Guideline Document:
Electrical Safety in Quarries

Introduction

Part of the ASPASA ISHE Audit (Health and Safety), ASPASA attempts to reduce any form of danger in the workplace and therefore the need to audit member quarries yearly.

Electricity kills! Every year many people at work suffer electric shocks and burns. Other injuries, such as fall are caused as a result of shock. The risk of electric shock is greater in quarries because cables or equipment may be exposed to wet conditions, damaged by plant (e.g. overhead power lines) or falling objects; or dug up during excavation.

This guideline gives practical guidance on electrical safety in higher risk areas in quarries. It does not cover offices or other low risk parts of quarries. The guidance is intended for quarry management, rather than electrical experts.

Health and safety document

ASPASA members should have a health and safety document dealing with this problem. Among other things this must identify the significant electrical risks and explain safeguards. The safeguards include ensuring the suitability, design, installation, maintenance and inspection of equipment and systems, and the competence of those involved in this work, or operating the equipment and systems. The health and safety document must be kept up to date. The management structure described in it must detail the duties of those involved in electrical work, including those of key contractors.

Suitability of equipment in a quarry

Electrical equipment used at a quarry must be suitable and safe for:

a) Its intended use;
b) The people who will use it;
c) The operating voltage, current and other equipment it is to be use with;
d) The environment – Will it get wet? Will vehicles drive over, or could they strike it? Could it be dug up? Could it be at risk from vandalism or damage from animals? Is it exposed to flammable vapours, mist or dust?

It must be designed and constructed to allow safe inspection and maintenance. It is strongly recommended that the design, construction and installation follow relevant South African standards.

Installation at a quarry

All electrical equipment must be designed and installed by competent persons. The installed system should:

a) be properly documented and labelled (individual conductors may need to be marked so that they can be readily identified, e.g. from drawings). Modifications to circuits also need to be documented;
b) ensure that all appropriate parts of the installation can be isolated by readily accessible switchgear that is clearly marked to show the circuits or equipment it controls;
c) provide appropriate protection against excess current (fuses or circuit breakers) and, where appropriate, against earth leakage;
d) facilitate safe inspection, testing, fault finding and maintenance;
e) be enclosed or placed so that direct contact with live conductors at dangerous voltages is not possible in normal use. Equipment that needs to be opened regularly also needs to be mechanically interlocked to prevent removal of covers or opening of access doors until the supply of electricity has been cut off, unless the interior parts are properly protected;
f) be sited to minimise the risks due to impact or environmental conditions, and where this cannot be achieved, protected to minimise these risks, for example by using suitable armoured cable, appropriate explosion protected equipment of mechanically robust enclosures;
g) have interlocks, and other controls, that are constructed and installed so that any failure causes the system to fail to safety;
h) include conductors and connections of adequate electrical and mechanical strength, with sufficient support where necessary, for any likely stresses;
i) restrict the access to areas such as switch rooms, substantiations or high voltage equipment to authorised persons; and
j) be commissioned and tested to verify that it is safe to use. A handover certificate should be issued to the operator to confirm that it is safe to use, following significant work.

Earthing

All electrical equipment which may become live in the event of a fault must be adequately earthed unless it is double or all insulted. For all installations that rely on earthing and bonding for electrical safety and protection the effectiveness of the earthing and bonding needs to be checked across the whole installation

Safe voltages

As a general rule the lower the voltage used the lower the risk of a serious electric shock. Where reasonably practicable hand held equipment should operate at 110V. This will virtually eliminate the risk of fatal electric shock if a cable supplying such voltage is damaged. Lower voltages are, however, necessary where conditions are very wet or when working inside a confined, conductive space, e.g. a metal tank. Hand lamps operating at 12 or 24V are suitable for most work, while the output voltage of open circuit arc welding handsets should be limited to 85V,

Where higher voltages (e.g. 23V a.c.) need to be used then the risk posed should be carefully assessed and additional safeguards, for example the use of suitable residual current devices at the point of supply, and/or armoured cable should be used where necessary.

The risk is greater when working on high voltage systems (e.g. 11kV a.c.) and those who do so need a high level of competence, and should be explicitly authorised to carry out such work.

Overhead electric lines

Overhead power lines are likely to pose a significant risk, unless vehicles and mobile plant cannot approach them. Vehicles and mobile plant do not need to strike the conductors of the overhead line for injury to occur – electricity can arc through a surprising distance depending on the voltage and conditions. Overhead lines should be re-routed, if necessary, away from areas where they pose a risk.

