

Australian/New Zealand Standard™

**Electrical equipment in mines and
quarries—Surface installations and
associated processing plant**



AS/NZS 3007:2013

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee EL-023, Electrical Equipment for Mines and Quarries. It was approved on behalf of the Council of Standards Australia on 29 April 2013 and on behalf of the Council of Standards New Zealand on 23 April 2013.
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Australian Coal Association
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Aviation and Marine Engineers Association
Consult Australia
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Department of Natural Resources and Mines, Qld
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This Standard was issued in draft form for comment as DR AS/NZS 3007.

Australian/New Zealand Standard™

Electrical equipment in mines and quarries—Surface installations and associated processing plant

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-023, Electrical Equipment for Mines and Quarries, to supersede Parts 1 to 5 of AS 3007—2004.

The objective of this Standard is to set out guiding principles for the design, installation, and operation of electrical equipment in mines and quarries so as to ensure the safety of persons, livestock and property, and the proper functioning of the plant.

Australian mining operations typically involve most aspects of electrical engineering, ranging from such areas as high voltage transmission to the control of undesirable static electricity. A substantial number of Standards therefore apply to such work. This Standard consolidates these requirements together into the one document.

This edition of the Standard differs from the previous editions in the following significant ways:

- (a) This Standard incorporates the requirements for the surface of underground mines in addition to surface mines, quarries and associated processing plant.
- (b) Where issues are adequately covered by AS/NZS 3000, AS 2067, and AS 60204, they have been removed from this version of AS/NZS 3007 to prevent conflict.
- (c) Relevant parts of AS/NZS 4871 (series) that apply to installations covered by the scope of this Standard have been included.
- (d) Particular requirements have been included to address known deficiencies in installation and practices.
- (e) Definitions have been aligned with other key Standards.
- (f) Requirements for transportable/relocatable distribution and control equipment have been added.
- (g) The requirements for flexible feeder, trailing, and reeling cables have been expanded.
- (h) The requirements for overhead lines have been expanded.
- (i) The requirements for specific types of power supplies have been updated.
- (j) Requirements for labelling have been updated.
- (k) Requirements for managing change within the mining operation have been added.
- (l) Information about the power supply to safety critical infrastructure for underground mines has been added.
- (m) Requirements for reclaim and transfer tunnels have been added.
- (n) Information about variable speed drives has been added.
- (o) Appendix F has been added to provide earthing requirements for mines. (This Appendix will be deleted by amendment when AS 2067 has been amended to include mine earthing.)

In recognition of changes introduced in this revision of this Standard, existing installations and equipment should be reviewed against the requirements of this Standard.

Descriptions of TN, TT and IT power supply systems have been retained as they are not found elsewhere within standards.

The terms ‘normative’ and ‘informative’ are used 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.

Statements expressed in mandatory terms in notes to tables are deemed to be requirements of this Standard.

CONTENTS

	<i>Page</i>
SECTION 1 SCOPE AND GENERAL	
1.1 SCOPE.....	7
1.2 REFERENCED DOCUMENTS.....	8
1.3 DEFINITIONS.....	11
SECTION 2 GENERAL REQUIREMENTS	
2.1 RISK MANAGEMENT	18
2.2 LOW VOLTAGE AND EXTRA LOW VOLTAGE INSTALLATIONS	18
2.3 HIGH VOLTAGE INSTALLATIONS	18
2.4 EARTHING.....	18
2.5 REMOVAL OF POWER AT A CLOSED ELECTRICAL OPERATING AREA	19
2.6 ELECTRICAL MACHINERY.....	19
2.7 PROTECTION FROM NON-ELECTRICAL HAZARDS	19
2.8 PROTECTION FROM ELECTRICAL HAZARDS.....	19
2.9 ISOLATING SWITCHES (DISCONNECTORS).....	20
2.10 CIRCUIT-BREAKERS.....	21
2.11 CABLES.....	21
2.12 SYSTEM DESIGN	21
2.13 GENERAL REQUIREMENTS FOR ELECTRICAL COMPONENTS	22
SECTION 3 PROTECTION AGAINST OVERLOADS AND FAULTS	
3.1 INTRODUCTION	25
3.2 GENERAL RULE.....	25
3.3 AUTOMATIC INTERRUPTION—PROTECTION AGAINST OVERCURRENT DUE TO OVERLOAD	25
3.4 COORDINATION OF OVERLOAD AND SHORT-CIRCUIT PROTECTION AFFORDED BY SEPARATE DEVICES	26
3.5 EARTH FAULT PROTECTION ON IMPEDANCE EARTHED IT SYSTEMS	26
SECTION 4 ELECTRICAL WIRING OF EQUIPMENT AND MACHINERY	
4.1 GENERAL.....	28
4.2 ELECTRICAL ISOLATION	28
4.3 ISOLATING FOR MECHANICAL MAINTENANCE	28
4.4 REMOTE CONTROL.....	28
4.5 PENDANT CONTROL (UMBILICAL CORD)	28
4.6 CABLING	29
4.7 ROTATING ELECTRICAL MACHINES.....	29
4.8 MOBILE MACHINERY CABLE ATTACHMENTS	30
4.9 CABLE REELS	30
4.10 MOBILE MACHINERY LIGHTING SYSTEMS	31
4.11 CONTROL CIRCUITS AND CONTROL DEVICES.....	31
SECTION 5 TRANSPORTABLE/ RELOCATABLE DISTRIBUTION AND CONTROL EQUIPMENT	
5.1 GENERAL	34
5.2 TRANSPORTABLE SUBSTATIONS.....	35
5.3 DISTRIBUTION AND CONTROL EQUIPMENT.....	38
5.4 FLEXIBLE CABLE TERMINATION BOXES	38

SECTION 6 FLEXIBLE FEEDER, TRAILING AND REELING CABLE SELECTION, APPLICATION AND USE

6.1	DESIGN OF CABLES.....	39
6.2	POWER CABLE TWIST LIMITATION.....	40
6.3	CABLE CONNECTORS	41
6.4	MOVING CABLES	41
6.5	INSTALLATION OF CABLES.....	43
6.6	CABLE REPAIR	48
6.7	PRECAUTIONS DURING LIGHTNING STORMS	48

SECTION 7 OVERHEAD LINES

7.1	GENERAL.....	49
7.2	EASEMENTS	49
7.3	MINE OWNED/OPERATED OHLS	50
7.4	OHL CORRIDORS AND WORK NEAR OHLS	51
7.5	CLEARANCE TO MOBILE PLANT	53
7.6	CLEARANCES TO HAND-HELD OBJECTS	55
7.7	CLEARANCE TO EXCAVATIONS	55
7.8	CLEARANCE TO BLASTING OPERATIONS	55
7.9	CLEARANCE TO STOCKPILE AND TAILING AREAS.....	56
7.10	CLEARANCE TO STORAGE AREAS.....	56
7.11	CLEARANCE TO STRUCTURES AND PEOPLE TRANSIT AREAS	56
7.12	REDUCTION OF CLEARANCES	56
7.13	MOVING OF OHLS.....	56
7.14	PRECAUTIONS DURING LIGHTNING STORMS	57
7.15	OPERATIONS INVOLVING LONG METALLIC STRUCTURES.....	57
7.16	CLEARING VEGETATION NEAR OHLS.....	57
7.17	MINE SITE INFORMATION ON OHLS	57
7.18	EMERGENCY RESPONSE PLAN FOR CONTACT WITH OHLS	57
7.19	EMERGENCY ACTION IF THERE IS AN ACCIDENT	58

SECTION 8 SPECIFIC POWER SUPPLIES

8.1	POWER SUPPLIES FROM MOBILE MACHINERY	59
8.2	SELF-CONTAINED POWER SYSTEMS.....	59
8.3	WELDING MACHINES AND EQUIPMENT.....	59
8.4	INVERTERS AND UNINTERRUPTABLE POWER SUPPLIES	59
8.5	RELOCATABLE BUILDINGS AND IT EARTHING SYSTEMS.....	60

SECTION 9 ELECTRICITY SUPPLY TO SAFETY CRITICAL MINE INFRASTRUCTURE FOR UNDERGROUND MINES

9.1	SAFETY CRITICAL ELECTRICAL SYSTEMS	61
9.2	CONTINUITY OF THE ELECTRICAL SUPPLY TO THE MINE.....	62
9.3	CONTINUITY OF SUPPLY TO THE UNDERGROUND WORKINGS CONTAINING SAFETY CRITICAL INFRASTRUCTURE.....	62
9.4	CONTINUITY OF SAFETY CRITICAL, ELECTRICALLY POWERED VENTILATION EQUIPMENT	64
9.5	MONITORING AND CONTROL	65
9.6	POWERED WINDING SYSTEMS	66
9.7	POWER SUPPLIES TO DE-WATERING AND FIREDAMP DRAINAGE PLANT AND EQUIPMENT	67

