

Safety of machinery — Electrical equipment of machines —

Part 1: General requirements

The European Standard EN 60204-1:1997 has the status of a British Standard

ICS 13.110; 29.020; 31.020

National foreword

This British Standard is the English language version of EN 60204-1:1997. It is identical with IEC 60204-1:1997. This British Standard supersedes BS EN 60204-1:1993 which remains current for use as a reference standard with BS EN 60204-31¹⁾.

The UK participation in its preparation was entrusted to Technical Committee GEL/44, Safety of machinery — electrotechnical aspects, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

Cross-references

Attention is drawn to the fact that CEN and CENELEC standards normally include an annex which lists normative references to international publications with their corresponding European publications. The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 66, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

¹⁾ In preparation.

Amendments issued since publication

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English version

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(IEC 60204-1:1997)

Sécurité des machines — Equipement
électrique des machines
Partie 1: Règles générales
(CEI 60204-1:1997)

Sicherheit von Maschinen — Elektrische
Ausrüstung von Maschinen
Teil 1: Allgemeine Anforderungen
(IEC 60204-1:1997)

This European Standard was approved by CENELEC on 1997-10-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

The text of document 44/205/FDIS, future edition 4 of IEC 60204-1, prepared by IEC TC 44, Safety of machinery: Electrotechnical aspects, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60204-1 on 1997-10-01.

This standard has been prepared under a mandate given to CEN/CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of the following EC Directives:

- Low Voltage Directive (73/23/EEC);
- Machinery Directive (89/392/EEC).

This European Standard supersedes EN 60204-1:1992 and its corrigendum December 1993. Significant technical differences have resulted from the amendments to the Machinery Safety Directive in 1991 covering mobility and lifting, and in 1993 covering safety components.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1998-11-01
- latest date by which national standards conflicting with the EN have to be withdrawn (dow) 2000-07-01

NOTE EN 60204-1:1985 remains applicable for use with EN 60204-3-1:1990.

Annexes designated “normative” are part of the body of the standard.

Annexes designated “informative” are given for information only.

In this standard, Annex ZA is normative and Annex A, Annex B, Annex C, Annex D and Annex E are informative.

Annex ZA has been added by CENELEC.

This standard has the status of a horizontal standard (type B in CEN) and may be used as a reference standard by technical committees in CEN and in CENELEC in the preparation of product family standards or dedicated product standards (type C in CEN as defined in EN 414:1992, 3.1) for machines. The requirements of this standard can also be applied by the supplier of a machine for which no product family or dedicated product standard exists. Where a product family or dedicated product standard exists, its requirements take precedence over the requirements of this standard.

EN 60204-1 gives a large number of general requirements that may or may not be applicable to the electrical equipment of a particular machine. A simple reference without any qualification to the complete standard EN 60204-1 is therefore not sufficient. Choices need to be made to cover all requirements of EN 60204-1. A technical committee preparing a product family or a dedicated product standard (type C in CEN) and the supplier of a machine for which no product family or dedicated product standard exists, should use this standard;

- a) by reference; and
- b) by selection of the most appropriate option(s) from the requirements given in the relevant clauses; and
- c) by modification of certain clauses as necessary where the particular requirements for the equipment of the machine are adequately covered by other relevant standards,

providing the options selected and the modifications made do not adversely affect the level of protection required for that machine according to the risk assessment.

When applying the three principles a), b) and c) listed above, it is recommended that;

- reference be made to the relevant clauses and subclauses of this standard
 - 1) that are complied with, indicating where relevant the applicable option;
 - 2) that have been modified or extended for the specific machine or equipment requirements; and
- reference be made directly to the relevant standard, for the requirements for the electrical equipment that are adequately covered by that standard.

In all cases expertise is essential to be able to:

- perform the necessary risk assessment of the machine;
- read and understand all of the requirements of EN 60204-1;

- choose the applicable requirements from EN 60204-1 where alternatives are given;
- identify alternative or additional particular requirements that differ from or are not included in the requirements of EN 60204-1, and that are determined by the machine and its use; and
- specify precisely those particular requirements.

Figure 2 of EN 60204-1 is a block diagram of a typical machine and can be used as the starting point of this task. It indicates the clauses and subclauses dealing with particular requirements/equipment. However EN 60204-1 is a complex document and the use of the following table will give help in the finding of a required area in this standard and gives reference to other relevant standards.

