

# **Appendix J – Guideline to investigating fume events**

## **Investigation of Fume Events**

The thorough investigation of a fume event is essential to:

- Prevent further instances of fumes being generated.
- Ensure fume events and potential fume events are managed to ensure exposures do not occur.
- Ensure persons exposed to fumes are treated promptly and effectively.
- Determine and understand the potential causes of fume.

The investigation must be thorough to ensure that the variables for the prevention of fumes are well understood for that blast, that the management of the fume event can be examined for effectiveness and that any exposures from the event are treated appropriately.

The investigation of a fume event may be undertaken by the following:

- Mine Operator (as part of mine SMS or a statutory direction from the regulator)
- Mines Inspectorate (Consider role of District Workers Representative)
- Explosives Inspectorate
- Explosives company whose explosives were used in the blast
- Blasting contractor (may be an Explosives company that was conducting the blast for the mine)
- A combination of the above

## **Composition of Investigation Team**

This will be determined by the Manager appointing a lead investigator and team members. Persons appointed to an investigating team should have appropriate experience, knowledge of the operation and training to undertake the investigation. A term of reference should be given to the lead investigator.

## **Guides to Investigation**

1. There are many investigation processes that can be used. The Incident Cause Analysis Method (ICAM) is an appropriate method to use for investigations. Investigation points directly relevant to Fume Events
2. The following points are directly applicable to fume event investigations:
  - a) Data collection
  - b) Analysis of data

## **Data associated with Fume Event**

- Blast Job Pack
- Drilling Records
- Environmental monitoring records prior to and at the time of the blast (wind speed, direction, humidity, etc)

## **Geology of Site**

- Drill log and reports confirm expected geological conditions
- Identify how to use geological data with explosive product selection and design layout

## **Blast Job Pack – The information available here is:**

- Blast plan as designed

- Blast plan as fired
- Timing for blast
- Initiation of sequence (Tie Up)
- Type of initiation method – electrical or detonating cord
- Presence of free faces
- Size of blast holes, collapsed holes
- Inter hole distance
- Hole loadings
- Stemming typed and depth
- Use of air bags
- Decking
- Hole Depth
- Variable to be monitored e.g. VOD, NO<sub>2</sub>, met conditions, recharge rates, H<sub>2</sub>O, etc.

### **Selection of explosives**

- Initiating system
- Detonators
- Boosters and number of boosters per hole
- Main charge including variations e.g. Emulsion, Heavy ANFO.
- Certificates for EP
- Density and other quality checks performed during the loading process
- Reason for decision on type of explosives to be used
- Method/procedure applied to determine appropriate explosives(shows transparency in decision process)

### **Concept Design Review**

This is a review of the proposed blast design involving the relevant team members who will do the blast activities.

- Who was involved
- Identified issues
- Proposed mitigations and controls for issues
- Review of previous blast data
- Responsibility and accountability of firing blast activity members
  - Operations
  - Blast Designer
  - Blast Controller / Preparation Leader
  - Shotfirer Supervisor
  - Drill and Blast Supervisor
  - Team Members

### **Loading information**

- Shotfirers dip sheet / standing water / wet sides.
- Drill Plan and drill reports.
- Hole loadings kg.

### **Procedures for Blasting**

- Mine
- Explosives supplier
- Blasting contractor
- Variations from procedures (good to bad) work around etc.

### **Explosives**

- Raw materials
- Quality – fumes or crystallisation

- Age of product

### **Equipment MMU**

- Adequate vehicles available for task
- Manufacture explosives vehicles
- Calibration by Truck ID
- Density of explosives checks
- Pump ability
- Is this truck an issue in involvement of fume events?
- Temperature of product
- Verification % of product to confirm ingredients mass balance
- % fuel
- Changes to truck settings

### **Dewater trucks**

- Adequate to meet task requirements
- Effective dewater
- Recharge rates
- Actual checks of holes

### **Training**

- Were persons competent?
- Were the competencies trained adequate for task?
- Experience and mentoring of new staff
- Understanding of how each member can reduce fume.
- Previous Involvement in other fume events
- How were the persons appointed to the job
- Supervision

### **Video of Blast**

- Examine
- Orientation of camera (N, S, E or W)
- Source of fume – consistent/inconsistent above shot % of shot covered by fume
- Time to form cloud, time to disperse to 'safe' level
- Direction of cloud
- Relate to blast plan as fired