SECTION 10 TRANSPORT CONVEYOR SYSTEMS

10.1 GENERAL.....	68
10.2 CONVEYOR CONTROLLERS	68
10.3 CABLES OF MOVEABLE CONVEYORS.....	69
10.4 BELT SPLICING EQUIPMENT	69

SECTION 11 DEEP-WELL TYPE PUMPS AT SURFACE MINING OPERATIONS

11.1 GENERAL.....	70
11.2 RISERS AS PROTECTIVE CONDUCTORS.....	70
11.3 CONTINUED OPERATION AFTER FIRST EARTH FAULT	70
11.4 EQUIPOTENTIAL BONDING	70
11.5 EXEMPTION FROM INSULATION-MONITORING DEVICE	71
11.6 DOUBLE LINE TO EARTH FAULTS	71

SECTION 12 RECLAIM AND TRANSFER TUNNELS FOR COAL MINES

12.1 GENERAL.....	72
12.2 AUTOMATIC GAS MONITORING SYSTEM.....	72

SECTION 13 FIRE DETECTION AND PROTECTION SYSTEMS FOR ELECTRICAL AREAS

13.1 GENERAL.....	74
13.2 GENERAL PROTECTION REQUIREMENTS.....	74
13.3 ADDITIONAL REQUIREMENTS AND RECOMMENDATIONS	76

SECTION 14 STATIC ELECTRICITY, RADIOACTIVE SOURCES AND INDUCTIVE SOURCES

14.1 STATIC ELECTRICITY	77
14.2 ELECTROSTATIC PRECIPITATORS	77
14.3 RADIOACTIVE SOURCES.....	77
14.4 HAZARDS FROM INDUCTION	77

SECTION 15 LABELS, SIGNAGE AND INFORMATION REQUIREMENTS AND COLOUR CODING OF ENCLOSURES

15.1 GENERAL	78
15.2 SPECIFIC REQUIREMENTS	78
15.3 ENCLOSURES WITH COVERS GUARDING ACCESS TO LIVE CONDUCTORS	79
15.4 VOLTAGE IDENTIFICATION OF ELECTRICAL ENCLOSURES.....	79

SECTION 16 OPERATIONAL REQUIREMENTS

16.1 GENERAL.....	80
16.2 RESTRICTIONS ON ACCESS BY PERSONNEL	80
16.3 OPERATIONS INVOLVING PERSONNEL WORKING IN THE VICINITY OF EXPOSED LIVE PARTS	80
16.4 USE OF RADIO REMOTE CONTROL EQUIPMENT.....	81
16.5 OVERHEAD LINES	81

SECTION 17 MANAGEMENT OF ALTERATIONS TO THE MINING OPERATION

17.1 GENERAL	82
17.2 MANAGEMENT OF CHANGE.....	82

APPENDICES

A TN, TT AND IT SYSTEMS DESCRIPTION 84

B PROTECTIVE DEVICES AND THEIR USES 92

C GUIDELINES FOR LOW SIGNAL LEVEL SYSTEMS AND
COMMUNICATION SYSTEMS 102

D VARIABLE SPEED DRIVES 107

E DOCUMENTATION..... 110

F EARTHING..... 112

STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard**Electrical equipment in mines and quarries—Surface installations and associated processing plant**

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard applies to the design, installation and operation of electrical plant and equipment installed at surface mining and quarrying operations, the surface of underground mines, and associated processing plants.

There are particular requirements for the following:

- (a) The operation of equipment and personnel interacting with electrical installations.
- (b) Trailing cable fed machinery used for digging/winning product (i.e. electric draglines, electric face shovels, floating dredges, and electric drills), and transporting, stacking and reclaiming product (i.e. conveying systems, balance machinery such as stackers and reclaimers).
- (c) Power generation and distribution equipment used to supply trailing cables and relocatable plant.
- (d) Power and distribution on IT (impedance earthed) systems, TN and TT systems.
- (e) Earthing systems for power distribution to underground mines.
- (f) Overhead lines on a mine site.
- (g) Relocatable plant and buildings.
- (h) Fixed plant.

This Standard does not apply to the following areas:

- (i) Earth moving machinery covered by ISO 6165 and not fed by trailing or reeling cables.
- (ii) The design of mine winder control systems.

The Standard describes the types of electrical distribution systems.

This Standard supplements the requirements of AS/NZS 3000, AS 2067, and AS 60204 for installations in the harsh environments found in mining and quarrying operations.

Where equipment is located on the surface and there is conflict with the AS/NZS 4871 series, this Standard takes precedence.

NOTES:

- 1 The requirements of this Standard may be read in conjunction with, but do not take precedence over, regulations of a regulatory authority that may apply in a specific area.
- 2 In some instances, State legislation refers to parts of the previous version of this Standard, therefore it is important to note that these parts have now been combined into the one document.

1.2 REFERENCED DOCUMENTS

The following documents are referenced in this Standard:

AS

- | | |
|----------|--|
| 1318 | Use of colour for the marking of physical hazards and the identification of certain equipment in industry (known as the Industrial Safety Colour Code) |
| 1319 | Safety signs for the occupational environment |
| 1603 | Automatic fire detection and alarm systems (series) |
| 1670 | Fire detection, warning, control and intercom systems—System design, installation and commissioning (series) |
| 1674 | Safety in welding and allied processes—Electrical |
| 1674.2 | Part 2: Electrical |
| 1755 | Conveyors—Safety requirements |
| 1824 | Insulation co-ordination (series) |
| 1851 | Routine service of fire protection systems and equipment |
| 2067 | Substations and high voltage installations exceeding 1 kV a.c. |
| 2118 | Automatic fire sprinkler systems (series) |
| 2187 | Explosives—Storage, transport and use |
| 2187.2 | Part 2: Use of explosives |
| 2290 | Electrical equipment for coal mines—Maintenance and overhaul |
| 2290.3 | Part 3: Maintenance of gas detecting and monitoring equipment |
| 2293 | Emergency escape lighting and exit signs for buildings |
| 2293.1 | Part 1: System design, installation and operation |
| 2444 | Portable fire extinguishers and fire blankets—Selection and location |
| 2467 | Maintenance of electrical switchgear |
| 2665 | Smoke/heat venting systems—Design, installation and commissioning |
| 2700 | Colour standards for general purposes |
| 4024 | Safety of machinery (series) |
| 4436 | Guide for the selection of insulators in respect of polluted conditions |
| 4777 | Grid connection of energy systems via inverters (series) |
| 7240 | Fire detection and alarm systems (series) |
| 60044 | Instrument transformers (series) |
| 60076 | Power transformers |
| 60076.1 | Part 1: General (IEC 60076-1, Ed. 2.1 (2000) MOD) |
| 60204 | Safety of machinery—Electrical equipment of machines |
| 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) |
| 60529 | Degrees of protection provided by enclosures (IP Code) |

AS

- 60974 Arc welding equipment
- 60974.1 Part 1: Welding power sources (IEC 60974-1:2000, MOD)
- 60974.6 Part 6: Limited duty portable arc welding and allied process power sources (IEC 60974-6:2003, MOD)
- 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems (series)
- 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

AS/NZS

- 1020 The control of undesirable static electricity
- 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
- 1668 The use of ventilation and airconditioning in buildings
- 1668.1 Part 1: Fire and smoke control in multi-compartment buildings
- 1747 Reeling, trailing and feeder cables used for mining—Repair, testing and fitting of accessories
- 1768 Lightning protection
- 1850 Portable fire extinguishers—Classification, rating and performance testing
- 2081 Electrical protection devices for mines and quarries
- 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)
- 3001 Electrical installations—Transportable structures and vehicles including their site supplies
- 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
- 3010 Electrical installations—Generating sets
- 3012 Electrical installations—Construction and demolition sites
- 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 control systems for mining equipment (series)
- 4763 Safety of portable inverters
- 4836 Safe working on or near low-voltage electrical installations and equipment
- 4853 Electrical hazards on metallic pipelines

