Vedanta Resources Plc

Sustainability Governance System

Guidance Note GN29

Explosives and Blasting

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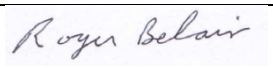
Prepared by:	Roger Belair
Signature	
Position:	Group Head – Safety

Authorized by:	Phillip Turner
Signature	
Position:	Group Head – HSE & Sustainability

Confidentiality

Contents

1. INTRODUCTION

1.1. Who is this Guidance Note aimed at?

This Guidance Note is aimed at all Vedanta subsidiaries, operations and managed sites with underground mining operations and other business where underground or excavations works may be undertaken, including new acquisitions, and to new and existing employees and contractor employees. This Guidance Note is applicable to all personnel responsible for the safe handling, use and/or management of explosives in the workplace and blasting operations.

1.2. What is the aim of this Guidance Note?

Explosives and Blasting contributes to fatalities within the underground mining industry, either directly or indirectly. The aim of this Guidance Note is to outline the company requirements which Vedanta implements in order to ensure that all risks associated with explosives and blasting are eliminated or minimized within an acceptable level.

1.3. What issues does this Guidance Note address?

This Guidance Note presents the framework for the management of explosives and blasting, and SOPs required to avoid untoward incidents within Vedanta operations. The focus of the Guidance Note is on the provision of preferred methods and outcomes rather than being prescriptive whilst at the same time representing a practical "how to" guide for all Vedanta operators.

It is however recognized that the different operations are at different levels of "maturity" with regards to the development of systems to manage the risk associated with explosives and blasting. The Guidance Note includes two approaches:

1.3.1. *Prescriptive Approach.* This establishes specific requirements that are deemed mandatory and are indicated by the term '**shall**.'

1.3.2. *Risk Based Approach.* This is less prescriptive and is driven from the site, acknowledging its specific requirements, mining methods, equipment, infrastructure and the competency of its personnel.

Those requirements that are associated with '**shall**' statement are mandatory irrespective of site maturity.

1.4. How should this Guidance Note be used?

This Guidance Note is mandatory (as per instructions in Section 1.3 above) and is intended to provide a standard baseline and reflect good practice whilst providing the basis for continual improvement of sustainability issues across the Vedanta business. The need for flexibility at a site is depending upon specific circumstances or regulatory specific requirements is also recognized. This Guidance Note is not designed to be definitive text, nor is it designed to provide prescriptive methods and procedures for undertaking tasks.

In most cases there will also be national and/or local regulatory requirements which address explosives and blasting management issues and sites must ensure that these requirements are identified and complied with.

The guidance has been designed to be applicable for all Vedanta operations. Some references are specific to underground mining operations.

The successful implementation of this Guidance Note is expected to require several years of dedicated commitment from all the Vedanta mining sites depending on their existing maturity and controls.

The following provides guidance on how this may be achieved. This is not a mandatory approach, but an equivalent implementation program must be designed where the guidance is not followed:

- **Explosives and Blasting Management** is the responsibility of the Mine Manager supported by the Safety Manager who will drive the implementation protocols and is supported by an appointed senior line manager, with authority to approve new requirements and who will be accountable for successful implementation.
- **The Explosives and Blasting Management team**, comprising of a diverse group of people from various departments, is responsible for the development and administration of the Explosives and Blasting Management Plan. Typically, the safety manager takes overall responsibility for developing the plan. However, it cannot be done by one person. In order to create 'buy in' it is important to have many different voices contributing to the design of the plan. At the very least the mine manager, mine production manager, technical services manager, maintenance manager, HR manager, engineering manager, and security manager should be included in the team. The success of the explosives and blasting management plan is largely dependent on the support of the chief executive officer of the operation.
- Once the **explosives and blasting management plan** is in place, an audit needs to be conducted with competent resources to determine the current status of the site with regard to the elements of this guidance; ideally this will use resources from across Vedanta sites to enable a peer review to be conducted and create a community of practice amongst champions.
- The results of this **audit** are to be used as the basis of an action plan to implement those aspects that are currently not in place.
- Once this process has been started, an **annual progress review** will be required to ensure implementation is on track.
- Each site is encouraged to **share experiences** and build further competencies and internal capacity within the Vedanta Group.

This document has been developed as a collaborative approach with input provided from within the Vedanta businesses.

The remainder of this Guidance Note will be structured into sub processes grouped under the following section:

- Section 2 –Explosives in a mine
- Section 3 – Overall Management Approach
- Section 4 – Explosives Management Plan Sections
- Section 5 – Competency, Training and Communications
- Section 6 – Monitoring & Review

2. EXPLOSIVES IN A MINE

2.1. Typical Explosives used in Mining

Explosives are utilized in mining operations for the purpose of breaking in-situ, and large quantities of rock into fragments suitable for transportation, which is call muck. Muck is the broken rock that is transported to surface for further processing or disposal.

2.2 Definition of explosives

When explosives are detonated chemical reactions take place right after the supersonic shock wave hits the material. Explosives are chemical mixtures or compounds that, when subjected to heat, impact, or shock, are capable of undergoing a rapid decomposition that releases heat and gases, which, in turn, expand to form high pressures.

Detonation occurs when the rate of chemical decomposition is greater than the speed of sound; deflagration occurs when the reaction rate is slower than the speed of sound. “High explosives” detonate, whereas “low explosives” deflagrate or burn.

A high-explosives detonation provides both shock, which fractures (or breaks) the rock, and force (in the form of gas products), which heaves and displaces the fractured rock.

A liter of modern high explosive will expand to around 1000 liters within milliseconds (ICI 1997), creating pressures in a blast hole of the order of 10,000 MPa (1,450,000 psi). Temperatures range from 1650-3870^{o}C and the velocity of detonation (VOD) is so high (2500-8000 m/s) that the power of a single charge is around 25,000 MW. This energy is highly dangerous and could create an injury to people by fly rocks, gas cloud or concussion waves.

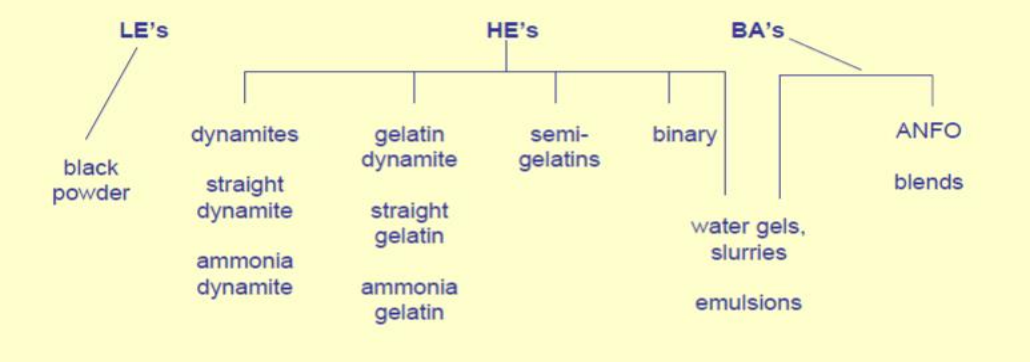
Classification of Explosives

There are many ways to classify explosives. Once such system defines explosives as:

Low explosive (LE) = an explosive material that can be caused to deflagrate (burn) when unconfined;

High explosive (HE) = an explosive material that can be caused to detonate with a No. 8 blasting cap when unconfined; and

Blasting agent (BA) = a mixture consisting of a fuel and oxidizer, intended for blasting but otherwise not an explosive (cannot be detonated with a No. 8 blasting cap). The graphic below provides some further insight into this classification system.



