

Australian/New Zealand Standard™

Electrical protection devices for mines and quarries



AS/NZS 2081:2011

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee EL-023, Electrical Equipment in Mines and Quarries. It was approved on behalf of the Council of Standards Australia on 23 September 2011 and on behalf of the Council of Standards New Zealand on 23 September 2011. This Standard was published on 4 November 2011.

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Australian Coal Association
Australian Industry Group
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Department of Employment, Economic Development and Innovation
Department of Mines & Petroleum (WA)
Department of Trade and Investment, Regional Infrastructure and Services, NSW
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This Standard was issued in draft form for comment as DR AS/NZS 2081.

Australian/New Zealand Standard™

Electrical protection devices for mines and quarries

Originated in Australia as AS C318—1958.
Previous editions, and first New Zealand editions, in part as AS/NZS 2081,
Parts 1 to 5 (2002).
Jointly revised, amalgamated and redesignated as AS/NZS 2081:2011.

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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 Parts 1 to 5 of AS/NZS 2081 (2002), *Electrical equipment for coal and shale mines—Electrical protection devices*.

This Standard specifies the performance requirements for protection devices intended for use with electrical supply networks utilizing earth fault current limitation techniques (IT networks). These protection devices include the following:

- (a) Earth fault current limiting devices.
- (b) Earth continuity protection devices.
- (c) Earth fault protection devices.
- (d) Earth fault lockout protection devices.
- (e) NER integrity protection devices.
- (f) Frozen contact protection devices.

Prospective touch voltage versus operating time characteristics are referenced to facilitate the key objectives of this Standard.

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

- (a) All parts have been combined into a single document.
- (b) Clarification of the Scope to indicate that the Standard is applicable to both above and below ground mines and quarries.
- (c) The addition of NER integrity protection devices.
- (d) The addition of frozen contact protection devices.
- (e) The inclusion of references to specific prospective touch voltage versus operating time characteristics that form the basis of the protection strategies implemented by the equipment covered by this Standard.
- (f) The addition of prescribed levels of immunity to conducted common mode signals and electromagnetic interference for protection devices containing active circuits.
- (g) The addition of requirements for vibration, shock and bump immunity.
- (h) Clarification of requirements for conformal coatings in lieu of environmental testing.
- (i) The revision of typical system electrical diagrams showing the application of the various protection systems detailed in this Standard.
- (j) The inclusion of partial discharge and impulse testing.

The term ‘informative’ has been used in this Standard to define the application of the appendix to which it applies. An ‘informative’ appendix is only for information and guidance.

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FOREWORD

The interrelationship of the techniques described in this Standard strives to create the lowest risk working environment possible in surface mines, underground mines and quarries, where electrically powered equipment is often mobile and supplied by trailing or reeling cables.

These techniques are as follows:

- (a) The use of earth fault current limiting devices to minimize the risk of touch and step potential reaching a level which would cause harm to personnel.
- (b) The continuous checking that the equipment is earthed, by monitoring the earth resistance in the supply cable to the equipment.
- (c) The measurement of leakage and fault currents to earth, and the initiation of disconnection of that circuit when the value of leakage or fault current exceeds a preset value.
- (d) The testing of a circuit prior to energizing, to ensure that the phase-to-earth insulation value of each and every phase conductor is above a preset value, before the circuit can be energized.
- (e) The monitoring of the earth fault current-limiting device, and the associated connections between the supply neutral and earth, to ensure the integrity of the earth fault current limitation system.
- (f) The initiation of the disconnection of the power supply upstream of the interrupting device in the event that either the interrupting device fails to open when signalled to do so, or a voltage is detected on any phase of the load side of the interrupting device after it has received a signal to open.

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Australian/New Zealand Standard
Electrical protection devices for mines and quarries

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard sets out the design, performance, manufacturing, and testing requirements for electrical protection devices for use in surface and underground mines and quarries, where IT supply networks are utilized, and provides information on the general principles of—

- (a) earth fault current limitation;
- (b) earth continuity protection;
- (c) earth fault protection;
- (d) earth fault lockout protection;
- (e) NER integrity protection; and
- (f) frozen contact protection.