### **Monitoring Equipment**

- Where placed – distance and orientation (base on expected met conditions)
- Readings PPM
- Type of equipment used
- Calibration records of monitoring equipment
- Video
- Smell and visual appearance

### **Meteorological Conditions**

- For loading period if rain – hole protectors – product selection
- For firing period
- After fume event
- wind speed and direction
- cloud cover
- time of day
- terrain
- rain occurring

- humidity

### **Pre Firing Review**

- Variations from drill and blast plan
- Variations in loading
- Materials used match the plan
- Calibration issues during load
- Raw material problems

### **Post Firing Review**

- Video
- Level of fume
- Incident report if required (Did the fume go outside the exclusion zone?)
- record and submit blast data to [fumesurvey@deedi.qld.gov.au](mailto:fumesurvey@deedi.qld.gov.au)
- identify what went well or not so well

### **Statement / Interview Personnel, witnesses and exposed persons**

- Story of the shot from all persons involved - separately
- Changed circumstances
- Variation from design
- Variation from product use
- Weather
- Unexpected water
- Equipment problems
- Procedural variations

### **Terms of Reference**

It is paramount to issue terms of reference to the person who is to lead the investigation. The terms of reference should be issued by the senior management team to all relevant persons within the organisation are made aware that a thorough investigation of the event is underway and that all employees are to fully co-operate with the lead investigator.

The team to investigate the fume incident should have appropriate knowledge in the operation of blasting and be competent in investigating an incident.

The terms of reference are to ensure that all applicable matters are covered in the investigation. It should also indicate that the investigator is to follow up on any pertinent matters that were not acknowledged in the terms of reference, but are issues that could have contributed to the fume event. Following is an example that may be used by a Mine Site or the Regulator to investigate a fume incident.

### **Sample: Terms of Reference.....**

#### **Investigation terms of reference for Fume Incident at Longbeach**

##### **Describe the incident and include the following:**

- Time/date and place at which the incident occurred
- Report of Injury or property damage
- Explosive type by brand name and composition
- Equipment involved

The licence and authority holder who manufactured the explosives involved. They must be described as they appear in the licence holder record.

**Sample:**

*The excessive post blast generation of oxides of nitrogen at ABC mine occurring at Longbeach on the 4 Sept 2010.*

*Slate Resources operate the Chandlers open cut coal mine at Longreach. Slate resources have site appointed shotfirers supported by a downhole service supplied by ABC Explosives. At 4.30pm on Sunday the 4<sup>th</sup> of January 2010 an overburden shot was fired. The shot generated a fume event that was rated extreme on 5 out of 5 on the ABC explosives fume scale. The fume cloud travelled 3 kilometres to the west of the site and entered the mine workshop area.*

*Nine workers from the workshop presented at the Longbeach base hospital reporting exposure to the fume cloud. Five persons were detained overnight at the hospital for observation.*

*A report provided to inspector of explosives XXX by the Slate resources Blast supervisor indicates that the operator had loaded the shot with a mixture of ANFO and HANFO. The ANFO and HANFO were manufactured on site by ABC Explosives. ABC Explosives have an MMU Licence to manufacture class one ammonium nitrate based explosives. ABC Explosives Pty Ltd had licensed the mobile manufacturing unit within Queensland under authority 100000.*

*The investigation is continuing to compose findings in relation to the incident to reveal conclusions from their findings.*

*Recommendations are to be made that would assist in preventing a recurrence of fume, manage a fume event and ensure appropriate treatment of exposed persons.*

*Without limiting the scope of your investigation, the following particulars should be established.*

***Consider the facts, sought after by the authority holder. Examine activities realistically occurring under legislation, codes, safety management system and operational procedures. See below for example:***

- *The specific facts and timeline surrounding the incident.*
- *Specific facts' relating to the ABC Explosives as it applies to the activity undertaken.*
- *What systems procedures were applied or absent in relation to this incident as detailed in schedule 3 part 1 of the Explosives Regulations 2003.*
- *What operational procedures were applied or absent in relation to this incident as detailed in schedule 3 part 2 of the Explosives Regulations 2003.*
- *If the authority holder has taken reasonable precautions and used reasonable care to avoid endangering any person's safety, health or property.*
- *Has the authority holder given effect to their safety management system as it applies to this incident?*
- *Interview of persons involved in shot from concept to clearance*
  - *Story of the shot*
  - *Changes to shot*
  - *Improvement opportunities*
  - *Site SOP's*
    - *Primarily loading and coping with change*
  - *Decking*

