Vedanta Limited

Sustainability Governance System

Guidance Note GN24

Underground Electrical Safety

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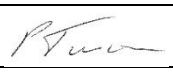
Signature	
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1. INTRODUCTION

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 Business Partner employees. This Guidance Note is applicable to the entire operation lifecycle (including exploration and planning, evaluation, operation and closure).

1.2 What is the aim of this Guidance Note?

Electrical incidents are a major contributor to fatalities and serious injuries within the mining industry. The aim of this Guidance Note is to outline the company requirements which Vedanta implements in order to ensure that all risks associated with electrical installations and equipment are eliminated or minimised within an acceptable level.

1.3 What issues does this Guidance Note address?

This Guidance Note presents the framework for the management of electrical installations and equipment and procedures 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 operations.

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 dependent upon specific circumstances or regulatory specific requirements is also recognised. 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 and assist mine operators, engineers and technicians comply with their duties about controlling the major hazards associated with the use of electricity in mines and operating sites. All sites must ensure that these requirements are identified and complied with.

The guidance has been designed to be applicable for all Vedanta 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 programme must be designed where the guidance is not followed:

- Electrical standards are the responsibility of the Site / Mine Manager and Engineering Manager who will drive the implementation of electrical standards and is supported by the SBU Head with authority to approve new requirements and will be accountable for successful implementation.
- The guidance for the control of specific hazards only applies where those hazards are present so, for example, in a mine where there is no likelihood of flammable gases, the mine operator will not need to take any specific action. Unless otherwise specified all voltages are alternating current (ac). Finally, the success of electrical standard implementation is largely dependent on the support of the SBU Head.
- Once the electrical standard is in place, an audit needs to be conducted with competent resources to determine the status of the site about 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.

The remainder of this Guidance Note is structured as follows:

- Section 2 – Analysis Hazards and Risks
- Section 3 – Planning the Installation of Electrical Equipment
- Section 4 – Electrical System Construction
- Section 5 – Oil-Filled and Dependent Manually Operated (DMO) Electrical Switchgear
- Section 6 – Zoning of Areas of a Mine Relating to Potentially Explosive Atmospheres
- Section 7 – Storage Batteries and Use of Safe Voltages on Hand-Held Equipment
- Section 8 – Adverse or Hazardous Environments
- Section 9 – Insulation, Protection and Placing of Conductors
- Section 10 – Earthling
- Section 11 – Referencing and Equipotential Bonding or Earthling
- Section 12 – Connections and Protection from Excess Current
- Section 13 – Earth Leakage Current
- Section 14 – Cutting Off the Supply to Underground
- Section 15 – Isolation and Actions where Flammable gas is Detected
- Section 16 – Isolation of Plant
- Section 17 – Work on Equipment Made Dead
- Section 18 – Work on or Near Live Conductors

- Section 19 – Electric Arc Welding
- Section 20 – Electric Shock Notices
- Section 21 – Implementation and Training
- Section 22 – Monitoring
- Section 23 – Review

Annex A: *IP rating chart*

Annex B: *Example of Main Substation Standard*

2. ANALYSIS HAZARDS AND RISKS

Electrical emergency events can introduce hazardous situations not normally encountered on a mine site. The site should conduct a comprehensive site-wide risk assessment to identify all major foreseeable electrical emergency events that could impact on the mining operation and its personnel.

3. PLANNING THE INSTALATION OF ELECTRICAL EQUIPMENT

The Site / Mine Manager and Engineering Manager should assess the inherent environmental conditions in each site and plan the installation and operation of electrical systems to control risk. This is particularly important where the potential for a flammable/explosive atmosphere exists. The SBU Head should consider arrangements for isolation or making safe and subsequent restoration to normal conditions when positioning equipment. Schematic diagrams of electrical equipment installations should be made, kept up to date and retained to enable effective planning and to facilitate safe operation. The diagrams should include any and all interlocking and other safety related arrangements.

The planning and installation of electrical infrastructure and equipment should consider the outcomes of the electrical risk assessment that proceeds the design of these.

Schematic diagrams of the distribution system should be clear and drawn utilizing standard graphic symbols in general use, and they should show all electrical equipment including cables operating at a voltage exceeding 220 Volts. Additionally, the diagram should show the planned settings of any electrical circuit protection devices which are designed to be adjustable.

Isolation arrangements should also be carefully considered, for example, to avoid isolation points being positioned on the return side of a fire source. Copies of the diagrams should be kept at the surface of the mine and posted at substations and distribution boards or at any point where isolation is complex, for example, ring main circuits or parallel feeds.

Schematic diagrams and plans should be updated periodically or after any major change. In addition to schematic diagrams designs should show the position of major assets and cable routes, and when planning these routes and positions, major hazards should be taken into consideration.

Consultation and exchange of information between electrical engineering staff, and those people responsible for ventilation should take place to ensure safety. Agreed plans should be endorsed (signed-off) by all parties.

4. ELECTRICAL SYSTEM CONSTRUCTION

Every electrical design has unique requirements, depending on the scope of the project. The project scope is determined by the project requirements and the type of structure that will be affected. The designer must evaluate the existing electrical system to ensure that existing electrical system can accommodate new additional electrical loads that will be imposed on them. When the design is for a new facility then the scope of the project is a much more complex electrical design.

Construction of an electrical system includes individual items of equipment and how they are assembled and connected. Equipment constructed to appropriate in-country standards or equivalent international specifications should be used (e.g. Ingress Protection (IP) rating chart in Annex A).

When planning and constructing a system the Site / Mine Manager and Engineering Manager shall:

- Ensure the system is planned, installed, protected, commissioned, tested and maintained to control risk.
- Select suitable equipment to ensure compatibility, e.g. connecting ATEX-certified to non-certified or pre-ATEX-certified equipment. ATEX is the abbreviation for explosive atmosphere. It is a European Union directive from the European Committee for Standardization that covers “equipment and protective systems intended for use in potentially explosive atmospheres.
- Where necessary to control risks, ensure the supply can be automatically de-energized to Zero energy or easily made safe.

  A secure power supply must be provided where electrical plant is an essential part of major hazard control. This may include environmental monitoring equipment, control rooms, winding apparatus and ventilation fans. Systems should be constructed to minimise the risk of, or arising from, total power loss for any significant period. This can be achieved through connection to a ring feed or a suitable sized backup generator.

  The mine manager should consider the overall characteristics of an electrical system before undertaking any modifications to the system, or part of the system. Examples include changes in fault levels, fault paths, fault clearing capabilities and switching arrangements.

