REQUIREMENTS OF AUSTRALIAN STANDARDS AS/NZS2081

White Paper

The implementation of an effective electrical protection scheme is critical in ensuring the safety of personnel and equipment working with electrical systems. AS/NZS2081 - Electrical Protection Devices for Mines and Quarries represents best practice in the design and verification of safe electrical protection schemes appropriate for the unique mining environment.

This paper outlines the types of electrical protection stipulated in AS/NZS2081 and explores the criteria for implementing each to ensure a safe and effective protection scheme.

1 AS/NZS2081 - BEST PRACTICE FOR MINE ELECTRICAL PROTECTION

Australian Standard AS/NZS2081 – Electrical Protection Devices for Mines and Quarries sets out the design, construction and testing requirements for electrical protection devices used in surface and underground mines and quarries. It sets out the performance criteria of such devices to ensure:

a. *"The maintenance of touch and step voltage levels against time within acceptable limits.*

b. *The minimization of risks associated with electrical arcing i.e. arc blast, arc flash, etc.*

c. *Reliable performance under predetermined operating conditions."*

That is, AS/NZS2081 provides a framework for the implementation of protection schemes to ensure a safe working environment. This standard is called up in AS/NZS4871 - Electrical Equipment for Mines and Quarries, fundamental to the design and construction of electrical equipment directly used in mining and quarrying.

2 THE MINING ENVIRONMENT

The mining environment presents unique system challenges and hazards. In particular, a number of defining characteristics of the environment include:

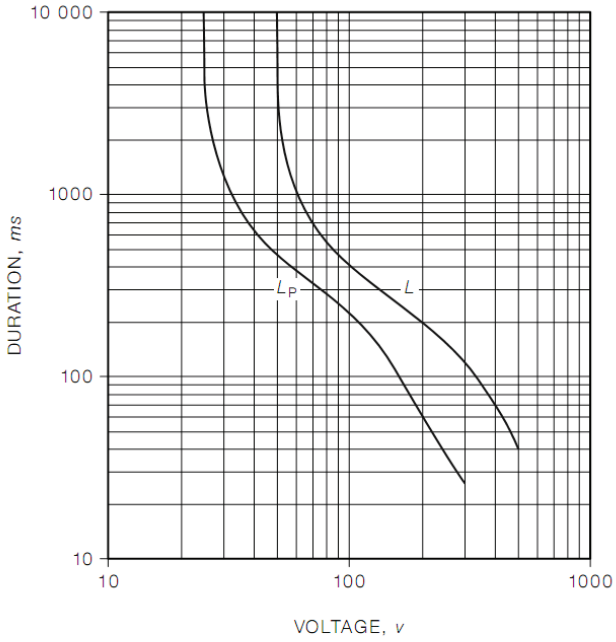
- Focus on maximising production and minimising downtime
- Increasing commitment to safety
- High voltage and current levels
- Long cable runs
- Potentially explosive atmosphere
- Heavy machinery used in harsh conditions
- Frequent interaction between people and equipment

Given these challenges it is critical that a safe and effective protection scheme is operating to protect people and equipment.

3 WHAT IS ELECTRICAL PROTECTION

Electrical protection refers to those devices whose function is to detect faulted conditions and isolate them from the rest of the electrical network to maintain a stable system. Electrical protection is used to minimise the risk of injury to personnel and damage to equipment caused by step and touch potentials on faulted electrical equipment as well as to limit the risk of fire and arcing due to electrical faults.

AS/NZS4871.1 describes acceptable touch potential levels using a series of curves, shown in Figure 1, and which are also referenced in AS/NZS2081.



L	for normal conditions	touch voltage limit 50 V
L_P	for wet conditions	touch voltage limit 25 V

NOTE: This curve is derived from AS/NZS 3000 and is based on a typical set of conditions and body resistance values.

FIGURE C1 MAXIMUM DURATION OF PROSPECTIVE 50 Hz TOUCH VOLTAGE

Figure 1 AS/NZS4871 Acceptable Touch Potential Levels

To ensure that touch potential are limited to within acceptable levels, a protection scheme which considers the entire electrical system is required. A typical electrical protection scheme for a mining system includes:

- Earth fault current limitation
- Earth continuity monitoring/protection
- Earth leakage protection
- Earth fault lockout protection

4 ELECTRICAL PROTECTION REQUIREMENTS

The requirements for the main forms of electrical protection are outlined in AS/NZS2081. The types of protection considered include:

- Earth Continuity
- Earth Leakage
- Earth Fault Lockout
- Neutral Earth Resistor Integrity
- Frozen Contactor

Figure 2 shows the typical arrangement of these types of protection.

