

Australian/New Zealand Standard™

Electrical equipment for mines and quarries

Part 1: General requirements



AS/NZS 4871.1:2012

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Australian Coal Association
Australian Industry Group
Consult Australia
Department of Employment, Economic Development and Innovation, Qld
Department of Mines and Petroleum, WA
Department of Trade and Investment, Regional Infrastructure and Services, NSW
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Australian/New Zealand Standard™

Electrical equipment for mines and quarries

Part 1: General requirements

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-023, Electrical Equipment in Mines and Quarries, to supersede AS/NZS 4871.1:2010, *Electrical equipment for mines and quarries*, Part 1: *General requirements*.

This Standard incorporates Amendment No. 1 (April 2014). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

The objective of this Standard is to set out the minimum design, manufacturing, testing and performance requirements for electrical equipment intended for use in mines and quarries.

This Standard is Part 1 of the series AS/NZS 4871, *Electrical equipment for mines and quarries*, which comprises the following parts:

- Part 1: General requirements (this Standard)
- Part 2: Distribution, control and auxiliary equipment
- Part 3: Substations
- Part 4: Mains powered electrical mobile machines
- Part 5: Battery powered electrical mobile machines
- Part 6: Diesel powered machinery and ancillary equipment

This Standard differs from the 2010 edition as follows:

- (a) Additional requirements for high voltage tests including partial discharge and impulse testing. Appendix H updated with details for partial discharge and impulse test methods.
- (b) Creepage and clearance requirements altered in light of additional high voltage testing.
- (c) Requirements for earth-protection scheme clarified and additional information included in Appendix C.
- (d) Revised requirements for pilot protection of restrained receptacles, earth fault lockout and earth continuity in hazardous zones.
- (e) Minor changes of clarification.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

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Australian/New Zealand Standard
Electrical equipment for mines and quarries

Part 1: General requirements

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard sets out the general requirements for the design, construction and testing of electrical equipment directly associated with mining and quarrying activities, and covers any plant intended to be relocated. This includes the types of equipment covered in AS/NZS 4871, Parts 2 to 6. These requirements are in addition to those in AS 60204.1 and AS 60204.11, which cover electrical safety of machinery. This Standard does not apply to handheld equipment.

NOTES:

- 1 For permanently fixed equipment and installations, such as equipment in offices or amenities and fixed processing plant, reference should be made to AS/NZS 3000, AS 3007 and AS 2067.
- 2 The requirements of this Standard should be read in conjunction with, but do not take precedence over, regulations of a regulatory authority that may apply in a specific area.

1.2 APPLICATION

Where there is conflict between AS 60204 series Standards and AS/NZS 4871 series Standards, then AS/NZS 4871 series Standards shall apply.

1.3 SERVICE CONDITIONS

Electrical equipment complying with this Standard shall be suitable, within the limits of its ratings, for installation under the following service conditions:

- (a) *Range of ambient temperature*—Ambient temperatures within the range of -5°C to 40°C .

NOTE: Where higher temperatures are possible, consideration should be given to the design of equipment.

- (b) *Humidity*—The relative humidity of the mine environment may vary between 30% and dew point.
- (c) *Environmental conditions*—Conditions peculiar to mining such as chemical fumes, wetting agents, stone dusting and corrosive agents present in mine water.

NOTE: Certain applications may require service conditions outside those specified above. For such applications reference should be made to AS 60204.1.

1.4 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS	
1319	Safety signs for the occupational environment
1824	Insulation co-ordination
1824.1	Part 1: Definitions, principles and rules