- *Production pressure*
- *Weather*
  - *Wind, speed and direction*
- *Training*
  - *Currency, relevance and competency in the field*
- *Examination and retention of documents and/or records including*
  - *The concept or pre blast review*
  - *Blast design*
  - *The job hazard/risk assessment*
  - *Drill plans*
  - *Drill logs*
  - *Dip Logs*
  - *Timing plans*
  - *Load plan*
  - *Tie in plans*
  - *Documents showing changes to plans*
  - *Other documents in the blast pack*
  - *MMU calibration records*
  - *MMU quality control records*
  - *Video of shot*
  - *Training records for the shotfirer, MPU operator and bench hands*
  - *Magazine records for class 1 explosives*
  - *Records for class 5.1 explosive precursors*
  - *Records for diesel and effect chemicals used in the manufacture of explosives*
- *An examination of the raw product used to manufacture and fire the explosive including*
  - *For initiating explosives – 1.1B detonators*
    - *The planned number of detonators for the shot, the actual number used, type and batch number, dates of manufacture and expiry.*
  - *For high explosives – 1.1D including boosters and detonating cord*
    - *The planned number of explosive items for the shot, the actual number used, type and batch number, dates of manufacture and expiry.*
  - *For prilled ammonium nitrate of UN1942*
    - *Certificates of compliance, date of manufacture and expiry, density, absorbcency and fines*
  - *For ammonium nitrate emulsions and water gels of UN3375*
    - *Manufacturers specifications, appropriateness for task, date of manufacture and expiry, density, temperature, viscosity, PH and QC records*
  - *Fuel oil*
    - *Specifications, storage location, temperature*
- *History on the site from a previous similar shot*
  - *Archived blast packs*
- *The mobile manufacturing unit*
  - *Calibration settings and records*
  - *Density of manufactured product*
  - *Start up records and defects*
  - *Temperatures*
  - *Load record*
  - *Is there sufficient support for the rate of loading*
    - *Dewaterers before the load front*
    - *MMU's to load the pattern in the time frame*

- *MMU's to accommodate servicing requirements*

A preliminary report is required by the **8<sup>th</sup> October 2010**

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The following pages include a template to indicate the key headings that can be used for a fume report to ensure it deals adequately with all aspects of an incident investigation. It has been based on the requirements of this QGN and review of actual investigations conducted by the regulator, explosives companies and mining companies. The template can be used and adapted by persons investigating fume events. The detailed data may be attached to the investigation report as appendices.



# Fume Investigation



# **Fume Investigation**

## **Contents**

**Executive summary**

***1. Introduction and Background***

***2. Findings***

***3. Conclusions***

***4. Recommendations***

## ***1. Responsibility and accountability***

- ❖ Blast Designer
  -
- ❖ Shotfirer
  -
- ❖ Driller
  -
- ❖ Blast Controller
  -
- ❖ Shotfirer Supervisor
  -
- ❖ Drill and Blast Supervisor
  -
- ❖ Team members
  - 
  - 
  -

## ***2. Blast location***

- ❖ Description
  - 
  - 
  - 
  -
- ❖ History of blasts from site location
- ❖
- ❖

## ***3. Geology***

Material Type	Density	UCS (MPa)	Youngs Modulus MPa (usually GPa)	Poissons ratio	Tensile strength (MPa)

## ***4. Moisture content before and after blast***

- ❖ Presence of water
  -

## 5. Blast design

*Summary Table*

Shot number	
Shot type	
Hole diameter	
Hole depth	
Stemming	
Burden and spacing	
Drill angles	
Total volume	
Number of holes	
Explosives used	
Design Quantities	
Emulsion	
Stemming	
Initiation	
Timing	
Priming	
Primer location	
Water	

## 6. Blast plan



## 7. Hole depth measurements



## 8. Charging plan



- Actuals



## 9. Timing plan



## 10. Stemming Type



## 11. Dewatering

- Which holes
- Gas bags

- Recharge rates
- Redipped

## ***12. Blast charging***

Charging problems	
Charging accuracy	
Final stemming height	
Dip sheets	
Load sheets	
Air bag use verses Planned	