Clauses and subclauses of EN 60204-1 where action should be considered (shown by X) with respect to: a) selection from the measures given; b) additional requirements; c) different requirements; d) other standards that can be relevant					
Subject	Clause or subclause	a)	b)	c)	d) ^a
Scope	1		X		EN 50014 to EN 50020
General requirements	4	X	X	X	EN 292, EN 1050
Supply disconnecting (isolating) device	5.3	X			
Excepted circuits	5.3.5	X		X	
Prevention of unexpected start up, isolation	5.4 5.5 5.6	X	X	X	EN 1037
Protection against electric shock	6	X			HD 384.4.41 S2
Emergency operations	9.2.5.4	X		X	EN 418, EN 1050, EN 954-1, (IEC 61508)
Two-hand control	9.2.5.7	X	X		EN 574, EN 954-1
Cableless control	9.2.7	X	X	X	
Control functions in the event of failure	9.4	X	X	X	EN 1050, EN 954-1 (IEC 61508)
Position sensors	10.1.4	X	X	X	EN 1088, EN 954-1
Colours and markings of control devices, indicators	10.2, 10.3 & 10.4	X	X		EN 61310
Emergency stop devices	10.7	X	X		EN 418, EN 1050
Emergency switching off devices	10.8	X			
Electronic equipment	11	X		X	(IEC 61508)
Controlgear — protection against contamination, etc.	12.3, 10.1.3	X	X	X	
Identification of conductors	14.2	X	X		
Testing	19	X	X	X	
Additional user requirements	Annex B		X	X	
^a The standards listed under d) do not include those to which reference is made in the requirements of this standard.					

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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.

High performance is not to be obtained at the expense of the essential factors mentioned above.

An example of a possible application of these requirements is a group of machines used in the production of discrete parts where a failure in such production machines or manufacturing systems or cells can have serious economic consequences.

Figure 1 and Figure 2 have 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 an overall block diagram of a typical manufacturing system (a group of machines working together in a co-ordinated manner) and Figure 2 is a block diagram of a typical machine and associated equipment showing the various elements of the electrical equipment addressed in this standard. Numbers in parentheses () refer to clauses and subclauses in this standard. It is understood in Figure 1 and Figure 2 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.

1 Scope

This part of IEC 60204 applies to the application of electrical and electronic equipment and systems to machines not portable by hand while working, including a group of machines working together in a co-ordinated manner but excluding higher level systems aspects (i.e. communications between systems).

NOTE 1 In this standard, the term *electrical* includes both electrical and electronic matters (i.e. *electrical equipment* means both the electrical and the electronic equipment).

NOTE 2 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 3 For the requirements for the electrical supply installation in buildings, see IEC 60364.

This part 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 and not exceeding 1 500 V for direct current, and with nominal frequencies not exceeding 200 Hz. For higher voltages or frequencies, special requirements may be needed.

