

Australian Standard[®]

**Safety of machinery—Electrical
equipment of machines**

**Part 1: General requirements
(IEC 60204-1, Ed. 5 (FDIS) MOD)**



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 - Department of Mineral Resources NSW
 - Electrical Regulatory Authorities Council
 - Federal Chamber of Automotive Industries
 - Victorian WorkCover Authority
-

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Australian Standard[®]

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equipment of machines**

**Part 1: General requirements
(IEC 60204-1, Ed. 5 (FDIS) MOD)**

Originated as AS 1543—1985.
Revised and redesignated AS 60204.1—2005.
Reissued incorporating Amendment No.1 (August 2006).

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PREFACE

This Standard was prepared by the Standards Australia Committee EL-017, Electrical Equipment of Industrial Machinery to supersede AS 1543—1985.

This Standard incorporates Amendment No. 1 (August 2006). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

The objective of this Standard is to provide requirements and recommendations for the electrical equipment of industrial machines with regard to safety of persons and property, consistency of control response, and ease of maintenance. This Standard includes provisions for two-hand control as a safety feature (not previously dealt with in AS 1543).

The need for this Standard was raised during the preparation of revisions to AS 4024.1—1996, *Safeguarding of machinery*, where the Standards Australia Committee SF-041 has adapted a number of International Standards (ISO, IEC, EN Standards) to replace the current AS 4024.1—1996 and include other safety requirements (in addition to safeguarding) associated with safety of industrial machines. These Standards provide guidance in risk control methods following the risk assessment process required in the relevant State and Commonwealth (Plant) Regulations. *Guidance in safety of machinery—Principles of risk assessment* is included in the new AS 4024.1—2004 (draft) and AS/NZS 4360:2004, *Risk management*. Since AS 1543—1985 is now obsolete, an up to date version is required. AS 1543—1985 was adapted from IEC 204-1 at the time and since that period, IEC 204-1 has been updated to IEC 60204.1.

This Standard is an adoption with national modifications and has been reproduced from the draft IEC 60204-1, Ed. 5 (FDIS), *Safety of machinery—Electrical equipment of machines – Part 1: General requirements*, and has been varied as indicated to take account of Australian/New Zealand conditions.

Variations to IEC 60204-1, Ed. 5 (FDIS) are indicated at the appropriate places throughout this standard. Strikethrough (**example**) identifies IEC text, tables and figures which, for the purposes of this Australian Standard, are deleted. Where text, tables or figures are added, each is set in its proper place and identified by shading (**example**). Added figures are not themselves shaded, but are identified by a shaded border.

As this Standard is reproduced from an International Standard, the following applies:

- (a) Its number does not appear on each page of text and its identity is shown only on the cover and title page.
- (b) In the source text 'IEC 60204-1' should read 'AS 60204.1'.
- (c) A full point should be substituted for a comma when referring to a decimal marker.
- (d) Any French text on figures should be ignored.
- (e) The recommended colour coding (see Clause 13.2) for neutral and live insulated conductors conflicts with the colour coding given in AS/NZS 3000 for fixed wiring.

The terms 'normative' and 'informative' are used to define the application of the annex to which they apply. A normative annex is an integral part of a standard, whereas an informative annex is only for information and guidance.

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INTRODUCTION

This part of IEC 60204 provides requirements and recommendations relating to the electrical equipment of machines so as to promote:

- safety of persons and property;
- consistency of control response;
- ease of maintenance.

More guidance on the use of this part of IEC 60204 is given in informative Annex F.

Figure 1 has been provided as an aid to the understanding of the inter-relationship of the various elements of a machine and its associated equipment. Figure 1 is a block diagram of a typical machine and associated equipment showing the various elements of the electrical equipment addressed in this document. Numbers in parentheses () refer to Clauses and Subclauses in this document. It is understood in Figure 1 that all of the elements taken together including the safeguards, tooling/fixtures, software, and the documentation, constitute the machine, and that one or more machines working together with usually at least one level of supervisory control constitute a manufacturing cell or system.

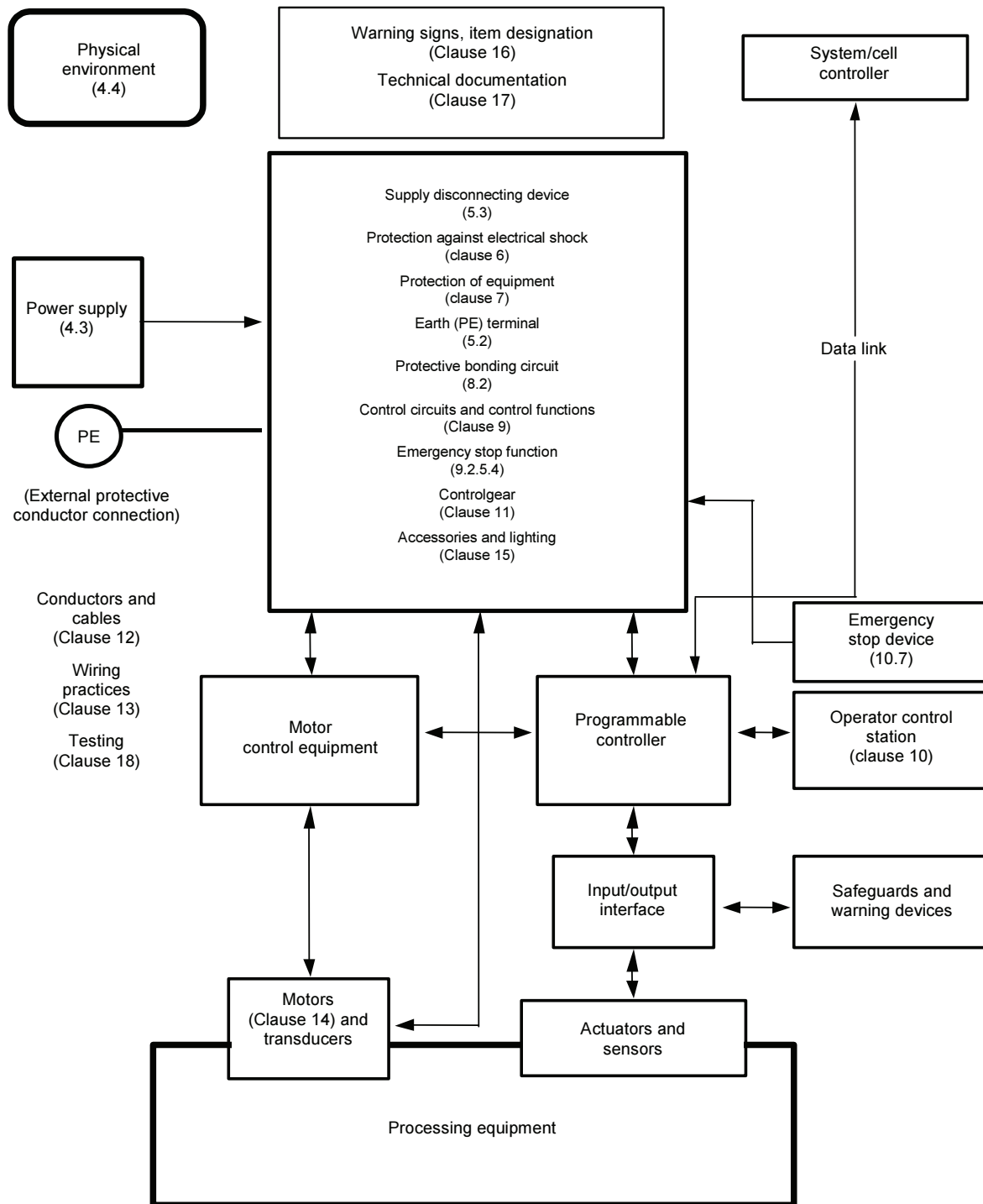


Figure 1 – Block diagram of a typical machine

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Safety of machinery—Electrical equipment of machines
Part 1: General requirements (IEC 60204-1, Ed. 5 (FDIS) MOD)

Any table, figure or text of the international standard that is struck through is not part of this standard. Any Australian/New Zealand table, figure or text that is added is part of this standard and is identified by shading.