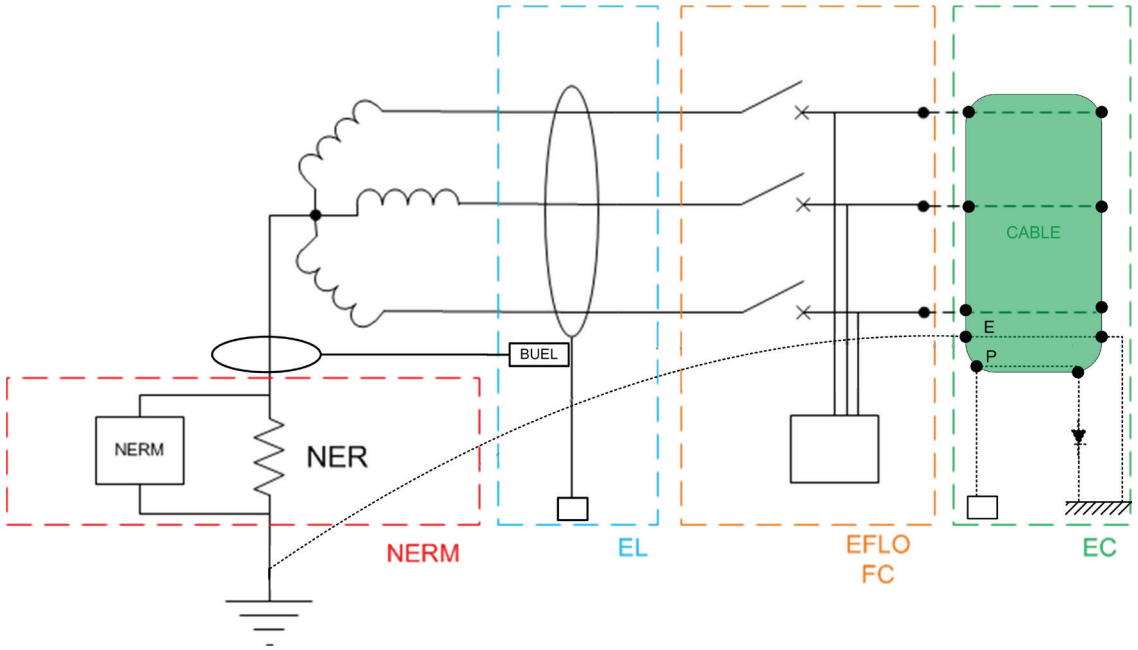


Figure 2 Typical Electrical Protection Arrangement

4.1 Earth Fault Current Limiting Devices

In a typical earth fault current limited network, earth faults are restricted with the use of an impedance device installed on the earth return path (neutral). The specific requirements for the earth fault current limiting device are outlined in AS/NZS2081, including manufacturing tolerances, operating electrical and temperature ratings and device labelling.

4.2 Earth Continuity Protection

Earth Continuity protection ensures the integrity of the earth connection between an outlet and a load, through a trailing or reeling cable, via the pilot conductor. The protection device initiates a trip when the resistance in the earth return path exceeds the preset value.

AS/NZS2081 sets out the requirements for the operation of earth continuity protection devices in electrical installations. In summary:

- The use of a pilot conductor to control or monitor other devices or equipment in conjunction with an earth continuity protection relay shall not compromise the earth return circuit.
- The device will trip when the earth resistance exceeds a set resistance level, typically 45Ω.
- The relay shall test the earth return resistance prior to energising.
- After energising, the earth continuity device shall continuously monitor the earth resistance.
- A trip shall be initiated or the device shall not be energised if the resistance between a pilot core and earth falls below 1kΩ.
- The minimum operating time of the device shall be 100ms. Provision may also be made for adjustment of the operating time to a maximum of 500ms.
- Remote start may be provided, and where included, provision shall be made for detecting a stuck start button condition.
- Provision shall be made for latching of the device.
- While in operation the protection device shall be provided with a means for indicating the status of the device.

4.3 Earth Leakage Protection

Earth leakage protection monitors the amount of leakage current to earth, initiating a trip within the operating time setting when the earth fault current exceeds the nominated trip current for the duration of the nominated time delay.