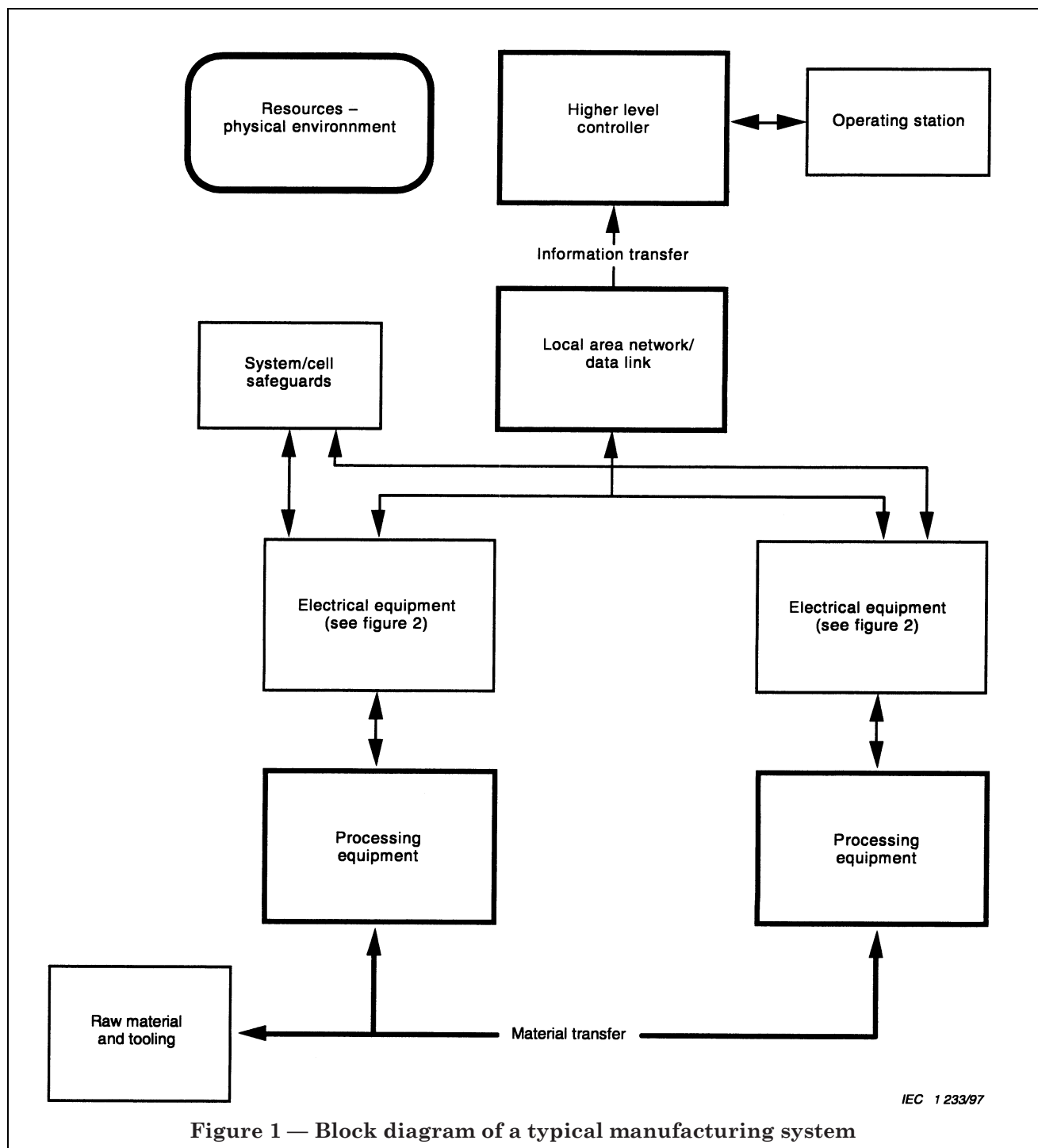
This part is an application standard and is not intended to limit or inhibit technological advancement. It does not cover all the requirements (e.g. guarding, interlocking, or control) that are needed or required by other standards or regulations in order to safeguard persons from hazards other than 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 3.33 (Annex A lists examples of machines whose electrical equipment may be covered by this standard).

Additional and special requirements can apply to the electrical equipment of machines that:

- are used in open air (i.e. outside buildings or other protective structures);
- use, process, or produce potentially explosive material (e.g. paint or sawdust);
- are used in potentially explosive and/or flammable atmospheres;
- have special risks when producing or using certain materials;
- are used in mines;
- are sewing machines, units, and systems (which are covered by IEC 60204-31);
- are hoisting machines (which are covered by 60204-32).