AS	
1931	High-voltage test techniques
1931.1	Part 1: General definitions and test requirements
1931.2	Part 2: Measuring systems
2067	Substations and high voltage installations exceeding 1 kV a.c.
2380	Electrical equipment for explosive atmospheres—Explosion-protection techniques (series)
2660	Hose and hose assemblies—Air/water—For underground coal mines
3007	Electrical installations—Surface mines and associated processing plant (series)
4024	Safety of machinery (series)
4024.1501	Part 1501: Design of safety related parts of control systems—General principles for design
60044	Instrument transformers
60044.1	Part 1: Current transformers (IEC 60044-1, Ed.1.2 (2003) MOD)
60044.2	Part 2: Inductive voltage transformers (IEC 60044-2, Ed.1.2 (2003) MOD)
60076	Power transformers
60076.1	Part 1: General (IEC 60076-1, Ed.2.1 (2000) MOD)
60204	Safety of machinery—Electrical equipment of machines (series)
60204.1	Part 1: General requirements (IEC 60204-1, Ed. 5 (FDIS) MOD)
60204.11	Part 11: Requirements for HV equipment for voltages above 1000 V a.c. or 1500 V d.c and not exceeding 36 kV (IEC 60204-11, Ed. 1.0 (2000) MOD)
60270	High-voltage test techniques—Partial discharge measurements
60529	Degrees of protection provided by enclosures (IP Code)
60890	A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of low-voltage switchgear and controlgear
61508	Functional safety of electrical/electronic/programmable electronic safety-related systems (series)
61508.3	Part 3: Software requirements
61800	Adjustable speed electrical power drive systems
61800.3	Part 3: EMC requirements and specific test methods
62061	Safety of machinery—Functional safety of safety-related electrical, electronic and programmable electronic control systems
62271	High-voltage switchgear and controlgear
62271.200	Part 200: A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (IEC 62271-200, Ed. 1 (2003) MOD)
AS/NZS	
1299	Electrical equipment for mines and quarries—Explosion-protected three-phase restrained plugs and receptacles for working voltages up to and including 3.3 kV
1300	Electrical equipment for mines and quarries—Bolted explosion-protected three-phase cable coupling devices
1802	Electric cables—Reeling and trailing—For underground coal mining purposes
1972	Electric cables—Underground coal mines—Other than reeling and trailing

AS/NZS

- 2081 Electrical protection devices for mines and quarries
- 2290 Electrical equipment for coal mines—Introduction and maintenance
- 2290.1 Part 1: For hazardous areas
- 2381 Electrical equipment for explosive atmospheres—Selection, installation and maintenance (series)
- 2381.1 Part 1: General requirements
- 2802 Electric cables—Reeling and trailing for mining and general use (other than underground coal mining)
- 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)
- 3008 Electrical installations—Selection of cables
- 3008.1.1 Part 1.1: Cables for alternating voltages up to and including 0.6/1 kV—Typical Australian installation conditions
- 3008.1.2 Part 1.2: Cables for alternating voltages up to and including 0.6/1 kV—Typical New Zealand installation conditions
- 3100 Approval and test specification—General requirements for electrical equipment
- 3439 Low-voltage switchgear and controlgear assemblies
- 3439.1 Part 1: Type-tested and partially type-tested assemblies
- 3800 Electrical equipment for explosive atmospheres—Repair and overhaul
- 4240 Remote controls for mining equipment (series)
- 4761 Competencies for working with electrical equipment for hazardous areas (EEHA) (series)
- 4871 Electrical equipment for mines and quarries
- 4871.2 Part 2: Distribution, control and auxiliary equipment
- 4871.3 Part 3: Substations
- 4871.4 Part 4: Mains powered electrical mobile machines
- 4871.5 Part 5: Battery powered electrical mobile machines
- 4871.6 Part 6: Diesel powered machinery and ancillary equipment
- 60079 Explosive atmospheres (series)
- 60079.0 Part 0: Equipment—General requirements
- 60079.1 Part 1: Equipment protection by flameproof enclosures ‘d’
- 60079.10.1 Part 10.1: Classification of areas—Explosive gas atmospheres
- 60079.11 Part 11: Intrinsic safety ‘i’
- 60079.14 Part 14: Electrical installations, design, selection and erection
- 60079.28 Part 28: Protection of equipment and transmission systems using optical radiation
- 60112 Method for the determination of the proof and the comparative tracking indices of solid insulating materials
- 60479 Effects of current on human beings and livestock
- 60479.1 Part 1: General aspects
- 61000 Electromagnetic compatibility (EMC) (series)

AS/NZS ISO

- 31000 Risk management—Principles and guidelines

IEC

- 60060 High-voltage test techniques
- 60060-1 Part 1: General definitions and test requirements

IEC/TR	
60479	Effects of current on human beings and livestock
60479-5	Part 5: Touch voltage threshold values for physiological effects
IEEE	
1584	Guide for performing arc-flash hazard calculation
NFPA-70E	Standard for electrical safety in the workplace

1.5 DEFINITIONS

For the purpose of this Standard the definitions below apply.