## ***13. Procedures***

- Blast
- Variations
- JSRA
- Priming position

## ***14. Blast monitoring***

Video	Number
Log	
Records from blast guards	
Observations	
Personal monitors	
Field monitors	

## ***15. Quality control***

- Emulsion and AN certificates
- AN bulk density
- EP temperature
- MMU Calibration
- Product density
- Raw material fumes or crystallisation

- Fuel Specification
- Charges to MMU settings
- Issues with deliveries
- Storage period

## ***16. Training***

- MMU
- Shotfirers
- Blast Designer

## ***17. Weather***

Wind direction and speed	
Cloud cover and height	
Signs of inversion	
Temperature	
Rain / storms in the area	
Fume modelling	
Weather observations (before/during/after)	
Firing	

## ***18. Fume risk management plan***

### **Discussion**

Water attack on AN

Groundwater level

Fume generation mechanism

### **Initiation design**

Explosives selection

QA checks

Procedures

## **19. Personal statements**

## **20. Photos and videos of blast**

## **21. Extracts**

## Appendix K – Bow tie risk diagram for fume

The bow tie technique has been used to examine the fume event. The diagram assists in identifying and recording hazards, the cause of the hazard as well as the consequences. It also shows the barriers that have been developed for the hazard and the consequence and demonstrates if they are effective. The colour coding of causes, consequences and barriers provides a visual aid to determine if there are sufficient barriers in place.


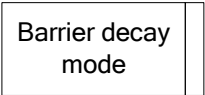
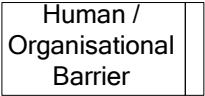
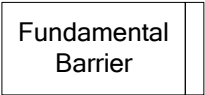

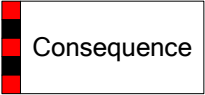

The bow tie diagram has been developed based around the six identified causes from this QGN. This is regarded as an ongoing document and persons who have any comments or improvement suggestions for the bow tie diagram should forward them to [fumesurvey@deedi.qld.gov.au](mailto:fumesurvey@deedi.qld.gov.au).

Note this Bowtie is currently being developed to improve the identification of process to improve the management of the consequences of a fume event.

**Six primary causes** of fume are listed below. Colour reference codes are also beneath capturing structured definition levels for easy reference to the bow tie diagrams.