NOTES:

- 1 Whereas this Standard is based upon 50 Hz supply systems, it is envisaged that the equipment described may also be installed in systems with higher, lower or variable frequencies, or in d.c. supplied systems.

The effect of current upon the human body in 50 Hz supplied installations needs to be considered as detailed in AS/NZS 3000.

AS/NZS 60479, Parts 1 and 2 should be referenced for consideration of the effects of current at other supply frequencies upon the human body.

- 2 Refer to Appendix A for general information on the principles of electrical protection relevant to this Standard.

1.2 OBJECTIVE

The key objectives of this Standard are to set the performance criteria of protection devices to facilitate:

- (a) The maintenance of touch and step voltage levels against time within acceptable limits.
NOTE: Guidance information relating to touch voltage versus clearance times is contained in Appendix B.
- (b) The minimization of risks associated with electrical arcing i.e. arc blast, arc flash, etc.
- (c) Reliable performance under predetermined operating conditions.

1.3 RELATIONSHIP TO REGULATIONS

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.

1.4 REFERENCED DOCUMENTS

The following documents are referenced in this Standard.

AS

1028	Power reactors and earthing transformers
1931	High-voltage test techniques
1931.1	General definitions and test requirements
2374	Power transformers (series)
60076	Power transformers
60076.11	Part 11: Dry-type transformers
60270	High-voltage test techniques—Partial discharge measurements
60529	Degrees of protection provided by enclosures (IP Code)
61508	Functional safety of electrical/electronic/programmable electronic safety-related systems (series)
62061	Safety of machinery—Functional safety of safety-related electrical, electronic and programmable electronic control systems

AS/NZS

1802	Electric cables—Reeling and trailing—For underground coal mining purposes
1972	Electric cables—Underground coal mines—Other than reeling and trailing
2381	Electrical equipment for explosive gas atmospheres—Selection, installation and maintenance
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)
3190	Approval and test specification—Residual current devices (current-operated earth-leakage devices)
4871	Electrical equipment for mines and quarries (series)
60079	Explosive atmospheres
60079.11	Part 11: Equipment protection by intrinsic safety ‘i’
60079.14	Part 14: Electrical installations design, selection and erection (IEC 60079-14, Ed. 4.0 (2007) MOD)
60479	Effects of current on human beings and livestock
60479.1	Part 1: General aspects
60479.2	Part 2: Special aspects
61000	Electromagnetic compatibility (EMC)
61000.4.4	Part 4.4 Testing and measurement techniques—Electrical fast transient/burst immunity test
61000.4.8	Part 4.8 Testing and measurement techniques—Power frequency magnetic field immunity test
61000.4.16	Part 4.16: Testing and measurement techniques—Test for immunity to conducted common mode disturbances in the frequency range 0 Hz to 150 kHz

IEC	
60255	Electrical relays
60255-21-1	Part 21-1: Vibration, shock, bump and seismic tests on measuring relays and protection equipment—Vibration tests (sinusoidal)
60255-21-2	Part 21-2: Vibration, shock, bump and seismic tests on measuring relays and protection equipment—Shock and bump tests
61000	Electromagnetic compatibility (EMC)
61000-4-10	Part 4-10: Testing and measurement techniques—Damped oscillatory magnetic field immunity test
61086	Coatings for loaded printed wire boards (conformal coatings)
61086-3-1	Part 3-1: Specifications for individual materials—Coatings for general purpose (Class 1), high reliability (Class 2) and aerospace (Class 3)
IEC/TR	
60479	Effects of current on human beings and livestock
60479-5	Part 5: Touch voltage threshold values for physiological effects
ANSI/IEEE	
IEEE 32	IEEE Standard Requirements, Terminology, Test Procedure for Neutral Grounding Devices

1.5 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

1.5.1 Active circuit

An electrical or electronic circuit that requires an external source of power to operate correctly.

NOTE: Equipment that consists of purely passive circuit elements, and does not require an external power supply, is not an active circuit.

1.5.2 Active conductor

Any conductor that is maintained at a difference of potential from the earthed conductor.

1.5.3 Back-up protection

Protection provided as a supplement to the main system of protection and which is required to operate in the event of failure of the main protection.

1.5.4 Circuit interrupting device

Device capable of making, carrying and breaking currents expected to occur within a circuit.