AS/NZS

- 4871 Electrical equipment for mines and quarries
- 4871.1 Part 1: General requirements
- 4871.2 Part 2: Distribution, control and auxiliary equipment
- 4871.3 Part 3: Substations
- 5603 Stand-alone inverters—Performance requirements
- 7000 Overhead line design—Detailed procedures
- 60079 Explosive atmospheres
- 60079.10.1 Part 10.1: Classification of areas—Explosive gas atmospheres (IEC 60079-10-1, Ed. 1.0 (2008) MOD)
- 60079.10.2 Part 10.2: Classification of areas—Combustible dust atmospheres
- 60079.14 Part 14: Electrical installations design, selection and erection (IEC 60079-14, Ed 4.0 (2007) MOD)
- 60079.17 Part 17: Electrical installations inspection and maintenance
- 60079.29.2 Part 29.2: Gas detectors—Selection, installation, use and maintenance of detectors for flammable gases and oxygen
- 61000 Electromagnetic compatibility (EMC) (series)
- 62040 Uninterruptible power systems (UPS) (series)

AS IEC

- 61511 Functional safety—Safety instrumented systems for the process industry sector (series)

AS ISO

- 14520 Gaseous fire-extinguishing systems—Physical properties and system design
- 14520.1 Part 1: General requirements (ISO 14520-1:2006, MOD)

AS/NZS

AS/NZS ISO

- 31000 Risk management—Principles and guidelines

IEC

- 61800 Adjustable speed electrical power drive systems
- 61800-5-1 Part 5-1: Safety requirements—Electrical, thermal and energy
- 61800-5-2 Part 5-2: Safety requirements—Functional
- 60255 Measuring relays and protection equipment (series)
- 60353 Line traps for a.c. power systems
- 60481 Coupling devices for power line carrier systems
- 60495 Single sideband power-line carrier terminals
- 60751 Industrial platinum resistance thermometers and platinum temperature sensors

IEC/TR

- 60663 Planning of (single-sideband) power line carrier systems

ISO

- 6165 Earth-moving machinery—Basic types—Identification and terms and definitions
- 13849 Safety of machinery—Safety-related parts of control systems
- 13849-1 Part 1: General principles for design
- 16732 Fire safety engineering—Fire risk assessment
- 16732-1 Part 1: General

BS

6657 Assessment of inadvertent initiation of bridge wire electro-explosive devices by radio-frequency radiation. Guide

ENA Guides

Doc 023 ENA guidelines for safe vegetation management works near overhead lines

EG0 A risk based approach to earthing

IEEE

80 Guide for Safety in Ac Substation Grounding

1584 Guide for performing arc-flash hazard calculations

NFPA

70E Electrical safety in the workplace

ANSI/IEEE

C37.2 Electrical power system device function numbers, acronyms and contact designations

ARPANSA

Code of practice and safety guide for radiation protection and radioactive waste management in mining and mineral processing, 2005.

1.3 DEFINITIONS

For the purpose of this Standard the following definitions shall apply:

1.3.1 Armour (of a cable)

A covering consisting of metal tapes or wires used to protect the cable from external mechanical effects.

1.3.2 Closed electrical operating area

An area dedicated for the operation of electrical installations and equipment to which access is intended to be restricted to skilled or instructed persons or to lay personnel under the direct supervision of skilled or instructed persons.

NOTES:

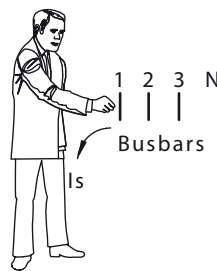
- 1 Examples of such locations include substations, enclosed switchgear and distribution installations, transformer enclosures, enclosed switchgear bays or cubicles, distribution installations in sheet metal housings or in other closed installations.
- 2 Typically access to closed areas is only by the use of a key or tool to open a door or remove a protective barrier, and where that access is clearly marked by appropriate warning signs.

1.3.3 Dead-man control

A control switch (or other similar device), either hand or foot operated, which upon release automatically returns to the off position and causes the machinery to be brought safely to rest.

1.3.4 Direct contact

Contact with a conductor or conductive part that is live in normal service.



I_s : touch current

FIGURE 1.1 DIRECT CONTACT

1.3.5 Direct supervision

Direct supervision is where a person is under the immediate control and direction of the supervisor of electrical work who will be in attendance at all times.

1.3.6 Earth electrode

Conductive part which may be embedded in the soil or in a specific conductive medium, (e.g. concrete or coke) in electric contact with the earth.

1.3.7 Earth fault current

A current which flows from phase conductors to earth, protective conductors or protective enclosures, etc., from the point of insulation breakdown.

[IEV 826-13-05]

1.3.8 Earthable point

The point in the power system (e.g. of the transformer or generator) which would be connected to earth if the system were to be earthed.

NOTE: The earthable point may be the neutral point depending on the type of power system.

1.3.9 Electrical equipment

Item used for such purposes as generation, conversion, transmission, distribution or utilization of electric energy, such as electric machines, transformers, switchgear and controlgear, measuring instruments, protective devices, wiring systems, current-using equipment.

[IEV 26-16-01]

1.3.10 Electrical installation

Electrical equipment installed for the purposes of conveyance, control, measurement or use of electricity, where electricity is or is to be supplied for consumption; includes electrical equipment supplied from a distributor's system or a private generating system.

NOTES:

- 1 An electrical installation usually commences at the point of supply and finishes at a point (in wiring) but does not include low voltage equipment connected by flexible cable or cord.
- 2 Unless the context otherwise dictates, the term 'installation' is used in this Standard to mean electrical installation.

1.3.11 Enclosure

A part providing an appropriate degree of protection of equipment against external influences and against contact with live parts.

1.3.12 Equipotential bonding

Provision of electric connections between conductive parts, intended to achieve equipotentiality.

[IEV 826-13-1]

1.3.13 Equipotential bonding conductor

A protective conductor for ensuring equipotential bonding.

1.3.14 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.

EXCEPTION: The term 'exposed conductive part' does not apply to the following:

- (i) Conductive parts within an enclosure where the parts cannot be touched unless a key or a tool is required to remove the covers of the enclosure.
- (ii) Conductive parts within electrical equipment where the parts cannot be touched in normal use and movement of the electrical equipment, because of its configuration and size.
- (iii) Conductive parts that are effectively and permanently separated from live parts by—
 - (A) double insulation; or
 - (B) other conductive parts that are earthed.
- (iv) Conductive parts that are in the form of nameplates, screw heads, covers and similar attachments that cannot become live in the event of failure of insulation of live parts because of the manner in which they are supported and fixed.
- (v) A removable or hinged conductive panel fitted to a switchboard or other enclosure containing conductors that are so located and/or restrained that, in the event of any conductor becoming detached from a terminal or mounting, the conductor is incapable of making contact with the panel.

1.3.15 Extraneous conductive part

A conductive part that does not form part of an electrical installation but that may be at the electrical potential of a local earth.

NOTE: Examples of extraneous conductive parts include the following:

- (a) Metal waste, water or gas pipe from outside.
- (b) Cooling or heating system parts.
- (c) Metal or reinforced concrete building components.
- (d) Steel-framed structure.
- (e) Floors and walls of reinforced concrete without further surface treatment.
- (f) Tiled surfaces, conductive wall coverings.
- (g) Conductive fittings in washrooms, bathrooms, lavatories, toilets, etc.
- (h) Metallized papers.

1.3.16 Fault current

A current resulting from an insulation failure or the bridging of insulation.

1.3.17 Flexible feeder cable

An insulated cable that may be moved from time to time according to the operation without necessarily following the movements of the machinery.

1.3.18 Highest voltage (of a three-phase system)

The highest r.m.s. phase-to-phase voltage which occurs under normal operating conditions at any time and at any point of the system, excluding voltage transients (such as those due to system switching) and temporary voltage variations due to abnormal conditions (such as those due to fault conditions or the sudden disconnection of large loads).

1.3.19 Indirect contact

Contact with a conductive part that is not normally live but has become live under fault conditions (because of insulation failure or some other cause).

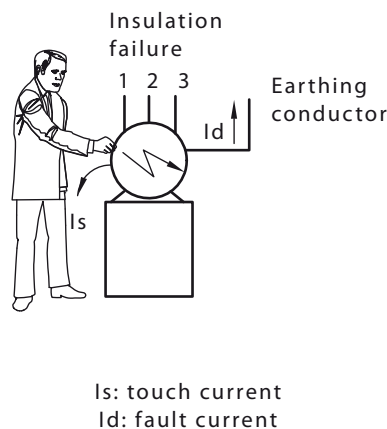


FIGURE 1.2 INDIRECT CONTACT

1.3.20 Instructed person

Person adequately advised or supervised by a skilled person to enable them to avoid dangers which electricity may create.

1.3.21 Insulation-monitoring device

A device which causes a signal to be given in the event of reduced insulation resistance to earth.

1.3.22 IT system

A power system having the earthable point not connected to earth, or connected to earth through impedance (resistor or reactor), the exposed conductive parts of the installation being connected to earth electrodes which may be the same as those used for the earthing resistor or reactor.