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



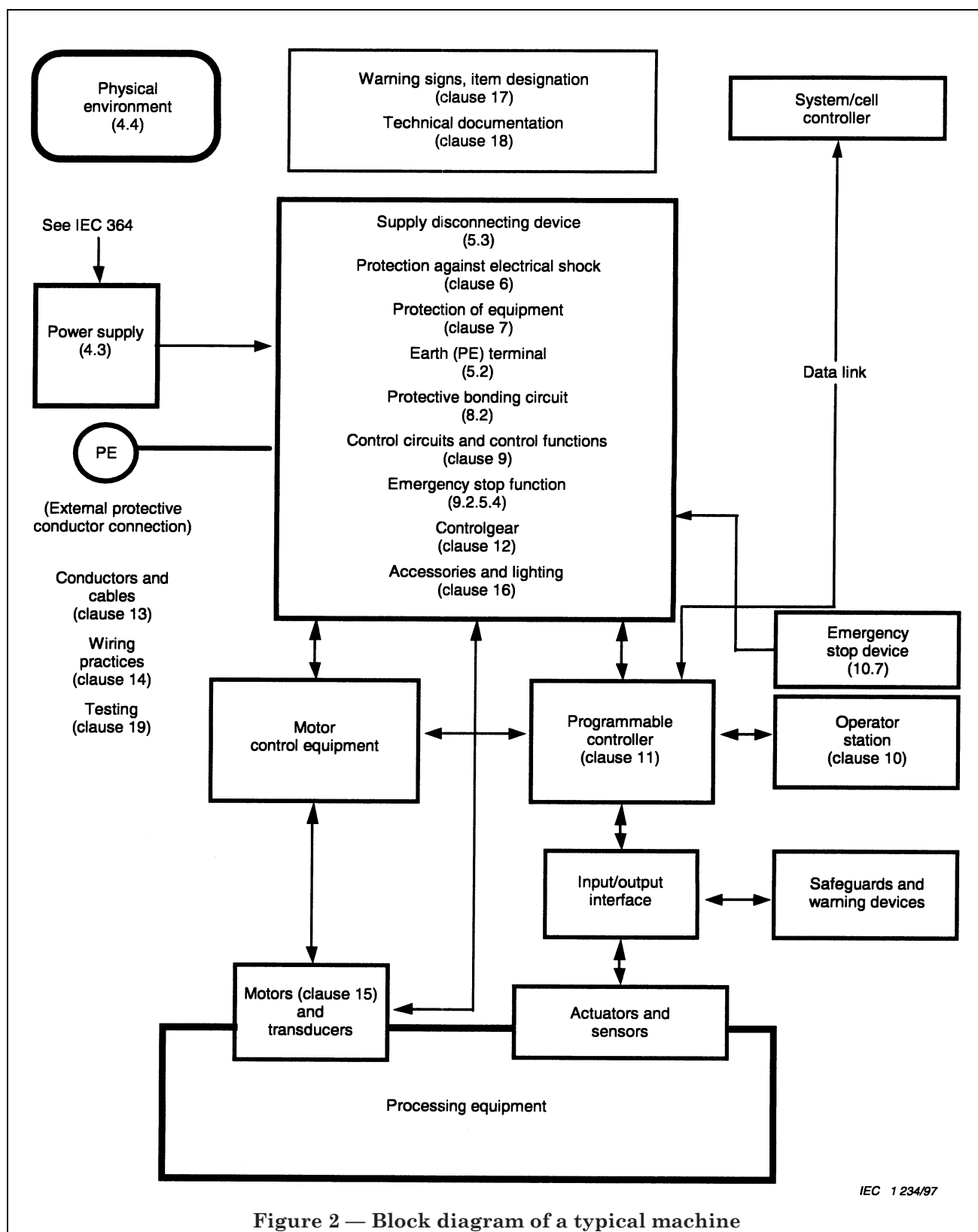


Figure 2 — Block diagram of a typical machine

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60204. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 60204 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid normative documents.

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

IEC 60034-5:1991, *Rotating electrical machines — Part 5: Classification of degrees of protection provided by enclosures of rotating electrical machines (IP code)*.

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

IEC 60050 (191):1990, *International Electrotechnical Vocabulary (IEV) — Chapter 191: Dependability and quality of service*.

IEC 60050 (441):1984, *International Electrotechnical Vocabulary (IEV) — Chapter 441: Switchgear, controlgear, and fuses*.

IEC 60050 (826):1982, *International Electrotechnical Vocabulary (IEV) — Chapter 826: Electrical installations of buildings*.

IEC 60072-1:1991, *Dimensions and output series for rotating electrical machines — 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 60073:1996, *Basic and safety principles for man-machine interface, marking and identification — Coding principles for indication devices and actuators*.

IEC 60076-5:1976, *Power transformers — Part 5: Ability to withstand short circuit*.

IEC 60146-1-1:1991, *General requirements and line commutated connectors — Part 1-1: Specifications of basic requirements*.

IEC 60204-31:1996, *Electrical equipment of industrial machines — Part 31: Particular requirements for sewing machines, units, and systems*.