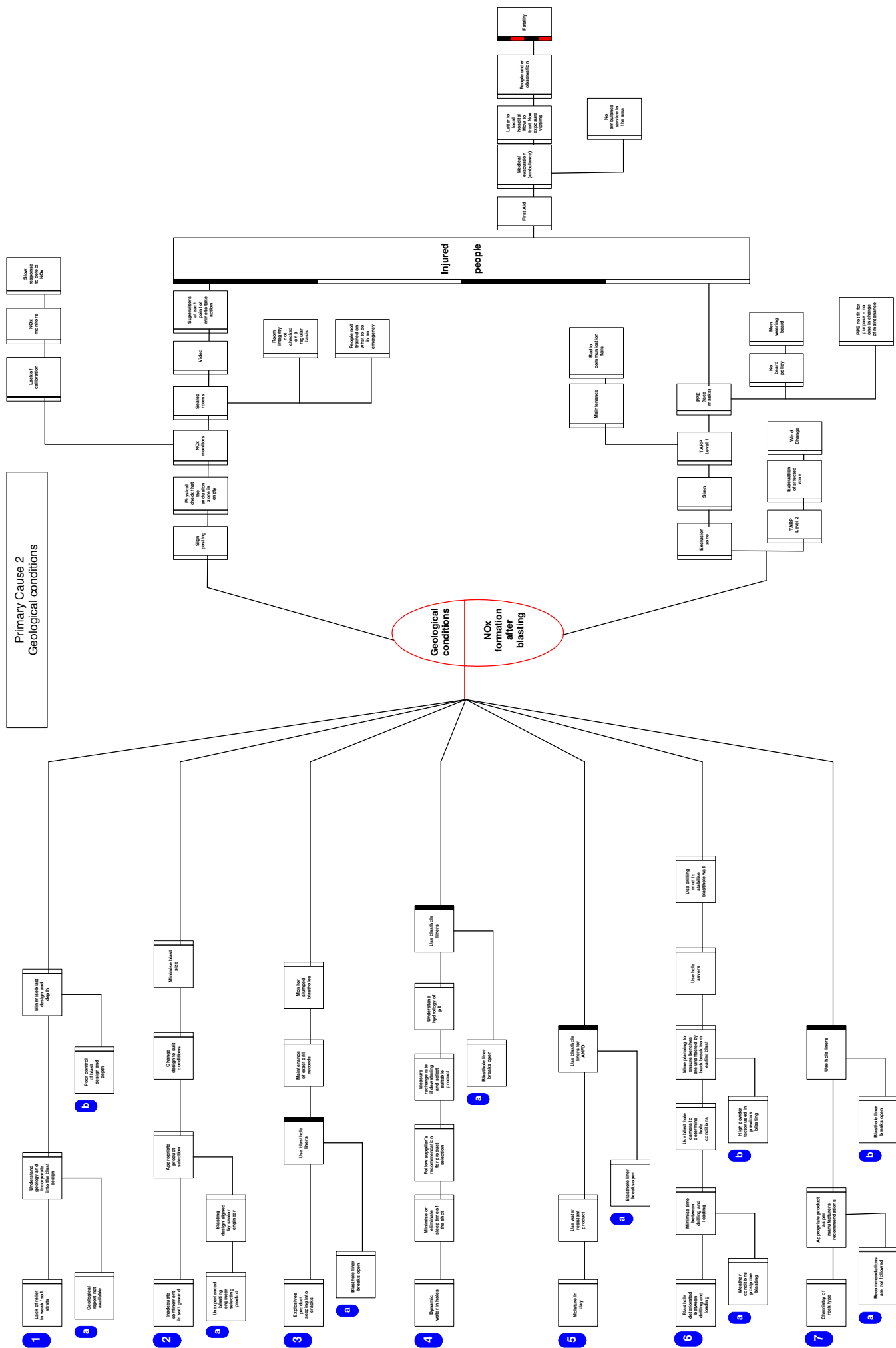
1. Poor explosive formulation and quality assurance
2. Geological conditions
3. Blast design
4. Incorrect explosive product selection
5. On bench practices
6. Contamination explosive in blast hole