1.5.1 Access cover

Cover that provides access to electrical equipment that—

- (a) may require adjustment or alteration;
- (b) is used to make and break load current under normal conditions; and
- (c) requires regular frequent removal or opening of the cover for maintenance.

1.5.2 Adaptor

Device designed to connect a cable coupling to apparatus in such a manner as will form a flameproof enclosure. It may be either attached to or integral with the apparatus.

1.5.3 Approved

Approved by the relevant regulatory system or regulatory authority.

1.5.4 Area, hazardous

An area in which an explosive atmosphere is, or may be expected to be, present in quantities such as to require special precautions for the construction, installation and use of electrical equipment.

1.5.5 Area, non-hazardous (safe)

An area in which an explosive atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of electrical equipment.

1.5.6 Automatic circuit opening device

A device that will automatically open the circuit under a predetermined condition without the intervention of an operator.

1.5.7 Automatic control

Control by means of any device other than a manually operated switch or control button.

1.5.8 Cable entry

Means of introducing an electric cable into electrical equipment.

1.5.9 Certification/Certify

Process whereby equipment is assessed and a certificate issued, verifying compliance with relevant explosion-protection standards in accordance with the IECEx or ANZEx schemes.

1.5.10 Certifying authority

Body responsible for issuing certificates of conformity.

1.5.11 Circuit-breaker

Device capable of making, carrying and breaking normal load currents and also making and automatically breaking (under predetermined conditions) abnormal currents, such as short-circuit currents.

1.5.12 Clearance

Shortest distance in air between two conductive parts.

1.5.13 Combination fuse switch (CFS)

A mechanical switching device incorporating fuses.

1.5.14 Conduit entry

A means of introducing a conduit into electrical equipment.

1.5.15 Connection facilities

Terminals, screws and other parts, used for the electrical connection of conductors of external circuits.

1.5.16 Contactor

Device designed for frequently making and breaking normal operating currents, including overload, and having one position of rest operated by means other than by hand.

1.5.17 Cover

Covers that are not normally used for access for routine maintenance or repair.

1.5.18 Creepage distance

Shortest distance along the surface of electrical insulating material between two conductive parts.

1.5.19 Dead front

A front covering that provides protection against contact with live parts from the front.

1.5.20 Disconnect (isolating switch)

An isolation device(s) that disconnects all conductors of a supply and is not used for functional switching.

1.5.21 Distribution, control box and auxiliary equipment

Equipment designed primarily for the connection of cables and in which the essential electrical equipment provides control and protection for mining equipment and associated cables.

1.5.22 Earth-continuity protection

A type of protection that operates when the resistance of the earthing circuit to the protected equipment exceeds a specified value.

1.5.23 Earth-fault current limitation

A system whereby the magnitude of earth-fault current is limited by an inductive or resistive device or both to prescribed values.

1.5.24 Earth-fault lockout protection

A type of protection that prevents a circuit being energized if the insulation resistance to earth of one or more of the conductors is below a predetermined value.

1.5.25 Earth-fault protection

Protection that operates in the event of a fault between active conductors and earth.

1.5.26 Electrical equipment

All items applied as a whole or in part for the utilization of electrical energy for the purpose of mining and quarrying activities, such as items for the generation, transmission, distribution, storage, measurement, regulation, conversion, and consumption of electrical energy, and items for telecommunications. This does not include reeling and trailing cables, unless forming part of an assembly as described in AS/NZS 4871, Parts 2 to 6.

1.5.27 Enclosure

All the walls that surround the live parts of electrical equipment including doors, covers, cable entries, rods, spindles and shafts, which ensure the protection of the electrical equipment (including rotating machines).

1.5.28 Equipotential bonding

Special electrical connections intended to bring exposed conductive parts or extraneous conductive parts to the same or approximately the same potential, but not intended to carry current in normal service.

1.5.29 Ex component

Part of electrical equipment for explosive atmospheres that is not to be used alone but that would form part of equipment which complies with recognized explosion-protection techniques.

1.5.30 Explosion protected

Technique of protection by one or more methods as defined in AS/NZS 3000 (hazardous areas section) to prevent the ignition of flammable vapours and gases or combustible dusts in a hazardous area.