IEC 60309-1:1988, *Plugs, socket-outlets, and couplers for industrial purposes — Part 1: General requirements*.

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

IEC 60364-4-41:1992, *Electrical installations of buildings — Part 4: Protection for safety — Chapter 41: Protection against electric shock*.

IEC 60364-4-46:1981, *Electrical installations of buildings — Part 4: Protection for safety — Chapter 46: Isolation and switching*.

IEC 60364-4-47:1981, *Electrical installations of buildings — Part 4: Protection for safety — Chapter 47: Application of protective measures for safety — Section 470: General — Section 471: Measures of protection against electric shock*.

IEC 60364-4-473:1977, *Electrical installations of buildings — Part 4: Protection for safety — Chapter 47: Application of protective measures for safety — Section 473: Measures of protection against overcurrent*.

IEC 60364-4-481:1993, *Electrical installations of buildings — Part 4: Protection for safety — Chapter 481: Choice of protective measures as a function of external influences — Section 481: Selection of measures for protection against electric shock in relation to external influences*.

IEC 60364-5-54:1980, *Electrical installations of buildings — Part 5: Selection and erection of electrical equipment — Chapter 54: Earthing arrangements and protective conductors*.

IEC 60364-5-523:1983, *Electrical installations of buildings — Part 5: Selection and erection of electrical equipment — Chapter 52: Wiring systems — Section 523: Current-carrying capacities*.

IEC 60364-6-61:1986, *Electrical installations of buildings — Part 6: Verification — Chapter 61: Initial verification as amended by Amendment 1 (1993)*.

IEC 60417:1973, *Graphical symbols for use on equipment. Index, survey, and compilation of the single sheets*.

IEC 60439-1:1992, *Low-voltage switchgear and controlgear assemblies — Part 1: Type-tested and partially type-tested assemblies*.

IEC 60445:1988, *Identification of equipment terminals and terminations of certain designated conductors including general rules for an alphanumeric system*.

IEC 60446:1989, *Identification of conductors by colours or numerals*.

IEC 60447:1993, *Man-machine interface (MMI) — Actuating principles*.

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*.

IEC 60536:1976, *Classification of electrical and electronic equipment with regard to protection against electric shock*.

IEC 60617:, *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*.

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

IEC 60742:1983, *Isolating transformers and safety isolating transformers*.

IEC 60947-2:1995, *Low-voltage switchgear and controlgear — Part 2: Circuit breakers*.

IEC 60947-3:1990, *Low-voltage switchgear and controlgear — Part 3: Switches, disconnectors, switch-disconnectors, and fuse combination units*.

IEC 60947-5-1:1990, *Low-voltage switchgear and controlgear — Part 5: Control circuit devices and switching elements — Section 1: Electromechanical control circuit devices*.

IEC 60947-7-1:1989, *Low-voltage switchgear and controlgear — Part 7: Ancillary equipment — Section 1: Terminal blocks for copper conductors*.

IEC 61082:, *Preparation of documents used in electrotechnology*.

IEC 61131-1:1992, *Programmable controllers — Part 1: General information*.

IEC 61131-2:1992, *Programmable controllers — Part 2: Equipment requirements and tests*.

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

ISO 3864:1984, *Safety colours and safety signs*.

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

ISO/TR 12100-1:1992, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*.

3 Definitions

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

3.1

actuator

the part of the actuating system to which an external actuating force is applied [IEV 441-15-22]

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 3.32.

3.2

ambient temperature

the temperature of the air or other medium where the equipment is to be used [IEV 826-01-04]

3.3

barrier

a part providing protection against direct contact from any usual direction of access [IEV 826-03-13]

3.4

cable tray

a 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

a 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, modified]

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

a 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)

a circuit used for the operational control of the machine and for protection of the power circuits

3.9

control device

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

3.10 controlgear

a general term covering 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]

3.11 controlled stop

the stopping of machine motion by, for example, reducing the electrical command signal to zero once the stop signal has been recognized by the control but retaining electrical power to the machine actuators during the stopping process

3.12 digital

operated by the use of discrete signals to represent data in the form of numbers or other characters

3.13 direct contact

contact of persons or livestock with live parts [IEV 826-03-05]

3.14 duct

an 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

a 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

that part of the electrical equipment containing circuitry mainly based on electronic devices and components

3.17 enclosed electrical operating area

a 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

3.18 enclosure

a 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 under the scope of this standard (see IEC 60529, 3.1):

- 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.

