
**Earth-moving machinery — Electrical
safety of machines utilizing electric
drives and related components and
systems —**

**Part 1:
General requirements**

*Engins de terrassement — Sécurité électrique des machines utilisant
des moteurs électriques et composants et systèmes connexes —*

Partie 1: Exigences générales

get full document from standards.iteh.ai



Sample Document

get full document from standards.iteh.ai



COPYRIGHT PROTECTED DOCUMENT

© ISO 2016, Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

	Page
Foreword	vii
Introduction	viii
1 Scope	1
2 Normative references	2
3 Terms, definitions and abbreviated terms	3
3.1 Electric shock protection-related terms and definitions.....	3
3.2 Control-related terms and definitions.....	5
3.3 Electrical infrastructure-related terms and definitions.....	6
3.4 Risk-related terms and definitions.....	7
3.5 Miscellaneous terms and definitions.....	8
3.6 Abbreviated terms.....	9
4 General requirements	9
4.1 General.....	9
4.2 Provisions for handling.....	9
4.3 Provisions for transportation and storage.....	10
4.4 Components and devices.....	10
4.5 Intended operating environment.....	10
4.5.1 General.....	10
4.5.2 Exposure.....	10
4.5.3 Altitude.....	11
4.5.4 Ingress protection.....	11
4.6 Electrical source.....	11
5 Protection against electric shock hazards	11
5.1 General.....	11
5.2 Protection by enclosures.....	11
5.3 Protection by insulation.....	12
5.4 Protection against residual voltages.....	13
5.5 Protection by barriers.....	13
5.6 Protection by inaccessibility.....	13
5.7 Special considerations for low voltage energy storage devices and related buses.....	13
5.8 Prevention of touch voltage.....	14
5.8.1 General.....	14
5.8.2 Protection by class II construction or equivalent.....	14
5.8.3 Protection by electrical separation.....	14
5.9 Protection by automatic disconnection of source.....	15
5.10 Protection by equipotential bonding.....	15
5.10.1 General.....	15
5.10.2 Protective equipotential bonding circuit.....	16
5.10.3 Functional equipotential bonding.....	18
5.10.4 Devices for earthing and short-circuiting live parts.....	19
5.11 Protection by use of PELV.....	19
5.11.1 General.....	19
5.11.2 Sources for PELV.....	19
6 Protection against electrical fire hazards	20
6.1 General.....	20
6.2 Fire hazard assessment.....	20
6.3 Prevention of ignition.....	20
6.4 Minimizing the spread of fire.....	20
7 Protection against thermal hazards	20
8 Protection against mechanical hazards	20
9 Protection against abnormal operation hazards	20

9.1	General.....	20
9.2	Overcurrent protection (OCP)	21
9.2.1	General.....	21
9.2.2	Transformers	21
9.2.3	Overcurrent protection (OCP) implementation.....	21
9.2.4	Rating and setting of overcurrent protective systems.....	21
9.2.5	Placement of overcurrent protective devices	21
9.3	Abnormal temperature protection	22
9.4	Earth (or chassis in the case of self-powered machines) fault/residual current protection.....	22
9.5	Protection against overvoltages due to lightning and to switching surges	22
9.6	Protection against other abnormal operation hazards.....	22
10	Electric power source	22
10.1	Disconnection of source.....	22
10.1.1	General.....	22
10.1.2	Source disconnecting devices.....	23
10.1.3	Equipment disconnecting devices.....	24
10.2	Prevention of unintended start-up.....	24
10.3	External electrical charging.....	24
11	Wiring.....	24
11.1	General.....	24
11.2	Conductors	25
11.3	Insulation.....	25
11.4	Conductor and cable ampacity.....	25
11.5	Flexible cables.....	26
11.5.1	General.....	26
11.5.2	Mechanical rating.....	26
11.5.3	Ampacity of cables wound on reels.....	26
11.6	Assemblies having sliding contacts.....	26
11.6.1	Accessibility of live parts.....	26
11.6.2	Protective conductor circuit.....	27
11.6.3	Protective conductor current collectors.....	27
11.6.4	Removable current collectors used for disconnection.....	27
11.6.5	Clearances.....	27
11.6.6	Creepage distances.....	27
11.6.7	Conductor system sectioning.....	28
11.6.8	Construction and installation	28
11.7	Connections and routing	28
11.7.1	General.....	28
11.7.2	Conductor and cable runs.....	28
11.7.3	Conductors of different circuits	29
11.8	Identification of conductors	29
11.8.1	General.....	29
11.8.2	Protective conductor identification.....	29
11.8.3	Neutral conductor identification	29
11.8.4	Identification by colour.....	30
11.9	Wiring inside enclosures.....	31
11.10	Wiring outside enclosures	31
11.10.1	General.....	31
11.10.2	External ducts.....	31
11.10.3	Connection to moving elements of the EMM.....	31
11.10.4	Interconnection of devices on the EMM	32
11.10.5	Plug/socket combinations.....	33
11.10.6	Dismantling for shipment.....	34
11.10.7	Spare conductors.....	34
11.11	Ducts and boxes.....	34
11.11.1	General.....	34