NOTE: For a description of the system, see Appendix A.

1.3.23 Leakage current (in an installation)

A current which, in the absence of a fault, flows to earth or to extraneous conductive parts in a circuit, and which may have a capacitive component including that resulting from the deliberate use of capacitors.

1.3.24 Lightning protection earth (LPE)

That part of a lightning protection system (LPS) intended to discharge lightning currents into the general mass of the earth.

1.3.25 Live part

A conductor or conductive part intended to be energized in normal use, including a neutral conductor.

NOTE: This term does not necessarily imply a risk of electric shock.

1.3.26 Machinery

- 1 Assembly of linked parts or components, at least one of which moves, with the appropriate machine actuators, control and power circuits, joined together for a specific application, in particular for the processing, treatment, moving or packaging of a material.
- 2 Assembly of machines which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole.

1.3.27 Main earthing terminal

A terminal or bar provided for the connection of protective conductors, including equipotential bonding conductors and conductors for functional earthing if any, to the means of earthing.

1.3.28 Mobile machinery

Machinery which is capable of being readily moved about whilst it is in operation, e.g. flexible conveyors, electric face shovels, draglines, and overburden drills.

1.3.29 Mine underground earth (MUE)

This is the power system earth for the underground electricity distribution whether into mine workings or ancillary boreholes.

1.3.30 Network earth (NE)

Network operators earth by virtue of connection of their overhead earth wire or cable screens or simply being the earth system that their fault level will impact.

1.3.31 Neutral conductor (symbol N)

The conductor of a three-wire or multi-wire system that is maintained at an intermediate and approximately uniform potential in respect of the active or outer conductors, or the conductor of a two-wire system that is connected to earth at its origin.

1.3.32 Nominal voltage (of a three-phase system)

The r.m.s. phase-to-phase voltage by which the system is designated and to which certain operating characteristics of the system are related.

1.3.33 Overhead line (OHL)

An electric line, having bare or insulated conductors, supported to maintain a specified minimum distance above ground level.

1.3.34 Prospective touch voltage

Voltage between simultaneously accessible conductive parts when those conductive parts are not being touched by a person or an animal.

[IEV 826-11-03]

1.3.35 Protective barrier (electrically)

A part providing protection against direct contact from any usual direction of access.

[IEV 826-12-02]

1.3.36 Protective conductor (symbol PE)

A conductor required by some measures for protection against electric shock for electrically connecting any of the following parts:

- (a) Exposed conductive parts.
- (b) Extraneous conductive parts.
- (c) Main earthing terminal (see Clause 1.3.27).
- (d) Earth electrode.
- (e) Earthed point of the source or artificial neutral.

NOTE: This is equivalent to protective earth conductor as defined in AS/NZS 3000.

1.3.37 Quarry

An open-air site for the extraction and processing of materials such as limestone, gravel, clay, etc.

NOTE: Any reference within this Standard to a mine or mining, also means quarry or quarrying.

1.3.38 Reeling and trailing cables

Cables having flexible conductors, insulation incorporating conductor and insulation screens where appropriate, filling, reinforcement where appropriate, one or more protective coverings, and being specially designed to provide flexible electrical connections between portable or mobile machinery and a point of supply.

1.3.39 Relocatable plant

Plant which is designed to be relocated from time to time during mining activities.

1.3.40 Residual current

Algebraic sum of the values of the electric currents in all live conductors, at the same time at a given point of an electric circuit in an electrical installation.

[IEV 826-11-1]

1.3.41 Restrained plug and receptacle

A restrained plug and receptacle is a device where the individual receiving sockets within the plug are arranged to have accessible pins. The plug is retained in the receptacle by a fixing device that can be operated without the use of a tool.

NOTE: For typical arrangements used in coal mining, see AS/NZS 1299.

1.3.42 Shall

Indicates that a statement is mandatory.

1.3.43 Should

Indicates a recommendation.

1.3.44 Skilled persons

Persons with technical knowledge or sufficient experience to enable them to avoid dangers which electricity may create.

1.3.45 TN system

A power system having the earthable point directly connected to earth and the exposed conductive parts of the installation being connected by protective conductors to the earthable point of the power system.

NOTE: For information on TN systems, see Appendix A.

1.3.46 Touch voltage

Voltage appearing between simultaneously accessible parts.

NOTES:

- 1 This term is used only in connection with fault protection.
- 2 In certain cases the value of the touch voltage may be appreciably influenced by the impedance of the person or livestock in contact with these parts.

1.3.47 TT system

A power system having the earthable point directly connected to earth, the exposed conductive parts of the installation being connected to earth electrodes which are electrically independent of the earth electrodes of the power system.

NOTE: For information on TT systems, see Appendix A.

SECTION 2 GENERAL REQUIREMENTS

NOTE: Specific requirements are given in Sections 3 to 17.

2.1 RISK MANAGEMENT

Risk management techniques shall be employed for the purposes of identification and assessment of risks associated with the use of electricity. This includes the identification of controls, and the implementation, validation and monitoring of those controls during the full life cycle, including the design, manufacture, commissioning, operation, maintenance and decommissioning of the equipment.

NOTE: 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/NZS ISO 31000, AS 60204.1, AS 62061, ISO 13849-1, AS 4024 (series) and AS/NZS 4240 (series).

For simple tasks, job safety analysis (JSA) or other site-specific procedures may be appropriate.

NOTE: The use of programmable electronic systems introduces an additional possibility of failure or defect if access to safety related software is not properly designed and monitored.

2.2 LOW VOLTAGE AND EXTRA LOW VOLTAGE INSTALLATIONS

Low voltage and extra low voltage electrical installations shall comply with the requirements of AS/NZS 3000.

2.3 HIGH VOLTAGE INSTALLATIONS

High voltage electrical installations shall comply with the requirements of AS/NZS 3000, AS 2067 and AS/NZS 7000.

2.4 EARTHING

Touch voltage clearance times shall be in accordance with AS/NZS 3000 and AS 2067 and Tables F2 and F3, Appendix F, as applicable.

Earthing for electrical supplies into underground mines and to flexible cable-fed plant shall be in accordance with Appendix F. These are supplementary to the requirements of AS 2067, AS/NZS 3000, AS 60204.1 and AS 60204.11.

NOTE: Appendix F has been added to this edition to provide detailed earthing requirements. Appendix F will be deleted by amendment when AS 2067 has been revised to address these issues.

The bond from the earthable point of the power system, if earthed, to the earthing system, is a highly critical connection. Performance, security, robustness, contingency, and proximity to the respective transformer are integral to the design.

The earthable point of a generator shall comply with AS/NZS 3010.

Equipotential bonding should be installed between metallic structures and plant that may be insulated from the structure (plant with rubber resilient mountings such as screens in processing plants).

Resistive, reactive, and resistive/reactive earth fault current limiting devices shall comply with AS/NZS 2081.

NOTE: Alternative technologies that provide an equivalent level of safety are not excluded (e.g. arc suppression coils).

When a system consists of multiple transformers, each with its own earth fault current limitation device, and the bus tie(s) between them is (are) closed, the total system fault current consists of the level of current flowing through each of the earth fault current limitation devices added together. This shall be taken into consideration when designing an installation and determining potential voltages that may result as a function of an earth fault within the installation.

2.5 REMOVAL OF POWER AT A CLOSED ELECTRICAL OPERATING AREA

Emergency shutdown facilities shall be provided to enable power to be removed from a closed electrical operating area without the need to enter that operating area, e.g. an emergency stop located external or remote to a switch room.

2.6 ELECTRICAL MACHINERY

Electrical machinery shall comply with AS 60204.1 and AS 60204.11.

2.7 PROTECTION FROM NON-ELECTRICAL HAZARDS

Where electrical technology is used to protect people from non-electrical hazards, the equipment and application shall comply with AS 4024 (series), AS 61508 (series), AS IEC 61511 (series), AS 62061 or ISO 13849-1 as appropriate.

2.8 PROTECTION FROM ELECTRICAL HAZARDS

2.8.1 General

Interlocking systems shall have a category of protection consistent with AS 4024.1501 or safety integrity level consistent with AS 62061 or performance level consistent with ISO 13849-1.

2.8.2 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.

NOTES:

- 1 Under-voltage releases, providing the function of 'no volt, no close' are the preferred form of electrical release for electrical interlocking.
- 2 Any circuitry used for electrical interlocking should be ELV or be suitably guarded to protect against inadvertent direct contact.

Where a shunt trip device is the only form of tripping, test facilities to test the integrity of the trip circuit should be incorporated. The trip system shall comply with AS 4024 (series), AS 61508 (series), AS IEC 61511 (series), AS 62061, or ISO 13849-1 as appropriate.