1 Scope

This part of IEC 60204 applies to the application of electrical, electronic and programmable electronic equipment and systems to machines not portable by hand while working, including a group of machines working together in a co-ordinated manner.

NOTE 1 This part of IEC 60204 is an application standard and is not intended to limit or inhibit technological advancement.

NOTE 2 In this standard, the term *electrical* includes electrical, electronic and programmable electronic matters (i.e. *electrical equipment* means electrical, electronic and programmable electronic equipment).

NOTE 3 In the context of this standard, the term *person* refers to any individual and includes those persons who are assigned and instructed by the user or his agent(s) in the use and care of the machine in question.

The equipment covered by this standard commences at the point of connection of the supply to the electrical equipment of the machine (see 5.1).

NOTE 4 The requirements for the electrical supply installation in buildings, and surface mines, are given in AS/NZS 3000 and AS 3007 IEC 60364 series.

This part of IEC 60204 is applicable to the electrical equipment or parts of the electrical equipment that operate with nominal supply voltages not exceeding 1 000 V for alternating current (AC) and not exceeding 1 500 V for direct current (DC), and with nominal supply frequencies not exceeding 200 Hz.

NOTE 5 For higher voltages, see IEC 60204-11.

This part of IEC 60204 does not cover all the requirements (for example guarding, interlocking, or control) that are needed or required by other standards or regulations in order to protect persons from hazards other than electrical hazards. Each type of machine has unique requirements to be accommodated to provide adequate safety.

This part specifically includes, but is not limited to, the electrical equipment of machines as defined in 3.35.

NOTE 6 Informative Annex C lists examples of machines whose electrical equipment can be covered by this standard.

NOTE 7 Fire protection for mobile and transportable machinery is covered by AS 5062.

This part of IEC 60204 does not specify additional and special requirements that can apply to the electrical equipment of machines that, for example:

- are intended for use in open air (i.e. outside buildings or other protective structures);
- use, process, or produce potentially explosive material (for example paint or sawdust) (which are covered by AS/NZS 60079 series);
- are intended for use in potentially explosive and/or flammable atmospheres;
- have special risks when producing or using certain materials;

- are intended for use in mines (which are covered by AS 1299, AS 1300, AS/NZS 4240, AS/NZS 4242 and AS/NZS 4871);
- are sewing machines, units, and systems (which are covered by IEC 60204-31);
- are hoisting machines (which are covered by IEC 60204-32).

Power circuits where electrical energy is directly used as a working tool are excluded from this part of IEC 60204.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

References to international standards that are struck through in this clause are replaced by references to Australian or Australian/New Zealand Standards that are listed immediately thereafter and identified by shading. Any Australian or Australian/New Zealand Standard that is identical to the International Standard it replaces is identified as such.

AS 1299, *Electrical equipment for coal mines—Flameproof restrained plugs and receptacles*

AS 1300, *Electrical equipment for coal mines—Bolted flame-proof cable coupling devices*

AS 2380, *Electrical equipment for explosive atmospheres—Explosion-protection techniques*

AS 2381, *Electrical equipment for explosive atmospheres—Selection, installation and maintenance*

AS 4024, *Safeguarding of machinery*

AS 4024.1, *Safeguarding of machinery, Part 1: General principles*

AS/NZS 4240, *Remote controls for mining equipment*

AS/NZS 4242, *Earth-moving machinery and ancillary equipment for use in mines—Electrical wiring systems at extra-low voltage*

AS/NZS 4871, *Electrical equipment for coal mines, for use underground*

AS/NZS 60079, *Electrical apparatus for explosive gas atmospheres*

AS/NZS 61241, *Electrical apparatus for use in the presence of combustible dust*

AS 61508, *Functional safety of electrical/electronic/programmable electronic safety-related systems*

~~IEC 60034-1:1996, *Rotating electrical machines — Part 1: Rating and performance*~~

AS 1359.101, *Rotating electrical machines—General requirements—Rating and performance (identical to IEC 60034-1)*

IEC 60034-5:2000, *Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification*

IEC 60034-11:1978, *Rotating electrical machines – Part 11: Built-in thermal protection – Chapter 1: Rules for protection of rotating electrical machines*

IEC 60072-1:1991, *Dimensions and output series for rotating electrical machines – Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1 080*

IEC 60072-2:1990, *Dimensions and output series for rotating electrical machines – Part 2: Frame numbers 355 to 1 000 and flange numbers 1 180 to 2 360*

IEC 60073:2002, *Basic and safety principles for man-machine interface, marking and identification – Coding principles for indication devices and actuators*

IEC 60076-5:2000, *Power transformers – Part 5: Ability to withstand short circuit*

~~IEC 60309-1:1999, *Plugs, socket-outlets, and couplers for industrial purposes – Part 1: General requirements*~~

AS/NZS 3123, *Approval and test specification—Plugs, socket-outlets and couplers for general industrial application*

~~IEC 60320-1, *Appliance couplers for household and similar general purposes – Part 1: General requirements*~~

AS/NZS 60320.1, *Appliance couplers for household and similar general purposes, Part 1: General requirements (IEC 60320-1 (MOD))*

IEC 60332-1:1993, *Tests on electric cables under fire conditions – Part 1: Test on a single vertical insulated wire or cable*

IEC 60364-1:2001, *Electrical installations of buildings – Part 1: Fundamental principles, assessment of general characteristics, definitions*

~~IEC 60364-4-41:2001, *Electrical installations of buildings – Part 4-41: Protection for safety—Protection against electric shock*~~

AS/NZS 3000 (Clause 1.7), *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

~~IEC 60364-4-43:2001, *Electrical installations of buildings – Part 4-43: Protection for safety—Protection against overcurrent*~~

AS/NZS 3000 (Section 2), *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

~~IEC 60364-5-52:2001, *Electrical installations of buildings – Part 5-52: Selection and erection of electrical equipment—Wiring systems*~~

AS/NZS 3108, *Approval and test specification—Particular requirements for isolating transformers and safety isolating transformers*

IEC 60364-5-54:2002, *Electrical installations of buildings – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors*

AS/NZS 3000 (Section 5), *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

IEC 60364-6-61:2001, *Electrical installations of buildings – Part 6-61: Verification – Initial verification*

AS/NZS 3000 (Section 6), *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

~~IEC 60417-DB:2002¹, *Graphical symbols for use on equipment*~~

AS 60417, *Graphical symbols for use on equipment (identical to IEC 60417)*

¹ "DB" refers to the IEC on-line database.

~~IEC 60439-1:1999, Low-voltage switchgear and controlgear assemblies—Part 1: Type-tested and partially type-tested assemblies~~

AS/NZS 3439.1, Low-voltage switchgear and controlgear assemblies—Type tested and partially type-tested assemblies (IEC 60439-1 MOD)

IEC 60445:1999, Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system

IEC 60446:1999, Basic and safety principles for man-machine interface, marking and identification – Identification of conductors by colours or numerals

IEC 60447:1993, Man-machine interface (MMI) – Actuating principles

~~IEC 60529:2001, Degrees of protection provided by enclosures (IP Code)~~

AS 60529, Degrees of protection provided by enclosures (IP Code) (identical to IEC 60529)

IEC 60617 (all parts)[DB]², Graphical symbols for diagrams

~~IEC 60621-3:1979, Electrical installations for outdoor sites under heavy conditions (including open-cast mines and quarries)—Part 3: General requirements for equipment and ancillaries~~

AS 3007.3, Electrical installations—Surface mines and associated processing plant, Part 3: General requirements for equipment and ancillaries

IEC 60664-1:1992, Insulation co-ordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests

~~IEC 60884-1, Plugs and socket-outlets for household and similar purposes—Part 1: General requirements~~

AS/NZS 3112, Approval and test specification—Plugs and socket-outlets

~~IEC 60947-1:2001, Low-voltage switchgear and controlgear—Part 1: General rules~~

AS 60947.1, Low-voltage switchgear and controlgear—General rules (identical to IEC 60947-1:2001)

IEC 60947-2:2003, Low-voltage switchgear and controlgear – Part 2: Circuit-breakers

~~IEC 60947-3:1999, Low-voltage switchgear and controlgear—Part 3: Switches, disconnectors, switch disconnectors, and fuse combination units~~

AS/NZS 3947.3, Low-voltage switchgear and controlgear—Switches, disconnectors, switch-disconnectors and fuse-combination units (identical to IEC 60947-3)

~~IEC 60947-5-1:2003, Low-voltage switchgear and controlgear—Part 5-1: Control circuit devices and switching elements: Electromechanical control circuit devices~~

AS 60947.5.1, Low-voltage switchgear and controlgear—Control circuit devices and switching elements—Electromechanical control circuit devices (identical to IEC 60947-5-1)

² "DB" refers to the IEC on-line database.