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.

3.19 equipment

a general term including material, fittings, devices, appliances, fixtures, apparatus, and the like used as part of, or in connection with, an electrical installation

3.20 equipotential bonding

electrical connection putting various exposed conductive parts and extraneous conductive parts at a substantially equal potential [IEV 826-04-09]

3.21 exposed conductive part

a conductive part of electrical equipment, which can be touched and which is not normally live, but which may become live under fault conditions

NOTE A conductive part of electrical equipment which can only become live under fault conditions through an exposed conductive part, is not considered to be an exposed conductive part.

[IEV 826-03-02]

3.22 extraneous conductive part

a conductive part not forming part of the electrical installation and liable to introduce a potential, generally the earth potential [IEV 826-03-03]

3.23 failure

the 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.

3.24 fault

the 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.

3.25 guard

part of a machine specifically used to provide protection by means of a physical barrier. Depending on its construction, a guard may be called casing, cover, screen, door, enclosing guard, etc. [ISO/TR 12100-1, 3.22, modified]

3.26 hazard

a source of possible injury or damage to health [ISO/TR 12100-1, 3.5, modified]

3.27 indirect contact

contact of persons or livestock with exposed conductive parts which have become live under fault conditions [IEV 826-03-06]

3.28 (electrically) instructed person

a 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]

3.29 interlock (for safeguarding)

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

3.30 limiting device

a device which prevents a machine or a machine element from exceeding a designed limit (e.g. space limit, pressure limit) [ISO/TR 12100-1, 3.23.7]

3.31 live part

a 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]

3.32 machine actuator

a power mechanism used to effect motion of the machine

3.33 machinery (machine)

an assembly of linked parts or components, at least one of which moves, with the appropriate machine actuators, control and power circuits, etc., 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 one and the same end, are arranged and controlled so that they function as an integral whole

machinery also means interchangeable equipment modifying the function of a machine, which is placed on the market (supplied) for the purpose of being assembled with a machine or a series of different machines, or with a tractor by the operator himself insofar as this equipment is not a spare part or tool

3.34 marking

signs or inscriptions for the identification of the type of a component or device attached by the manufacturer of the component or device

3.35 neutral conductor (symbol N)

a conductor connected to the neutral point of a system and capable of contributing to the transmission of electrical energy [IEV 826-01-03]

3.36 obstacle

a part preventing unintentional direct contact, but not preventing direct contact by deliberate action [IEV 826-03-14]

3.37 overcurrent

any current exceeding the rated value. For conductors, the rated value is the current-carrying capacity [IEV 826-05-06]

3.38 overload (of a circuit)

the 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*.

3.39**plug/socket combination**

a plug and socket-outlet, a cable coupler, or an appliance coupler, in accordance with IEC 60309-1

3.40**positive opening operation (of a contact element)**

the achievement of contact separation as the direct result of a specified movement of the switch actuator through non-resilient members (e.g. not dependent upon springs) [IEC 60947-5-1, chapter 3, 2.2]

3.41**power circuit**

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

3.42**protective bonding circuit**

the whole of the protective conductors and conductive parts used for protection against electric shock in the event of an insulation failure

3.43**protective conductor**

a conductor required 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.

[IEV 826-04-05, modified]

3.44**redundancy**

the 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

3.45**reference designation**

a distinctive code which serves to identify an item in a diagram, list, chart, and on the equipment

3.46**risk**

a combination of the probability and the degree of possible injury or damage to health in a hazardous situation [ISO/TR 12100-1]

3.47**safe working procedure**

a method of working that reduces risk

3.48**safeguard**

a guard or protective device used as a means to protect persons from a present or impending hazard

3.49**safeguarding**

safety measures consisting of the use of specific means called safeguards to protect persons from hazards that cannot reasonably be removed or are not sufficiently limited by design

3.50**servicing level**

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

3.51**short-circuit current**

an overcurrent resulting from a short circuit due to a fault or an incorrect connection in an electric circuit [IEV 441-11-07]

3.52**(electrically) skilled person**

a person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create [IEV 826-09-01, modified]

3.53**supplier**

an entity (e.g. manufacturer, contractor, installer, integrator) who provides equipment or services associated with the machine

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

3.54**switching device**

a device designed to make or break the current in one or more electric circuits [IEV 441-14-01]

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

3.55**terminal**

a conductive part of a device provided for electrical connection to external circuits

3.56**uncontrolled stop**

the stopping of machine motion by removing power to the machine actuators, all brakes and/or other mechanical stopping devices being activated

3.57**user**

an 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 acceptable level of risk, 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.