To prevent inadvertent short circuiting of interlock switches, totally enclosed interlock switches of robust construction shall be used. Switch terminals shall be shrouded.

2.8.3 Electrical interlocking for restrained plugs and receptacles

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. The provision should also prevent automatic restoration of electricity on the insertion of the plug into its receptacle.

Loss of vacuum/frozen contact protection shall be provided to detect the failure to open of the switching device that supplies the restrained receptacles. Where a switching device is used for the control of restrained outlets, and elsewhere where determined by the risk management process, an upstream switching device shall be fitted with a shunt and/or under-voltage release to remove power from the faulted switching device.

2.8.4 Electrical protection tripping systems for distribution networks

Electrical protection tripping systems for distribution networks shall not be disabled by a single undetected failure of the tripping system.

NOTES:

- 1 AS/NZS 3000 and AS 2067 include particular requirements for electrical protection.
- 2 Design of the electrical tripping system should be consistent with functional safety principles.

The following considerations apply:

- (a) Where a single shunt release is used as the only form of tripping, two energy sources should be used for normal operation. One source may be a stored energy type that is capable of operating the shunt release at least once when the normal power supply is removed.
- (b) The status of the shunt trip coil should be monitored.

Where access to the stored energy device is required, tripping of the circuit-breaker shall occur and access to the stored energy device shall not be possible until the stored energy device has discharged to a safe level.

2.8.5 Arc flash/blast protection

Design shall include provisions for the prevention of arc flash/blast injury. This shall include the positioning of operating handles, explosion vents, integrity and guarding of windows.

NOTES:

- 1 Consideration should be given to the use of remote switching.
- 2 For information on arc flash/blast protection, see IEEE 1584 and NFPA-70E.

For remote operation of equipment or plant, such as a circuit-breaker operated by a pendant, the safety of the control shall be taken into account and shall be rated in accordance with a functional safety analysis.

2.9 ISOLATING SWITCHES (DISCONNECTORS)

Isolating switches shall be mounted for external operation with a minimum degree of protection to the operator of IP2X to AS 60529.

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 devices.

NOTE: Off load make/off load break devices may be used provided they are equipped with an interlocking device that removes the load before the device is operated and has a suitable category or performance level or safety integrity rating relevant to the risk.

2.10 CIRCUIT-BREAKERS

2.10.1 General

The mounting of the circuit-breaker shall provide for external operation with a minimum degree of protection to the operator of IP2X to AS 60529.

It shall not be possible to re-close a circuit-breaker (including momentary closure, i.e. close-re-trip) that has tripped without first resetting the protection system that caused the circuit-breaker to trip.

NOTE: This may be achieved by systems that have their protection trip interfaced into the motor recharge/closing coil circuit to prevent their operation.

2.10.2 Low voltage distribution boards

For low voltage distribution boards containing miniature circuit-breakers, where two or more circuit-breakers are mounted in the same row, the operating mechanism of each shall cause the circuit to open when the operating means are orientated in one general direction. Where multiple horizontal rows of circuit-breakers are contained within a switchboard, each row of circuit-breakers shall operate in the one general direction, and shall have additional labelling to clearly indicate the ON/OFF position.

2.11 CABLES

Cables used for power supply and distribution shall be suitable for the intended application, duty and environment including exposure to high temperatures.

Cables that are likely to endure damage to non-protected external insulation during normal operation due to moisture, vibration or mechanical damage shall have metallic screens and/or armouring or shall be provided with conducting elastomeric screens of substantial cross-sectional area so placed as to limit to acceptable levels the touch voltages, as specified in Clause 2.4, and step voltages, as specified in IEEE 80, which may arise in the event of a cable fault.

NOTES:

- 1 Examples of high vibration areas include process plants and crushing plants.
- 2 Examples of areas where mechanical damage to insulation can occur include industrial workshops and welding bays.

For low voltage cables, the suitability of the earthing conductor cross-sectional area shall be confirmed in accordance with AS/NZS 3008.1.1.

For high voltage cables, the suitability of the sheath bonding method shall be confirmed in accordance with AS 2067.

2.12 SYSTEM DESIGN

2.12.1 General

The supply system shall meet the requirements of cyclic or periodic loads, motor starting, inherent a.c. motor oscillations, transient load changes and regeneration from large motors.

2.12.2 Harmonic sources

Harmonic sources such as rectifiers, switch mode power supplies and inverter-fed drives have the potential to create high frequency (capacitive) zero sequence ground currents that flow back to the supply neutral during normal operations.

In cases where neutral earthing impedance is installed, zero sequence currents create a voltage across the impedance. Care should be taken to avoid nuisance trips, alarms, or general maloperation of protection systems. The sizing and rating of the impedance should also be considered to ensure it can handle these currents.

2.12.3 Supply system to trailing cable and reeling cable fed machinery

Touch potentials and step potentials are a function of the resistance of the earth return circuit and the current that flows through the earth return circuit. To minimize the touch and step potentials either—

- (a) the resistance of the earth return circuit shall be reduced; or
- (b) the currents that can flow through the earth return circuit shall be limited.

NOTES:

- 1 Reducing the resistance of the earth return circuit is not always practicable, especially when the fault current can be in the magnitude of thousands of amps or where long runs of cables are required to power mobile or transportable equipment.

Limiting the magnitude of the fault current reduces prospective touch potentials at remote equipment without the need to use large CSA earthing cables. The earth fault current limitation device also has the advantage of reducing touch potentials for all circuits fed from the transformer.

For these reasons the supply system associated with power to mining and quarrying machinery that are supplied via trailing or reeling cables should have earth fault current limitation, i.e. an impedance earthed IT system.

- 2 For details of the IT system and other systems, see Appendix A.

2.12.4 Switch mode power supplies

Switch mode power supplies are widely used. Numerous electric shocks have occurred on mine sites (involving vending machines, battery chargers and welders) when the earth connection has been compromised. The EMC/RFI filters within these machines utilize the protective earth as a discharge path for the filter; if the earth connection is lost, the discharge path can be to the frame of the device, resulting in the potential of the frame rising above earth.

Care shall be taken to ensure that the machine is installed within an appropriate environment, and the maintenance scheme concentrates on ensuring the integrity of the earth connection.

2.13 GENERAL REQUIREMENTS FOR ELECTRICAL COMPONENTS

2.13.1 Relevant Standards

The electrical specifications of all components shall be not less than that required by the relevant Australian or IEC Standards.

2.13.2 Design and selection

Design and selection of components shall be on the basis of expected loading, operating characteristics and cyclic duty, taking into consideration the protection required in special and arduous environmental, operational, transportation and storage conditions.

Some of these conditions are as follows:

- (a) High altitude.
- (b) Low and/or high ambient temperature.
- (c) Supply voltage variations.
- (d) Supply frequency variations.
- (e) Insecure power supply and transients.
- (f) High or low humidity.
- (g) Environment, e.g. dust, wind pressure, marine atmosphere.
- (h) Flammable and/or explosive materials and/or atmospheres.

- (i) Vermin, including rodents or other small animals.
- (j) Localities prone to natural catastrophes.
- (k) Ecological impact.
- (l) Corrosive environments.
- (m) Wet/hose down-environments.
- (n) Ultraviolet light.

In order to ensure that correct design parameters are selected, mutual agreement shall be reached between the user and the supplier as to the quantitative and/or qualitative conditions.

Equipment shall be applied, installed, and operated in accordance with the manufacturer's instructions.

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

2.13.3 Construction of components and enclosures

Design shall incorporate features to deal with arduous handling and transportation conditions to which the equipment is to be subjected. Suitably rated lifting and towing points, skid bases, fork lift facilities, etc., shall be included in the design.

The design of all enclosures shall provide operator safety by means of—

- (a) doors, fixed panels and partitions to prevent contact with live conductors and exposure to arcing products;
- (b) an enclosure rated to contain or control the effects of the prospective fault energy;
- (c) vents located in a position to direct any arc products away from the operator; and
- (d) pressure relief to atmosphere so that any abnormal pressures that develop are directed away from the operator.

Enclosures shall have a minimum degree of ingress protection in accordance with AS 60529 appropriate for the installation location and conditions.

Unused openings and threaded entries shall be closed or plugged so the degree of ingress protection of the enclosure is maintained.

2.13.4 Terminals

The majority of mining cables have flexible multi-stranded conductors. The different cross-sections and manufacturer's recommendations are relevant when selecting the dimensions of the terminals and crimp lugs to which they may be connected.

2.13.5 Measuring instruments

Measuring instruments shall not be connected into any protective circuit such that the measuring instrument may impair the operation of the protective circuit.