1.5.5 Conformal coating

An electrical insulating material applied as a coating to loaded printed circuit boards to produce a thin layer conforming to the surface in order to provide a protective barrier against deleterious effects from environmental conditions.

1.5.6 Control device

A device that executes pre-defined responses to nominated inputs so as to initiate subsequent actions.

1.5.7 Core-balance (residual current) earth fault protection

A protection system in which the current sensing transducer monitors all active conductors (and, where appropriate, neutral conductors) of a circuit.

1.5.8 Critical component

A component or assembly that, if defective, may compromise the designed operation of the protective device.

1.5.9 Current-transformer-operated earth fault protection

Protection that is operated by the out-of-balance current produced by a parallel connected group of current transformer (CT) secondary windings. An individual CT is located on each active conductor of the system. An earth fault on the protected system results in an out-of-balance (operating) current.

1.5.10 Earth-continuity protection system

Form of protection that monitors the continuity of the protective earth circuit in cables supplying electrical power to equipment.

NOTE: This protection may involve a pilot conductor in conjunction with the protective earth circuit.

1.5.11 Earth fault current

Current that will flow between an energized conductor and earth as the result of insulation failure.

1.5.12 Earth fault current limitation

The limitation of fault currents to earth by an impedance device connected between the star point of the supply transformer and earth or by a series connected zero phase sequence reactor or for an un-earthed supply an impedance device connected between the star point of a zig-zag earthing transformer and earth.

NOTE: The impedance may be purely resistive.

1.5.13 Earth fault lockout protection device

A device that monitors the insulation of the active conductors within a cable and any connected equipment prior to the application of power and prevents power being applied in the event of one or more active conductors having a resistance to earth below a predetermined value.

1.5.14 Earth fault protection

Protection provided to detect earth fault current and initiate disconnection of the electrical supply from a fault zone.

1.5.15 Earth leakage current

Current that flows between an energized conductor and earth as the result of a reduction in the value of insulation resistance.

1.5.16 Extra-low voltage

Voltage that does not exceed 50 V a.c. or 120 V ripple-free d.c. For sinusoidal ripple voltage, the ripple content does not exceed 10% r.m.s.

1.5.17 Frozen contact

An electrical contact that fails to change state when commanded.

1.5.18 Hazardous area

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

1.5.19 Healthy

Condition indicating that the power supply and associated protection systems are functioning without faults, and the disconnection of electrical supply has not been initiated due to detection of a fault condition.

1.5.20 Instantaneous trip time

Operating time of the protection device without the introduction of any intentional delay.

1.5.21 IT system

A power distribution system that has no physical connection to earth, or has an impedance connection to earth, so as to limit the earth current that flows from a phase-to-earth fault.

1.5.22 NER

Refer to Neutral-connected (zero-sequence) impedance.

1.5.23 Neutral

The star point connection of a three phase transformer winding.

1.5.24 Neutral-connected (zero-sequence) impedance

Impedance that is connected between the neutral point of a transformer winding and earth to restrict the earth fault current in the circuit associated with that transformer winding.

1.5.25 Operating time

Total time taken by a protection device to initiate trips or alarms, inclusive of any intentional delay but exclusive of any delays inherent in the tripping circuit after a trip is initiated.

1.5.26 Operating value

Nominal value at which the protection device is set to initiate a trip of, or lockout, the circuit interrupting device.

1.5.27 Prospective earth fault current of a system

Theoretical fault current that flows as a result of a short-circuit of a phase to earth.

1.5.28 Protection device

Device comprising one or more subassemblies of components and designed to provide a type of protection covered by this Standard.

1.5.29 Rated operating value

Value, or range of values specified by the equipment manufacturer as being the operating value(s) of the device.

1.5.30 Rated supply voltage

Voltage specified by the equipment manufacturer as being the nominal voltage for which the protection device is designed to be connected.

1.5.31 Relay

An electromechanical control element.

1.5.32 Resetting value

Value of the actuating quantity that, for a manually reset device, will allow the device to be reset, or for an automatically reset device, will cause the device to be reset.

1.5.33 Series star-point connected earth fault protection

Protection system that has the sensing device connected between the star-point of the protected system and earth.