2.3 Bulk Emulsion

Emulsion is a primer sensitive pumped emulsion which is manufactured at the blast site from a manufacturer pumping unit, where non-explosive emulsion is sensitized to deliver the water-resistant product to the blast hole. Density can normally be varied from 0.8 to 1.2 g/cm^3. Emulsion is suitable for a blast hole with a minimum diameter of 38mm and fires at a velocity of detonation of 4.5 to 6.2 km/s.

Given that bulk emulsion is not classified as an explosive until it is sensitized in the blast hole, it does not warrant special handling as an explosive.

2.4 Ammonia Nitrate Fuel Oil (ANFO)

Ammonium nitrate fuel oil (ANFO) consists of small granules of ammonium nitrate (AN) called prills, coated with a special grade of fuel oil (FO). There are 3 types of ingredient.

- Oxidizer: Ammonium nitrate
- Fuel: Fuel oil/distillate
- Sensitizer: Entrapped air

ANFO cannot be initiated on its own by heat, shock or by a detonator. It must be detonated by a primer, which is a cartridge of high explosive with detonator, and the detonation pressure of the primer should be greater than that of the ANFO.

2.5 Packaged Explosives

Packaged explosives will most likely be emulsion based as they have a high-water resistance and have a density of approximately 1.2 g/cm3. Packaged emulsions come in a variety of sizes and weights and have a designation of Hazard Class 1.1D*.

*Note: United Nations hazard classification system for classifying explosive materials and explosive components, which is recognized internationally.

2.6 Detonators

Different explosives require different amounts of energy (their activation energy) to detonate. Commercial explosives are normally formulated with a high activation energy requirement, to make them more stable and safer to handle so they will not explode if accidentally dropped, mishandled, or exposed to heat. These are called secondary explosives. However, they are correspondingly difficult to detonate intentionally, and require a small initiating explosion. This is provided by a detonator. A detonator, frequently called a blasting cap, is a device used to trigger an explosive device. Detonators can be chemically, mechanically, or electrically initiated, the latter two being the most common.

Each detonator normally includes a primary load of explosives, a secondary load and a delay series if the design requires it.

2.7 Electrical detonators

There are three categories of electrical detonators: instantaneous electrical detonators (IED), short period delay detonators (SPD) and long period delay detonators (LPD). SPDs are measured in milliseconds and LPDs are measured in seconds.

The benefits of electronic detonators are:

- Safety mechanisms within the fuse head ensure detonators do not fire unexpectedly.
- Delay range of 1–30,000 MS in millisecond or sub-millisecond increments.
- Precision of 0.01% of nominal delay time.
- Safe and reliable initiation of up to 3000 units per blast.
- Unique ID in each detonator.
- Testing of detonators and the network prior to each blast.

2.8 Non-electric Detonators

A non-electric detonator system is a shock tube detonator designed to initiate explosions.

Instead of electric wires, a hollow plastic tube delivers the firing impulse to the detonator, making it immune to most of the hazards associated with stray electric current. It consists of a small diameter, three-layer plastic tube coated on the innermost wall with a reactive explosive compound, which, when ignited, propagates a low energy signal, similar to a dust explosion. The reaction travels at approximately 6,500 ft/s (2,000 m/s) along the length of the tubing with minimal disturbance outside of the tube.

Each unit consists of a precise in-hole delay detonator, linked by a length of shock tube. Some units come with a delay detonator housed in a plastic connector block on the opposite side of the in-hole detonator to ensure the energy is contained in the drilled hole and transferred to the surrounding rock structure. These in-hole delay detonators are available in various lengths and delay times.

Non-electric detonators are classified as Hazard Class 1.1B.

2.9 Boosters

A booster is a high-power explosive, made of a highly safe pentolite charge (a blend of TNT and PETN) for the initiation of blasting agents. Its main purpose is to provide an energetic pulse high enough to rapidly achieve an optimum velocity of detonation of the explosive column.

They are safe, reliable and functional explosives, with a plastic container that provides better water resistance properties, ideal for the most severe field conditions if stored properly.

Small hole boosters, often 15mm in diameter and 180mm in length are used for development blasting, with a Hazard Class 1.1D

Cast Boosters, 53mm in diameter and 120mm in length will be used for production blasting, with a Hazard Class 1.1D.

2.10 Electronic Detonators

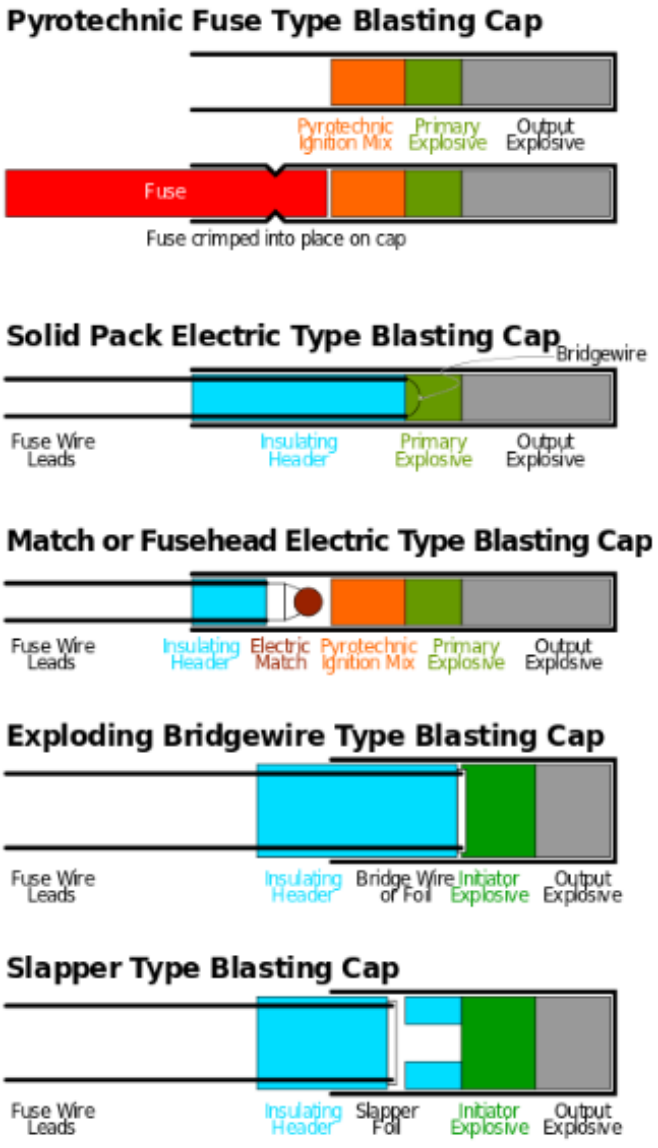
Electronic detonators have a better precision for delays. Electronic detonators are designed to provide the precise control necessary to produce accurate and consistent blasting results in the mining, quarrying, and construction industries. Electronic detonators are fully programmable and have on board digital timing circuits and energy storage to enable them to function independently. They work in conjunction with a data logger, which allows the detonators to be programmed from 0 to 15,000ms. Hazard Class 1.1B