  The demarcation of responsibilities between the electrical power supply provider and the mine should be determined and agreed upon between the parties. Materials used in the construction of electrical equipment should be selected to minimise risks. Items to be avoided include:

  - Some insulating materials (typically phenolic types) which decompose when subject to arcing and give off large volumes of potentially toxic or flammable fumes. Consider using cables having a high oxygen index number for confined spaces or underground installations. The number allotted to material depending on minimum percentage of oxygen required to sustain combustion. If the

material used is having oxygen index number 27, it means that minimum percentage of oxygen required to burn the material is 27 % which is well above the normal atmospheric oxygen percentage of 21 %. Thus, the insulation material should not catch fire.

- Equipment containing polychlorinated biphenyls (PCBs) and polychlorinated terphenyls (PCTs).
- Exposed light metals and their alloys, e.g. aluminium and magnesium or titanium and zirconium where the electrical equipment is to be used in a potentially flammable atmosphere. Aluminium and magnesium can produce incendive sparking if subject to frictional contact with rusty iron or steel. Titanium and zirconium can produce incendive sparks under impact or friction against any hard material, even in the absence of rust.

Where the use of such light metals or their alloys cannot be avoided, they should be encased or covered with alternative material to minimise the risk. Where low-current auxiliary circuits are connected to high fault level bus bars suitable protection, such as fuses, should be provided as near to the bus bars as practicable to protect the auxiliary circuit wiring. The electrically unprotected connections between the fuses and bus bars should be arranged to avoid faults by, for example:

- Keeping the leads as short as possible.
- Physical segregation.
- The use of reinforced insulation.

Electrical signalling, control and interlocking systems should be designed, constructed and installed, so far as is reasonably practicable, so that any electrical failure causes the equipment they are controlling to fail to a safe condition. Where any power backup system, vehicle or locomotive with a battery or alternator is to be operated in a potentially flammable atmosphere, or for carrying explosives, the chassis or frame should not be used as the current carrying path for any electrical circuit capable of igniting that atmosphere. This does not preclude the earthing or referencing of the chassis or frame to enable suitable electrical protective or monitoring devices to operate.

Where more than one plug or socket of the same type is used at the same place, and danger could arise if unrelated plugs and sockets were coupled together, then precautions such as keyway coding, padlocking or marking of switchgear and plugs and sockets should be taken to control risks. Transformers should be constructed to ensure lower voltage conductors cannot become charged above their normal voltage.

Where a potentially dangerous defect is found, then it must be recorded and action taken as swiftly as possible to control the risks. If repair is not undertaken immediately, safeguards must be implemented, e.g. by isolation of equipment and the application of personal padlocks with tag. A system of appropriately colour-coded locks or departmental locks with identification tags should be used for defective plant as fully described in the Lock-out Tagout guidance note. The supply voltage for use underground should not normally exceed 11 000 V. In certain circumstances system voltages should be restricted to lower values; these include:

- 6600 V supplying equipment which is normally stationary but is moved at certain times with the power applied to it, e.g. a transformer which moves in fixed increments in relation to a working mineral face.
- 3300 V supplying motors or machines (excluding distribution transformers) which are designed to be moved while working and which are served by flexible (trailing) cable.
- Systems supplying electric traction equipment by means of contact lines:
  650 V with rail returns.
  1200 V for other systems.
- lighting systems:
  125 V at or within 10m of a workface
  250 V elsewhere.

Appropriate precautions should be taken to avoid damage to electrical equipment arising from other activities, e.g. contact with mobile plant, shot firing or dinting operations. Control measures include shielding, isolating, or removing and reinstalling. Mine managers should have arrangements in place, prior to any work on equipment, to ensure that all potentially dangerous sources of electrical energy have been isolated and discharged. Appropriate safety checks and tests should be carried out to identify and isolate cables correctly, before equipment is dismantled or cables are removed from any system – and prior to restoration of power.

5. OIL-FILLED AND DEPENDENT MANUALLY - OPERATED (DMO) ELECTRICAL SWITCHGEAR

Electrical equipment using oil as a means of cooling, insulation or arc suppression poses a significant fire hazard. No new oil-filled equipment should be introduced below ground. Existing underground oil-filled equipment should be replaced with equipment that does not contain oil as soon as practically possible. Risks may be reduced by replacing the oil with synthetic fluids specifically manufactured for switchgear, which have a much higher flashpoint; checks should be made with the electrical equipment manufacturer regarding suitability.

DMO electrical switchgear poses significant risks to personnel during switching and existing equipment should be replaced. In the interim an assessment of the safe operation of DMO switchgear should be made in accordance with the guidance in keeping electrical switchgear safe.

In switchgear fitted with DMO mechanisms, the operator opens and closes the contacts within the switchgear solely by manual effort. Movement of the contacts is dependent on the speed and actions of the operator. Hesitancy can lead to failure of the switchgear with potentially fatal consequences. Under some circumstances, such as operation during fault conditions, it may be physically impossible to close a DMO switch due to the electromagnetic forces involved. This type of switchgear should be phased out as a matter of priority.

6. ZONING OF AREAS OF A MINE RELATING TO POTENTIALLY EXPLOSIVE ATMOSPHERES

Site / Mine Manager and Engineering Manager should prepare and keep updated a suitable plan at every site showing any zones in which flammable gas or flammable dusts, whether or not normally present, are likely to occur in a quantity sufficient to indicate danger, that is, zones classified under the requirements

of the in-country Dangerous Substance and Explosive Atmosphere regulations. If no in - country regulation is in place, it is recommended the mine follow DSEAR regulation 7(1), HSE, UK or similar regulation. The mine operator must ensure that overall explosion safety is verified by a competent person.

Electrical equipment intended for permanent installation and use in such zones must be of an appropriately certified type, unless the Site / Mine Manager and Engineering Manager's risk assessment finds otherwise. New equipment must meet the certification requirements of the Equipment and Protective Systems (EPS) intended for use in Potentially Explosive Atmospheres Regulations. Equipment that predates the updated EPS Regulations of the UK that was certified for use in potentially explosive atmospheres to earlier standards, can continue to be used providing it is correctly repaired and maintained. Where the use of equipment from the EU or wider European Economic Area is considered, it must have CE certification, from areas outside the European Economic Area it must be certified by an ATEX-notified body to ensure safety.

Where the mine's risk assessment indicates that circumstances allow for the safe use of electrically-powered equipment not of the type described in the paragraph above and not permanently installed in the mine, e.g. for monitoring, testing, recording, measurement or other special purposes, then suitable arrangements for its safe use should be set out. This could be in the form of a method of work which allows such equipment to be used safely.