~~IEC 60947-7-1:2002, Low-voltage switchgear and controlgear—Part 7-1: Ancillary equipment—Terminal blocks for copper conductors~~

AS 60947.7.1, Low-voltage switchgear and controlgear—Ancillary equipment—Terminal blocks for copper conductors (identical to IEC 60947-7-1)

~~IEC 61082-1:1991, Preparation of documents used in electrotechnology—Part 1: General requirements~~

AS/NZS 4383.1, Preparation of documents used in electrotechnology—General requirements (identical to IEC 61082-1)

~~IEC 61082-2:1993, Preparation of documents used in electrotechnology—Part 2: Function-oriented diagrams~~

AS/NZS 4383.2, Preparation of documents used in electrotechnology—Function-oriented diagrams (identical to IEC 61082-2)

~~IEC 61082-3:1993, Preparation of documents used in electrotechnology—Part 3: Connection diagrams, tables and lists~~

AS/NZS 4383.3, Preparation of documents used in electrotechnology—Connection diagrams, tables and lists (identical to IEC 61082-3)

~~IEC 61082-4:1996, Preparation of documents used in electrotechnology—Part 4: Location and installation documents~~

AS/NZS 4383.4, Preparation of documents used in electrotechnology—Location and installation documents (identical to IEC 61082-4)

IEC 61140:2001, Protection against electric shock – Common aspects for installation and equipment

IEC 61310-1:1995; Safety of machinery - Indication, marking and actuation - Part 1: Requirements for visual, auditory and tactile signals

IEC 61310-2:1995; Safety of machinery - Indication, marking and actuation - Part 2: Requirements for marking

IEC 61310-3:1999; Safety of machinery - Indication, marking and actuation - Part 3: Requirements for the location and operation of actuators

IEC 61346-1:1996, Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules

IEC 61557-3:1997, Electrical safety in low voltage distribution systems up to 1000 V a.c. and 1500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 3: Loop impedance

~~IEC 61558-1:1998, Safety of power transformers, power supply units and similar—Part 1: General requirements and tests~~

AS/NZS 61558.1, Safety of power transformers, power supply units and similar—General requirements and tests (IEC 61558-1 MOD)

IEC 61984:2001, Connectors – Safety requirements and tests

IEC 62023:2000, *Structuring of technical information and documentation*

IEC 62027:2000, *Preparation of parts lists*

IEC 62061:2005, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*

IEC 62079:2001, *Preparation of instructions - Structuring, content and presentation*

ISO 3864-1:2002, *Graphical symbols – Safety colours and safety signs – Part 1: Design principles for safety signs in workplaces and public areas*

ISO 7000:1989, *Graphical symbols for use on equipment – Index and synopsis*

ISO 12100-1: 2003, *Safety of machinery – Basic concepts, general principles for design – Part 1: Basic terminology, methodology*

ISO 12100-2:2003, *Safety of machinery – Basic concepts, general principles for design – Part 2: Technical principles*

ISO 13849-1:1999, *Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design*

ISO 13850:1996, *Safety of machinery - Emergency stop - Principles for design*

3 Definitions

For the purposes of this part of IEC 60204, the following definitions apply.

3.1

actuator

part of a device to which an external manual action is to be applied

NOTE 1 The actuator may take the form of a handle, knob, push-button, roller, plunger, etc.

NOTE 2 There are some actuating means that do not require an external actuating force but only an action.

NOTE 3 See also 3.34.

3.2

ambient temperature

temperature of the air or other medium where the equipment is to be used

[IEV 826-01-04]

3.3

barrier

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

[IEV 826-03-13]

3.4

cable tray

cable support consisting of a continuous base and raised edges and no covering

NOTE A cable tray may be perforated or non-perforated.

[IEV 826-06-07]

3.5**cable trunking system**

system of closed enclosures comprising a base with a removable cover intended for the complete surrounding of insulated conductors, cables, cords and for the accommodation of other electrical equipment

[IEV 826-06-04]

3.6**concurrent**

acting in conjunction; used to describe a situation wherein two or more control devices exist in an actuated condition at the same time (but not necessarily synchronously)

3.7**conduit**

part of a closed wiring system of circular or non-circular cross-section for insulated conductors and/or cables in electrical installations, allowing them to be drawn in and/or replaced

NOTE Conduits should be sufficiently close-jointed so that the insulated conductors and/or cables can only be drawn in and not inserted laterally.

[IEV 826-06-03]

3.8**control circuit (of a machine)**

circuit used for the control, including monitoring, of a machine and the electrical equipment

3.9**control device**

device connected into the control circuit and used for controlling the operation of the machine (for example position sensor, manual control switch, relay, contactor, magnetically operated valve)

3.10**controlgear**

switching devices and their combination with associated control, measuring, protective, and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures, and supporting structures, intended in principle for the control of electrical energy consuming equipment

[IEV 441-11-03, modified]

3.11**controlled stop**

stopping of machine motion with electrical power to the machine actuators maintained during the stopping process

3.12**direct contact**

contact of persons or livestock with live parts

[IEV 826-03-05]

3.13**direct opening action (of a contact element)**

achievement of contact separation as the direct result of a specified movement of the switch actuator through non-resilient members (for example not dependent upon springs)

[IEC 60947-5-1, K.2.2]

3.14**duct**

enclosed channel designed expressly for holding and protecting electrical conductors, cables, and busbars

NOTE Conduits (see 3.7), cable trunking systems (see 3.5) and underfloor channels are types of duct.

3.15**electrical operating area**

room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons, by the opening of a door or the removal of a barrier without the use of a key or tool, and which is clearly marked by appropriate warning signs

3.16**electronic equipment**

part of the electrical equipment containing circuitry dependent for its operation on electronic devices and components

3.17**emergency stop device**

manually actuated control device used to initiate an emergency stop function

[ISO 13850]

NOTE See informative Annex E.

3.18**emergency switching off device**

manually actuated control device used to switch off the supply of electrical energy to all or a part of an installation where a risk of electric shock or another risk of electrical origin is involved

NOTE See informative Annex E.

3.19**enclosed electrical operating area**

room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons by the opening of a door or the removal of a barrier by the use of a key or tool and which is clearly marked by appropriate warning signs

3.20**enclosure**

part providing protection of equipment against certain external influences and, in any direction, protection against direct contact

[IEV 826-03-12]

NOTE The definition taken from the existing IEV needs the following explanations within the scope of this standard:

- a) Enclosures provide protection of persons or livestock against access to hazardous parts;
- b) Barriers, shaped openings, or any other means suitable to prevent or limit the penetration of the specified test probes, whether attached to the enclosure or formed by the enclosed equipment, are considered as part of the enclosure, except where they can be removed without the use of a key or tool.
- c) An enclosure may be:
 - a cabinet or box, either mounted on the machine or separate from the machine;
 - a compartment consisting of an enclosed space within the machine structure.

3.21**equipment**

material, fittings, devices, components, appliances, fixtures, apparatus, and the like used as part of, or in connection with, the electrical equipment of machines

3.22**equipotential bonding**

provision of electric connections between conductive parts, intended to achieve equipotentiality

[IEV 195-1-10]

3.23**exposed conductive part**

conductive part of electrical equipment, which can be touched and which is not live under normal operating conditions, but which can become live under fault conditions

[IEV 826-03-02, modified]

3.24**extraneous conductive part**

conductive part not forming part of the electrical installation and liable to introduce a potential, generally the earth potential

[IEV 826-03-03, modified]

3.25**failure**

termination of the ability of an item to perform a required function

NOTE 1 After failure the item has a fault.