Precautions are required if a vehicle or mobile plant can reach the danger zone around the overhead line. Assessment of the risk must take account of the possibility of tipper lorries travelling with the tipper portion in the raised position.

Buried cables

The routes of all buried cables should be located when planning an excavation. This information should be recorded in the health and safety document, Cables should be diverted, if necessary, but all cables and their routes should be clearly marked. Other cables could be marked when they are installed or discovered to minimise the risk of them being accidently dug up. Cables do not need to be broken to cause danger, high voltage cables can explode violently if they are struck or bent sharply.

Even where cables runs are ***known,*** areas should be checked using cable location devices before any excavation work is started. Careful hand digging is often necessary to precisely locate the cable.

Flexible cables

Cables that may be moved while energised must be suitable for that purpose. Systems using flexible cables need to be designed and installed carefully, paying particular attention to the risk of mechanical damage and the importance of maintaining the integrity of the earthing. Earth monitoring systems are useful when the risk, in the vent of earth failure, is high. Cables with conducting flexible screens or armouring should be used where the risk of damage is significant.

Explosives and explosive atmospheres

Electrical installations in explosive stores need to be designed and constructed to a high standard. Radio frequency transmitters, electrically powered plant and overhead power lines can create a risk of accidental initiation with certain detonators. The electrical installation should be designed to minimise such risks when explosives are to be used at a quarry. Electrical equipment which is liable to be exposed to explosive atmospheres, for example methane from landfill, must be suitable for use in such conditions.

Switch rooms, or substations, should not be used as a storage area, particularly of flammable or explosive substances.

Maintenance

All electrical equipment must be maintained in a safe condition. All electrical systems must be subject to appropriate inspection, examination, testing and preventative maintenance by competent people. (For simplicity, on this page, the word maintenance includes inspection, examination and testing which is required to identify any deterioration and the necessary remedial work to keep electrical equipment and systems safe.) Good visual inspection will pick up a large percentage of common faults, but some faults cannot be found solely by an inspection.

Written scheme

The operator must have a written scheme for the systematic maintenance of electrical equipment. This must include electrical safeguards which form part of machinery guarding, for example, interlocks, trip wires, and emergency stops. The scheme should:

a) specify the maintenance to be carried out and frequencies – preventative maintenance should normally be in accordance with designers/manufacturer's recommendations. Taking into account the conditions of use;
b) set out the methods to be used, the record keeping, and the skills necessary for the people who will do the work;
c) set out the action to be taken is an imminent risk of serious injury is discovered, to safeguard those at risk; and
d) set out the arrangements for auditing the scheme.

People carrying out maintenance need;

a) drawings of the electrical installation, including modifications,
b) list of equipment to be maintained and

c) other relevant information, including design specifications and previous test results

They also need to use suitable test equipment in accordance with the manufacturer's recommendations. Such equipment must be properly maintained to ensure that it is safe, the results are reliable and that trends can be identified, It is useful to mark equipment which has been maintained with a tag or clear mark indicating the next due date for maintenance, so that any equipment that has been overlooked can be easily identified.

Inspection and other reports must be in a format that is suitable for the person who has to act on them. Any significant faults should be pointed out clearly using minimum of technical jargon.

Scope

The following need to be covered by the scheme:

- External inspection
- Internal inspection
- Conductivity of circuits
- Earth fault loop impedance
- Effectiveness of electrical protection
- Insulation resistance of circuits
- Insulation resistance of apparatus
- Prospective fault circuit
- Residual current device operation
- Effectiveness of earthing and bonding
- Portable apparatus
- Polarity
- Earth electrode resistance

Inspection, test and examination frequency

The frequency of inspection, etc. should be set to enable faults to be identified and corrected before they pose a significant risk. The frequency will depend on;

a) the type of equipment and installations;
b) where they are used, for example if they are wet or at risk of physical damage;
c) if they are fixed or mobile; and
d) frequency of use (e.g. 24 hours a day or once a year).