Only certified approved electrical equipment shall be used in zones in which flammable gas or flammable dusts, are likely to occur in a quantity sufficient to indicate danger. Notices should be posted at the entrances to the zones to warn people that only suitable types of electrical equipment are to be used beyond that point.

The introduction, location and use of equipment in zones where flammable gas is likely to exceed 25% LEL (1.25% v/v for methane – should be carefully planned and controlled). Mine managers should implement procedures for ensuring that all equipment is safe when deployed in these conditions.

Blind ends require additional features to reduce risks. The arrangements should include locating the controlling switchgear and power supply on the intake side of any blind end. In addition, a fan interlock should be included to ensure the electrical supply is removed in the event of the auxiliary fan stopping. This is to ensure that electrical equipment does not remain, or become, energised in an unventilated location. Where the potential for an explosive atmosphere exists, fan interlocking should be mandatory.

When the air to a working place has previously circulated through an area where a potentially explosive atmosphere may be present, then flammable gas monitoring should be provided to detect the approach of flammable gas. Interlocks should be provided to remove power to all rotating cutting elements at 25% LEL. This is to provide protection from any plug of flammable gas created in other areas passing over rotating cutting element where incendive sparks can occur.

7. STORAGE BATTERIES AND USE OF SAFE VOLTAGE ON HAND-HELD EQUIPMENT

Traction batteries should only be changed at designated charging or transfer stations which should be of adequate size and suitably equipped for the purpose, e.g. provided with arrangements for lifting or handling batteries and adequate means to combat fire. Charging apparatus should be on the intake side of the battery racks and air passing from the battery racks should not subsequently ventilate any working place.

Where the transfer of traction batteries requires the use of trailing cables, arrangements should be made to protect the cable from damage due to over-tension and particular care should be taken to maintain plugs and sockets in a clean and dry condition. Only traction batteries having a mid-point isolator should be stored below ground at places other than the designated charging stations.

During the transportation or storage of traction batteries all isolators provided on the battery container should be switched off. Batteries should be transported in a suitable purpose-designed carrying device or vehicle. Charging apparatus for traction batteries shall incorporate means of automatically cutting off the charging current if excessive leakage current between the battery under charge and its container is detected. The permanent lighting provided in underground charging stations shall be certified for use in potentially explosive atmospheres.

To avoid electric shock from exposed, charged, conductive parts only low voltages, at or below 50 V ac or 120 V DC, should be used as a substitute for earthing or other precautions. Hand-held equipment used at greater voltages will require additional precautions, including double insulation or supply from an isolating transformer.

In highly conducting locations, or where the person working in the area with a damp body and have a large area of contact with earthed or referenced conductors, consideration should be given to using DC hand-held equipment.

8. ADVERSE OR HAZARDOUS ENVIRONMENTS

Equipment must be sited to obviate its exposure to conditions which might adversely affect its safe operation. Where this cannot readily be achieved equipment must be suitably protected from adverse conditions, including:

- Impact, stress, strain, abrasion, vibration or crushing.
- Liquids or vapour (see IP rating chart in Annex 1).
- Dirt or dust (see IP rating chart in Annex 1).
- Low ventilation movement through the area

Where equipment may be exposed to atmospheres containing combustible dust it should be constructed to avoid any external part achieving a surface temperature in excess of 33% of the ignition temperature of the dust in normal operation (150^{o}C for coal dust).

Where a potentially flammable or explosive atmosphere could occur at the surface of a mine, e.g. a flammable gas drainage plant or at places containing large quantities of explosive or flammable materials, electrical equipment should be selected, installed and maintained to minimise the ignition risk. Lightning protection devices and anti-static materials or devices should be used where necessary.

9. INSULATION, PROTECTION AND PLACING OF CONDUCTORS

The mine manager must institute measures to ensure that no person suffers any electrical shock, arc flash or electrocution as a result of:

(a) Exposure to electrical current flow;

(b) A person coming into contact with live exposed parts of any electrical apparatus;

(c) Exposure to electricity, arc flash, all fault currents, overvoltage and surges;

(d) Any electrical apparatus failing due to electromagnetic interference from other equipment;

(e) Any electrical apparatus being incorrectly designed, installed, operated or maintained; and

(f) Any exposure to blasts, fires or arc flashes resulting from electrical faults.
These measures include, but is not limited to:

- Proper fencing off or enclosures or clearances of electrical apparatus
- That any extension of any electrical reticulation system is approved by a competent person before being energised, considering the reticulation network and the effect thereon;
- That only competent persons are permitted to energise, de-energise or isolate electrical apparatus where the operation of such apparatus poses a significant risk and that such apparatus are protected against unauthorised access and operation;
- That only competent persons authorised in writing by the employer to do so; carry out switching procedures on MV or HV equipment; and
- That where the interruption of electrical supply to any equipment could result in a significant risk, such electrical supply can be provided from another source or network, which can include an emergency supply alternator or generator, for power supply in the event of an interruption to the normal power supply.

Where the conductors or insulation may be vulnerable, additional protection against physical, mechanical, chemical or other foreseeable damage should be provided by means of enclosure or armouring and sheathing.

Circuit conductors must be suitably placed or otherwise safeguarded to prevent risks through unintentional contact or should be covered with insulating material of suitable quality and thickness. Additionally:

- Conductors used at a voltage exceeding 125 V, where necessary, should be further protected by metallic screen, armour, or conduit. Semi-conductive materials may also be used where they afford a similar level of protection.

- Conductors used below ground where flammable gas or dust may occur should be provided with a metallic covering, screens or armour so arranged to minimise the ignition of flammable gas or dust. This is not required where conductors are connected to intrinsically safe circuits incapable of producing incendive sparks or arcing.

Steps must be taken to ensure that exposed conductive parts either do not become charged or, if they do, the values of voltage and current and their duration are such that negative consequences will not be possible. These include:

- Referencing, and equipotential bonding or earthing.
- Use of safe voltages.
- Current limitation.

The outermost protective covering provided for any conductor in cables should not readily propagate flame. All terminations of cable coverings, armourings or conducting screens should be securely attached to the apparatus and adequately sealed, where necessary, to prevent the ingress of substances likely to affect the integrity of the insulation or circuit conductors.

The conducting coverings, armourings or screens provided in any cables should be connected to the frame or case of the associated equipment to ensure adequate mechanical strength for the duty and to provide a low-resistance path. Armourings should be protected, as necessary, against corrosion and enclose all the conductors in the cable.

For fixed cables operating above 650 V, the metallic screens should be of steel wire armour or another suitable hard metallic sheath. Where necessary to increase conductivity, steel armouring may be supplemented by copper strands.