2.11 Detonating Cord

Detonating cord is a thin, flexible tube usually filled with pentaerythritol tetranitrate. With the PETN exploding at a rate of approximately 6400 m/s, any common length of detonation cord appears to explode instantaneously.

Detonating cord allows simultaneous initiating of several independent and inter-related blast holes. The cord is used to initiate a blasting sequence from a safe distance. Detonating cord is a high explosive and therefore must be treated like detonators, boosters and connectors. Hazard Class 1.1D.

Below is a figure indicating the basic construction of different detonator types:



2.12 Blast Initiation

As a rule, before choosing an initiation system, one should familiarize themselves with numerous site-specific factors at your operation. Consider the following topics and use them with manufacturer recommendations to evaluate:

- Geology (rock properties and structure);
- Geometry (typical pattern dimensions);
- Vibration (recommended criteria, including regulations), in particular;
- Peak particle velocity;
- Frequency;
- Air blast (recommended criteria, including regulations);
- Fragmentation (with respect to blasting goals);
- Explosive performance (know your explosive!); and,
- Borehole conditions (water, voids, weak walls, etc.).

Underground development blasting is normally initiated for multiple headings at the end of each shift from a central blasting point on surface or underground.

Explosives must always be considered a hazard in the workplace, be it, underground or surface operations. Due to the potential for extremely high energy release, explosives must be carefully managed for the delivery to destruction stage.

At all Vedanta sites, the use of open flame initiation systems is completely prohibited.

2.13 Blast design

The primary objectives in rock blasting are to optimize blast performance and ensure the safety of everyone by implementing safe practices in and around the blast site.
Secondary objectives include:

- Maintaining the stability of the surrounding rock, so that men and equipment working under them are safe;
- Fragmenting rock masses to reduce their downstream hauling and crushing costs; and
- Moving rock masses to facilitate their load-out by site-specific equipment.

Proper fragmentation is a critical outcome of blasting. A proper blast design will yield adequate fragmentation, which will make loading and hauling safer and more effective and lower costs related to loading, hauling, equipment maintenance, and crushing.

2.14 Blast hole drilling

Drilling Pre-Start

During the prestart checks for drilling conduct at least the following activities:

- Perform pre-start on equipment.
- Check/replace:
  - Worn shank adapters
  - Worn centralizers
- Check out and use boom parallelism.
- Ensure adequate lights are on and working on the jumbo.
- Fill out Equipment pre-start operations card with all required information.
- Enter Engine and impact drilling hours meter readings.
- Fill all oil lubrication reservoirs

Drilling Setup

- Place the cable for the jumbo in the desired location before turning on the power.
- The feed cable should be hung on the wall in its proper location.
- The feed cable must be safely secured to the wall to prevent stretching and damage to the plug.
- Unreel trailing cable and hang on screen or sign boards to keep the cable out of the water.
- Position the Jumbo as required to keep holes parallel to back sites and face markings.
- Ensure the booms are properly aligned with the markings on the face, back and walls prior to collaring a drill hole.
- Sting the boom to the face.
- Collar the holes precisely with the hole markings, using the collaring feed device to collar all holes.
- DO NOT MOVE BOOM ONCE STUNG AND COLLARED!

Drilling

- Keep the face square at all times by adjusting hole depth throughout the face as required.
- Drill the reamer holes 4" deeper that the remainder of the round for breakage, and visibility for the next round.
- Angle the cut holes looking up slightly.
- Drill the round according to the blast design.
- Blow out each hole in the round, including the reamers before extracting the drill rods.
- In broken ground, try to clean out the holes by running the drill steel in and out.
- Sequence the drilling to drill an even number of holes with each boom to improve productivity.
- Both booms should finish around the same time.
- Ensure that all holes have been drilled prior to pulling the jumbo out/away from the face.

Changing bits

- No one is allowed to approach the face beyond the jumbo's front jacks while drilling is under way.
- The Jumbo operator must shut down all drills / pumps before attempting to change bits or rods.
- Pull the boom back from the face and ensure the face is well scaled when changing bits or rods.
- In bad ground, move the jumbo back to ensure safety of the driller.

Blast hole loading

Pre-start

- Perform pre-op on all loading equipment.
- Fill out equipment pre use checklist.
- Report any defects immediately and tag out unit for "no-go" items.
- Ensure that the inside of the loader is clean, clear, and free of any obstructions.
- Set the recommended operating air pressures, if using a pressure vessel, check that the pressure relief valve is functional.
- Loading hose must be antistatic, which is often indicated by a stripe on the hose.

Loading Explosives

- Scale the face completely and ensure all loose is removed.
- Practice good housekeeping remove all materials from the face that are not required in the loading cycle.
- Before loading or priming, blow out the holes with air to remove residual cuttings and water, including the reamers.
- Mark every hole that is making water to avoid loading with ANBA.

Loading Dry holes with ANBA

- Place Detonator in the notch of the loading hose, push gently to the toe of the hole and start to load, while slowly retracting the loading hose.
- Ensure that a minimum of 30cm of shock tube hangs out of the borehole.
- No Reverse Priming is allowed.

- Retract the hose at a steady rate, if it is withdrawn too quickly, air gaps or sections of low density will be produced, if withdrawn to slowly, ANBA will blow out the collar.
- Leave 60cm collar with ANBA

Loading Wet holes

- Gently push 1 stick powder to the toe of the hole with the detonator inserted.
- Gently push one more cartridge up to the primer assemble and tamp with loading pole.
- Load the remainder of the blast hole up to the desired 60cm collar.
- A maximum of two cartridges is to be loaded at the same time.
- NEVER TAMP PRIMER CARTRIDGE

Hook up Safety

- Always handle detonators (caps) with care.
- Rough handling or excessive walking on exposed tubes could lead to misfire.
- Never pull so hard that you stretch or break a tube.
- Watch when loading from equipment that tubes don't get caught in equipment resulting in pulling on the NONEL Tube.
- Always use the same delay detonators.
- Use the correct length detonators, don't stretch NONEL creating tight connections that could pop out.
- Ensure proper sequencing, when cut is offset, sequence the top of the round using the detonators from the long side of the slashing.