NOTE 2 "Failure" is an event, as distinguished from "fault", which is a state.

NOTE 3 This concept as defined does not apply to items consisting of software only.

[IEV 191-04-01]

NOTE 4 In practice, the terms fault and failure are often used synonymously.

3.26**fault**

state of an item characterized by inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources

NOTE 1 A fault is often the result of a failure of the item itself, but may exist without prior failure.

NOTE 2 In English the term "fault" and its definition are identical with those given in IEV 191-05-01. In the field of machinery, the French term "défaut" and the German term "Fehler" are used rather than the terms "panne" and "Fehlzustand" that appear with this definition.

3.27**functional bonding**

equipotential bonding necessary for proper functioning of electrical equipment

3.28**hazard**

potential source of physical injury or damage to health

NOTE 1 The term hazard can be qualified in order to define its origin (for example mechanical hazard, electrical hazard) or the nature of the potential harm (for example electric shock hazard, cutting hazard, toxic hazard, fire hazard). See also the definition of hazard given in AS 4024.

NOTE 2 The hazard envisaged in this definition:

- either is permanently present during the intended use of the machine (for example motion of hazardous moving elements, electric arc during a welding phase, unhealthy posture, noise emission, high temperature);
- or can appear unexpectedly (for example: explosion, crushing hazard as a consequence of an unintended/unexpected start-up, ejection as a consequence of a breakage, fall as a consequence of acceleration/deceleration).

[ISO 12100-1, 3.6, modified]

3.29**indirect contact**

contact of persons or livestock with exposed conductive parts which have become live under fault conditions

[IEV 826-03-06]

3.30**inductive power supply system**

system of inductive power transfer, consisting of a track converter and a track conductor, along which one or more pick-up(s) and associated pick-up converter(s) can move, without any galvanic or mechanical contact, in order to transfer electrical power for example to a mobile machine

NOTE The track conductor and the pick-up are analogous to the primary and secondary of a transformer respectively.

3.31**(electrically) instructed person**

person adequately advised or supervised by an electrically skilled person to enable him or her to perceive risks and to avoid hazards which electricity can create

[IEV 826-09-02, modified]

3.32**interlock (for safeguarding)**

arrangement that interconnects guard(s) or device(s) with the control system and/or all or part of the electrical supply to the machine

3.33**live part**

conductor or conductive part intended to be energized in normal use, including a neutral conductor, but, by convention, not a PEN conductor

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

[IEV 826-03-01]

3.34**machine actuator**

power mechanism used to effect motion of the machine

3.35**machinery****machine**

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.

The term "machinery" also covers an assembly of machines which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole

[ISO 12100-1, 3.1, modified]

NOTE The term "component" is used here in a general sense and it does not refer only to electrical components.

3.36**marking**

signs or inscriptions primarily for the purpose of identifying equipment, components and/or devices, which can include certain features thereof

3.37**neutral conductor****N**

conductor connected to the neutral point of a system and capable of contributing to the transmission of electrical energy

[IEV 826-01-03]

3.38**obstacle**

part preventing unintentional direct contact, but not preventing direct contact by deliberate action

[IEV 826-03-14]

3.39**overcurrent**

current exceeding the rated value. For conductors, the rated value is the current-carrying capacity

[IEV 826-05-06, modified]

3.40**overload (of a circuit)**

time/current relationship in a circuit which is in excess of the rated full load of the circuit when the circuit is not under a fault condition

NOTE *Overload* should not be used as a synonym for *overcurrent*.

3.41**plug/socket combination**

component and a suitable mating component, appropriate to terminate conductors, intended for connection or disconnection of two or more conductors

NOTE Examples of plug/socket combination include:

- connectors which fulfil the requirements of IEC 61984;
- a plug and socket-outlet, a cable coupler, or an appliance coupler in accordance with IEC 60309-1;
- a plug and socket-outlet in accordance with IEC 60884-1 or an appliance coupler in accordance with IEC 60320-1.

3.42**power circuit**

circuit that supplies power from the supply network to units of equipment used for productive operation and to transformers supplying control circuits

3.43**protective bonding**

equipotential bonding for protection against electric shock

NOTE Measures for protection against electric shock can also reduce the risk of burns or fire.

3.44**protective bonding circuit**

protective conductors and conductive parts connected together to provide protection against electric shock in the event of an insulation failure

3.45**protective conductor**

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

- exposed conductive parts;
- extraneous conductive parts;
- main earthing terminal (PE)

[IEV 826-04-05, modified]

3.46**redundancy**

application of more than one device or system, or part of a device or system, with the objective of ensuring that in the event of one failing to perform its function another is available to perform that function

3.48**reference designation**

distinctive code which serves to identify an item in the documentation and on the equipment

3.48**risk**

combination of the probability of occurrence of harm (i.e. physical injury or damage to health) and the severity of that harm

[ISO 12100-1, 3.11, modified]

3.49**safeguard**

guard or protective device provided as a means to protect persons from a hazard

3.50**safeguarding**

protective measure using safeguards to protect persons from the hazards which cannot reasonably be eliminated or from the risks which cannot be sufficiently reduced by inherently safe design measures

[ISO 12100-1, 3.20]

3.51**servicing level**

level on which persons stand when operating or maintaining the electrical equipment

3.52**short-circuit current**

overcurrent resulting from a short circuit due to a fault or an incorrect connection in an electric circuit

[IEV 441-11-07]

3.53**(electrically) skilled person**

person with relevant training, education and experience to enable him or her to perceive risks and to avoid hazards associated with electricity

[IEV 826-09-01, modified]

3.54**supplier**

entity (for example manufacturer, contractor, installer, integrator) who provides equipment or services associated with the machine

NOTE The user organization may also act in the capacity of a supplier to itself.

3.55**switching device**

device designed to make and/or break the current in one or more electric circuits

[IEV 441-14-01, modified]

NOTE A switching device may perform one or both of these actions.

3.56**uncontrolled stop**

stopping of machine motion by removing electrical power to the machine actuators

NOTE This definition does not imply any particular state of other stopping devices, for example mechanical or hydraulic brakes.

3.57**user**

entity who utilizes the machine and its associated electrical equipment

4 General requirements**4.1 General considerations**

This part of IEC 60204 is intended to apply to electrical equipment used with a wide variety of machines and with a group of machines working together in a co-ordinated manner.

The risks associated with the hazards relevant to the electrical equipment shall be assessed as part of the overall requirements for risk assessment of the machine. This will determine the adequate risk reduction, and the necessary protective measures for persons who can be exposed to those hazards, while still maintaining an acceptable level of performance of the machine and its equipment.

Hazardous situations can result from, but are not limited to, the following causes:

- failures or faults in the electrical equipment resulting in the possibility of electric shock or electrical fire or explosion;
- failures or faults in control circuits (or components and devices associated with those circuits) resulting in the malfunctioning of the machine;
- disturbances or disruptions in power sources as well as failures or faults in the power circuits resulting in the malfunctioning of the machine;
- loss of continuity of circuits that depend upon sliding or rolling contacts, resulting in a failure of a safety function;
- electrical disturbances (for example electromagnetic, electrostatic either from outside the electrical equipment or internally generated, resulting in the malfunctioning of the machine;
- release of stored energy (either electrical or mechanical) resulting in, for example, electric shock, unexpected movement that can cause injury;
- audible noise at levels that cause health problems to persons;
- surface temperatures that can cause injury.

Safety measures are a combination of the measures incorporated at the design stage and those measures required to be implemented by the user.

NOTE 1 – Safety measures also need to be considered in the context of the safety life cycle. More information is given in AS 61508 and AS 4024.

The design and development process shall identify hazards and the risks arising from them. Where the hazards cannot be removed and/or the risks cannot be sufficiently reduced by inherently safe design measures, protective measures (for example safeguarding,) shall be provided to reduce the risk. Additional means (for example, awareness means) shall be provided where further risk reduction is necessary. In addition, working procedures that reduce risk can be necessary.