1.5.31 Explosion protection

Specific measures applied to electrical equipment to avoid ignition of a surrounding explosive atmosphere.

1.5.32 Explosive atmosphere

Mixture with air, under normal atmospheric conditions, of flammable materials in the form of gas, vapour, mist or dust, in which, after ignition, combustion spreads through the unconsumed mixture.

1.5.33 Exposed conductive part

A conductive part of electrical equipment that—

- (a) can be touched with the standard test finger as specified in AS/NZS 3100; and
- (b) is not a live part but can become live if basic insulation fails.

1.5.34 Fail-to-safety (fail-safe)

Any failure to the machinery, its associated safeguards, control circuits or its power supply that leaves the machinery in a safe condition.

1.5.35 Fixed equipment

Equipment that normally remains in its installed position.

1.5.36 Flame resistant

As applied to cable, hose and insulating materials, means material that will not support combustion.

1.5.37 Flameproof enclosure

Enclosure for electrical equipment that will withstand, without damage, an explosion of a prescribed flammable gas or vapour within the enclosure and will prevent the transmission of flame such as will ignite the external prescribed flammable gas or vapour for which it is designed, and which operates at an external temperature that will not ignite a surrounding flammable atmosphere.

NOTE: A flameproof enclosure, in accordance with the foregoing definition, will not necessarily or ordinarily be weatherproof or dustproof.

1.5.38 Fuse, HRC

A device for protecting a circuit from damage of excessive currents by opening the circuit as a result of the fuse element melting due to excessive currents.

1.5.39 Handheld equipment

Equipment intended to be held in the hand during normal use.

1.5.40 Ignition temperature

Lowest temperature of a heated surface at which, under specified conditions, the ignition of a flammable substance in the form of a gas, vapour or dust mixture with air will occur.

1.5.41 Interlocking device

A device that makes the operation of a switching device dependent upon the position or operation of one or more other pieces of equipment.

1.5.42 Intrinsically safe circuit

Circuit in which any spark or thermal effect produced, either normally or in specified fault conditions, is incapable under prescribed test conditions of causing ignition of a given gas or vapour.

1.5.43 Inverse time-delay overcurrent release

Release that operates after a time-delay inversely dependent upon the value of the overcurrent.

1.5.44 Light alloy

Alloys of aluminium, magnesium, titanium and zirconium in which the total content of these metals exceeds 15% by mass and in which the content of magnesium, titanium and zirconium together exceeds 7.5% by mass.

1.5.45 Local control

A push button, switch or other device that operates the plant or equipment upon which it is located or adjacent to.

1.5.46 Maximum surface temperature

Highest temperature attained in service under the most adverse conditions (but within the tolerances) by any part or surface of electrical equipment, which would be able to produce an ignition of the surrounding atmosphere.

NOTE: The most adverse conditions include recognized overloads and any fault conditions recognized in the specific standard for the type of protection concerned.

1.5.47 Mobile machine

A machine capable of being readily moved about while it is in operation, e.g. continuous miners, shuttle cars, roof bolters, jumbos, flexible conveyors and similar machinery.

1.5.48 Outlet

A means of connecting an external circuit to the equipment. It may consist of a receptacle as defined in AS/NZS 1299, an adaptor as defined in AS/NZS 1300 or a glanding arrangement.

1.5.49 Overload protection

Type of protection that causes the circuit to open automatically when the actual load current is in excess of the rated load current.

1.5.50 Pilot core

A pilot conductor with insulation or covering and which is installed either in the centre of a cradle separator (central pilot core) or in any of the outer interstices between the power cores (interstitial pilot core), or is otherwise laid up in the cable for use in conjunction with an earth-continuity system.

1.5.51 Portable equipment

Equipment capable of being carried by a person while in operation, or which can easily be moved from one place to another while connected to the supply.

1.5.52 Protective earthing conductor

A conductor, except a main earthing conductor, connecting any portion of the earthing system to the portion of the electrical installation or electrical equipment required to be earthed, or to any other portion of the earthing system.

1.5.53 Rated conditional short-circuit current

Value of the prospective current that a circuit protected by a current-limiting switching device or fault-limiting fuse can satisfactorily withstand for the operating time of the limiting device under specified test conditions. The value of current is the r.m.s. value of the a.c. component of the current.