2.13.6 Isolation of data and communication lines

Where data communications devices are used they shall be arranged to minimize the coupling of hazardous voltages onto data communications lines.

In particular, data modems that connect or couple to power cables shall be suitably rated for the application and type tested to withstand the expected voltage range.

NOTES:

- 1 This should include consideration of any coupling to any energized circuits at remote locations and possibly different voltages to ensure these circuits are effectively isolated.
- 2 For guidance on low level signal and communication systems, see Appendix C

2.13.7 Clearance and creepage

Design of electrical equipment shall take into account the arduous environment in which the equipment is to be installed. Clearance and creepage shall be appropriate for the level of moisture and pollution that the electrical equipment is likely to be subjected to. The minimum distances for clearance and creepage shall be in accordance with Table 2.1.

NOTE: For details of the degree of pollution expected in particular locations, see AS 4436.

TABLE 2.1
MINIMUM CLEARANCE AND CREEPAGES IN AIR

	Clearance of creepage, mm						
	≤15 V	300 V	600 V	1000 V	3300 V	6600 V	11000 V
Clearance phase-to-phase direct	3	5.5	8	14	51	89	127
Clearance phase-to-earth direct	3	5.5	8	14	51	64	76
Creepage phase-to-phase over insulation	5	10	20	32	76	146	216
Creepage phase-to-earth over insulation	5	10	20	32	51	89	127

NOTES:

- Clearances and creepages ≤ 1000V are derived from AS/NZS 3439.1:2002.
- It should be realized that any tabulation of pollution characteristics cannot cover the complete range of pollution possible and hence it may be necessary, in particular cases, to increase creepage distances for the special pollution encountered. Consideration should also be given to the possibility of varying pollution levels due to seasonal changes and exceptional climatic conditions.
- Except for Pollution degree I as defined in AS/NZS 3439.1, condensation of water will always be considered arising from either—
 - the temperature of the insulation surface falling below the dew-point of the surrounding air; or
 - hygroscopic dust or salt contamination causing moisture to deposit at low relative humidity.
- Conductive dusts may originate from the environment (e.g. material being mined or processed), or from within an enclosure (e.g. dust from carbon or metallic brushes).
- The voltage corresponds to the system highest voltage (phase-to-phase).
- This Table supplements the creepage and clearance requirements of AS 2067.

2.13.8 Information requirements

A Safety File (or Verification Dossier) shall be maintained over the life cycle of all electrical equipment, to provide traceable evidence relating to the safety of the equipment over each of the phases of the life cycle, and provide a reference to consider prior to carrying out any upgrades, modification or changes to maintenance practices.

NOTES:

- The information may be supplied by manufacturers and overhaul service providers, and some may be operationally managed by the mine operators.
- For a list of topics that should be taken into consideration, see Appendix E.

SECTION 3 PROTECTION AGAINST OVERLOADS AND FAULTS

3.1 INTRODUCTION

3.1.1 General

This Section sets out the minimum requirements for protection against overcurrent in respect of overload protection and short-circuit protection, together with the coordination of overload and short-circuit protection and the coordination of this protection with the conductors and apparatus.

Earth fault protection on earth fault restricted systems is specifically covered.

This Section supplements the requirements of AS/NZS 3000, AS 2067, AS 60204.1 and AS 60204.11.

NOTE: For information on the types of protective devices and their maintenance, see Appendix B.

3.1.2 System fault levels

Consideration shall be given to the fault levels of electrical circuits to ensure the electrical equipment and cabling are rated for the system fault level.

NOTES:

- 1 Any protection study undertaken should take into consideration the effects of minimum and maximum possible fault levels.
- 2 Overcurrent protection arrangements should take into consideration the reduction of risk from arc flash and blast by ensuring short-circuit faults are detected at the minimum practicable current and the fault cleared in the quickest possible time.
- 3 The use of impedance earthed IT systems and the potential advantages in reducing arc flash risks are given in Paragraph A5.1, Appendix A.
- 4 The use of arc-detection devices or other specialist arc flash protection devices may reduce the impact of an arc flash/blast event.

3.2 GENERAL RULE

Electrical equipment and live conductors shall be protected by one or more devices for automatic interruption of the supply in the event of overcurrent due to overload and short-circuits except as identified in Clause 3.3.

Protection against overload and against short-circuits shall be coordinated in accordance with Clause 3.4.

3.3 AUTOMATIC INTERRUPTION—PROTECTION AGAINST OVERCURRENT DUE TO OVERLOAD

Any electrical equipment which may cause overcurrent due to overload should be provided with an overload protective device to automatically interrupt the supply to the equipment.

Devices for protection against overcurrent shall not be provided for circuits where unexpected opening of the circuit could cause a danger greater than overcurrent.

NOTE: Examples of such circuits are certain safety system supplies, lifting magnets, exciter circuits of machines and the secondary circuits of current transformers. In such cases the provision of an overload alarm is strongly recommended.

Overload protective devices should not be installed in conductors supplying electrical equipment where the unexpected opening of the circuit could cause a danger greater than not opening the circuit. Such cases may include but not be limited to the following:

- (a) Excitation circuits for d.c. and a.c. (synchronous) motors.
- (b) Supply circuits of lifting magnets.
- (c) Current transformer secondary circuits.
- (d) Fire service pumps and certain drainage pump installations.
- (e) Elevators (lifts).
- (f) Hoists.
- (g) Special hydraulic pumps.
- (h) Excavator main drives.
- (i) Certain conveyors.
- (j) Certain braking circuits.
- (k) Emergency lighting and signalling.
- (l) Certain drainage pump installations.

NOTE: Where thermal overload protection is not provided in the above examples, additional fire proofing measures should be considered, for example, oversized or fire-resistant cabling.

3.4 COORDINATION OF OVERLOAD AND SHORT-CIRCUIT PROTECTION AFFORDED BY SEPARATE DEVICES

Where the short-circuit and overload protection is provided by separate devices, the characteristics of the devices shall be coordinated so that the breaking capacity of the overload device is not exceeded.

3.5 EARTH FAULT PROTECTION ON IMPEDANCE EARTHED IT SYSTEMS

Earth fault protection shall be provided on all impedance earthed IT systems except as allowed for in Clause 11.3 (see Note 1).

Where an earth fault current limitation device is not continuously rated, it shall be protected by duplicate protection schemes (see Note 3).

NOTES:

- 1 The ratio of earth fault current-to-earth fault protection trip should be as high as practical, whilst taking into consideration nuisance tripping caused by capacitive current.

Mechanical failure of an earth fault limitation device caused by vibration, shock, corrosion, insulation failure or external force applied to terminals can cause an IT system to become—

- (a) open circuit and thus disconnected from the earth reference; or
- (b) shorted to earth thus bypassing all or part of the impedance of the device and therefore increasing the value of the prospective earth fault current.

The thermal failure of an earth fault current limitation device can cause an IT system to become disconnected from the earth reference.

The above scenarios present extremely dangerous outcomes that can ultimately lead to the inability to detect an earth fault or increased touch and step potentials or cascaded system insulation failure.

- 2 Consideration should be given to the installation of an NER integrity monitoring device complying with AS/NZS 2081.
- 3 Continuously rated earth fault limitation devices are not normally manufactured above 25A.

Earth fault current limiting devices should be inspected annually.

Following the activation of a backup earth fault protection scheme, the earth fault current limiting device shall be inspected unless an NER integrity monitor is fitted.

Consideration should be given to utilizing duplicate systems for earth fault protection.

NOTES:

- 1 Examples of duplicate protection schemes include the following:
 - (a) Utilizing two current transformers, two separate earth fault protection relays, and duplicate fault clearing mechanisms.
 - (b) Single earth fault protection scheme and negative phase sequence protection scheme upstream which operates a separate fault clearing mechanism.
 - (c) Single earth fault protection scheme and negative phase sequence protection scheme upstream.
- 2 Examples of duplicate fault clearing mechanisms include the following:
 - (a) Duplicate series circuit-breakers.
 - (b) Dual trip coils on single circuit-breaker.
 - (c) Schemes based on circuit-breaker fail principles.
- 3 The assessment may take into consideration a 10:1 trip ratio with a time delay as a backup to a primary non-delayed trip at a lower trip ratio.
- 4 During the inspection of an earth fault current limitation device, particular attention should be paid to the condition and integrity of earth and neutral terminal bushings, bolted connections, and corrosion on the element and any welds within the device. Applying a current significantly less than the let-through value of the device in order to measure the resistance and therefore make an assessment of the integrity of the device, without an additional physical inspection, is not a reliable means of assessment.
- 5 Further information on the installation and use of earth fault protection systems is given in AS/NZS 2081.