The use of the enquiry form as shown in informative Annex B of this part of IEC 60204 is recommended in order to facilitate an appropriate agreement between the user and the supplier(s) on basic conditions and additional user specifications related to the electrical equipment. Those additional specifications are to:

- provide additional features that are dependent on the type of machine (or group of machines) and the application;
- facilitate maintenance and repair; and
- advance the reliability and ease of operation.

4.2 Selection of equipment

4.2.1 General

Electrical components and devices shall:

- be suitable for their intended use; and
- conform to relevant Australian and IEC standards where such exist; and
- be applied in accordance with the supplier's instructions.

4.2.2 Electrical equipment in compliance with the IEC 60439 series

The electrical equipment of the machine shall satisfy the safety requirements identified by the risk assessment of the machine. Depending upon the machine, its intended use and its electrical equipment, the designer may select parts of the electrical equipment of the machine that are in compliance with relevant parts of the IEC 60439 series (see also informative Annex F).

NOTE The IEC 60439 series specifies requirements for equipment covering a wide range of possible applications of low-voltage switchgear and controlgear assemblies.

4.3 Electrical supply

4.3.1 General

The electrical equipment shall be designed to operate correctly with the conditions of the supply:

- as specified in 4.3.2 or 4.3.3, or
- as otherwise specified by the user (see informative Annex B), or
- as specified by the supplier in the case of a special source of supply such as an on-board generator.

4.3.2 AC supplies

Voltage	Steady state voltage: 0,9 to 1,1 of nominal voltage.
Frequency	0,99 to 1,01 of nominal frequency continuously; 0,98 to 1,02 short time.
Harmonics	Harmonic distortion not exceeding 10 % of the total r.m.s. voltage between live conductors for the sum of the 2 nd through to the 5 th harmonic. An additional 2 % of the total r.m.s. voltage between live conductors for the sum of the 6 th through to the 30 th harmonic is permissible.
Voltage unbalance	Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in three-phase supplies exceeding 2 % of the positive sequence component.
Voltage interruption	Supply interrupted or at zero voltage for not more than 3 ms at any random time in the supply cycle with more than 1 s between successive interruptions.
Voltage dips	Voltage dips not exceeding 20 % of the peak voltage of the supply for more than one cycle with more than 1 s between successive dips.

4.3.3 DC supplies

From batteries:

Voltage	0,85 to 1,15 of nominal voltage; 0,7 to 1,2 of nominal voltage in the case of battery-operated vehicles.
Voltage interruption	Not exceeding 5 ms. From converting equipment:
Voltage	0,9 to 1,1 of nominal voltage.
Voltage interruption	Not exceeding 20 ms with more than 1 s between successive interruptions.

NOTE This is a variation to IEC Guide 106 to ensure proper operation of electronic equipment.

Ripple (peak-to-peak) Not exceeding 0,15 of nominal voltage.

4.3.4 Special supply systems

For special supply systems such as on-board generators, the limits given in 4.3.2 and 4.3.3 may be exceeded provided that the equipment is designed to operate correctly with those conditions.

4.4 Physical environment and operating conditions

4.4.1 General

The electrical equipment shall be suitable for the physical environment and operating conditions of its intended use. The requirements of 4.4.2 to 4.4.8 cover the physical environment and operating conditions of the majority of machines covered by this standard. When special conditions apply or the limits specified are exceeded, an agreement between user and supplier (see 4.1) can be necessary.

4.4.2 Electromagnetic compatibility (EMC)

The equipment shall not generate electromagnetic disturbances above levels that are appropriate for its intended operating environment. In addition, the equipment shall have a level of immunity to electromagnetic disturbances so that it can function in its intended environment.

NOTE 1 The generic EMC standards IEC 61000-6-1 or IEC 61000-6-2 and CISPR 61000-6-3 or IEC 61000-6-4 give general EMC emission and immunity limits.

NOTE 2 IEC/TR 61000-5-2 gives guidelines for earthing and cabling of electrical and electronic systems aimed at ensuring EMC. If specific product standards exist (for example, IEC 61496-1, IEC 61800-3, IEC 60947-5-2) they take precedence over generic standards.

Measures to limit the generation of electromagnetic disturbances, i.e. conducted and radiated emissions include:

- power supply filtering;
- cable shielding;
- enclosures designed to minimize RF radiation;
- RF suppression techniques.

Measures to enhance the immunity of the equipment against conducted and radiated RF disturbance include:

- design of functional bonding system taking into account the following;
 - connection of sensitive electrical circuits to the chassis. Such terminations should be marked or labelled with the symbol IEC 60417-5020 (DB:2002-10³):
 - 
 - connection of the chassis to earth (PE) using a conductor with low RF impedance and as short as practicable;
- connection of sensitive electrical equipment or circuits directly to the PE circuit or to a functional earthing conductor (FE) (see Figure 2), to minimize common mode disturbance. This latter terminal should be marked or labelled by the symbol IEC 60417-5018 (DB:2002-10⁴):
- 
- separation of sensitive circuits from disturbance sources;
- enclosures designed to minimize RF transmission;
- EMC wiring practices:
 - using twisted conductors to reduce the effect of differential mode disturbances,
 - keeping sufficient distance between conductors emitting disturbances and conductors of sensitive circuits,
 - using cable orientation as close to 90° as possible when cables cross,
 - running the conductors as close as possible to the ground plane,
 - using electrostatic screens and/or electromagnetic shields with a low RF impedance termination.

³ "DB" refers to the IEC on-line database

⁴ "DB" refers to the IEC on-line database

4.4.3 Ambient air temperature

Electrical equipment shall be capable of operating correctly in the intended ambient air temperature. The minimum requirement for all electrical equipment is correct operation between air temperatures of +5 °C and +40 °C. For very hot environments (for example hot climates, steel mills, paper mills) and for cold environments, extra requirements can be necessary (see informative Annex B).

NOTE – In parts of Australia allowance should be made for higher ambient temperatures.

4.4.4 Humidity

The electrical equipment shall be capable of operating correctly when the relative humidity does not exceed 50 % at a maximum temperature of +40 °C. Higher relative humidities are permitted at lower temperatures (for example 90 % at 20 °C).

Harmful effects of occasional condensation shall be avoided by design of the equipment or, where necessary, by additional measures (for example built-in heaters, air conditioners, drain holes).

NOTE – In parts of Australia allowance should be made for higher levels of humidity.

4.4.5 Altitude

Electrical equipment shall be capable of operating correctly at altitudes up to 1 000 m above mean sea level.

4.4.6 Contaminants

Electrical equipment shall be adequately protected against the ingress of solids and liquids (see 11.3).

The electrical equipment shall be adequately protected against contaminants (for example dust, acids, corrosive gases, salts) that can be present in the physical environment in which the electrical equipment is to be installed (see informative Annex B).

4.4.7 Ionizing and non-ionizing radiation

When equipment is subject to radiation (for example microwave, ultraviolet, lasers, X-rays), additional measures shall be taken to avoid malfunctioning of the equipment and accelerated deterioration of the insulation. A special agreement can be necessary between the supplier and the user (see informative Annex B).

4.4.8 Vibration, shock, and bump

Undesirable effects of vibration, shock and bump (including those generated by the machine and its associated equipment and those created by the physical environment) shall be avoided by the selection of suitable equipment, by mounting it away from the machine, or by provision of anti-vibration mountings. A special agreement can be necessary between the supplier and the user (see informative Annex B).

4.5 Transportation and storage

Electrical equipment shall be designed to withstand, or suitable precautions shall be taken to protect against, the effects of transportation and storage temperatures within a range of – 25 °C to +55 °C and for short periods not exceeding 24 h at up to +70 °C. Suitable means shall be provided to prevent damage from humidity, vibration, and shock. A special agreement can be necessary between the supplier and the user (see informative Annex B).

NOTE Electrical equipment susceptible to damage at low temperatures includes PVC insulated cables.

4.6 Provisions for handling

Heavy and bulky electrical equipment that has to be removed from the machine for transport, or that is independent of the machine, shall be provided with suitable means for handling by cranes or similar equipment.

4.7 Installation

Electrical equipment shall be installed in accordance with the electrical equipment supplier's instructions and applicable requirements of regulatory bodies.