Proper Cap tie in Cap

Cap tie in:

- Insert only one shock tube at a time into the Connector Block.
- Maximum of six (6) shock tubes per connector block.
- Ensure that shock tube is correctly inserted in connector.
- Text styles.

Caps – Thing to Remember

- It is a single path system, double-triple up whenever possible.
- Don't step on NONEL Tubing from knee and lifter holes.
- Make sure NONEL tube is connected properly in the surface connector.
- Check your connections for loose caps when finished hooking up the blast.
- Place your initiation cap away from the face.

Geology and blasting

A blaster should understand the properties of the different types of rock he or she intends to blast. Typically, rock "properties" are described in terms of composition and structural characteristics. The methods selected to drill blastholes, the type and placement of explosives, the layout of blastholes or the drilling pattern, and the type of initiation system all are greatly influenced by rock type and structural geology.

Just as important to rock breakage using explosives are the properties of rock. These include the rocks:

- Bedding planes;
- Joints and faults;
- Stratigraphy (or the variation in different rock materials with depth);
- Hydraulic properties;
- Mud or clay seams; and,
- Open voids.

These features often control the safety and performance of explosives and the size of the blasted rock particles (termed fragmentation), as well as the direction and distance of rock movement during the blast. If explosives are loaded within zones of weakness, bedding planes, mud or clay seams, joints and faults, the chances of fly rock and excessive air blast will increase.

2.15 Controlling the adverse effects of blasting

Explosive energy is used to break rock. However, the use of this energy is not 100-percent efficient. Some of the energy escapes into the atmosphere to generate airblast or air vibrations. Some of the energy also leaves the blast site through the surface soil and bedrock in the form of ground vibrations.

Both air and ground vibrations create waves that disturb the material in which they travel. When these waves encounter a structure, they cause it to shake. Ground vibrations enter the house through the basement and airblast enters the house through the walls and roof.

Airblast may be audible (noise) or in-audible (concussion). When outside a house the blast may be heard because of the noise, however noise has little impact on the structure. The concussion wave causes the structure to shake and rattles objects hanging on walls or sitting on shelves. This “interior noise” will alarm and startle people living in the house.

Flyrock is debris ejected from the blast site that is traveling through the air or along the ground. Flyrock is the single most dangerous adverse effect that can cause property damage and personal injury or death.

The best way to ensure that these adverse effects of blasting is controlled is to ensure that there are no persons in the vicinity of the blast when setting off the blast. Remote detonation is always the best option.

3. OVERALL MANAGEMENT APPROACH

Each site shall establish and implement an Explosives Management Plan. The objective of the plan is to eliminate the risk of fatalities or serious injuries resulting from explosives and blasting in underground and open pit mines.

The purpose of the Explosives Management Plan is to outline the framework and principles that will guide the working site in the selection, procurement, storage, safe handling and use of explosives; and to ensure methods and procedures are in place to mitigate the risks associated with explosives, and comply with all applicable regulations, standards, and legislation in that regard.

The Plan has the following objectives:

- Provide a systematic approach for the use, storage, and transport of explosives;
- Identify and develop systems, standards, and procedures;
- Define the duties and responsibilities of people required to work with, dispense, and transport explosives;
- Manage explosives stocks within the manufacturer’s recommended storage conditions and shelf life; and,
- Provide a secure system for storage and control.

The Plan can be further enhanced with the following:

- Be designed by a competent person(s).
- Have suitably qualified people trained in explosives and blasting control.
- Take the risk assessment into consideration when implementing explosives and blasting safety controls.
- Incorporate lessons learned from other mine explosives and blasting incidents at the site and other group operations.

- Be reviewed annually by a competent or external person(s), with a review report signed off by the mine Manager.

All employees and business partners working underground or on surface shall undergo training in line with the Plan and the training must be delivered by competent persons. Refresher training shall be carried out on an annual basis. Mine Managers and relevant Supervisors shall receive additional levels of training to include details of the Plan.

A competent person(s) shall design the Plan to include the following sections:

- Regulatory Obligations
- Health, Safety and Environmental Considerations
- Best Practice Management
    - Safe Operating Procedures (SOP)
    - Risk and Change Management
    - Compliance
- Types of explosives to be used on site
- Selection of Explosives/ accessories and supply requirements
    - Explosives
    - accessories
    - Selection of Supplier
    - Blasting Equipment
- Explosives quantities
- Storage of Explosives and accessories
    - Surface Magazines
    - Underground Storage
- Explosives transport equipment
- Distributing Explosives and accessories
    - Issuing Explosives
    - Issuing of accessories
- Explosives Usage in the Workplace
    - Adverse conditions
    - Smoke, dust and fly rock
    - Misfires
    - Vibration
    - Inventory management
    - Inspections
    - Reports and record keeping
    - Old explosives
    - Explosives preparation
    - Onsite handling
- Blasting operations
    - Planning
    - Safety procedures
    - Training
- Competency, Training and Communications

- Authorized personnel
- Audit and Review
- Hazardous materials management
- Explosives housekeeping
- Explosives disposal
- Nitrate management

Each operation must have the resources to ensure effective implementation of Plan.

Explosives and blasting management shall be aligned with the emergency management and response planning at each operation and this requires alignment with the:

- Crisis Management Plan
- Emergency and Fire Prevention Plans

4. EXPLOSIVES MANAGEMENT PLAN SECTIONS

4.1. Regulatory Obligations

The regulatory requirements must be clearly defined and presented for interpretation at each Vedanta Site. Regulations should be implemented as the base case and further improvements sought to achieve best class.

In the case of Indian Regulations, the following steps should be taken:

- Clarify the classification of explosives with respect to classification under the Explosives Act 1884 (2006) and the mergence in line with UN Classification.
- Provide clear interpretation of the MMR 1961 with respect to explosive regulations or supporting regulations to the Explosives Act 1884.
- Ensure local laws applicable to the purchase, storage, delivery and use of explosives is clearly interpreted and implemented.

In addition, regulatory obligations may exist where localized requirements such as blast vibration, noise over pressure times, permits to blast, and security considerations must be recognized.

4.2. Health, Safety and Environment Considerations

The Plan is designed such that all mitigating factors are implemented, to ensure hazards and associated risks with explosives and blasting are managed to ensure risks are minimized.