1.5.34 Service temperature

Ambient temperature immediately surrounding the protection device when operating. This may be the air temperature within the enclosure housing the device.

1.5.35 System voltage

Voltage of the supply system, expressed as the r.m.s. value of the phase-to-phase voltage.

1.5.36 Time delay

That part of the operating time that is deliberately introduced to delay operation.

1.5.37 Tripping ratio

Ratio of potential earth fault current to the operating value of the earth fault current protection.

1.5.38 Zero sequence reactor

Device that is inserted in series with the active conductors of a multiphase circuit, to restrict the level of current flowing to earth during an earth fault situation to a pre-determined value on the load side of the device. Refer to Figure A1.

NOTE: Its operation does not require any part of the system to be earthed other than the star-point of the supply transformer.

1.6 MANUFACTURERS' DOCUMENTS

Manufacturers shall make readily available all relevant information, including installation, commissioning, maintenance and operating instructions, required for the safe use of the applicable device for its intended function.

1.7 CATEGORIES OF TESTS

Two categories of tests are recognized:

- (a) Type tests, the purpose of which is to establish that the design complies with this Standard. Such tests shall be in accordance with Section 10.
- (b) Routine tests by the manufacturer on the protection device to demonstrate consistency of the manufactured product against the type tested design. Such tests shall be in accordance with Section 11.

SECTION 2 DESIGN AND CONSTRUCTION — GENERAL REQUIREMENTS

2.1 MOUNTING

Wherever possible, a protection device shall be designed so that it can operate regardless of its mounting orientation.

If the mounting or the method of mounting can affect the performance of the protection device or its subassemblies, the manufacturer shall provide specific instructions for the mounting of the device.

2.2 CONNECTIONS

All electrical connections shall comply with relevant requirements of AS/NZS 3000.

Where the protection device or its subassemblies are designed for plug-in connection, means shall be included to—

- (a) prevent the insertion of the device or subassemblies into a socket for which it is not intended; and
- (b) prevent the device or its subassemblies from inadvertently becoming loose in service.

2.3 PROTECTION AGAINST FAILURE

The range of electrical protection devices covered in this Standard are intended to be used as a part of a safety system. This means that the protection device may be installed in a protection system for the purpose of performing a safety function to protect personnel and/or plant.

Protection devices complying to this Standard, with the exception of earth fault current limiters, shall comply with either—

- (a) any failure of an internal or external component essential to the protection device performing its designed protection function shall initiate tripping, and prevent closure, of the circuit interrupting device supplying the system being protected; or
- (b) information that enables a functional safety assessment to be undertaken on a safety system containing electrical protection devices complying with this Standard shall be provided.

The typical range of information required includes:

- (i) Safe failure fraction.
- (ii) Probability of dangerous failure – detected.
- (iii) Probability of dangerous failure – undetected.
- (iv) A statement confirming validation of software.
- (v) Recommended proof test and diagnostic test intervals.

NOTE: The data supplied may be derived from technical assessment or by historical field data.

For further information on the information required and terms and definitions, refer to AS 61508 or AS 62061.

2.4 EQUIPMENT FOR USE IN HAZARDOUS AREAS

Electrical protection devices intended for use in hazardous areas shall comply with the relevant requirements of AS/NZS 60079.11.

2.5 SERVICE CONDITIONS

Electrical protection devices complying with this Standard, when installed, shall be suitable for use under the following service conditions:

- (a) *Range of service temperature* Temperatures within the range 0°C to +60°C.
- (b) *Humidity* Between 10% relative humidity and the dew point, non-condensing.

2.6 IMMUNITY TO INTERFERENCE

2.6.1 General

Although electrical and electronic devices and components are usually extremely reliable, it is possible that the proper operation of a protection device may be affected by interference generated by other electrical equipment connected to the network, and/or located close by.

Electronic protection devices have high switching speeds, and low signal voltages and currents that can respond adversely to electrical interference that might not affect other electrical equipment. Protection systems should not be compromised by any mains-borne or irradiated interference that can occur in the environment for which it is intended to operate.

All protection devices addressed by this Standard that contain active circuits shall demonstrate immunity to interference as documented in Clauses 2.6.2 below.