5 Incoming supply conductor terminations and devices for disconnecting and switching off

5.1 Incoming supply conductor terminations

It is recommended that, where practicable, the electrical equipment of a machine is connected to a single incoming supply. Where another supply is necessary for certain parts of the equipment (for example, electronic equipment that operates at a different voltage), that supply should be derived, as far as is practicable, from devices (for example, transformers, converters) forming part of the electrical equipment of the machine. For large complex machinery comprising a number of widely-spaced machines working together in a co-ordinated manner, there can be a need for more than one incoming supply depending upon the site supply arrangements (see 5.3.1).

Unless a plug is provided with the machine for the connection to the supply (see 5.3.2 e), it is recommended that the supply conductors are terminated at the supply disconnecting device.

Where a neutral conductor is used it shall be clearly indicated in the technical documentation of the machine, such as in the installation diagram and in the circuit diagram, and a separate insulated terminal, labelled **N** in accordance with 16.1, shall be provided for the neutral conductor (see also informative Annex B).

There shall be no connection between the neutral conductor and the protective bonding circuit inside the electrical equipment nor shall a combined PEN terminal be provided.

Exception: a connection may be made between the neutral terminal and the PE terminal at the point of the connection of the power supply to the machine for TN-C systems.

All terminals for the incoming supply connection shall be clearly identified in accordance with IEC 60445 and 16.1. For the identification of the external protective conductor terminal, see 5.2.

NOTE – Definitions of earthing systems are given in IEC 60364-1.

5.2 Terminal for connection to the external protective earthing system

For each incoming supply, a terminal shall be provided in the vicinity of the associated phase conductor terminals for connection of the machine to the external protective earthing system or to the external protective conductor, depending upon the supply distribution system.

The terminal shall be of such a size as to enable the connection of an external protective copper conductor with a cross-sectional area in accordance with Table 1.

Table 1 – Minimum cross-sectional area of the external protective copper conductor

Cross-sectional area of copper phase conductors supplying the equipment $S \text{ mm}^2$	Minimum cross-sectional area of the external protective copper conductor $S_p \text{ mm}^2$
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	$S/2$

Where an external protective conductor of a material other than copper is used, the terminal size shall be selected accordingly (see also 8.2.2).

At each incoming supply point, the terminal for connection of the external protective earthing system or the external protective conductor shall be marked or labelled with the letters **PE** (see IEC 60445).

5.3 Supply disconnecting (isolating) device

5.3.1 General

A supply disconnecting device shall be provided:

- for each incoming source of supply to a machine(s);
NOTE The incoming supply can be connected directly to the machine or via a feeder system. Feeder systems of machines can include conductor wires, conductor bars, slip-ring assemblies, flexible cable systems (reeled, festooned) or inductive power supply systems;
- for each on-board power supply.

The supply disconnecting device shall disconnect (isolate) the electrical equipment of the machine from the supply when required (for example for work on the machine, including the electrical equipment).

When two or more supply disconnecting devices are provided, protective interlocks for their correct operation shall also be provided in order to prevent a hazardous situation, including damage to the machine or to the work in progress.

5.3.2 Type

The supply disconnecting device shall be one of the following types:

- a switch-disconnector, with or without fuses, in accordance with IEC 60947-3, utilization category AC-23B or DC-23B;
- a disconnector, with or without fuses, in accordance with IEC 60947-3, that has an auxiliary contact that in all cases causes switching devices to break the load circuit before the opening of the main contacts of the disconnector;
- a circuit-breaker suitable for isolation in accordance with IEC 60947-2;
- any other switching device in accordance with an IEC product standard for that device and which meets the isolation requirements of IEC 60947-1 as well as a utilization category defined in the product standard as appropriate for on-load switching of motors or other inductive loads;
- a plug/socket combination for a flexible cable supply.

5.3.3 Requirements

When the supply disconnecting device is one of the types specified in 5.3.2 a) to d) it shall fulfil all of the following requirements:

- isolate the electrical equipment from the supply and have one OFF (isolated) and one ON position marked with "O" and "I" (symbols IEC 60417-5008 (DB:2002-10⁵) and IEC 60417-5007 (DB:2002-10⁶), see 10.2.2);
- have a visible contact gap or a position indicator which cannot indicate OFF (isolated) until all contacts are actually open and the requirements for the isolating function have been satisfied;
- have an external operating means (for example handle), (**exception:** power-operated switchgear need not be operable from outside the enclosure where there are other means to open it). Where the external operating means is not intended for emergency operations it is recommended that it be coloured BLACK or GREY (see 10.7.4 and 10.8.4);
- be provided with a means permitting it to be locked in the OFF (isolated) position (for example by padlocks). When so locked, remote as well as local closing shall be prevented;
- disconnect all live conductors of its power supply circuit. However, for TN supply systems, the neutral conductor may or may not be disconnected except in countries where disconnection of the neutral conductor (when used) is compulsory;
- have a breaking capacity sufficient to interrupt the current of the largest motor when stalled together with the sum of the normal running currents of all other motors and/or loads. The calculated breaking capacity may be reduced by the use of a proven diversity factor.

When the supply disconnecting device is a plug/socket combination it shall fulfil the following requirements:

- have the switching capability, or be interlocked with a switching device that has a breaking capacity, sufficient to interrupt the current of the largest motor when stalled together with the sum of the normal running currents of all other motors and/or loads. The calculated breaking capacity may be reduced by the use of a proven diversity factor. When the interlocked switching device is electrically operated (for example a contactor) it shall have an appropriate utilisation category.
- a) to f) of 13.4.5.

NOTE A suitably rated plug and socket-outlet, cable coupler, or appliance coupler, in accordance with IEC 60309-1 can fulfil these requirements.

Where the supply disconnecting device is a plug/socket combination, a switching device with an appropriate utilisation category shall be provided for switching the machine on and off. This can be achieved by the use of the interlocked switching device described above.

5.3.4 Operating means

The operating means (for example, a handle) of the supply disconnecting device shall be easily accessible and located between 0,6 m and 1,9 m above the servicing level. An upper limit of 1,7 m is recommended.

NOTE The direction of operation is given in IEC 61310-3.

⁵ "DB" refers to the IEC on-line database

⁶ "DB" refers to the IEC on-line database

5.3.5 Excepted circuits

The following circuits need not be disconnected by the supply disconnecting device:

- lighting circuits for lighting needed during maintenance or repair;
- plug and socket outlets for the exclusive connection of repair or maintenance tools and equipment (for example hand drills, test equipment);
- undervoltage protection circuits that are only provided for automatic tripping in the event of supply failure;
- circuits supplying equipment that should normally remain energized for correct operation (for example temperature controlled measuring devices, product (work in progress) heaters, program storage devices);
- control circuits for interlocking.

It is recommended, however, that such circuits be provided with their own disconnecting device.

Where such a circuit is not disconnected by the supply disconnecting device:

- permanent warning label(s) in accordance with 16.1 shall be appropriately placed in proximity to the supply disconnecting device;
- a corresponding statement shall be included in the maintenance manual, and one or more of the following shall apply;
 - a permanent warning label in accordance with 16.1 is affixed in proximity to each excepted circuit, or
 - the excepted circuit is separated from other circuits, or
 - the conductors are identified by colour taking into account the recommendation of 13.2.4.

5.4 Devices for switching off for prevention of unexpected start-up

Devices for switching off for the prevention of unexpected start-up shall be provided (for example where, during maintenance, a start-up of the machine or part of the machine can create a hazard).

Such devices shall be appropriate and convenient for the intended use, shall be suitably placed, and readily identifiable as to their function and purpose (for example by a durable marking in accordance with 16.1 where necessary).

NOTE 1 This standard does not address all provisions for prevention of unexpected start up. See ISO 14118 (EN 1037).

Means shall be provided to prevent inadvertent and/or mistaken closure of these devices either at the controller or from other locations (see also 5.6).

The following devices that fulfil the isolation function may be provided for this purpose:

- devices described in 5.3.2,
- disconnectors, withdrawable fuse links and withdrawable links only if located in an enclosed electrical operating area (see 3.19).