The requirements for earth leakage protection, as outlines in AS/NZS2081 can be summarised as:

- Protection shall be capable of accurately sensing and initiating a trip for values of earth fault current ranging from <0.1A up to 5A. The device shall have an accuracy of ±10% of the device setpoint value.
- The instantaneous trip time of the protection device shall be no greater than 50ms.
- Where adjustable time delays are provided, these would not usually exceed 500ms.
- Provision shall be made for an external reset facility.
- Earth fault protection devices shall latch when tripped and remain in this state until reset. The latch shall not reset on loss of supply to the earth fault protection device.
- It shall not be possible for the resetting mechanism to override the tripping operation.
- All fault trips shall be manually reset: automatic resetting is not permitted.
- While in operation the protection device shall be provided with a means for indicating the status of the device.

4.4 Earth Fault Lockout Protection

This form of protection is designed to monitor an outlet connected cable for a fault between each phase and earth. Earth fault lockout protection continually tests the resistance of the three phases to earth and if the measured value is less than a set level, a trip is initiated.

AS/NZS2081 provides guidance on the operating requirements of this type of protection:

- The following tests shall be successfully completed in sequence immediately before energising the circuit:

  a. Extra low voltage earth fault lockout test.

  b. Non-extra low voltage insulation test where applicable), conducted only while the earth continuity circuit remains healthy.
- The energisation of the device will be prohibited when the insulation resistance of any active conductor is below 1MΩ. The device will not be reset until the insulation resistance level of all conductors has been increased above 1MΩ, or the selected setpoint, whichever is greater.
- Earth fault lockout devices shall latch when tripped and remain so until reset. Provision shall be made for an external reset facility. The latch shall not reset itself on loss of power supply to the device.
- All faults shall be manually reset.
- While in operation the protection device shall be provided with a means for indicating the health of the device.

4.5 Neutral Earth Resistor (NER) Integrity

Neutral earth resistor integrity protection monitors the integrity of the connection of the NER and initiates a trip if the NER fails to operate as expected. The protection will also prohibit the circuit from energising if it is not yet energised and the NER is not operating as expected.

The main requirements for NER integrity protection are outlined in AS/NZS2081 and include:

- Current flowing in the NER shall not affect the operating values or time.
- The protection device shall be configured for use at an operating impedance that corresponds with the impedance of the current limiting device that the protection device is to function with.
- The protection device shall be configured to operate when there is an increase in impedance of more than 100%, or a decrease of more than 50% from the nominal value. Tripping values or user selectable tripping set points may be provided within this operating range.
- A maximum operating time of not more than ten seconds.
- Provision shall be made for an external reset facility. The trip shall be latched and shall not reset on loss of supply to the device.
- All fault trips must be manually reset.
- While in operation the device shall be provided with a means for indicating the status of the device.

4.6 Frozen Contactor Protection

Frozen contactor protection monitors the auxiliary contacts of the main contactor in a system to ensure that there is negligible voltage on the load side of the contactor after it has opened, and that the contactor operates correctly on receiving a signal to open or close. If the contactor fails to operate correctly a trip is initiated.

The standard sets out the criteria for the operation of frozen contactor protection:

- If a voltage exceeding 25VAC or 60VDC is detected on any phase on the load side of the circuit interrupting device when it is expected to be in the open position, the device shall initiate a trip.
- The device may have adjustable trip set points, allowing for voltages up to 10% of the nominal supply voltage to be detected on any phase of the load side of the circuit interrupting device before initiating a trip; adjustable between 1 and 20s.
- A trip shall be initiated if the mechanical state of the circuit interruption device is different to that expected not exceeding a time of 1s.
- Frozen contactor protection devices shall latch when tripped and remain in this state until reset. The latch shall not reset on loss of supply to the protection device.
- It shall not be possible for the resetting mechanism, when held in the reset position, to override the tripping operation. The reset facility shall be integral to the protection device.
- All fault trips shall be manually reset.
- The protection device shall be provided with a means for indicating the health of the device.

5 TESTING AND VERIFICATION

AS/NZS2081 outlines the requirements for testing of the various protection functions to assess the effectiveness of an electrical protection scheme to operate as expected under fault conditions. This takes the form of type (compliance) and routine testing. Such testing verifies that the protection scheme performs consistently in accordance with the requirements discussed above, with consideration of:

- Interference
- Temperature and moisture
- Vibration
- Component life

6 SUMMARY

Electrical protection is critical in ensuring the safety of personnel and equipment working in the mining environment. AS/NZS2081 outlines the requirements for a safe and effective electrical protection scheme, applying rigour to the design and implementation of protection in mining applications. This standard is best practice when considering the protection of mining electrical systems.

When assessing an electrical installation, it is critical to review and manage the protection system to ensure that it complies with AS/NZS2081, and thus operates safely. A risk assessment/risk management based approach should be taken in assessing protection requirements to ensure the needs of the system are met.