Permanently or semi-permanently installed cables should be positioned or properly supported at suitable intervals throughout their length, to minimise the risk of damage. Where the route of a cable is not obvious, e.g. a cable in a trench, it should be marked by marker tape or ‘danger’ tiles buried with the cable and its position kept on a plan at the mine office.

For flexible cables which are designed to move while energised, the metallic covering may be:

- Steel wire armouring which are suitably flexible and enclose all the conductors in the cable and are protected, as necessary, against corrosion; or
- Conducting screens which are suitably flexible and protect each circuit conductor individually; or
- A suitable flexible conducting screen protecting the circuit conductors collectively, containing an independent earth or reference conductor of at least the same cross-sectional area as the largest circuit conductor; or
- A combination of the above.

Unarmoured and unscreened flexible cables, where used in adverse conditions, should be positioned within shielding (cable tray) and protected to avoid inadvertent contact or damage whilst energised.

Mains-powered (230 V and above) flexible cables used at places where they are vulnerable to damage, except those forming parts of intrinsically safe circuits, should be:

- Operated in a system which is earthed or referenced.
- Of a type in which the circuit conductors are individually enclosed by metallic or conducting elastomeric screens electrically connected to earth or the reference.
- Provided with suitable leakage protection arranged to cut off the supply in the event of the screens becoming connected to a live conductor.

Where flexible trailing cables do not need to be moved, they should be effectively supported and protected against physical damage. Wherever trailing cables supply 3300 V to mobile machinery they should, where necessary, be safeguarded by an appropriate cable handling system. Trailing cables that are used to supply mobile plant in multi-entry systems, arrangements should ensure that the risks of cable damage are minimised. These may include ramps to allow vehicles to cross over cables and cables being positioned away from moving machinery.

Manual handling of flexible cables should be minimised using appropriate cable reeling or handling devices. Exposed conductors should be placed so that they are not normally accessible.

Where the placing or safeguarding of conductors is insufficient to prevent exposure to risk other precautions should be taken, e.g. padlocked rooms with controlled access. Notices should be attached to enclosure covers to warn if live conductors are enclosed. Access should only be permitted using keys or tools by a competent person.

The risk of incendive sparking or shock from conductors which have become charged from high-voltage sources should be minimised by placing, or otherwise protecting, conductors to avoid induction or leakage of current. Intrinsically safe circuits and other low-voltage cables are vulnerable to induction from high-voltage sources and should be segregated and protected to minimise these effects.

The mine manager must implement measures to ensure that all suspended electrical cables that could cause a fire due to faults or mechanical damage, in stopes, haulages or shafts either through damage by moving machinery or by fall of ground are properly protected by a suitable and sufficient means such as:

(a) Switchgear which is electrically supplied and commissioned with discrimination settings for overload and earth fault protection to prevent a fire.

(b) Switchgear installed which is correctly rated to prevent a fire or explosion.

(c) All cables in areas where a fire can occur must be fire retardant cables or be coated with fire retardant material at areas in close proximity with timber.

10. EARTHING

The mine manager shall implement measures to ensure that the cross-sectional area of any earthing conductor is calculated to be capable of withstanding the maximum possible earth fault current condition.

Steps should be taken to ensure referenced conductors that carry electric current in normal conditions, e.g. combined neutral and earth, are prevented from reaching significant potentials above the reference level. Where potentially explosive atmospheres may occur, combined neutral and protective conductors should not be used. Open circuit or high impedance in a combined neutral and protective conductor can result in the exposed conductors, connected to the protective conductor, becoming charged at a significant potential leading to an increased risk of electric shock or burn.

Engineered joints, bolted links or bus bar primaries of current transformers may be installed in a referenced conductor provided the integrity of the conductor is maintained. If removable links or manually operated knife switches are inserted in a referenced conductor, suitable arrangements should be made to maintain the reference point.

Where a protective conductor is combined with a neutral conductor, precautions should be taken to prevent persons from simultaneously contacting the protective conductor and earth. All metalwork which may reasonably become charged should be bonded together and connected to the protective conductor.

When work is to be carried out on electrical apparatus which have been isolated from all sources of electrical supply, effective precautions shall be taken to prevent electrocution:

- By discharging all stored electrical energy, and,
- Testing for zero energy including any ring feeds by earthing such apparatus and, in the case of ring-feeds or dual supplies of power, by earthing on both sides of the associated electrical apparatus worked on, so as to prevent any conductor or apparatus from being made live.

The mine manager must implement measures to ensure that whenever work is carried out on electrical apparatus which has been isolated from all sources of supply, effective precautions have been taken by earthing or other means to discharge electrically such electrical apparatus or any adjacent electrical apparatus to prevent any conductor or apparatus from being made live accidentally or inadvertently while any person is working thereon.

11. REFERENCING AND EQUIPOTENTIAL BONDING OR EARTHING

The electrical system should be connected to a reference point such as the general mass of earth or the metallic framework of an installation to facilitate correct operation of the system to:

- Enable fault protection or insulation monitoring systems to function, e.g. earth fault protection.
- Stabilise the potential between circuit conductors and the reference point.
- Reduce the prospective shock voltage between circuit conductors and the reference point.

For underground mines the actual connection to earth shall be made to the earth electrode situates at the surface substation, which is the collecting point for all the mine earthing system conductors and is the main earth terminal for underground earthing.

Equipotential bonding or earthing reduces hazards arising from:

- Potential differences between exposed conductive parts.

- The passage of stray fault currents through fortuitous paths, e.g. people.

Where single-phase systems are earthed or connected to a reference point the connection should be at the mid-voltage point. This does not normally apply to 110 V contactor control circuits. In the case of polyphase systems, the neutral point should be earthed or referenced at the source of supply.

Where the mid-point or neutral point is artificially created by the use of balanced impedances or resistances, protection should be no less effective than earthing or referencing at the source. Site / Mine Manager and Engineering Manager should be aware that earthing practices for electric arc welding in mines differ from industrial practices and these are outlined in Electrical earthing.

A conductor used to connect a system to earth or a reference point should not incorporate any switch, fuse or other device that results in loss of reference. This does not preclude the use of current limiting devices or suitable arrangements to transfer the reference from one point to another, nor the use of switches designed to open all the circuit conductors (including the neutral) simultaneously to prevent danger. Where the continuity of earth or reference conductors is interrupted by disconnection of restrained and interlocked plugs and sockets, the earth or reference circuit should be the first to make on connection and the last to break on disconnection.