The following hazards are examples of key considerations:

- Supply and delivery of explosives and accessories to site
- On site handling and storage of delivered explosives and accessories
- Access to explosives – authorization and verification process
- Scheme of Transit on site for the transport arrangements to the workplace
- Issue and return/disposal of explosives in the workplace
- Security of explosives and accessories

- Use of transmitting devices in the vicinity of explosives
- Blasting management in relation to clearance, mitigating blast damage, dealing with misfires and incomplete explosions

Once all hazards have been identified they should be incorporated into the Plan under procedures, monitoring and reconciliation forms.

- All transport of explosives and accessories is conducted in accordance with established procedures outlined in the Plan.
- Only authorized/licensed suppliers will enter into a procurement arrangement for supply of explosives and accessories.
- Explosives permits must list and categorize explosives permitted on site.
- The storage, handling and transport of explosives and accessories can only be carried out by designated personnel, having the necessary qualifications and authorizations in accordance with training, regulatory examination and approval by authorizing body.
- The blasting activities will only be performed by a qualified blaster in accordance with training, regulatory examination and approval by authorizing body. Blasting should be carried out by two persons, one of which must have a blaster ticket.
- All transmitting devices such as radios, phones, remote controls for mining activity, electrical outlets, must have rules applied whereby they do not come within a certain distance of the explosives or accessories.
- Similarly, strict observation of applied rules for surface activities such as electrical storms must be monitored. Where charging operations cease, personnel are removed from the area, and only return once the weather condition has ceased.

The risk associated with Explosives and Blasting should be included in the risk register. The emergency response plan must also address the remedial risks and set out clear measures for the response to incidents that may occur.

4.3. Practical Explosives Management

4.3.1. Safe Operating Procedures (SOP)

Safe Operating Procedures will be developed for each task associated with explosives, such as but not limited to transportation, storage, handling, development charging, production charging and blasting, misfires and ventilation requirements. These SOPs shall be included in the Plan.

Examples of SOP types are:

- Charging a development face
- Firing a development blast
- Managing a misfire

4.3.2. Risk and Change Management

A formal risk assessment process should be undertaken to assess the risks to people, the environment, infrastructure and equipment. The Risk and Change Management Plan should become the central document for management of risks, both in the short term and through a process of regular review, over the long term.

These reviews should be carried out at set intervals nominated by the management team, and where:

- An incident occurs that undermines the integrity of the original risk assessment/controls
- A significant change in the process, system or procedure relating to the delivery, storage, transport and use of explosives

Records must be maintained of all documentation associated with risk assessment, control implementations and roles and responsibilities.

4.3.3. Compliance

Control measures for the risks identified will be achieved through the robust set of standards, procedures and reconciliation forms. All forms must be relevant and up to date.

The following plans should also refer to the Plan:

- HSE Policy
- Business Partner Management Plan
- Risk and Change Management Plan
- Emergency Response Plan
- Ground Control Management Plan
- Dangerous Good and Hazardous Material Management Plan

4.4. Explosives Management Plan Document

The factors influencing the type of explosives to be used on any particular mine is a complex decision dependent on as wide a number of issues as one would like to list. These will include:

- Economic factors;
- Logistical factors;
- Safety factors;
- In-situ rock types;
- Geological structures;
- Mining design;
- Available technology;
- Education level of labor force;
- Type of mineral mined; and,
- Extraction methodology.

Once all these and other factors have been considered each mine shall develop an Explosives Management Plan for use on the mine. The objectives of the Explosives Management Plan must include the following:

- Communicate a methodical approach to explosives management for the mine;
- Ensure that infrastructure constructed for explosives is compliant with all applicable regulations;

- Ensure that structures are constructed to prevent any safety or environmental incidents relating to onsite explosives storage;
- Ensure that handling of explosives is done in a manner that will minimize the possibility of safety or environmental incidents;
- Prescribe safe and environmentally sound measures for disposal or destruction of explosives;
- Prescribe procedures for safe blasting;
- Prescribe procedures for dealing with spills of explosives materials; and,
- Indicate the chain of responsibility for explosives management.

This plan must define:

- The applicable legislation for the management of explosives on the mine
- The various explosives permit requirements
- The types of explosives to be used on site that includes the use, risk and a full description of each type
- The quantities of each type of explosives that may be kept on the mine
- Explosives inventory management
- If applicable, the preparation of explosives on the mine
- Details of the storage requirements for each type of explosives
- On site explosives handling requirements, including:
  - Authorized personnel
  - Site specific hazardous materials management requirements
  - Housekeeping rules
  - Explosives disposal methods to be utilized
- Blasting operations, with sections on:
  - Planning
  - Safety
  - Training
  - Explosives transport including the equipment to be used
- Safety during blasting with sections on:
  - Preventing exposure to blasting fumes
  - Minimizing the liberation of dust
  - Minimizing vibration damage
  - Minimizing the effect of air blasts
  - Fly Rock Prevention
  - Preventing and dealing with misfires
- Ensuring compliance
- Reports and record keeping
- Environmental issues

4.5. Selection of Explosives/ accessories and Supply Requirements

4.5.1. Explosives

As stated previously, only explosives that are authorized under the regulatory legislation can be utilized. These explosives must comply with the legislation, permits, and approval of the Mine Manager.

The explosives used on site must be licensed under the explosives act, and all technical data sheets relative to the explosives must be readily available on site and no older than 3 years old. The Mine Manager must review the Risk and Change Management Plan prior to sign off that all risks and controls are identified and actioned.

The intended purpose for the explosives must be clearly defined prior to selection.

4.5.2. Detonators

As stated previously, only detonators that are authorized under the regulatory legislation can be utilized. These detonators must comply with the legislation, permits, and approval of the Mine Manager.

The detonators used on site must be licensed under the explosives act, and all technical data sheets relative to the detonators must be readily available on site. The Mine Manager must review the Risk and Change Management Plan prior to sign off that all risks and controls are identified and actioned.

The intended purpose for the detonators must be clearly defined prior to selection.

4.5.3. Selection of Supplier

The supplier of explosives and accessories must be a licensed supplier of explosive products. The supplier should be assessed with respect to Vedanta standards, and aligned with the Business Partner Management Plan. All accessory devices utilized in the storage and use of explosives must be approved by the manufacturer of the explosives. For instance, punchers used in the process of making a hole in the gelatin explosive cartridge must be preapproved by the manufacturer.

4.5.4. Blasting Equipment

The blasting equipment must be permitted, statutory compliant, licensed as a blasting accessory and approved by the Mine Manager.

Only authorized equipment should be used, any defects or damage to blasting equipment should be logged, recorded and remediated.

4.6. Explosives quantities

The license issues to each mine will state the types and maximum quantities of explosives which may be stored in every magazine on the mine, together with other conditions that the issuing authority may considers necessary. Complying with the individual requirements is essential as a mine may lose the explosives use and or storage license.