1.5.54 Rated peak withstand current

Value of peak current that a circuit can withstand under specified test conditions.

1.5.55 Rated prospective short-circuit current

Value of current that would flow if the incoming terminals were short-circuited by conductors of negligible impedance.

1.5.56 Rated short-time withstand current

The r.m.s. value of current that a circuit can carry for a specified short-time under specified test conditions.

1.5.57 Rating

The whole of the electrical and mechanical quantities assigned to the apparatus by the designer to define its working in specified conditions.

1.5.58 Regulatory authority

Relevant authority responsible for the implementation of government regulations applying to mines in each of the jurisdictions in Australia and New Zealand.

1.5.59 Relevant standards

A published standard with a scope and requirements that relate to the application of this Standard. These would principally be Australian, Australian/New Zealand, or IEC Standards. Other standards may be considered relevant where they are equivalent to AS, AS/NZS, or IEC Standards, or where the scope of the other standard is not covered by an AS, AS/NZS, or IEC Standard.

1.5.60 Restrained plug and receptacle

A plug and socket arrangement having a mechanism for retaining the plug in place whilst connected and used for the connection of items of equipment by means of trailing cables. (Refer to AS/NZS 1299.)

1.5.61 Section circuit-breaker

Equipment that is intended for use as a means of isolating and protecting sections of a high voltage network.

1.5.62 Section isolator

Equipment that is intended for use as a means of isolating sections of a high voltage network for operational and maintenance purposes.

1.5.63 Sensitive earth-fault protection

Type of fault protection with an operation value at or below 30 mA.

1.5.64 Short-circuit protection

A fault current resulting from a fault of negligible impedance between live conductors having a difference in potential under normal operating conditions.

1.5.65 Shunt release

Means of causing a circuit breaker to open that is de-energized in normal service and energized by a voltage source to cause a trip.

NOTE: The source of voltage may be independent of the voltage of the main circuit.

1.5.66 Substation

Equipment generally consisting of a primary enclosure, transformer and secondary enclosure.

1.5.67 Switching device

A device designed to make or break the current in power circuits.

1.5.68 Temperature classification

System of classification by which electrical equipment is allocated one of six temperature classes according to its maximum surface temperature.

1.5.69 Terminal compartment

A compartment, either separate or part of the main compartment, that has facilities for the termination of conductors.

1.5.70 Testing station

Testing organization commissioned to carry out inspections and tests in order to determine compliance with a Standard.

1.5.71 Transportable equipment

Equipment that, due to the nature of its use, needs to be moved to a new position from time to time between periods of operation.

1.5.72 Transportable substation

A transportable piece of equipment generally consisting of a primary switchgear, transformer and secondary switchgear mounted on a common base.

1.5.73 Undervoltage release

Means of causing a circuit-breaker to open with or without delay when the voltage across the terminals of the release mechanism falls below a predetermined value.

1.5.74 Voltage

Differences of potential normally existing between conductors and between conductors and earth as follows:

- (a) *Extra-low voltage (ELV)*—Not exceeding 50 V a.c. or 120 V ripple-free d.c.
- (b) *Low voltage*—Exceeding extra-low voltage, but not exceeding 1000 V a.c. or 1500 V d.c.
- (c) *High voltage*—Exceeding low voltage.

NOTE: Regulatory authorities may allow for variation to the limits for low voltage.

1.6 EXISTING EQUIPMENT

In recognition of revisions introduced in this edition of this Standard, existing equipment should be assessed for risk and interim control measures should be implemented where necessary.

Compliance with the revisions should be made within a time frame that takes into consideration the associated risk levels.

SECTION 2 COMMON REQUIREMENTS

2.1 GENERAL

2.1.1 Risk management

Risk management techniques shall be employed. This shall include identification, assessment, control, implementation and validation, covering the full life cycle including the design and use of the equipment. Techniques may include hazard analysis, risk assessment, failure mode and effect analysis, and functional safety analysis. Control measures shall be implemented as appropriate to account for all foreseeable hazards. Reference should be made to AS 4024 (series), AS/NZS 4240 series, AS/NZS ISO 31000, AS 60204.1, AS 61508 series and AS 62061.