Where referencing and equipotential bonding or earthing is adopted, any exposed conductive parts should be efficiently connected to the reference point. All electrical network reference points should be connected to the general mass of earth by means of suitable earth electrodes.

The resistance between the earth electrodes and the general mass of earth should be low enough to allow the electrical protection equipment to operate in the event of a fault occurring. This resistance should not exceed 2 Ω. Where ‘earth-free’ referencing is used a specific reference point should be created (e.g. the metal framework of a vehicle) and all exposed conductive parts of equipment bonded to this part by suitable conductors.

The design and construction of an earthing or referencing conductor should be suitable for the maximum current it may carry under fault conditions. Consideration should be given to the selection of cables where the earth conductor is a screen enclosing a circuit conductor. This is to ensure cables can carry the maximum earth fault current that can occur, and for the duration that the fault may be sustained, before the protection operates.

Earthing or referencing conductors, including joints and connections, in fixed equipment or cables should have a combined conductivity of not less than 50% of that of the largest associated circuit conductor. In the case of cables having metallic coverings, not less than half of the minimum 50% conductivity should be provided by the metallic covering. A lower level of conductivity may be used for fixed cables operating on power systems at the surface of mines where the maximum earth fault current is restricted, and automatic leakage fault trip devices are provided. The protection should be no less than that on an equivalent unrestricted system.

Earthing or referencing conductors in flexible cables should have a combined conductivity, including any joints or connections, of not less than that of the largest conductor in the cable. In systems containing flexible cables where the maximum earth fault current is restricted, a lower level of conductivity may be used but the combined conductivity of the earthing or referencing conductors should not be less than half of that of the largest conductor in the cable. Unscreened flexible cables, including pliable wire armoured, should incorporate an earth conductor or conductors in addition to any armouring provided for mechanical protection.

12. CONNECTIONS AND PROTECTION FROM EXCESS CURRENT

Connections should:

- Incorporate adequate insulation to prevent electric shock.
- Be made to avoid high resistances which can lead to overheating, arcing and incendive sparking, particularly where a flammable atmosphere may be present, to avoid fire or ignition.

Circuit conductors with differing current carrying capacities should not be connected, unless the circuit electrical protection is arranged to protect the circuit conductor having the lowest current carrying capacity. Cable glands, couplers, plugs and sockets, and cable entries of junction and sealing boxes, should be constructed to maintain effective electrical continuity and be sealed to prevent ingress of contaminants.

To avoid any potentially dangerous arcing while any plug is being inserted or removed from any socket, interlock circuit pins must be shorter than power circuit pins. Plugs and sockets used below ground should be of the restrained or bolted and interlocked type. To restrict interference by unauthorised personnel, plugs and sockets should be of a bolted type where they are used on equipment served by flexible cable and operating at above 1100 V.

In all cased where it is possible cablers must be hard wired to the distribution panel.

Systems should incorporate some form of excess current protection. The excess current protection must match the characteristics of the system and be supplemented, if necessary, by other devices, e.g. thermal protection against overheating. It should be set to operate at as low a value of time and current as possible. The settings should be arranged to give the necessary discrimination to permit the effective operation of equipment.

Circuit breakers should be capable of making and breaking the most onerous short-circuit current without danger. Equipment not required to make or break a short circuit should be capable of carrying such a short-circuit current either indefinitely or until such time (normally less than five seconds) as the system fault can be cleared.

13. EARTH LEAKAGE CURRENT

The danger from earth leakage can be minimised by limiting the prospective fault current in the system and consequent selection of appropriate protection devices. In assessing the risk, the Site / Mine Manager

and Engineering Manager should consider the characteristics of the system and the maximum energy available.

The person responsible for the safety of electrical equipment at a mining operation must ensure that an earth leakage protection device is provided for:

- All alternating current circuits installed in underground mines, quarries, or other part of the mine
- All circuits providing alternating current supply to portable, mobile or moveable equipment.

Where a high voltage circuit supplies alternating current exceeding 1,000 V, the circuits specified above must have an earth leakage protection device that operates at an earth leakage current not exceeding 2A. This must be achieved in the context of safe step and touch voltage limits.

For low voltage electricity, the circuits must have an earth leakage protection device that incorporates a readily accessible means for testing the operation of the device.

Residual current devices (RCDs) are earth leakage protection devices provided to final sub-circuits to isolate the electrical supply to socket outlets if the current flow to earth exceeds 30 mA

If the leakage fault currents are limited by high-integrity resistors or reactors, the risk of electric shock from exposed conductive parts, e.g. the framework of machines, is correspondingly reduced. This technique should be used for equipment that is moved while energised.

Power systems which are referenced to earth (excluding those using an earth return) should have protection provided to cut off the supply automatically in the event of excess leakage to earth, or reference as follows:

- Above 650 V for systems comprising equipment designed not to move while energised.
- Above 125 V for systems comprising equipment that is intended to move while energised.

For power systems with their reference connected solidly to earth the fault current and its duration should be limited to as low a value as reasonably practicable. The maximum value of trip settings should not exceed 2 A, or 15% of the rated load current, whichever is the greater. Where cables containing conducting elastomeric (semi-conducting, non-metallic material) screens are used, the trip setting should take account of the low screen conductivity and should be less than 1 A.

In power systems the following values of earth fault current limits should be adopted:

- 1 A for mains lighting at or within 10 m of a production face.
- 2 A where more than one neutral point is connected to earth.
- 2 A on every system below ground operating at voltages between 650 and 1200 V.
- 2 A on every system supplying equipment designed to be moved while working, and which is served by flexible (trailing) cable, up to 3300 V.
- 16 A on every other system below ground operating at voltages between 250 and 650 V, and supplying electrical equipment installed in potentially explosive atmospheres.

No system that operates above 1200 V and has a maximum prospective earth fault current exceeding 150 A should be installed below ground in a mine. To ensure effective operation, the settings of earth leakage fault protective devices should have a ratio between the maximum prospective earth fault current and that required to operate the tripping mechanism of at least 3:1 and preferably 5:1.

14. CUTTING OFF THE SUPPLY TO UNDERGROUND

Surface switchgear should be provided for all underground electrical systems supplied from the surface, except ventilations and communication systems, to allow the power supply to be cut off and isolated. Competent people should be available at the surface to operate the switchgear and be contactable whenever people are below ground. Operation may be manual or remote. Any remote tripping circuit should be monitored and reliable.

The supply may be cut off automatically or manually and the switchgear should be:

- Capable of cutting off the supply under all foreseeable normal and abnormal conditions.
- Located in a suitable and convenient place.
- Arranged for the continuity of electrical power to equipment essential for the safety of people, such as ventilating fans, winding apparatus and water pumps.
- Clearly marked to indicate the equipment which it controls.