2.6.2 EMI tests

2.6.2.1 General

The tests of Clause 2.6.2.2 to 2.6.2.5 shall demonstrate suitability for a 'typical industrial environment' as specified in the applicable test Standard.

2.6.2.2 Conducted common mode disturbances

The manufacturer shall provide information that identifies the level of immunity to Common Mode disturbance to all ports of the protection device.

AS/NZS 61000.4.16:2002 provides guidance in the undertaking of these tests.

Where tests are undertaken using an alternate method to that identified in that Standard, details of the tests, and the results obtained, shall be made available by the manufacturer for review by the end user.

2.6.2.3 Fast transient burst tests

The protection device shall be tested in accordance with the requirements of AS/NZS 61000.4.4.

2.6.2.4 Power frequency magnetic field test

The protection device shall be tested in accordance with the requirements of AS/NZS 61000.4.8.

2.6.2.5 Damped oscillatory magnetic field immunity test

The protection device shall be tested in accordance with the requirements of IEC 61000-4-10.

NOTES:

- 1 These tests check the device immunity to false operation during switching of high voltage circuits and motor starting and stopping.
- 2 Notwithstanding the requirements above, users should assess the levels of any and all conducted or radiated interference and ensure that the protection device is not adversely affected by that interference. Much can be done to guard against malfunction from external interference by careful design of the system and the use of interference mitigation equipment.

2.6.3 Performance under test

For tests documented in Clause 2.6.2, there shall be no loss of function or degradation of performance of the prescribed protection function, in accordance with the requirements of this standard, during each test.

Other functions, e.g. indications and display units, may suffer a temporary loss of function or degradation of performance which ceases after the disturbance ceases, and from which the protection device recovers its normal performance, without operator intervention.

2.7 VIBRATION, SHOCK AND BUMP IMMUNITY

Protection devices with the exception of earth fault current limiters shall, as a minimum, meet the vibration, shock and bump test requirements of IEC 60255-21-1 (1988) and IEC 60255-21-2 (1988) for Class 1 equipment.

2.8 IP RATING

Control devices shall be rated to a minimum of IP20 in accordance with AS 60529.

2.9 PRINTED CIRCUIT BOARD SURFACE PROTECTION

All fully assembled printed circuit boards (PCBs) and otherwise exposed electronic componentry shall be protected by either—

- (a) two conformal coatings that have properties that meet the requirements of IEC 61086-3-1; or
- (b) encapsulation or conformal coatings in accordance with the requirements of AS/NZS 60079.11.

NOTE: While AS/NZS 60079.11 is specific to the requirements of intrinsically safe equipment, the methods of encapsulation prescribed therein are adopted as some of these protection devices are required to be certified as complying with AS/NZS 60079.11.

2.10 RELAY CONTACTS

The voltage, current and VA ratings for relay contacts shall be nominated by the manufacturer.

The maximum VA rating assigned to the protection device switching contacts shall have a factor of safety of five (5) applied to the rating nominated by the manufacturer of the output contact relay.

All information relating to the switching capacity of the output relay contacts shall be included in product data sheets for the protection device. This information shall include values for voltage, current, inductive a.c. and d.c. ratings along with power factor limits.

NOTE: In determining the rating of relay contacts, the very low power factor current associated with tripping coils should be taken into account.

2.11 FAULT INDICATION

Provision shall be made for fault indicators associated with a protection device to be viewed from the outside of any enclosure that the protection device is mounted in.

2.12 ADJUSTMENT OF RELAY PARAMETERS

No adjustment shall be possible that allows the protection device to operate outside the limits set in this Standard.

Where the protection device has adjustable parameters and/or a calibration facility, provision shall be made for access to such adjustments to be restricted.

2.13 MARKING

2.13.1 Labelling of main unit

The identity of each protection device shall be visible when mounted in its service position (but not necessarily energized).

The protection device shall also be marked in a legible and durable manner with the following additional information:

- (a) Name or registered trademark of the manufacturer, or that of the manufacturer's agent where the agent is the holder of the certification or approval.
- (b) Catalogue number, type number, or other identification marking.
- (c) Function of device, e.g. 'earth-continuity relay'.
- (d) Compliance to the relevant section(s) of this Standard.
- (e) Hazardous area certification markings, if the device is intended for use in hazardous areas.
- (f) Where required, the identification of associated ancillary equipment (such as current sensing transducers).
- (g) The voltage, current and VA rating of the device output contacts.
- (h) Device supply voltage and frequency (nominal value $\pm\%$ tolerance).
- (i) Where applicable, a manufacturer shall provide a means of identification of the program or software version associated with a specific device.