SECTION 4 ELECTRICAL WIRING OF EQUIPMENT AND MACHINERY

4.1 GENERAL

This Section applies to the following:

- (a) Machinery which is capable of being readily moved about whilst it is in operation, e.g. flexible conveyors, electric face shovels, draglines and overburden drills.
- (b) Fixed and mobile processing plant (grinding circuits, mills, crushers, thickeners, etc.).
- (c) Refineries.

Electrical equipment of machinery and associated accessories shall be well constructed, rugged, based on sound engineering principles and designed in a manner that will facilitate inspection and maintenance.

Components shall be designed to meet such conditions as vibration, acceleration, deceleration, slewing and angles of inclination (tilting and mounting), which may occur under expected operational conditions.

Enclosures with withdrawable and plug-in equipment on such machinery as draglines and face shovels 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.

4.2 ELECTRICAL ISOLATION

Isolating facilities by means of which all power to the machinery can be isolated for the purpose of carrying out electrical work shall be provided.

The isolating facilities shall be capable of being locked in the isolated position.

The isolating facilities shall be either in a separate compartment or remote from the machinery to isolate the supply cable.

4.3 ISOLATING FOR MECHANICAL MAINTENANCE

An isolating device to isolate all power to the machinery for the purposes of carrying out non-electrical work on the machine shall be provided.

The main isolating device shall isolate all electrical power circuits that may affect movement.

NOTE: On the load side of the isolating device, functional switching devices may be used for individual drives or groups of drives.

4.4 REMOTE CONTROL

Remote control of mobile machinery shall comply with the AS/NZS 4240 series.

NOTE: It is not intended that the AS/NZS 4240 series be applied to equipment not covered by the scope of that series.

4.5 PENDANT CONTROL (UMBILICAL CORD)

Pendant control of mobile machinery should comply with the AS/NZS 4240 series.

NOTE: It is not intended that the AS/NZS 4240 series be applied to equipment not covered by the scope of that series.

4.6 CABLING

4.6.1 Single-core cables

Single-core cables which are installed in intimate contact in a common duct, conduit or sleeving may be used for both power and control circuits. All such cables shall be insulated for the maximum voltage applied to any cable in the duct, conduit or sleeving.

When using single-core cables for alternating current circuits, all conductors of a given circuit shall follow the same magnetic path to neutralize the resultant magnetic flux.

NOTES:

- 1 For recommendations relating to the segregation and/or screening of cables to minimize interference to low signal level systems and communication systems, see Appendix C.
- 2 For the correct arrangement of phase, neutral and protective earth conductors in single-core wiring systems, see AS/NZS 3008.1.1.

4.6.2 Machinery cables

The following requirements apply to all cables installed external to an electrical enclosure on mobile machinery:

- (a) They shall be arranged clear of moving parts.
- (b) They shall be protected from hot surfaces that may adversely affect the insulation of cables.
- (c) They shall be arranged so as to prevent excessive bending or twisting.
- (d) They shall be clamped in place to prevent undue movement.
- (e) They shall be protected from mechanical damage by being correctly positioned within the body of the machinery.
- (f) They shall be impervious to or be protected from ultraviolet degradation.
- (g) They shall be protected from hydraulic lines and abrasions.
- (h) They shall be of the same temperature rating or higher as the environment in which they are installed.

NOTE: Consideration should be given to possible sheath and insulation damage due to the presence of oils, greases and other fluids and materials.

4.7 ROTATING ELECTRICAL MACHINES

4.7.1 Mechanical construction

Rotating machines used in applications where high acceleration, overspeed, reversing or braking may be employed shall be designed and constructed so as to withstand expected stresses that may occur to parts such as rotor windings or cages, stators, stator end windings, shafts and couplings.

4.7.2 Guarding

Electrical rotating machines shall be so located or guarded as to prevent inadvertent contact with moving parts.

NOTE: Guarding should be in accordance with the AS/NZS 4024 series.

4.7.3 Particular features

For rotating electrical machines, the following should be taken into consideration:

- (a) Accessible connections to motor leads or terminals, including earth connection.
- (b) Devices that secure screwed covers into place so that unauthorized persons cannot unscrew the cover.

- (c) Lifting lugs to facilitate handling on and off the machinery.

NOTE: In general, the eye provided on a motor is not rated for lifting the motor. For means to lift the motor, the supplied technical information should be consulted.

- (d) Adequate mounting fixings or supports, with reasonable access to all fasteners, which are required for routine inspection and maintenance.

- (e) Avoidance of entries that will allow water to enter the motor enclosure during normal operating conditions.

NOTE: It may necessitate consideration of protection in the machinery design to prevent a direct fall of water on motors.

4.7.4 Variable speed drives

Variable speed drives shall comply with IEC 61800-5-1 and IEC 61800-5-2.

NOTE: Refer to Appendix D for information on variable speed drives.

4.8 MOBILE MACHINERY CABLE ATTACHMENTS

Attachments should be provided for anchoring trailing cables where the cable attaches to the machinery.

The design should allow for all machinery movements to minimize the risk of cable damage. Where the cable is secured to allow reeling of the cable, means should be provided to reduce shock loading on the cable in excess of the safe working load of the cable.

4.9 CABLE REELS

4.9.1 Introduction

Cable reel drums and bending radii for reeling cables (frequently reeled on and off a cable drum) shall be designed according to Clause 4.9.2 to 4.9.5.

4.9.2 General

Cable reel drums shall comply with AS 60204.1 and for high voltage machinery with AS 60204.11.

The driven reel shall maintain positive tension on the trailing cable during reeling and unreeling operations. The tension shall be within the cable manufacturers' specified operating tensions under all operating conditions.

Cable reel bearings shall not be an integral part of a circuit for transmitting electrical energy nor form part of the earthing circuit.

NOTE: Cable reel drums should be designed to prevent undue bending of cables outside the cable manufacturers' specified operating bending radius for continuous reeling and sheathing duty.

4.9.3 Drum rating factors

Provision should be made in the design of ventilated cylindrical cable reel drums to space each turn apart by at least 10% of the cable diameter.

4.9.4 Permissible reductions in cable reel drum diameters

A reduction of the cable reel drum diameter with consequent reduction of cable life may be employed where critical space limitations on certain plant, such as in winning machinery or conveyors, preclude the use of the limiting values specified in AS 60204.1. Similar reductions may be employed where cables are specifically designed for the arduous duty associated with certain specialized equipment or where cables are reeled infrequently.

4.9.5 Cable reel interlock limit

Cable reels shall be fitted with a protective device to stop the machinery travel. The functionality of the protection device shall be determined by the risk management process.

The protective devices shall operate in the event that—

- (a) the cable exceeds the maximum safe limit of cable on the reel (over fill limit);
- (b) the quantity of cable falls below the minimum safe limit (run out limit); or
- (c) the cable reel is in contact with the ground and the cable will be damaged if the cable reel continues to rotate (jacking limit).

The above mentioned devices shall—

- (i) automatically bring the machinery safely to a stop and apply the brakes; and
- (ii) be part of a control circuit so arranged that resetting of the device does not automatically restart the machinery.

The above requirements do not apply to machinery within a defined boundary, e.g. track-mounted stackers and reclaimers.

4.10 MOBILE MACHINERY LIGHTING SYSTEMS

Mobile machinery shall be provided with a lighting system that is appropriate for the machinery's operation.

Design of machinery lighting shall consider the effects of light pollution on machinery operators and affected neighbours.

Lighting circuits shall be arranged with emergency lighting or multiple circuits to ensure sufficient lighting is available during partial or total power loss.

NOTE: The design and installation of emergency escape lighting and exit signs should take into consideration AS 2293.1.

4.11 CONTROL CIRCUITS AND CONTROL DEVICES

4.11.1 Control, protection and auxiliary conductors

Where there is a reduction of cross-sectional area of conductors connecting the power source to an auxiliary circuit protective device, the conductors shall be double insulated and as short as practicable.

4.11.2 Centre tapped control circuits

Where the control supply is earthed via the centre tap of a transformer, operating coils shall not hold in at a voltage that exists between one leg and the earth point.

NOTE: This may require the addition of further protection such as 30 mA earth leakage protection or insulation monitoring where the control circuit extends to field devices.

4.11.3 Unearthed control circuits

For unearthed control circuits, measures shall be implemented which ensure in case of normal operating conditions with no circuit faults that, after an operational switch-off, the total current flowing through the closing coil of a switching device shall be less than the current needed for holding the switched-on position of the switching device.