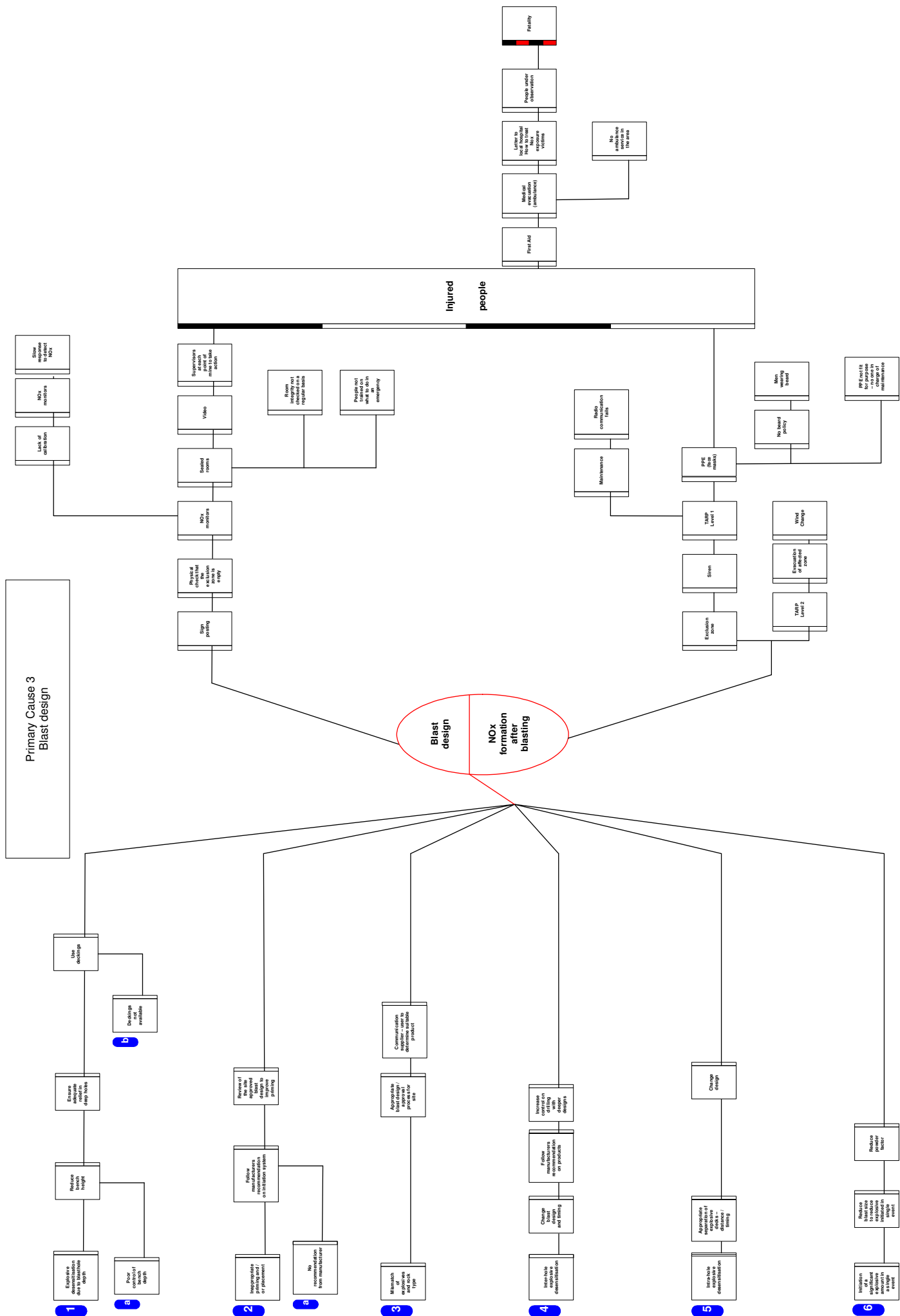
### Symbols

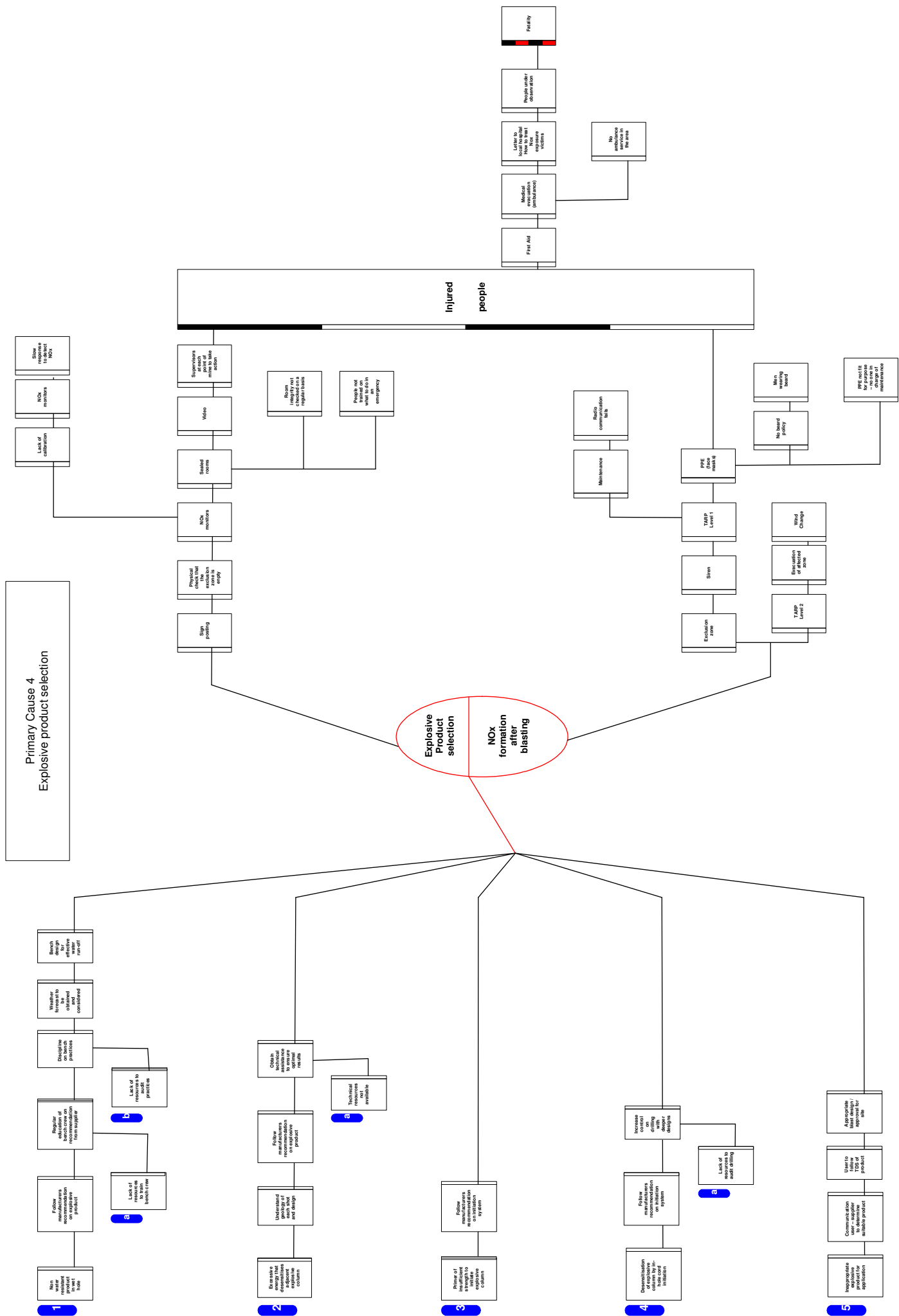
	Threat	Means by which a hazard can be realised. Explosives is a hazard, and handling them is a threat. Handling has the potential to release the hazard.
	Barrier decay mode	Departure of the barrier function from the design intent. Road in good conditions is a technical barrier to prevent trucks from rolling over. A decay mode is a poor maintenance of the road.
	Human / Organisational Barrier	Barriers - Obstacle that prevent, control, mitigate or protect from accidents or undesired events. An example of human / organisational barrier: procedure to check palletising of loads 100% of the time.
	Fundamental Barrier	An example of fundamental barrier: safety culture, design review of plants every 5 years.
	Technical Barrier	An example of technical barrier: a smoke detection alarm.
	Consequence	Results that follow the realisation of the hazard or degree of harm caused by an accident (injury or death of people, damage to environment, loss of assets, reputation damage).
	Hazard Initiating event	Realisation of the hazard and unintended departure from normal situation or point of loss of control in which some degree of harm is caused.