The mine manager is responsible to ensure that a suitably qualified person draws up and implement a procedure for all energising, de-energising and isolation of medium or high voltage electrical apparatus.

15. ISOLATION AND ACTIONS WHERE FLAMMABLE GAS IS DETECTED

Mine manager should have arrangements in place to ensure that when any person or system at a mine detects flammable gas in a concentration exceeding 25% LEL in the general body of the air, either below ground or at any place on the surface:

- The supply of electricity is immediately cut off to any electrical equipment, other than electrical equipment certified to remain energised, situated at the place where the flammable gas concentration is detected.
- Where this is not possible, take all reasonably practicable steps to make such equipment safe.
- If unable to make safe for any reason, then this should be reported immediately to the most senior person on duty.

Where action has been taken details of the time, duration and location should be recorded. If the supply of electricity to electrical equipment is cut off, or the equipment made safe, it should remain in that condition until the senior person on duty at the mine, having determined that it is safe to do so, directs that the supply can be re-established.

Where equipment derives power from an internal source, e.g. a battery, then additional precautions may be needed in addition to cutting off the supply to make that equipment safe. Such precautions may include removal to a non-hazardous area and re-introduction following permission from the senior person

on duty at the mine. When equipment has been exposed to flammable gas exceeding 40% LEL some flammable gas may remain within equipment. Enclosures which include devices that arc or produce sparks in normal operation should be purged to remove flammable gas before power is restored.

16. ISOLATION OF PLANT

A switch to cut off the power supply between a flexible cable and a fixed cable should be provided at the interconnection. Where this is not the case, protection should be provided to trip and shut off the supply in the event of movement of the joint. Where a flexible cable feeds a framework supporting electrical gear over a conveyor near to workface from a fixed cable a means to trip the supplying switch and cut off the power should be provided at the pantechnicon.

A switch should also be provided on or near mobile machines to cut off the power in an emergency. Where switchgear cannot be sited near the operator, remote tripping devices should be used and be arranged to fail to safety. Any isolation switch on a mobile machine should be suitable for immobilisation purposes and form part of the machine itself.

Isolation arrangements should be accessible, and procedures should be simple to prevent mistaken operation. Batteries cannot be totally de-energised and should, if possible, be removed from any zones where conditions indicate an increased risk of fire or explosion. Where equipment, other than batteries, may store energy, e.g. capacitors, provision should be made for the energy to be discharged as part of the isolation procedure.

17. WORK ON EQUIPMENT MADE DEAD

Isolation should only be carried out by competent and authorised people. Precautions must be taken to ensure that the equipment remains isolated during the time people are working on it or for as long as is necessary. To avoid any unplanned restoration of power while work is being carried out, facilities for LOTOV or removable isolator handles should be provided. If the continued control of isolation of equipment cannot be guaranteed additional precautions such as earthing must be taken.

Equipment may become live as a result of induction, back feeds or leakage. Low voltages from other circuits inadvertently impressed on the secondary side of the transformer may cause a hazard when transformed up and this should be considered when working on the primary side. It may be necessary to apply the earth to the circuit through a circuit breaker capable of making and breaking fault current safely. If necessary, additional earthing may be applied in accordance with a safe method of work.

The different methods of LOTOV is fully described in the evenly names guidance note.

The Permit-to-work system must be used when working on certain electrical systems as outlined in the mine SOP. The permit to work system is to be folowed.

18. WORK ON OR NEAR LIVE CONDUCTORS

Work on live equipment shall not be allowed except in circumstances where it is essential to have equipment energized, such as testing or fault finding, and only with the necessary Arc Flash PPE and insulated tools, rescue plan and a stand-by emergency rescue person overseeing the work at all times.

Unless the mine manager can demonstrate that de-energizing introduces additional or increased hazards or is not feasible due to equipment design or operational limitations work on live equipment will be prohibited.

All energised electrical work will require a safe work procedure based on a comprehensive risk assessment specifically done for the task at hand and, with the exception of voltage testing or where no tools are used, will require an Electrical Work Permit reflecting the controls identified during the risk assessment.

Personnel must wear all PPE and die-electric gloves, flame resistant coveralls and full-face shield and helmet and standing on die-electric mats to do voltage testing.

Work on live conductors should only be considered on those systems where it is impracticable to make them dead before the work is carried out, e.g. work on storage battery terminals, or the carrying out of certain electrical tests. To reduce risks associated with live working, mine operators should consider the provision of alternative power supplies, properly laid out distribution systems and engineered equipment housings with inbuilt test facilities at the design stage of an installation.

Site / Mine Manager and Engineering Manager must ensure that no person attempts to work on, or near, any live conductor unless all the associated risks have been competently assessed for risks and controls implemented. Where it is not practicable to make the conductors dead, and it is reasonable in all the circumstances for the work to be performed live, the assessment should consider:

- Electric shock. In wet situations or conductive locations live work should not take place above 25 V ac or 60 V dc.
- Arc burn and fire.
- Ignition of flammable gases.
- Electrical fire.

Following assessment, the procedures for safe working should include:

- Adequate information about the electrical system and its risks.
- The use of suitable insulated barriers or screens.
- The use of suitable equipment, instruments and test probes. Testing to establish whether electrical conductors are alive or dead should always be done on the assumption they may be live.
- Effective control of the access to live conductors. Unauthorised people should be prevented from entering the area by the provision of barriers or lockable enclosures and warning notices.
- The use of personal protective equipment and clothing.
- The presence of an additional person, suitably trained to recognise danger, render first aid & CPR and call for assistance in an emergency.

Intrinsically safe circuits should, where practicable, be zero energy prior to any work taking place. Incendive sparking can occur as a result of interconnecting, multiple intrinsically safe circuits. To minimise this risk only one live circuit should be worked on at a time.

19. ELECTRIC ARC WELDING

Electric arc welding is a special case of work near live conductors. The precautions should include insulated electrode holders and provision of suitable protective clothing. In addition, the article being welded, and any associated metalwork should be earth bonded to any surrounding metalwork or framework which the operator is in contact with.

Certain types of plasma arc cutters have high open-circuit strike voltages, significantly greater than those of welding equipment. Where these devices are used additional controls will be required to minimise the risk of electric shock.

20. ELECTRIC SHOCK NOTICES

Access to first aid or emergency treatment following electric shock may involve lengthy delay at large mines and those located in remote areas. To provide instruction for non-first aid trained personnel, notices should be displayed in a form which can be easily read and understood and contain information on the appropriate first-aid treatment for electric shock and emergency action.