2.13.2 Labelling of ancillary components

Any ancillary component which forms an essential part of the protection system, i.e. CTs, toroids, etc. shall be marked with catalogue number, type number, identification marking and/or other details relevant to its application, and where applicable, its certification number.

2.14 CONTROL POWER SUPPLY VOLTAGE VARIATION

The protection device shall be designed so that its normal operation remains unaffected while the control power supply voltage is varied within the range of 75% to 120% of the nominated supply voltage.

The device shall continue to operate correctly for at least 2 s after the supply voltage is reduced to 50% of its nominal value.

NOTE: A voltage dip in the power supply (e.g. caused by a motor start) should not cause false operation of the earth fault device.

2.15 WITHSTAND RATINGS OF POWER CIRCUIT INTERFACES

2.15.1 General

Where a protection device detailed in this Standard is connected to or has an electrical interface to phase conductors of power circuits that operate at 240 V or above, it shall be subjected to the tests of Clauses 2.15.2 to 2.15.5.

2.15.2 Temperature withstand

The device shall be able to operate for the rated duty cycle of the device when rated voltage +20% is applied to the interface.

For continuously rated equipment the voltage shall be applied for a period of 60 min.

No component of the device shall exceed its stated maximum operating temperature.

2.15.3 Power frequency voltage withstand

The device shall be subjected to a power frequency voltage for 1 min in accordance with Table 2.1. Refer to AS 1931.1 for guidance.

2.15.4 Lightning impulse voltage withstand

The device shall be subjected to a 1.2/50 μ s lightning impulse voltage in accordance with Table 2.1.

The test voltage shall be of negative polarity.

The waveform shall have a wavefront of 1.2 μ s $\pm$ 30% and a trailing edge of 50 μ s $\pm$ 20%.

NOTE: Refer to Appendix I Paragraph I2 for information on a typical lightning impulse wave shape.

The test sequence for each line terminal shall be one calibration impulse at between 50% and 75% of the full impulse voltage followed by three impulses at full impulse voltage.

The waveforms of voltage and current shall be recorded. The absence of significant differences between voltage and current transients recorded at reduced voltage and those recorded at full test voltage constitutes evidence that the insulation has withstood the test.

2.15.5 Partial discharge

The power circuit interface of the protection device shall be subjected to a partial discharge test on all components designed to operate at a system voltage of 4 kV and above. Refer to AS 60270 for guidance.

A phase-to-phase (or phase-to-neutral as appropriate) voltage of 1.8 U_m shall be applied for 30 s followed without interruptions by a voltage at 1.3 U_m for 3 min during which the partial discharge shall be measured.

The partial discharge shall be no more than 10 pico Coulombs (pC).

NOTES:

- 1 U_m is the rated phase-to-phase voltage (or phase-to-earth where the device is connected between phase and earth only).
- 2 Refer to Appendix I Paragraph 13 for information on typical time versus voltage profile.

TABLE 2.1
TEST VOLTAGE LEVELS

Maximum voltage— U_m kV	Power frequency voltage withstand level kV	Lightning impulse level kV
0.275	2.5	None
0.450	3	None
1.2	4	10
3.6	10	40
7.2	20	60
12	28	75
24	50	125
36	70	170
72.5	140	325

NOTE: The values for U_m in this Table relate to the phase-to-phase maximum voltage of the system to which a device is intended to be connected.

SECTION 3 SOFTWARE CONTROLLED DEVICES

3.1 GENERAL

The requirements of this Section shall apply to protection devices as detailed in this Standard that use software for control or display of information integral to the operation of the device.

3.2 SECURITY AGAINST ALTERATIONS TO MANUFACTURER'S SOFTWARE

The manufacturer shall implement a method that will ensure the prevention of unauthorized alterations to the software.