The end user/operator should provide adequate information relating to the mine or quarry's environment, electrical systems and protection schemes to the equipment designer.

NOTE: Information to be supplied by the purchaser is listed in Appendix A.

Where personnel may be in proximity of any moving machinery or plant during normal mining activities, consideration should be given to appropriate technologies such as proximity detection of persons to provide a means of ensuring power is removed if personnel are in an area not deemed to be a safe working zone, i.e. personnel entering an area of danger and not required to be there as part of normal operation of the equipment.

NOTES:

- 1 For information on integrated control systems refer to Appendix B.
- 2 The use of programmable electronic systems introduces an additional possibility of failure or defeat if access to safety related software is not properly designed and monitored.

2.1.2 Supply system

The supply system associated with power to mining and quarrying equipment and machines covered by this Standard shall have earth-fault current limitation, i.e. an IT system.

NOTE: AS 3007 provides detail of the IT system and other systems.

Except for battery powered mobile machines, electrical equipment shall be suitable for operating on a power supply that incorporates earth-fault current limitation.

Consideration should be given to voltage and frequency regulation, when designing equipment.

2.1.3 System fault levels

Consideration shall be given to the fault levels of electrical circuits to ensure the electrical equipment and cabling are selected and installed to match the system design fault level. Any protection study undertaken should consider the effects of minimum and maximum possible fault levels.

2.1.4 Equipment selection

For further information, selection of equipment is covered by AS 60204.1.

Electrical components and devices shall—

- (a) be suitable for their intended use;
- (b) conform to relevant standards where such exist; and
- (c) be applied in accordance with the supplier's instructions.

The electrical equipment should be suitable for the switching and interrupting capacity relevant to rated voltages and short-circuit currents.

NOTES:

- 1 All electrical equipment should be installed and operated in accordance with manufacturer's instructions.
- 2 Risk management in accordance with Clause 2.1.1 should be applied in regards to the use of oil-filled transformers or oil-filled switch gear in an underground mine.

2.1.5 Temperature rating

To protect against the risk of burn injury, the maximum external surface temperature of accessible parts of electrical equipment enclosures intended to be touched shall not exceed 70°C under normal operating conditions.

Refer to AS 60204.1 for use of appropriate warning signs.

Additional precautions may be necessary to prevent the risk of injury to persons. Refer to Section 3 for hazardous areas.

The temperature rating of all selected electrical/electronic equipment to be installed within the enclosure shall be suitable for use at the operational temperature within the enclosure, at maximum load.

In assessing service temperature, the ambient temperature at the mine or quarry shall be considered.

NOTE: See Appendix A, Paragraph A1.

2.1.6 Assembly

The equipment shall be assembled so as to guard against mechanical and electrical failure under normal conditions of use, and to maintain the degree of protection (IP rating) required by component parts.

The equipment shall be arranged to be accessible for mounting, wiring, maintenance and replacement.

Operating devices, such as handles, push buttons and levers, shall be accessible and designed and arranged to minimize the risk of inadvertent operation or damage.

Components should be installed and wired in such a manner that proper functioning is not impaired by interactions, including heat, arcs, vibration and fields of energy under normal and rated-through-fault conditions.

2.1.7 Construction

Consideration, during the design stage, shall be given to the arduous handling and transportation conditions to which the equipment is to be subjected. Suitably rated lifting and towing points, skid bases, forklift facilities and the like should be included in the design.

2.1.8 Arc blast protection

Consideration shall be made for the prevention of arc blast injury. This shall include the positioning of operating handles, explosion vents, integrity and guarding of windows. Consideration should be given to the use of remote switching.

NOTE: Further information is given in IEEE 1584 and NFPA-70E.

2.2 ENCLOSURE REQUIREMENTS

2.2.1 General

The design of all enclosures used in both safe and hazardous areas shall consider the following parameters:

- (a) Component layout.
- (b) Shock loading and vibration levels.
- (c) Operator safety by means of—
 - (i) doors, fixed panels and partitions to prevent contact with live conductors and exposure to arcing products;
 - (ii) an enclosure rated to contain or control the effects of the prospective fault energy;
 - (iii) vents located in a position to direct any arc products away from the operator; and
 - (iv) pressure relief to atmosphere for any abnormal pressures developed in safe area equipment directed away from and with due regard to the safety of the operator. The location and size shall be adequate for the nominated fault rating and to limit internal pressures to safe limits for the equipment.
- (d) Operating environment.