4.7. Storage of Explosives and Accessories

4.7.1. Surface magazines

Storage of explosives and accessories must be carried as per the relevant legislation, licenses, permits and approvals. Storage Magazines must be constructed in accordance with relevant legislation and using proper engineering standards.

The capacity of each magazine should be clearly stated, and the quantities allowable at any one time communicated to the authorized personnel. It is good practice to follow the “first in -first out” approach to ensure explosives or accessories are not stored beyond their shelf life.

Magazines shall be clearly identified with quantities of explosives permitted at each location.

It must be clearly stated on the plan the required separation distances between surface magazines and addition infrastructures such as dwellings, offices, public roadways or populated areas.

The following signs are required: Explosive storage pictogram, No smoking pictogram, Fire extinguisher pictograms and etc.

Rules of conformity should be based on the initial risk assessment. The conditions under which they are stored should take the following into account:

a) Compatibility Group

Primary explosive substance.	**A**
Article containing a primary explosive substance and not containing two or more effective protective features.	**B**
Propellant explosive substance or other deflagrating explosive substance or article containing such explosive substance.	**C**
Secondary detonating explosive substance or black powder or article containing a secondary detonating explosive substance, in each case without means of initiation and without a propelling charge, or article containing a primary explosive substance and containing two or more effective protective features.	**D**
Article containing a secondary detonating explosive substance without means of initiation with a propelling charge (other than one containing a flammable or hypergolic liquid).	**E**
Article containing a secondary detonating explosive substance with its own means of initiation, with a propelling charge (other than one containing a flammable or hypergolic liquid) or without a propelling charge.	**F**
Pyrotechnic substance, or article containing a pyrotechnic substance, or article containing both an explosive substance and an illuminating, incendiary, lachrymatory or smoke-producing substance (other than a water-activated article or one containing white phosphorus, phosphide or a flammable liquid or gel).	**G**
Article containing both an explosive substance and white phosphorus.	**H**
Article containing both an explosive substance and a flammable liquid or gel.	**J**
Article containing both an explosive substance and a toxic chemical agent.	**K**
Explosive substance or article containing an explosive substance and presenting a special risk needing isolation of each type.	**L**
Article containing only extremely insensitive detonating substances.	**N**
Substance or article so packed or designed that any hazardous effects arising from accidental functioning are confined within the package unless the package has been degraded by fire. In this case all blast or projection effects are limited to the extent that they do not significantly hinder or prohibit fire fighting or other emergency response efforts in the immediate vicinity of the package.	

Table 1 Compatibility Groups

Explosives that are assigned the UN HD Number 1.1-1.5, are also assigned compatibility designations. The compatibility groups are designed to identify the groups of explosives that can be stored together, the combinations of explosives stored together and the permitted mixing of compatibility groups.

It should be verified at each site, classification of explosives and accessories, and the subsequent storage arrangements based on the compatibility groups.

For example, Explosives 1.1A should at all times where practically possible be segregated from Detonators 1.1B, and at no time should the two groups come in contact other than when they are inserted into the blast hole.

b) Cleanliness and Maintenance of Surface Magazines

The interior and exterior of the surface magazine must be maintain to a high standard. Clean and orderly state, with weatherproof condition.

The magazines should be inspected by the safety department on a periodic basis, ensuring permitting, licenses and internal standards are maintained.

Should any repairs be required in the magazine, an official permit for maintenance should be secured, all items in the magazine removed or adequately protected. If hot works are required, mechanical or electrically powered hand tools are to be used, then all explosives and accessories should be removed from the magazine and placed in a safe location. This approach should be addressed in the Dangerous Good and Hazardous Material Management Plan.

c) Access to Surface Magazine

Only authorized personnel signed off by the Mine Manager or designated body should be issued with a key to the surface magazine. Any personnel required in the magazine must always be supervised by the authorized person.

Access keys to the surface magazine should be stored in accordance with the licenses, permit and relevant legislation. Keys should be registered and kept in a safe, where codes are only granted to authorized personnel. Keys should only be taken from the safe once access is required and return immediately once access is no longer required, keys should be signed out and signed back in by the authorized person.

An oversight control must be established, whereby a central controller (control room) is designated as the custodian of the magazine key safe, who will ensure that control and security of the keys is maintained. If a key is unaccounted for the custodian must take immediate action to secure the effected magazine, arranged for inventory check, file an incident report and take the subsequent steps as outlined by the applicable procedure.

d) Delivery of Explosives and accessories

Deliveries to site of explosives and accessories should consider mitigating standards required by the supplier such as:

- As per the hazard classification and compatibility grouping, the delivery must conform to segregation rules, as per legislation, and engineered accordingly.
- An authorized person must be present when deliveries are made and prior to acceptance of the delivery. authorized person must:
    - Confirm that the explosives are of the correct type, have the correct labeling and their date of manufacture is current, and they have not been damaged.
    - Confirm that detonator manufacture date on the packing carton does not exceed the appropriate expiry, and they are of the correct type, and they have not been damaged.
    - Confirm that quantities receipted are correct against the delivery docket.

- Record all necessary information regarding the delivered product.

- The delivery truck must be mechanically sound in as far as is practically possible, fitted with fire extinguishing equipment and driven by a competent person, familiar with the site layout and site magazine rules.
- The delivery truck (unless otherwise facilitated by the site) should have a mechanical means of unloading material, duly certified and fit for purpose. All efforts should be made to avoid manual unloading where possible.
- Loading and unloading areas must be clearly designated and must comply with legislation.

It is suggested that all receipts and signed documents are maintained under the custody of the mine manager of authorized person.

e) Magazine Inspections

Magazine inspections should be carried out periodically, an inspection list should be created addressing legislation, permits and standards mentioned earlier. Non-compliances must be logged and addressed following a pre-determined protocol, the Mine Manager must be the directly involved with the design and implementation of remedial action reports.

Items that are found to be damaged, with expired shelf life or appear abnormal in any way, should be treated as a product that should disposed of, following a procedure for disposal of explosives or accessories that is provided by the manufacture. A record of the same should be filed by the authorized persons and a separate incident report circulated.

f) Security

Daily security checks must be carried out on the surface magazine area, which should include inspection of the security fences, locks on the doors, fire extinguisher stations, camera functionality if applicable and general cleanliness of the surface area.

A daily report should be recorded noting the above, and any deviations must be reported to the Mine Manager and safety department.

4.7.2. Underground Storage

Local Explosives Regulations normally permit different types of storage types for underground storage of explosives. These may be:

- Day boxes
- Relocatable magazines
- Underground storage magazines at a fixed location.

Day boxes are explosives storage magazines designed for the transfer and temporary supervised storage of explosives and accessories. These magazines are normally designed to be light enough for daily transport from an overnight storage area to the job site while keeping the contents safe and secure.