Hazards 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;
- 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 (e.g. electromagnetic, electrostatic or radio interference) either from outside the electrical equipment or internally generated;
- stored energy (either electrical or mechanical);
- audible noise at levels that cause health problems to persons.

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

Design and development shall be the first consideration in the reduction of risks. Where this is not sufficient, safeguarding and safe working procedures shall be considered. Safeguarding includes the use of safeguards and awareness means.

The use of the inquiry form as shown in 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 requirements related to the electrical equipment. Those additional requirements 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

Electrical components and devices shall be suitable for their intended use and shall conform to relevant IEC standards where such exist.

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 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 ... 1,1 of nominal voltage.
Frequency	0,99 ... 1,01 of nominal frequency continuously; 0,98 ... 1,02 short time.

NOTE The short time value may be specified by the user (see Annex B).

Harmonics	Harmonic distortion not to exceed 10 % of the total r.m.s. voltage between live conductors for the sum of the second through to the fifth harmonic. An additional 2 % of the total r.m.s. voltage between live conductors for the sum of the sixth through to the 30th harmonic is permissible.
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Voltage unbalance	Neither the voltage, of the negative sequence component nor the voltage of the zero sequence component in three-phase supplies shall exceed 2 % of the positive sequence component.
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Voltage interruption	Supply interrupted or at zero voltage for not more than 3 ms at any random time in the supply cycle. There shall be more than 1 s between successive interruptions.
Voltage dips	Voltage dips shall not exceed 20 % of the peak voltage of the supply for more than one cycle. There shall be more than 1 s between successive dips.

4.3.3 DC supplies

From batteries:

Voltage	0,85 ... 1,15 of nominal voltage; 0,7 ... 1,2 of nominal voltage in the case of battery-operated vehicles.
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Voltage interruption	Not exceeding 5 ms.
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From converting equipment:

Voltage	0,9 ... 1,1 of nominal voltage.
Voltage interruption	Not exceeding 20 ms. There shall be more than 1 s between successive interruptions.

Ripple (peak-to-peak) voltage.	Not exceeding 0,15 of nominal
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NOTE This is a variation to IEC Guide 106 to ensure proper operation of electronic equipment.

4.3.4 On-board power supply

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 use in the physical environment and operating conditions specified in 4.4.2 to 4.4.8. When the physical environment or the operating conditions are outside those specified, an agreement may be needed between the supplier and the user (see Annex B).

4.4.2 Electromagnetic compatibility (EMC)

The equipment shall not generate electromagnetic disturbances above levels that are appropriate for its intended places of use. In addition, the equipment shall have an adequate level of immunity to electromagnetic disturbances so that it can operate correctly in its intended environment.

NOTE 1 European standards EN 50081 and EN 50082-2 give general EMC emission and immunity limits. Those requirements are also under consideration by IEC TC 77 and CISPR.

NOTE 2 Product standards (e.g. IEC 60439-1) may give more specific EMC requirements.

Generated disturbances can be limited by:

- suppression at the source by using capacitors, inductors, diodes, Zener diodes, varistors or active devices, or a combination of those components; or
- screening of the equipment in a bonded electrically conductive enclosure to provide segregation from other equipment.

Undesirable effects of electrostatic discharge, radiated electromagnetic energy and mains borne disturbances shall be avoided, for example by the use of appropriate filters and time delays, a choice of certain power levels, and the use of suitable wiring types and practices.