2.2.2 Ingress protection (IP)

Enclosures shall—

- (a) have a minimum degree of protection IP 55 in accordance with AS 60529; or
- (b) be located in a controlled environment that eliminates exposure to water spray.

NOTE: In selecting an appropriate IP rating, consideration should be given to the intended operating environment including physical location and level of exposure to water and dust. Refer to Appendix A for guidance on supplying information.

This requirement applies to non-hazardous and hazardous areas.

2.2.3 Internal segregation

Where possible, components and wiring of high voltage, low voltage and extra-low voltage installed in a common enclosure should be segregated. Where compartmental segregation is not possible then techniques including insulation, earth barrier, restraint, creepage and clearance between different voltages should be employed.

2.2.4 Withdrawable and plug-in equipment

Enclosures with withdrawable and plug-in equipment shall be constructed so the equipment modules cannot be dislodged from their position during normal operation.

Withdrawable and plug-in equipment containing power circuits shall not operate unless fully engaged.

2.2.5 Unused openings and threaded entries

Unused openings and threaded entries shall be closed or plugged so the degree of protection (see Clause 2.2.2) or the explosion-protection integrity of the enclosure or both is maintained. Precautions shall be taken to prevent release during normal service conditions.

2.2.6 Interlocking

2.2.6.1 General

The requirement to fit interlocking shall be determined by risk management. The following factors shall be considered when determining if and where required:

- (a) Exposure to live conductors.
- (b) Accessibility to the enclosure.
- (c) Special fasteners and tools.
- (d) Live line indication.

Equipment shall be designed to minimize the risk of inadvertent exposure to live electricity.

Interlocking shall not be relied upon as a means of isolation to gain access to enclosures supplied with greater than extra-low voltage.

The system shall be designed to prevent the easy or inadvertent removal of access covers on enclosures when the power is switched on, and in addition shall prevent restoration of power to the enclosure while the access cover is open.

Access covers shall be interlocked with a switching device, or padlocked or bolted with warning signs so it is not possible to inadvertently open or remove the cover with the power on.

Interlocking systems shall have a category of protection consistent with AS 4024.1501 or safety integrity levels consistent with AS 62061.

If the enclosure to which the cover provides access contains live conductors above ELV that either—

- (i) can be contacted by persons; or
- (ii) are not protected by acceptable insulation material of thickness and grade appropriate to the voltage, to prevent inadvertent contact by a person, then covers and access covers shall be marked in accordance with Clause 5.4.

2.2.6.2 Interlocking methods

Every interlocking system that does not have a rigid mechanical link between the isolating device and the latch on the enclosure being protected shall be designed using functional safety principles. Refer to Clause 2.1.1.

Acceptable interlocking methods are as follows:

- (a) *Mechanical interlocking* Where mechanical system of interlocking is used in conjunction with an isolating switch, the following apply:
 - (i) The isolating switch assembly shall be arranged so that, when mounted in its enclosure, it is only possible for the actual position of the isolating switch contacts to correspond to the external position indicator forming part of the operating handle.
 - (ii) A method of captive interlocking will be acceptable as mechanical interlocking between the isolating switch and enclosure(s).
- (b) *Electrical interlocking* Undervoltage releases, providing the function of ‘no volt, no close’ is the preferred form of electrical release for electrical interlocking.

Where a shunt trip device is the only form of tripping, a safety appraisal in accordance with Clause 2.1.1 shall be undertaken. Appropriate facilities to monitor or test the functionality shall be provided as determined in the safety appraisal.

Only totally enclosed interlock switches of robust construction shall be used. Switch terminals shall be shrouded.

Any electrical interlocking switch circuit shall be ELV.

- (c) *Electromechanical interlocking* Where electromechanical interlocking is used, it shall comply with the relevant parts of the requirements in Items (a) and (b), to achieve an equivalent level of safety.

NOTE: It is recognized that methods of interlocking to prevent inadvertent access to HV enclosures may not be possible due to the use of HV supply cables not having pilot cores (e.g. PILSWA cable). Consideration should be given to alternate control measures such as an audio/visual device inside the enclosure to warn if the cover is removed with the enclosure energized.