Relocatable magazines may be used as underground working party magazines, but all underground magazines must comply with the applicable design requirements of the relevant statutory requirements.

The quantity of explosives that may be stored in a relocatable magazine used as an underground working party magazine are normally defined in legislation. The spacing of these magazines in the underground working areas are also strictly legislated and should be complied with.

The quantity of explosives stored in a fixed underground magazine should be minimized. A combination of both surface and underground storages may provide operational flexibility for sites requiring large quantities of explosives. A risk assessment must be conducted to determine the maximum quantity that may be safely stored. It is the norm that no more than one week's worth of explosives may be stored in an underground magazine, and justification of this quantity must be demonstrated through historical blast records.

The consequence of an unconfined explosion of many tons of explosives within a mine must not be underestimated. Such an event could be fatal. Ventilation fans would be damaged or destroyed, people and plant both near and far from the magazine would be thrown against walls and objects, the mine or portions of the mine may collapse, access and escape routes may be isolated and refuge chambers may not be adequately engineered to withstand the forces of the blast or the resulting reverse-blast wave (backdraft). The rescue effort may involve challenges and difficulties unlike other anticipated emergencies.

Risk assessments must ensure the potential effects of an unconfined explosion are adequately addressed. Crib rooms and other non-production facilities must be adequately separated from the magazine. As a rule of thumb, a separation distance of twice the vulnerable facilities distance for surface stores is suggested, as measured through tunnels and passages. For example, the separation distance between a crib room and a magazine storing 15 tons of explosives would be 2200 m. An emergency response plan for the worst-case scenario of an unconfined explosion at a magazine must also be developed. The risk register must address and identify mitigation controls to reduce the risk for the following hazards: -

- Adverse conditions
- Smoke, dust and fly rock
- Misfires
- Vibration
- Inventory management
- Inspections
- Reports and record keeping
- Old explosives

4.8 Distributing Explosives and Accessories

This section addresses the issuing, transportation and delivery to the underground working face/stope, or area where blasting is planned, and the delivery to underground magazines.

4.8.1 Issuing Explosives

Explosives and accessories can only be issued to the authorized blaster and should only be issued for transport in an authorized vehicle. The blaster or authorized person may transport the load to either the working face or the designated magazine underground.

The following information should be readily available to the person issuing the explosives and accessories:

- Quantity of explosives and accessories requested – pre-form completed
- Destination of explosives
    - Working face – Name of face
    - Underground Magazine
        - Current Stock Levels in the UG Magazine
        - Capacity and Allowable quantities for 24hr storage

All relevant information should be logged and signed off by the blaster and Authorized Person.

4.8.2 Transportation & Delivery

Within the authorized vehicle, approved transport containers must maintain the segregation rules. Vehicles must be inspected and maintained according to a pre-set maintenance interval.

Fueling should never be carried out while there are explosives or accessories in the vehicle. Breakdown maintenance should never be carried out while explosives or accessories are in the vehicle. The cargo should be unloaded into a standby vehicle or some secure arrangement made to safeguard the load away from the vehicle while breakdown maintenance is being carried out.

The scheme of transit should recognize the explosives carrier vehicle as the priority vehicle in the work area, giving unobstructed passage when encountered. The vehicle should be fitted with lighting (as stipulated in the site SOP) that indicates to pedestrians and other vehicles the nature of the load.

4.8.3 Explosives and Detonator Storage Underground

Explosives and accessories should only be stored in designated magazines or reserves stations underground. The design of the holding area should conform the legislation, permits and licensing.

Underground Magazines should be maintained to the same levels as the surface magazine, complying with segregation rules, inspection and recording of stock.

The system utilized for recoding stock levels should give a true balance of explosives and accessories stored in the underground mine prior to reordering from the surface magazine.

At no stage should unauthorized access be granted to individuals to enter the magazine.

4.8.4 Explosive and Detonator Usage in the Workplace

Once systems are in place to safely allow the explosives and accessories to be supplied, stored and delivered to the working area, it is now the usage section where unintentional or unwanted events may occur.

When explosives are delivered to the workplace, they must be received by authorized personnel and stored appropriately if not being used immediately. Only authorized shot firers can direct charging operations.

Charged faces or faces being charged shall be secured and all ignition sources removed.

Explosives and accessories have a relatively short exposure time when they are supplied to the working face. The charging crew, monitored by the blaster, insert the detonators into the charging holes and once completed, the process of attaching the primer and charging the hole takes place.

These can be controlled environments, where there is a set procedure for handling the explosives and accessories prior to and during the charging process. An engineered design will indicate the charging densities, volume or tonnage to use, the type of detonators and the sequencing of the blast.

The areas where the results can be considered unpredictable is where there is no engineering design; for instance, blasting practices in a chute, crusher, passes, hang-ups, grizzlies, boulders, draw points or storage bins. The blasting practice in these instances can sometimes be carried out without a procedure or adequate risk assessment. The blasting in such instances may not have a direct negative impact in the immediate aftermath, however, such blasts may change the integrity of the surround environment, both from a structural infrastructure perspective and a change in the ground support or ground conditions.

A warning system shall be in place prior to blasting using either a siren or guarding system to ensure no person can access the area.

Following charging of a blast, any unused explosives shall be removed to a designated safe location, as outlined in the appropriate SOP.

Blasting shall be undertaken by an authorized shot firer only at designated times unless special arrangements are made.

Following each blast, the area shall be checked at a time that has allowed adequate ventilation to take place. This must be done by a ‘competent’ person.

Barricades and signage shall be placed at appropriate locations for charging, blasting and post-blasting, until the area has been checked and made safe.

Non-standard blasting shall be formally risk assessed to ensure warning systems, ventilation, permissions and other details are safely managed.

A Misfire is the term used to describe incomplete or remnant explosions, these can be seen as having the tail of a detonator coming from the charge hole or the physical presence of explosives in the hole.

Misfires are to be treated as a charged hole, and before any work is carried out on the face, the misfire must be removed, either through blasting or cleaning. The procedure for dealing with misfires should be covered in all procedures relevant to working at the face. The misfires should then be disposed of as per the misfire procedure (SOP).

Sufficient time should be given for charging practices, it is common theme in mining that the charging is rushed at the end of the shift in order to produce a blast. Given its significant hazard rating and the potential consequence from unwanted or unintentional detonation, the process should be allocated sufficient time to ensure charging, safeguarding of charged faces, return to underground magazine or other assigned area.

4.8.5 Blast Design

All blasting shall be designed by competent mining engineers. Development drilling and blasting shall have guidelines which can be modified by experienced and authorized drillers and shot firers, depending on local conditions. Production blasts shall be designed and approved for each blast and instructions issued to the mining department. A plan for each production blast shall be issued to mining personnel, including details of holes to be charged, explosives to be used, timing of initiation, tonnage and any other information.