Devices that do not fulfil the isolation function (for example a contactor switched off by a control circuit) may only be provided after a risk assessment has been conducted and only where intended to be used for situations that include where:

- persons are not within the confines of the machine;
- in the event that the machine starts, the person has sufficient time and space to avoid any hazards;

- there is no hazard arising from electric shock (see clause 6), burn or arc blast injury;
 - the switching off means cannot be negated by the work;
 - the switching off mechanism can be locked in the off position;
 - the switching off means has an appropriate safety integrity level (refer to AS 61508), or an appropriate safety category (refer to AS 4024);
 - the switching off means cannot be defeated by other work that may be being conducted, such as shorting of control circuit elements to force contactors;
 - any electrical work is of a minor nature (e.g. replacement of plug-in devices without disturbing existing wiring);
 - no significant dismantling of the machine; and
 - adjustments only require a relatively short time.
- ~~inspections;~~
 - ~~adjustments;~~
 - ~~work on the electrical equipment where:~~
 - ~~there is no hazard arising from electric shock (see Clause 6) and burn;~~
 - ~~the switching off means remains effective throughout the work;~~
 - ~~the work is of a minor nature (for example replacement of plug-in devices without disturbing existing wiring).~~

NOTE 2 The selection of a device will be dependent on the risk assessment, taking into account the intended use of the device, for example, the use of disconnectors, withdrawable fuse links or withdrawable links located in enclosed electrical operating areas can be inappropriate for use by cleaners (see 17.2 I)).

5.5 Devices for disconnecting electrical equipment

Devices shall be provided for disconnecting (isolating) electrical equipment to enable work to be carried out when it is de-energised and isolated. Such devices shall be:

- appropriate and convenient for the intended use;
- suitably placed;
- readily identifiable as to which part(s) or circuit(s) of the equipment is served (for example by durable marking in accordance with 16.1 where necessary).

Means shall be provided to prevent inadvertent and/or mistaken closure of these devices either at the controller or from other locations (see also 5.6).

The supply disconnecting device (see 5.3) may, in some cases, fulfil that function. However, where it is necessary to work on individual parts of the electrical equipment of a machine, or on one of a number of machines fed by a common conductor bar, conductor wire or inductive power supply system, a disconnecting device shall be provided for each part, or for each machine, requiring separate isolation.

In addition to the supply disconnecting device, the following devices that fulfil the isolation function may be provided for this purpose:

- devices described in 5.3.2;
- disconnectors, withdrawable fuse links and withdrawable links only if located in an electrical operating area (see 3.15) and relevant information is provided with the electrical equipment (see 17.2 i) and I)).

NOTE Where protection against electric shock is provided in accordance with 6.2.2 c), withdrawable fuse links or withdrawable links for this purpose are intended for use by skilled or instructed persons.

5.6 Protection against unauthorized, inadvertent and/or mistaken connection

The devices described in 5.4 and 5.5 that are located outside an enclosed electrical operating area shall be equipped with means to secure them in the OFF position (disconnected state), (for example by provisions for padlocking, trapped key interlocking). When so secured, remote as well as local reconnection shall be prevented.

Where a non-lockable disconnecting device (for example withdrawable fuse-links, withdrawable links) other means of protection against reconnection (for example warning labels in accordance with 16.1) may be provided.

However, when a plug/socket combination according to 5.3.2 e) is so positioned that it can be kept under the immediate supervision of the person carrying out the work, means for securing in the disconnected state need not be provided.

6 Protection against electric shock

6.1 General

The electrical equipment shall provide protection of persons against electric shock from:

- direct contact (see 6.2 and 6.4);
- indirect contact (see 6.3 and 6.4).

The measures for this protection given in 6.2, 6.3, and, for PELV, in 6.4, are a recommended selection from IEC 60364-4-41. Where those recommended measures are not practicable, for example due to the physical or operational conditions, other measures from IEC 60364-4-41 may be used.

6.2 Protection against direct contact

6.2.1 General

For each circuit or part of the electrical equipment, the measures of either 6.2.2 or 6.2.3 and, where applicable, 6.2.4 shall be applied.

Exception: where those measures are not appropriate, other measures for protection against direct contact (for example by using barriers, by placing out of reach, using obstacles, using construction or installation techniques that prevent access) as defined in IEC 60364-4-41 may be applied (see 6.2.5 and 6.2.6).

When the equipment is located in places open to all persons, which can include children, measures of either 6.2.2 with a minimum degree of protection against direct contact corresponding to IP4X or IPXXD (see IEC 60529), or 6.2.3 shall be applied.

6.2.2 Protection by enclosures

Live parts shall be located inside enclosures that conform to the relevant requirements of Clauses 4, 11, and 14 and that provide protection against direct contact of at least IP2X or IPXXB (see IEC 60529).

Where the top surfaces of the enclosure are readily accessible, the minimum degree of protection against direct contact provided by the top surfaces shall be IP4X or IPXXD.

Opening an enclosure (i.e. opening doors, lids, covers, and the like) shall be possible only under one of the following conditions:

- a) The use of a key or tool is necessary for access. For enclosed electrical operating areas, see IEC 60364-4-41, or IEC 60439-1 as appropriate.

NOTE 1 The use of a key or tool is intended to restrict access to skilled or instructed persons (see 17.2 I)).

All live parts, that are likely to be touched when resetting or adjusting devices intended for such operations while the equipment is still connected, shall be protected against direct contact to at least IP2X or IPXXB. Other live parts on the inside of doors shall be protected against direct contact to at least IP1X or IPXXA.

- b) The disconnection of live parts inside the enclosure before the enclosure can be opened.

This may be accomplished by interlocking the door with a disconnecting device (for example the supply disconnecting device) so that the door can only be opened when the disconnecting device is open and so that the disconnecting device can only be closed when the door is closed.

Exception: a special device or tool as prescribed by the supplier can be used to defeat the interlock provided that:

- a risk assessment has been conducted by the supplier;
- specific situations and work activities have been identified where the defeating mechanism can be used;
- competencies required to carry out that specific work have been identified;
- detailed procedures for carrying out that work by skilled and instructed persons have been documented;
- the tools, testing devices/instruments and personal protective clothing required to carry out the work have been identified;
- the above details are provided with each tool provided by the supplier;
- it is possible at all times while the interlock is defeated to open the disconnecting device and lock the disconnecting device in the OFF (isolated) position or otherwise prevent unauthorised closure of the disconnecting device;
- upon closing the door, the interlock is automatically restored;
- all live parts, that are likely to be touched when resetting or adjusting devices intended for such operations while the equipment is still connected, are protected against direct contact to at least IP2X or IPXXB and other live parts on the inside of doors are protected against direct contact to at least IP1X or IPXXA;
- relevant information is provided with the electrical equipment (see 17.2 i) and I)).

NOTE 2 The special device or tool is intended for use only by skilled or instructed persons (see 17.2 I)).

Means shall be provided to restrict access to live parts behind doors not directly interlocked with the disconnecting means to skilled or instructed persons. (See 17.2 I))

All parts that are still live after switching off the disconnecting device(s) (see 5.3.5) shall be protected against direct contact to at least IP2X or IPXXB (see IEC 60529). Such parts shall be marked with a warning sign in accordance with 16.2.1 (see also 13.2.4 for identification of conductors by colour).

Excepted from this requirement for marking are:

- parts that can be live only because of connection to interlocking circuits and that are distinguished by colour as potentially live in accordance with 13.2.4;
- the supply terminals of the supply disconnecting device when the latter is mounted alone in a separate enclosure.

- c) Opening without the use of a key or a tool and without disconnection of live parts shall be possible only when all live parts are protected against direct contact to at least IP2X or IPXXB (see IEC 60529). Where barriers provide this protection, either they shall require a tool for their removal or all live parts protected by them shall be automatically disconnected when the barrier is removed.

NOTE 3 Where protection against direct contact is achieved in accordance with 6.2.2 c), and a hazard can be caused by manual actuation of devices (for example manual closing of contactors or relays), such actuation should be prevented by barriers or obstacles that require a tool for their removal.