2.2.6.3 *Electrical interlocking of restrained plugs*

Where restrained plugs and receptacles above ELV are used and there is likelihood of a person coming in contact with live pins, provision shall be incorporated to automatically disconnect electricity when the plug is removed, and to prevent automatic restoration of electricity on the insertion of the plug into its receptacle.

The interlocking shall not be relied upon as a means of isolation.

2.2.7 Protection against direct and indirect contact

Design considerations shall include protection from electric shock caused by direct or indirect contact with electricity.

NOTE: See Appendix C. Also refer to AS/NZS 3000, AS 60204.1 and AS 60204.11 for guidance.

2.3 COMPONENTS REQUIREMENTS

2.3.1 Creepage and clearance

It is recommended that the characteristics of the component and the insulation of the associated circuit be examined to assess the need for protection against transient over voltages that may occur during closure or interruption of the circuit.

Consideration should be given in the design to the selection and construction of electrical components to prevent the occurrence of an arcing fault. The following provisions apply:

- (a) All insulation other than battery cells and boxes shall have a minimum comparative tracking index (CTI) of 400 in accordance with AS/NZS 60112 or a suitable BIL or impulse level. Refer to AS 1824.1.
- (b) Insulation techniques, creepage and clearance dimensions shall be appropriate for each system voltage and operating condition.

NOTES:

- 1 Appendix D provides recommendations for minimum creepage and clearance distances in air and in clean environments. In abnormally dusty, moist or corrosive environments greater distances should be considered.
- 2 In IT systems the phase-to-earth creepage and clearance distances should match the phase-to-phase distances. On a three-phase impedance earthed (IT) system, the two unfaulted phases will rise from phase-to-earth voltage to phase-to-phase voltage.
- (c) Impulse testing may be applied as an alternative to establish suitable creepage and clearance distances. Refer to Clause 4.5 and Appendix H, Paragraph H1.5.

The manufacturer's recommendations shall be followed regarding special measures to prevent a gradual reduction in the insulation values due to unfavourable ambient conditions (e.g. deposits of conductive dust and chemical attack).

- (d) Components shall be adequately rated.

- (e) Interphase barriers shall be either earthed metal or insulated types.
- (f) Cable terminations shall meet the general electrical requirements and, where relevant, the specific standards relating to explosion-protection techniques.

2.3.2 Switching devices

2.3.2.1 General

Switching devices, as detailed below, shall comply with a relevant standard appropriate to the application.

Reference should be made to manufacturers published performance data to ensure the protection provided is appropriate to the application, including maximum and minimum fault currents and maximum clearance time.

Consideration shall be given to the mechanical endurance requirements of switching devices, the electrical switching capacity (including short-circuit) and low power factor when subject to frequent operation.

All switching devices shall be mounted, keeping spaces, clearances and orientation in accordance with the manufacturer's instructions and in a manner that provides optimum accessibility for maintenance purposes.

Where the switching device is required for the purpose of isolation for the safety of personnel carrying out maintenance or repair, provision shall be made for locking the switching device in the off position.

Where the switching device is required to be operated by the general workforce at the mine or quarry, the device should not be capable of being locked in the on position. A safety assessment shall be conducted where a device is capable of being locked in the on position. See also Clause 2.3.2.2(c).

Where required, switching devices may have provision for the following features associated with the means of isolation:

- (a) Test position.
- (b) Earth position.
- (c) Phase reversal position.

2.3.2.2 Isolating switches (disconnectors)

Isolating switches shall be mounted for 'dead front' operation.

Isolating switches shall be of the following types:

- (a) Fault make, fault break.
- (b) Fault make, load break.
- (c) Off load make, off load break. Where used, this type shall be equipped with an interlocking device that removes the load before the device is operated and has a suitable category or safety integrity level relevant to the risk. Refer to Clause 2.1.1.

Isolating switches shall be capable of being locked into the open position.

2.3.2.3 Circuit breakers

The mounting of the circuit breaker shall provide for 'dead front' operation.

Where a trip-free mechanism forms part of the main power supply switching device, it shall not be possible for the moving contacts to close onto the fixed contacts while the trip mechanism is held in the tripped position, either by manual means or under the influence of a de-energized undervoltage release.