5. COMPETENCY, TRAINING AND COMMUNICATIONS

The provision of information, instruction, training and supervision is an essential component of any safe system of work in relation to explosives and blasting. Training and competency assessment are important to ensure all employees, including any personnel who have an association with explosives at different levels, can effectively implement the site's safe systems of work and comply with the Plan. Training may be:

- Formal, through accredited courses – Blasters Course.
- Undertaken on site while being supervised or mentored by trainers and assessors, competent in the subject matter.
- Provided by the Manufacture
- A combination of these approaches.

A training needs analysis helps identify the required competencies, training needs and skill gaps for the site and individual workers, with the goal of giving the person the opportunity to fulfil their accountabilities, some of which are described below.

Role	Accountabilities
Mine Manager	• Ensure that the requirements of the Plan are implemented and maintained. • Ensure the Plan is reviewed and updated every two years, or earlier whenever relevant circumstances change or when incidents occur that necessitate a revision. • Allocate resources to implement this plan for continued compliance. • Allocate and designate required people to effectively apply necessary controls. • Ensure all appropriate corrective actions identified through incident reports, hazard reports, reviews, and audits are implemented and verified in a timely manner. • Submit Alerts for critical and HIPO incidents within 24 hours to Site Heads. • Initiate third party audits of the Plan, as required.
Stores Manager/Controller	• Maintain and implement an Explosives Reconciliation Procedure. • Initiate explosives reconciliation in accordance with all relevant legislation, licenses, permits, and approvals. • Maintain any other procedures to affect the safe delivery, inspections and handling of explosives and accessories through the Lead Blaster/Blaster or authorized persons appointed by the Mine Manager. • Ensure all records related to the receipt of the explosives and accessories are maintained. • Ensure all legislative requirements regarding Transportation of Dangerous Goods (TDG) are complied with, including up to date TDG training for all appropriate personnel who may receive or ship explosives and accessories to and from the site.

Lead Blaster	• Must be authorized by the Mine Manager. • Maintain a current Blaster's Certificate or equivalent certification as required under legislation. • Receive all new inventory of explosives and accessories, and ensure they are delivered immediately to the underground magazines or working face. • Issue explosives and accessories to Blasters for approved shot firing purposes at the working face, or designated area for blasting. • Maintain an up to date reconciliation of the explosives and accessories contained in the underground magazines for each visit whereby explosives or accessories are issued or received from within. • Maintain the underground magazines clean and well organized, in accordance with all relevant legislation, licenses, permits and approvals, ensuring segregation rules are applied. • Arrange disposal of any explosives and accessories, where necessary.
Blaster	• Must be authorized by the Mine Manager. • Maintain a current Blaster's Certificate or equivalent certification as required under legislation. • Transport, use, and return explosives and accessories in accordance with the Plan and all procedures, guidelines and forms; in accordance with the onsite Blaster's Manual; and in accordance with all relevant legislation, licenses, permits, and approvals.
Designated Inspection Manager Safety/Environmental	• Conduct inspections of the magazines and assess compliance against all Plan requirements and relevant legislation, licenses, permits and approvals. • Prepare monthly reports to the Mine Manager summarizing what corrective actions were recommended and approved, and the status of the corrective actions.

5.1. Competency and Training

Based on the requirements of an Plan, the training needs analysis should be undertaken to determine training and verification of competency requirements for the team at varying levels:

Primary – People directly involved with the daily management of explosives and blasting in the workplace.

Secondary – People who receive and use the explosives daily

Tertiary – People who do not work directly with explosives but are exposed to the hazards associated with explosives (driller identifying misfires, maintenance fitter attending breakdown on explosive carrier).

This includes:

- Identifying the required competencies to perform the role, job or task
- Identifying current competencies of personnel
- Identifying gaps by comparing personnel competencies against role requirements
- Planning and implementing a means of filling the gaps

This may involve:

- Questionnaires and interviews
- Practical tasks observations and assessment
- Third-party reports
- Training records
- Résumés

A training matrix assists in identifying training needs to be addressed and the content of training delivered.

5.2. Training records

A formal record must be kept of training conducted, which may be accredited or non-accredited. Records to be kept should include:

- Name of person who received the training
- Dates and times when training was provided (including refresher training)
- Specific details of what was covered
- Duration of the training session or course
- How the training outcomes (competency) were assessed?

5.3. Communications

All of the systems, SOPs and Plan shall be communicated to key stakeholders on a regular basis. This includes all persons involved in purchasing, handling, transporting and supervising explosives on the mine site.

6. MONITORING AND REVIEW

To ensure the effectiveness of controls is maintained at the site, a monitoring and review program shall be implemented that includes inspections, testing and auditing of the systems associated with explosives. This should cover the effectiveness and limitations of the systems in place.

As part of the site's validation process, responsibilities and accountabilities should be clearly defined and assigned and may include independent auditing. The findings of the monitoring and review process should be used to:

- Confirm the recommendations of previous reviews were actioned
- Confirm responses were appropriate for any incidents relating to explosives issues
- Verify compliance with specifications (e.g. inspection, monitoring, and quality control)
- Confirm site practices comply with the Explosives Management Plan

If significant gaps are identified, this should prompt a review of the risk assessment process. Throughout the risk management process, it is vital to ensure that key stakeholders and subject matter experts are consulted where appropriate.

References

Doc. Ref.	Document name
POL 06	HSE Policy
VSS	Vehicles and driving
VSS	Ground Control
VSS13	Emergency and Fire Prevention Plan
VSS15	Explosives and Blasting
VSS17	Hoisting in Shaft
VSS18	Inflow or Inundation of Liquids
VED/CORP/SUST/MS 6	Competency, Training and Awareness
VED/CORP/SUST/TS 10	Safety Management
GN 19	Permit to Work
VED/CORP/SUST/MS 1	Leadership, Responsibilities and Resources
VED/CORP/SUST/MS 9	Documentation and Record Management
VED/CORP/SUST/MS 11	Incident Reporting and Investigation
	Auditing and Assurance
VED/CORP/SUST/TS 13	Emergency and Crisis Management
VED/CORP/SUST/MS 14	Management Review and Continual Improvement
GN 01	Incident Investigation
GN 07	Risk Assessment
GN 10	PPE
GN 14	Health and Safety Management Systems
VED/CORP/SUST/MS 13	Corrective and Preventive Action Management

NOTE: The explosives hazard classification used in this guidance note is as prescribed in the International Ammunition Technical Guideline (IATG) 01.50, UN explosive hazard classification system and codes, Second edition, 2015-02-01.

This United Nations guidance note, (IATA) 01.50, can be obtained at:

https://unoda-web.s3.amazonaws.com/wp-content/uploads/assets/convarms/Ammunition/IATG/docs/IATG01.50.pdf