## Appendix L – Data recording for non fume and fume event

Recent fume events within open cut mining in Queensland have led to the exposure of mine workers to post blast fume and gases. The workers were sent to hospital as a precautionary measure to manage the exposure to these gases, there were no long term health effects from these exposures.

A working group has been established to identify actions to prevent, manage and treat exposure to post blast fume events. The working group has drawn participants from the regulator, industry safety and health representatives, mining houses and explosives manufacturers. This working group will continue to meet, review fume event and data until July 2012.

An examination by the working group of reported fume events has identified a lack of consistent data being recorded from blasting. The working group has completed a spreadsheet that requires sites to capture data from each blast that is relevant to the formation, or not, of post blast gases.

The information should be entered into the attached excel spreadsheet and the completed spreadsheet shall be returned weekly by COB Friday to [fumesurvey@deedi.qld.gov.au](mailto:fumesurvey@deedi.qld.gov.au) . Weekly reporting will enable the appropriate and timely tasking of the working group.

The reporting was initially to run until 26 June 2011; however the Fume Meeting Group has requested that this data collection phase continue until the end of July 2012. This is essential to cover a full year of blasting operations across the four seasons. The analysis of data over this period should enable the identification of trends that may be associated with seasonal variation.

For any queries in relation to this worksheet please contact Principal Inspector of Explosives Haydn Isaac at Rockhampton on 07 4938 6777 or [haydn.isaac@deedi.qld.gov.au](mailto:haydn.isaac@deedi.qld.gov.au)

### Data Analysis

There are X blasts in the dataset. This information has been analysed to look at the following:

- 1) Product performance (fume)
- 2) Mine site performance (fume)
- 3) Mining company performance
- 4) Explosives supplier company

The information obtained from the data analysis will be made available to mining companies, mine sites, explosive suppliers and contractors on request. Specific information on product performance and mine contribution performance will only be supplied to the originator of the data. All other information will be kept confidential.

## **Appendix M – Fume Management Plan**

To be issued.