These notices should be posted in sub-stations, control and switch rooms, engine houses and in reasonable proximity to other places where switchgear and motors are installed or where electric arc welding is taking place. Also, at places where electrical energy is being generated, transformed or used at a nominal voltage in excess of 125 V AC or 250 V DC.

The notices should also include a prohibition on unauthorised people tampering with electrical equipment and directions on action to be taken in the event of fire or explosion.

21. IMPLEMENTATION AND TRAINING

Roles and responsibilities should be assigned to competent individuals for the implementation and maintenance of all electrical management at each location.

There should be a process in place for the on-going communication between the electrical function, operations management and operators. Change procedures should include the requirement to notify and document relevant personnel of planned electrical move-ups as development advances and any changes to the electrical reticulation and substation locations. Electrical drawings and related documents should be readily accessible by all relevant and authorised employees as electronic copies for control purposes. Printed and unsigned copies should be treated as unauthorised copies.

All electrical personnel, business partner employees, technicians and engineers shall have the accredited and certified training and competency as per the country's regulation, with the necessary re-training as directed by legislation and regulation.

There shall be a site-specific electrical competency standard covering all electrical work including construction, usage, maintenance, repair, decommissioning and demolition of electrical equipment, and including arc flash protection;

The site-specific competency standards shall specify the frequency for this re-certification, which shall be no less than every two years.

The site-specific electrical competency training shall include all the requirements contained in this guidance note.

Competency and training requirements shall be clearly defined in the operation's systems and procedures, and appropriate records maintained.

22. MONITORING

Inspections and auditing shall be carried out on a frequent basis and include;

- Recording and measurement of compliance to standards by the operation.
- Regular underground visits and inspection of compliance by line managers.
- Regular underground visits and monitoring by electrical engineering department.
- Regular underground visits by the safety department.
- Planned task observations.
- Periodic audits.

Clear procedures and processes should be in place for the identification, reporting and investigation of all electrical hazards and risks.

A mine site culture should be developed such that miners are willing to report all incidents without fear of retribution.

23. REVIEW

A formal, documented, annual review should be carried out of the continuing adequacy and effectiveness of the electrical management at the operation and associated arrangements and practices for the management of electrical hazards and risks.

The review should:

- Consider advances and changes of the mining methods used at the mine and technology that could potentially be adopted to improve the sites electrical requirements; and
- Include input by relevant technical specialists as well as senior mine management.

Based on the review, any necessary changes to the electrical management at the operation should be identified and implemented.

RELATED DOCUMENTATION

A summary of the references and supporting documents relevant to this document is provided in the

Following table.

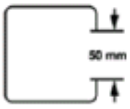
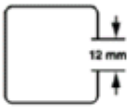
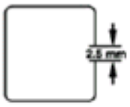
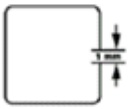
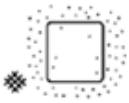
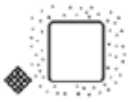
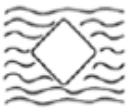
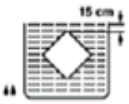
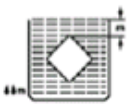
Doc. Ref. Document name

VSS	Underground Electrical Safety Standard
POL 06	HSE policy
VSS	Vehicles and driving
VSS	Ground Control – Underground Mines
VSS13	Emergency Response and fire management
VSS15	Explosives and Blasting
VSS17	Hoisting in Shaft
VSS18	Inflow or Inundation of Liquids
TS 06	Supplier and Business Partner Management
VED/CORP/SUST/MS 1	Leadership, Responsibilities and Resources
VED/CORP/SUST/MS 3	New Projects, Planning Processes and Site Closure
VED/CORP/SUST/POL 5	Supplier and Business Partner Management
VED/CORP/SUST/MS 6	Competency, Training and Awareness
VED/CORP/SUST/MS 9	Documentation and Records Management
VED/CORP/SUST/TS 10	Safety Management
VED/CORP/SUST/MS 11	Incident Reporting and Investigation
VED/CORP/SUST/MS 12	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 14	Health and Safety Management Systems

***Annex A*: IP Rating Chart**

The IP Code (International Protection Marking, contained in IEC standard 60529) sometimes also interpreted as Ingress Protection Marking, classifies and rates the degree of protection provided by mechanical casings and electrical enclosures against intrusion, dust, accidental contact, and water. Below is a graphic explaining the code numbers.

Reference Table of IP Rating Code

1st Digit	Symbol	Solid Object Protection	2nd Digit	Symbol	Water Protection
0		Not protected	0		Not protected
1		Protected against solid objects greater than 50mm	1		Protected against vertically dripping water
2		Protected against solid objects greater than 12.5mm	2		Protected against dripping water when tilted up to 15°
3		Protected against solid objects greater than 2.5mm	3		Protected against spraying water
4		Protected against solid objects greater than 1.0mm	4		Protected against splashing water
5		Protected from the amount of dust	5		Protected against jetting water
6		Dust tight	6		Protected against powerfully jetting water
IP 6 6 Code Letters — 1st Digit — 2nd Digit			7		Protected against temporary immersion in water
			8		Protected against continuous immersion in water

Annex B: **Template of Main Substation Standard for Mines**

MAIN SUBSTATIONS STANDARDS

1. CLEANLINESS

Each substation shall always be kept clean and clear of debris and no flammable materials should be allowed to be stored in or near the substation.

Cleaning utensils and materials should be available at each substation in order to maintain the standards of cleanliness required.

Substation entrances and egresses should always be kept clear and accessible.

Each substation floor shall be painted according to Mine Standards for substations.

2. ROOF AND SIDEWALLS

All sub stations should be excavated in an area of un-faulted, dry ground in the main ventilation air stream to assist in cooling of transformers etc.

The excavated area should be supported by bolts and shotcreted and a coating of whitewash applied where possible on the roof and sidewalls and kept in a safe condition at all times.

If it is not possible to prevent total overhead water ingress, a protective roof of such dimensions as to ensure that all electrical equipment beneath it are covered and protected from moisture, should be erected.

All substations shall be provided with a fence or wall around the entire area and an access gate which will always remain locked to prevent unauthorised entry must be erected.

An up to date line diagram must be displayed at the entrance to every substation or distribution board.

A sign “Authorized Personnel Only” must be attached to the outside of the access gate

Suitable and sufficient fire extinguishers must be placed on the outside of the substation, near the entry and at the fresh air side of the ventilation flow.

Sufficient lights and emergency exit signs must be installed basted on a risk assessment of the area.