6.2.3 Protection by insulation of live parts

Live parts protected by insulation shall be completely covered with insulation that can only be removed by destruction. Such insulation shall be capable of withstanding the mechanical, chemical, electrical, and thermal stresses to which it can be subjected under normal operating conditions.

NOTE Paints, varnishes, lacquers, and similar products alone are generally considered to be inadequate for protection against electric shock under normal operating conditions.

6.2.4 Protection against residual voltages

Live parts having a residual voltage greater than 60 V after the supply has been disconnected shall be discharged to 60 V or less within a time period of 5 s after disconnection of the supply voltage provided that this rate of discharge does not interfere with the proper functioning of the equipment. Exempted from this requirement are components having a stored charge of 60 μC or less. Where this specified rate of discharge would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the delay required before the enclosure may be opened shall be displayed at an easily visible location on or immediately adjacent to the enclosure containing the capacitances.

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (for example pins), the discharge time shall not exceed 1 s, otherwise such conductors shall be protected against direct contact to at least IP2X or IPXXB. If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved (for example in the case of removable collectors on conductor wires, conductor bars, or slip-ring assemblies, see 12.7.4), additional switching devices or an appropriate warning device (for example a warning notice in accordance with 16.1) shall be applied.

6.2.5 Protection by barriers

For protection by barriers, 412.2 of IEC 60364-4-41 shall apply.

6.2.6 Protection by placing out of reach or protection by obstacles

For protection by placing out of reach 412.4 of IEC 60364-4-41 shall apply. For protection by obstacles, 412.3 of IEC 60364-4-41 shall apply.

For conductor wire systems or conductor bar systems with a degree of protection less than IP2X, see 12.7.1.

6.3 Protection against indirect contact

6.3.1 General

Protection against indirect contact (3.29) is intended to prevent hazardous situations due to an insulation fault between live parts and exposed conductive parts.

For each circuit or part of the electrical equipment, at least one of the measures in accordance with 6.3.2 to 6.3.3 shall be applied:

- measures to prevent the occurrence of a touch voltage (6.3.2); or
- automatic disconnection of the supply before the time of contact with a touch voltage can become hazardous (6.3.3).

NOTE 1 The risk of harmful physiological effects from a touch voltage depends on the value of the touch voltage and the duration of possible exposure.

NOTE 2 For classes of equipment and protective provisions see IEC 61140.

6.3.2 Prevention of the occurrence of a touch voltage

6.3.2.1 General

Measures to prevent the occurrence of a touch voltage include the following:

- provision of class II equipment or by equivalent insulation;
- electrical separation.

6.3.2.2 Protection by provision of class II equipment or by equivalent insulation

This measure is intended to prevent the occurrence of touch voltages on the accessible parts through a fault in the basic insulation.

This protection is provided by one or more of the following:

- class II electrical devices or apparatus (double insulation, reinforced insulation or by equivalent insulation in accordance with IEC 61140);
- switchgear and controlgear assemblies having total insulation in accordance with IEC 60439-1;
- supplementary or reinforced insulation in accordance with 413.2 of IEC 60364-4-41.

6.3.2.3 Protection by electrical separation

Electrical separation of an individual circuit is intended to prevent a touch voltage through contact with exposed conductive parts that can be energized by a fault in the basic insulation of the live parts of that circuit.

For this type of protection, the requirements of 413.5 of IEC 60364-4-41 apply.

6.3.3 Protection by automatic disconnection of supply

This measure consists of the interruption of one or more of the line conductors by the automatic operation of a protective device in case of a fault. This interruption shall occur within a sufficiently short time to limit the duration of a touch voltage to a time within which the touch voltage is not hazardous. Interruption times are given in Annex A.

This measure necessitates co-ordination between:

- the type of supply and earthing system;
- the impedance values of the different elements of the protective bonding system;
- the characteristics of the protective devices that detect insulation fault(s).

Automatic disconnection of the supply of any circuit affected by an insulation fault is intended to prevent a hazardous situation resulting from a touch voltage.

This protective measure comprises both:

- protective bonding of exposed conductive parts (see 8.2.3),
- and either:
 - a) overcurrent protective devices for the automatic disconnection of the supply on detection of an insulation fault in TN systems, or
 - b) residual current protective devices to initiate the automatic disconnection of the supply on detection of an insulation fault from a live part to exposed conductive parts or to earth in TT systems, or
 - c) insulation monitoring or residual current protective devices to initiate automatic disconnection of IT systems. Except where a protective device is provided to interrupt the supply in the case of the first earth fault, an insulation monitoring device shall be provided to indicate the occurrence of a first fault from a live part to exposed conductive parts or to earth. This insulation monitoring device shall initiate an audible and/or visual signal which shall continue as long as the fault persists.

Where automatic disconnection is provided in accordance with a), and disconnection within the time specified in A.1 cannot be assured, supplementary bonding shall be provided as necessary to meet the requirements of A.3.

Socket outlets provided on machinery for connection of tools shall be protected by a residual current detector set to operate at 30 mA.

6.4 Protection by the use of PELV

6.4.1 General requirements

The use of PELV (protective extra-low voltage) is to protect persons against electric shock from indirect contact and limited area direct contact (see 8.2.5).

PELV circuits shall satisfy all of the following conditions:

- a) the nominal voltage shall not exceed:
 - 25 V AC r.m.s. or 60 V ripple-free DC when the equipment is normally used in dry locations and when large area contact of live parts with the human body is not expected; or
 - 6 V AC r.m.s. or 15 V ripple-free DC in all other cases;

NOTE *Ripple-free* is conventionally defined for a sinusoidal ripple voltage as a ripple content of not more than 10 % r.m.s.
- b) one side of the circuit or one point of the source of the supply of that circuit shall be connected to the protective bonding circuit;
- c) live parts of PELV circuits shall be electrically separated from other live circuits. Electrical separation shall be not less than that required between the primary and secondary circuits of a safety isolating transformer (see IEC 61558-1 and IEC 61558-2-6);
- d) conductors of each PELV circuit shall be physically separated from those of any other circuit. When this requirement is impracticable, the insulation provisions of 13.1.3 shall apply;
- e) plugs and socket-outlets for a PELV circuit shall conform to the following:
 - i) plugs shall not be able to enter socket-outlets of other voltage systems;
 - ii) socket-outlets shall not admit plugs of other voltage systems.

6.4.2 Sources for PELV

The source for PELV shall be one of the following:

- a safety isolating transformer in accordance with IEC 61558-1 and IEC 61558-2-6;
- a source of current providing a degree of safety equivalent to that of the safety isolating transformer (for example a motor generator with winding providing equivalent isolation);
- an electrochemical source (for example a battery) or another source independent of a higher voltage circuit (for example a diesel-driven generator);
- an electronic power supply conforming to appropriate standards specifying measures to be taken to ensure that, even in the case of an internal fault, the voltage at the outgoing terminals cannot exceed the values specified in 6.4.1.

7 Protection of equipment

7.1 General

This Clause details the measures to be taken to protect equipment against the effects of:

- overcurrent arising from a short circuit;
- overload and/or loss of cooling of motors;
- abnormal temperature;
- loss of or reduction in the supply voltage;
- overspeed of machines/machine elements;
- earth fault/residual current;
- incorrect phase sequence;
- overvoltage due to lightning and switching surges.

7.2 Overcurrent protection

7.2.1 General

Overcurrent protection shall be provided where the current in a machine circuit can exceed either the rating of any component or the current carrying capacity of the conductors, whichever is the lesser value. The ratings or settings to be selected are detailed in 7.2.10.

7.2.2 Supply conductors

Unless otherwise specified by the user, the supplier of the electrical equipment is not responsible for providing the overcurrent protective device for the supply conductors to the electrical equipment (see informative Annex B).

The supplier of the electrical equipment shall state on the installation diagram the data necessary for selecting the overcurrent protective device (see 7.2.10 and 17.4).

7.2.3 Power circuits

Devices for detection and interruption of overcurrent, selected in accordance with 7.2.10, shall be applied to each live conductor.

The following conductors, as applicable, shall not be disconnected without disconnecting all associated live conductors:

- the neutral conductor of AC power circuits;
- the earthed conductor of DC power circuits;