Measures that can be used to reduce the effects of disturbances on equipment include:

- connections of circuits to a reference potential: each circuit is connected to a terminal on a ground plane (chassis) (see Figure 3) that is connected to earth using an insulated conductor of large cross-sectional area (e.g. a minimum area of 6 mm² of type class 6 in accordance with Table C.4);
- interconnections of conductive structural parts of the equipment: conductive structural parts are connected to a common point using conductors of large cross-sectional area that are as short as is possible. Conductive parts connected to the equipment enclosure via sliding contacts or hinges are also connected to that enclosure using large section braided conductors (see also 8.3.3 and Figure 3);
- wiring practices: using electrostatic screens, electromagnetic shields, twisted conductors, and cable orientation (i.e. crossing cable runs at as near to 90° as is practicable), or running the conductors parallel to and as close as is practicable to the ground-plane, to minimize the disturbances from power cables to low level control wiring;
- separation of equipment: separating and/or shielding sensitive equipment (e.g. units working with pulses and/or at low signal levels) from switching equipment (e.g. electromagnetic relays, thyristors); separating low level signal wiring from control and power cables.

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 (e.g. hot climates, steel mills, paper mills) and for cold environments, extra requirements may be necessary (see Annex B).

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 may be permitted at lower temperatures (e.g. 90 % at 20 °C).

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

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 solid bodies and liquids (see 12.3).

Consideration should be given to the suitability of the electrical equipment where contaminants (e.g. dust, acids, corrosive gases, salt) are present in the physical environment in which the electrical equipment is to be installed (see Annex B).

4.4.7 Ionizing and non-ionizing radiation

When equipment is subject to radiation (e.g. 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 may be necessary between the supplier and the user (see 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 the use of antivibration mountings. A special agreement may be necessary between the supplier and the user (see 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.

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 (see also 14.4.6).

4.7 Installation and operation

Electrical equipment shall be installed and operated in accordance with the supplier's instructions and ergonomic principles should be taken into account.

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 should be connected to a single power supply. Where it is necessary to use another supply for certain parts of the equipment (e.g. electronic circuits, electromagnetic clutches), that supply should be derived, as far as is possible, from devices (e.g. 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 may 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 d)], it is recommended that the supply conductors are terminated at the supply disconnecting device. When that is not practicable, separate terminations shall be provided.

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, shall be provided for the neutral conductor (see also 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 used.

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. For the identification of the external protective conductor terminal, see 5.2.

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 (see 8.2.1) for connection of the machine to the external protective earthing system or to the external protective conductor, depending upon the supply distribution system, and in accordance with the relevant installation standards. 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 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 the external protective conductor shall be identified by marking with the letters PE (see IEC 60445), in order to avoid confusion at the point(s) of connection between machine and fixed installation.

The other terminals used for the connection of machine components or subassemblies to the protective bonding circuit of the machine shall be identified either by the graphic symbol 60417-2-IEC-5019:



or with the letters PE, the graphical symbol being preferred, or by use of the bicolour combination GREEN-AND-YELLOW.

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;
- for the source of supply to a feeder system using collector wires, collector bars, slip-ring assemblies, flexible cable systems (reeled, festooned), to a machine or a number of machines;
- for each on-board power supply.

The supply disconnecting device shall disconnect (isolate) the electrical equipment of the machine from the supply when required (e.g. 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 be used where a hazardous condition or damage to the machine or to the work in progress can occur.

5.3.2 Type

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

- a) a switch-disconnector, with or without fuses, in accordance with IEC 60947-3, utilization category AC – 23B or DC – 23B;
- b) 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;
- c) a circuit-breaker suitable for isolation in accordance with IEC 60947-2;
- d) a plug/socket combination for a machine with a rated current not exceeding 16 A and a total power rating not exceeding 3 kW;
- e) a plug and socket-outlet or an appliance coupler (see 3.39) for a flexible cable supply (e.g. reeled, festooned) to a mobile machine under the following conditions:
 - it shall not be possible to connect or disconnect a plug and socket-outlet or an appliance coupler, without breaking capacity, during load conditions;
 - the plug and socket-outlet or the appliance coupler shall be so connected that the part connected to the incoming supply is that which is protected to at least IP2X or IPXXB.

Where a plug/socket combination with breaking capacity is used, it shall have a breaking capacity of at least the rated current of the machine at rated voltage (see also 14.4.5). Where a plug/socket combination is used for disconnection under overload (e.g. locked rotor), the rating should be at least locked rotor current. In addition, the electrical equipment shall have a device for switching the machine on and off.