NOTE: If changes to the protection relay software are made by the manufacturer after testing and certification, attention is to be paid to the processes detailed in AS 61508 (series) and AS 62061.

SECTION 4 EARTH FAULT CURRENT LIMITING DEVICES

4.1 GENERAL

The requirements of this Section shall apply to protection devices designed to provide limitation of earth fault currents by the use of reactive or resistive devices, or both.

NOTES:

- 1 In some cases neutral connected earth fault current limiting reactive devices can give rise to detrimental harmonics and voltage transients.
- 2 Refer to Appendix C for guidance information relating to the installation and use of earth fault current limitation devices.

4.2 COMPLIANCE WITH STANDARDS

Earth fault current limiters shall comply with this Standard and, where applicable, the relevant requirements of AS 1028, AS 2374 (series) and AS 60076.11.

4.3 MANUFACTURING TOLERANCE

The impedance of the device shall have a tolerance of $\pm 5\%$ of the rated impedance.

NOTES:

- 1 This manufacturing tolerance differs from AS 1028.
- 2 The use of current limiting reactors will necessitate attention to the nominal system operating frequency for which they are designed, and/or on which they are deployed.

4.4 RATINGS

4.4.1 Zero sequence reactor

4.4.1.1 *Earth fault current*

Series connected impedance devices shall be rated to carry the earth fault limited current continuously.

4.4.1.2 *Load current*

Series-connected devices shall be continuously rated for the stated full load three phase through-current.

4.4.1.3 *Short circuit current*

Series-connected devices shall have an assigned phase-to-phase through fault short-circuit capacity complying with AS 1028.

4.4.1.4 *Inrush current*

The peak value of inrush current in the event of a phase-to-earth fault under the worst conditions at rated voltage shall not exceed a value of two (2) times the current value under steady-state phase-to-earth fault conditions.

NOTE: This limitation on inrush currents imposes design considerations for the transient performance of current limiting reactors.

4.4.2 Neutral-connected (star-point to earth) impedance

4.4.2.1 *Current*

A neutral connected impedance device shall be rated for its stated earth fault current at rated phase-to-earth system voltage.

4.4.2.2 Time

A neutral connected impedance device shall be either—

- (a) continuously rated; or
- (b) short time rated for a load time of at least 10 s.

NOTE: Additional guidance information on the selection of continuous or short time rated earth fault current limitation devices and associated protection devices is contained in Appendix C.

4.4.2.3 Power factor

The power factor of the earth fault current limiting impedance, assuming zero cable capacitance, shall be not less than 0.65 lagging, thus limiting the inrush current to a maximum of 1.6 times the designed steady-state earth fault limited current.

NOTE: See also Appendix A2.

4.5 WITHSTAND VOLTAGES

The device shall achieve power frequency and lightning impulse withstand voltages as set out in Table 2.1.

4.6 SPECIFIC REQUIREMENTS FOR RESISTOR DEVICES

Resistive earth fault current limiting devices shall comply with the following:

- (a) Temperature ratings:
 - (i) For resistors located above ground and mounted within a separate, standalone enclosure outdoors, the temperature rise shall comply with ANSI IEEE 32.
 - (ii) For all other installations, the maximum temperature rise shall not exceed 200°C after the application of rated phase-to-earth voltage for rated time; and the device shall be capable of functioning at a temperature rise of 350°C above ambient, without suffering damage to its insulation.

NOTES:

- 1 This temperature rise of 350°C makes provision for a safety factor above a normal operating temperature rise of 200°C above ambient.
 - 2 The maximum temperature rise of 200°C has been selected to minimize heat radiation to other equipment in proximity to the device and to minimize ageing (through oxidation) of the resistive element.
- (b) The temperature coefficient of resistance of resistive elements shall be positive, and shall be such that following application of rated voltage for rated time the change in resistance shall be not more than +10%.
 - (c) The external neutral and earth connection terminals shall be suitable for the termination of cables with a cross-sectional area of between 10 mm² and 95 mm².
 - (d) Where a resistor bank requires interconnection of elements, the connections shall have a current/time rating equal to that of the resistor bank.
 - (e) Special attention shall be made during design and implementation to ensure that no connections can loosen during operations.
 - (f) The resistive elements and all connections shall be manufactured from a corrosion-resistant material.