This total current shall also be less than the drop-out current of the switching device with the smallest drop-out current. This total current includes those currents caused by capacitance and leakage to earth and capacitance and leakage between the cores of the control circuit.

The value of the drop-out current for the switching device in use shall be measured and used as a basis for determining the total permissible capacitance and leakage currents, which shall not exceed 70% of the drop-out current.

4.11.4 Earthed control circuits

For earthed control circuits where a single-pole switch(es) is used for actuating the control device, the switch(es) shall be in the phase conductor to the device. The neutral conductor shall be directly connected to the other terminal of the device. Double-pole switch(es) may be used for actuating the control device provided that they operate simultaneously in both the phase and neutral conductors.

After an operational switch-off—in the case of normal operating conditions with no circuit faults—the total current flowing through the closing coil of a device shall be less than the current needed for holding the switched-on position of the device. This total current shall be less than the drop-out current of the device having the smallest drop-out current. The total current includes those currents caused by capacitance and leakage between the cores of the control circuit.

The value of the drop-out current for the device in use shall be measured and used as a basis for determining the total permissible capacitance and leakage currents which shall not exceed 70% of the drop-out current.

4.11.5 Control device location

Controls on all machinery shall be located so they are within easy reach of the operator.

NOTE: Consideration should be given to sound ergonomic principles for location and means of operation.

Where dual-driving cabs are fitted to machinery (e.g. draglines and EWPs), a control direction device shall be fitted and set to give control to one driving cab and to immobilize the controls in the second driving cab.

4.11.6 Synchronous motor control

4.11.6.1 Automatic discharge of field energy

Where synchronous motors are used, provision shall be made for automatic discharge of the field energy (i.e. field removal or suppression) upon disconnection of the motor.

4.11.6.2 Automatic field excitation control

Where synchronous motors are used to drive periodic or cyclic loads (a type of duty in which operation whether at constant or variable load is regularly repeated), an automatic field excitation control is recommended.

4.11.6.3 Power loss protection

Where synchronous motors are used to drive loads which may be regenerative, means shall be provided to trip the motor starting switch or incoming line switch upon loss of power supply.

NOTE: Frequency-sensitive devices are recommended.

4.11.7 Dead man control

Where a 'dead man control' is required, its operation shall stop travel movement and bring the machinery safely to rest.

NOTE: The principles described in AS 4024 (series) should be used in the design of the control.

4.11.8 Start controls

Where equipment is started manually from one or more locations, or is started automatically, a suitable audible warning device, together with appropriate notices, shall be provided to give advance warning of equipment starting, unless one or more of the following conditions apply:

- (a) Guarding is provided to prevent personnel access to hazardous parts.

- (b) Danger to personnel does not exist from equipment starting.

NOTE: For sequential starting of a localized plant group, a single warning system may be sufficient.

The audible alarm shall sound for a specified time (determined by a risk management process) before any movement occurs; in addition visual alarms may be required.

The alarms shall be operational regardless of what form of control has been selected.

SECTION 5 TRANSPORTABLE / RELOCATABLE DISTRIBUTION AND CONTROL EQUIPMENT

5.1 GENERAL

5.1.1 Issues

This Section covers distribution and control equipment which is required to be moved from place to place between periods of operation.

The types of issues commonly associated with the use of this type of equipment on a mine or quarry include the following:

- (a) The movement of the equipment around the site.
- (b) The verification of the design after relocation.
- (c) The supply of trailing cable fed machinery from a significant amount of this equipment.
- (d) The control of touch voltages.
- (e) The control of transfer voltages due to earth potential rise.
- (f) Lightning protection.
- (g) The operation of switchgear in a confined area.
- (h) The change of operating location and the resulting impact on system characteristics including verification of the electrical protection devices settings under the new conditions and location within the network.
- (i) The ability to supply power to a variety of loads.
- (j) Potential variability in the voltage at the point of connection and/or in the equipment being supplied.
- (k) The emergency removal of power.
- (l) Access to high voltage equipment.
- (m) Proximity to shot firing operations with respect to direct damage from overpressure waves, fly rock and excessive vibration.
- (n) Control of documentation.

5.1.2 Enclosures

Enclosures shall comprise single or multiple compartments, each fitted with suitable covers or access covers.

NOTE: Enclosures should incorporate facilities for lifting and transport.

Where enclosures are required to be coupled together, the coupling arrangement shall prevent, in normal use, undue strain being placed on any busbars, flanges or interconnecting cable coupling devices.

5.1.3 Means of isolation

A means shall be provided to isolate all circuits above extra-low voltage (ELV).

All isolators shall be externally operated and fitted with lockout facilities. The switched position and function of all isolators shall be clearly labelled.

Auxiliary circuits that are required to remain energized while the main power is isolated, such as lighting and power sources, shall be provided with a means of isolation. These auxiliary circuits shall only remain energized while the main power is isolated, provided such equipment and cabling associated with the auxiliary circuits are not housed in the same compartment(s) as equipment isolated by the main switching device.

5.1.4 Location of explosion vents

Particular care should be taken with the location of explosion vents on transportable equipment due to the different methods of access compared to fixed equipment.

5.1.5 Positioning of outlets

All outlets shall be positioned to allow ease of connection, removal of plugs, adequate bending radius of cables and ready access to outlet controls.

5.1.6 Lighting

Area lighting should be considered to improve the visibility of outlets, indicators, labels and instructions.

5.1.7 Internal wiring

Through-conductors shall maintain the same phase polarity and phase rotation on any extension supply.

5.1.8 Control, protection and auxiliary conductors

Where there is a reduction of cross-sectional area of conductors connecting the power source to an auxiliary circuit protective device, the conductors shall be double-insulated and as short as practicable.

5.1.9 Monitoring protective conductor continuity in trailing cables

Continuous continuity monitoring should be provided for the protective conductor of trailing cables supplying mobile machinery. Where such monitoring is used, the operating coils shall not be inserted in protective conductors.

5.2 TRANSPORTABLE SUBSTATIONS

5.2.1 General requirements

For substations supplied at 11 kV or below, substations constructed in accordance with AS/NZS 4871.3 may be used.

If cable droppers are used to provide high voltage supply to the transportable substation, the droppers shall be affixed to the powerline by suitably designed clamps and shall be provided with additional mechanical support to prevent tension to the electrical connection of these clamps.

NOTES:

- 1 These substations are commonly used to supply trailing cable fed mobile machinery and underground workings. They should be fitted with a form of earth fault current limitation.
- 2 For typical electrical protection arrangements and a diagrammatic example (see Figure B1, Appendix B).

5.2.2 Earthing terminals

Provision shall be made on each enclosure of the substation for the attachment of an external earthing terminal. There shall be at least two accessible terminals for connection to any associated earth grids/stakes. Earthing terminals shall be bonded together via copper straps or flexible conductors.

NOTE: The recommended minimum bonding conductor cross-sectional area (CSA) is 70 mm².

5.2.3 Primary switchgear

Circuit-breakers or combination fuse switch (CFS) units shall be provided in conjunction with protection devices to provide a means of protection against a range of fault conditions.

NOTE: Circuit-breakers are preferred.

5.2.4 Primary protection

Where utilized, the following protection shall clear the primary protection device of the transformer:

- (a) Short-circuit.
- (b) Overload.
- (c) Transformer differential.
- (d) Backup secondary side earth leakage.
- (e) Circuit-breaker loss of gas/vacuum.
- (f) Transformer over-temperature.
- (g) Transformer loss of gas, if gas pressurized.
- (h) NER integrity monitor.
- (i) Bucholz relay.
- (j) Overpressure switch.

For short-circuit, earth-leakage and loss of gas/vacuum trips, a positive means of fault diagnosis shall be provided to identify individual fault trips after loss of power.

5.2.5 Transformers

5.2.5.1 General

Power transformers shall comply with AS 60076.1 or equivalent.

NOTE: Electrostatic shielding between primary and secondary windings should be considered.

5.2.5.2 Core, coil and tank bracing

The core and coils of the transformer shall be securely clamped in order to ensure the whole assembly is sufficiently rigid to withstand any electrical or mechanical stresses, caused by the arduous cyclic duty and vibration, which may occur in service and when being transported around the mine.

Guides, locating lugs or a combination of both, shall be mounted with adequate fixing bolts inside the tank to register the location of the core.

NOTE: Means for attaching lifting tackle should be provided on the core frame.

5.2.5.3 Enclosures

Any transformer breather or pressure-relief means shall be fitted in such a way as to minimize degradation of the cooling medium (coolant) through condensation.

5.2.5.4 Off-load tap changing

Off-load tap changers shall—

- (a) have all positions clearly marked;
- (b) be visible from a safe position; and
- (c) have provision for securing in any position.