All exit doors and gates must be equipped with panic bar on the inside to allow for quick exit in an emergency.

3. MAINTENANCE / PERMIT CABINET

No unauthorised item may be stored inside a substation or distribution board.

A cabinet shall be provided in each substation in which will be kept the following: -

a) Permit to work / isolation book

b) Lock box containing a suitable number of all LOTOV gear required for use in the substation.

c) “Caution – out of service” tags

d) “Electrical Hold off” tags

e) “Danger – do not operate” tags

f) Any spares and tools required to maintain the substation in good order

g) Retrieval hook

h) Emergency plan and emergency phone numbers

i) Phone

j) No flammable material may be stored in this cabinet.

4. RACKING EQUIPMENT

Where applicable, each substation shall carry its own racking equipment for the racking in and out of all electrical switchgear being utilised in that substation

5. PROTECTIVE EQUIPMENT

- Insulated mat
- Retrial hook
- HT earthing stick and cable

Note All the above items to be 11kv rated.

6. FIRST AID EQUIPMENT

Burns box

7. TELEPHONES

Each substation shall be equipped with a telephone and a current up-to date telephone listing and emergency contact list shall always be posted at or near the telephone

8. FIRE EXTINGHISHERS

Each substation shall be equipped with firefighting equipment that shall be mounted on the wall outside the substation and shall be checked at regular intervals by the responsible person in charge.

9. DUSTBINS

Each substation shall be equipped with a dustbin.

10. MANDATORY SIGNS & NOTICES

1) Directions as to how to rescue persons in contact with live electrical conductors and to restore persons from the effects of electrical shock.

2) Directions as to the procedure to be followed in case of electrical fire.

3) A prohibition on any person other than an authorised person handling or interfering with electrical apparatus.

4) A warning of danger and an indication of the highest voltage used in relation to the apparatus to which the notice relates.

5) Directions as to how to communicate with the manager of the mine or the person in charge of the electrical apparatus.

6) A notice detailing who the responsible persons are for the specific substation.

7) The LOTOV 9 Step process poster.

Each substation shall have displayed a current schematic line diagram detailing where all electrical equipment within that sub is fed from and to where all associated equipment that is feeding.

1. SAFETY REQUIREMENTS FOR ISOLATION OF ELECTRICAL EQUIPMENT

A. Plan a job.

B. The electrical equipment or part of the equipment on which work is to be carried out, whether for the purposes of maintenance or testing, shall be effectively ISOLATED.

C. The equipment or part of the equipment on which work is to be carried out shall be, where practicable, effectively EARTHED at the point of isolation unless the part involved is physically detached from the isolated equipment (e.g. withdrawable circuit breaker etc.).

D. The isolator or shutters or whatever means are employed for isolation shall be LOCKED in the SAFE position using a personal isolation padlock and tag.

E. A 'DANGER NOTICE' shall be affixed at the point of isolation.

F. At the point of isolation, the person responsible for isolation shall observe isolator windows and live line indicators where fitted to check for effective isolation.

G. The member of the electrical engineering staff (AUTHORISED PERSON) is responsible for the isolation shall issue a 'PERMIT to WORK' to the person(s) who are to carry out the work.

H. Prior to commencing work SAFETY CHECKS shall be carried out to confirm correct isolation and may include; -

- observation of live line indicators and/or isolator windows,
- trying to start a piece of equipment which was running immediately prior to isolation,
- checking transformers for hum and other visual indicators

I. A DEAD LINE CHECKER or 10KV VOLTAGE STICK (WHICHEVER IS APPLICABLE) shall be used on all a.c. circuits as a final check that the apparatus is not live.

J. Isolating or restoring the supply by signalling or after a pre-arranged interval of time is STRICTLY FORBIDDEN.

2. SAFETY PROCEDURES

To enable safe isolation and Permit to Work systems to be operated effectively, it is essential that the following minimum procedures be adopted: -

2.1 Records and Diagrams

- An up to date diagram of the Main Electrical Distribution System at the Mine shall be kept in an office at the surface of the Mine.
- In surface and underground sub-stations an up to date diagram of the distribution switchgear associated with that sub-station shall be displayed. The diagram should show the purpose of each circuit breaker and the bus-bar arrangement.

2.2 Labelling of Switchgear

- All switchgear shall be labelled to indicate the plant or circuit it supplies. The label used should be robust and durable and the marking indelible.
- On ring main feeders and parallel feeder switches, where there is a possibility of reserve power flow (back feed), a notice must be attached to the switchgear indicating the possibility.

2.3 Identification of Cables

Where similar power cables run together, and confusion could arise:

- cables shall be clearly marked at each end and at 500mts intervals.
- Cable tracing shall be carried out by at least two persons, starting from either end to confirm correct identification. If it is not possible to clearly identify the cable, then: -
  - i. isolate all the cables in the area being checked and
  - ii. use cable spiking

2.4 Isolation Padlocks and Tag

- Each member of the Electrical Engineering Staff shall be issued with a 'Personal Padlock' that is individually keyed.
- In situations where a personal lock cannot be physically fitted then a secondary device (e.g. multilock) shall be used in conjunction with a personal lock.

2.5 Dangers Notices

- Each member of the Electrical Engineering Staff shall be issued with a substantially constructed label for his personal use when using his personal lock. The label shall be indelibly engraved:

DANGER LOCKED OFF or ISOLATED BY (NAME).

2.6 Planning Work

- An essential part of safe working is planning the job and instructing the people who are going to perform the work. It is the responsibility of the instructor to ensure his instructions are clearly understood. Written and/or verbal communications can be used for this purpose.
- A Planned Job Instruction Sheet (PJIS) shall be used when issuing instructions in writing.
- The PJIS shall specify: -
    i. Isolation and safety check Instructions
    ii. Job to be accomplished
    iii. Existing and proposed circuit arrangements
    iv. Any additional information required for safe completion of the work.
    v. Switching Plan if required
- The PJIS shall be prepared, checked and issued by persons in the AUTHORISED PERSON capacity.
- The SENOR AUTHORISED PERSON nominated to be responsible for isolation and in charge of the work shall receive and sign the PJIS to indicate understanding of the isolation procedures and the work detail.
- Where the work extends over more than one shift the AUTHORISED PERSON in charge of the work on each shift shall sign the PJIS sheet to indicate the sections of work which have been completed on his shift.
- If the work specified cannot be carried out as planned the work must stop and the AUTHORISED PERSON in charge of the work must re-plan the work.
- Additional information to that specified above may be included on the PJIS. However, the information called for above shall be included as a minimum.