The chosen frequencies need to be reviewed regularly in the light of experience. Some commonly used frequencies, for LV equipment operating at 110V, are set out below:

Visual inspections	**Frequency**
Hand held tools – including plugs and sockets cables etc	Daily or before use
Other portable equipment	3 monthly
More detailed inspection/examination	
External parts of the installation	6 monthly
Accessible internal parts of electrical equipment	Yearly
All other parts of the electrical installation, including normally parts, e.g. internal parts of switchboard, motor terminal boxes an boxes	5 yearly
Test	
Effectiveness of earthing and bonding high risk moveable Apparatus Other systems	Monthly Every 6 months or yearly if risk of deterioration is low
Re-validation of the line resistance	3 Yearly
Earth Electrode Resistance	Yearly – in warm dry periods
Visual inspection	**Frequency**

Insulation resistance Earth Fault Loop Impedance Disconnection times for the protective devices (calculated)	Every 6 months, or yearly if risk of deterioration is low Every 6 months, or yearly if risk of deterioration is low Follow earth loop impedance tests
Residual current devices (fixed)	3 Monthly using the test button Every six months – timing test
Polarity	10 yearly (different 10% each year)
Portable apparatus	3 monthly to yearly
Preventative maintenance	As recommended by the manufacturer/designer, taking account of conditions of use

Working Methods

Safe working practices are especially important when inspecting, testing or repairing electrical equipment. Working on electrical equipment often means removing covers or dismantling the equipment, removing safeguards built into the equipment which increases the risk of injury. Anyone doing such work must be competent for the work they do. High risk work should normally be carried out under a permit to work system. but much work can be done safely using good isolation procedures.

Live working

Work may only be carried out on or near exposed live conductors when, in all the circumstances, it is;

a) unreasonable for it to be dead; **and**
b) it is reasonable for the work to be done live; **and**
c) suitable precautions have been taken to prevent injury.

All these conditions must be met before work can be done on or near exposed live conductors.

In practice there are few occasions when work cannot be carried out with the equipment dead. A decision to work live should usually not be left solely to the discretion of the person carrying out the work. The operator should set out the rules, the conditions under which any live work is permitted and the precautions that should be in place. If live working e.g. diagnostic testing, is justified it needs careful planning to minimise the risk of injury. This may involve the use of temporary barriers or insulating screens to prevent accidental contact, insulating mats and protective clothing. Test equipment and tools also need to be designed, used and maintained to minimise risks, Such work should only be carried out by persons who are competent to carry out such work.

It is good practice to specify in the site rules that live working, at dangerous voltages, other than testing is not allowed. If necessary work should be scheduled outside normal working hours, at weekends, during holidays or maintenance shutdowns. Live working cannot be justified because it is inconvenient to switch off the system.

Isolating equipment

Isolation must be carried out carefully to ensure that the equipment is actually dead before work on it begins and that it cannot be accidently reconnected. It is not sufficient top switch off the circuit. Isolation needs to be planned carefully to ensure that all ways in which the circuit can be made live are properly isolated and secured.

Isolation can often be achieved by padlocking switches in the open position. Keys should be unique and kept by the person doing the work with any spare keys kept securely. Removing and retaining the fuses for the duration of the work is only acceptable if, in addition:

a) there is no chance of someone putting in a spare fuse or
b) the fuse-way is secured with adhesive tape with appropriate warnings printed on it; or
c) the fuse-way can be secured with a locking fuse carrier; or
d) the enclosure using the fuse-way is secured.

After a circuit has been isolated it must always be tested carefully, to prove the circuit is dead, before attempting any work to it. A permit to work may be required to ensure clear understanding of the isolation and scope of the work in complex situations e.g. where there is more than one source of supply to the point of work.

High voltage (HV) equipment

Work on or near high voltage (HV) equipment presents a **higher** risk which requires careful assessment. Only competent persons, fully trained and experienced in this particular work, and authorised in writing, should be allowed to implement the permit system and operate the HV switchgear.

Before any work is carried out on or near HV equipment, precautions must be taken to avoid risks from the HV system. The risks, and the action to avoid them should be set out before work begins. In general circuits should be isolated, tested to ensure they are dead and earthed and secured in the earthed position i.e. locked. Additional precautions in the form of portable earths may be required in particular circumstances e.g. for work on overhead lines. Caution notices should be posted at points of isolation and danger notices posted on adjacent live equipment.

Competency

All persons required to carry out work on electrical equipment must be competent to carry out those duties. This means that maintenance and installation staff must have sufficient knowledge and experience to carry out their duties. It also means that staff who operate electrical equipment must be competent to carry out their tasks safely and understand the limits of their particular duties and competence. Persons not competent to work on their own, for example, trainees, should be adequately supervised. Consideration should be given to the qualities and experience of the persons selected to fulfil supervisory duties.

In some instances greater engineering expertise than available on site may be required to assess the results of inspections or to carry out electrical projects. Access to this expertise should be made available when necessary.

Way of having confidence in the competence of inspection personnel is to use inspection bodies who are either accredited or are members of a recognised trade association and have experience of this type of work in quarries.