11.11.2	Rigid metal conduit and fittings	35
11.11.3	Flexible metal conduit and fittings	35
11.11.4	Flexible nonmetallic conduit and fittings	35
11.11.5	Cable trunking systems	35
11.11.6	EMM compartments and cable trunking systems	35
11.11.7	Boxes	35
11.11.8	Motor wiring boxes	35
12	Electric motors and generators	36
12.1	General	36
12.2	Enclosures	36
12.3	Dimensions	36
12.4	Mounting and compartments	36
12.5	Criteria for motor selection or design	36
12.6	Overheating protection	37
12.7	Overspeed protection	37
13	Non-motor loads	37
13.1	Accessories	37
13.2	Local lighting	38
13.2.1	General	38
13.2.2	Source	38
13.2.3	Protection	38
13.2.4	Fittings	38
14	Controls	39
14.1	Control circuits	39
14.1.1	Control circuit voltages	39
14.1.2	Protection	39
14.2	Control functions	39
14.3	Protective interlocks	39
14.3.1	Reclosing or resetting of an interlocking safeguard	39
14.3.2	Operating limits, auxiliary functions, interlocks, and reverse current braking	39
14.4	Control functions in the event of failure	39
14.4.1	General	40
14.4.2	Measures to minimize risk in the event of failure	40
14.4.3	Protection against malfunction due to earth (or chassis in the case of self-powered machines) faults, voltage interruptions and loss of continuity	41
14.5	Operator interface and machine-mounted control devices	42
14.5.1	General	42
14.5.2	Push-buttons	42
14.5.3	Indicator lights and displays	43
14.5.4	Illuminated push-buttons	43
14.5.5	Rotary control devices	43
14.5.6	Start devices	43
14.5.7	Emergency stop devices	43
14.5.8	Emergency switching off devices	43
14.5.9	Enabling control devices	43
14.6	Controlgear: location, mounting, and enclosures	43
14.6.1	General	43
14.6.2	Location and mounting	43
14.6.3	Degrees of protection	44
14.6.4	Enclosures, doors, and openings	45
14.6.5	Access to controlgear	46
14.7	Access to low and high-voltage equipment	46
15	Manuals and technical documentation	46
15.1	General	46
15.2	Information to be provided	46
15.3	Documentation	46

15.4	Overview diagrams and function diagrams	47
15.5	Circuit diagrams	47
15.6	Operator's manual	47
15.7	Maintenance manual and service literature	47
15.7.1	General	47
15.7.2	Reduction of electrical hazards while servicing	48
15.8	Parts list	48
16	Marking	49
16.1	General	49
16.2	Warning signs	49
16.2.1	Electric shock hazard	49
16.2.2	Hot surfaces hazard	49
16.2.3	Magnetic field hazard	49
16.2.4	Arc flash hazard	49
16.2.5	Residual voltage hazard	50
16.3	Functional identification	50
16.4	Marking of equipment	50
16.4.1	General	50
16.4.2	Indication of hazardous voltages (all machines)	50
16.5	Reference designations	50
16.6	Protective equipotential bonding terminals	50
17	Tests	50
17.1	General	50
17.2	Protective equipotential bonding circuit continuity	51
17.3	Conditions for protection by automatic disconnection of source	51
17.3.1	General	51
17.3.2	Fault loop impedance verification and suitability of the associated overcurrent protective device in TN systems	52
17.4	Insulation resistance tests	52
17.4.1	Low-voltage insulation resistance test	52
17.4.2	High-voltage insulation resistance test	52
17.5	Voltage withstand tests	52
17.6	Protection against residual voltages	53
17.7	Functional tests	53
17.8	Retesting	53
17.9	IP test for high-voltage equipment	53
	Annex A (informative) List of significant hazards	54
	Annex B (normative) TN systems — Protection against indirect contact	56
	Annex C (informative) Explanation of emergency operation functions	59
	Annex D (informative) Comparison of selected requirements of ISO 14990, UN ECE R100 and ISO 6469-3	60
	Bibliography	65

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html

The committee responsible for this document is ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 3, *Machine characteristics, electrical and electronic systems, operation and maintenance*.

This document is intended to be used in conjunction with ISO 14990-2 and ISO 14990-3.

Introduction

This document is a type-C standard as defined in ISO 12100.

The machinery concerned and the extent to which hazards, hazardous situations, or hazardous events are covered are indicated in [Annex A](#) of this document.

When requirements of this type-C standard are different from those stated in type-A or type-B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

Electrification is an enabling technology providing increased flexibility in machine form packaging. Because in the past earth-moving machinery (EMM) electrical systems have predominately been in the 12–24 V DC range, two safety aspects require particular attention:

- significantly higher voltages, such as are utilized in industrial or structural applications and in other transportation sectors;
- greater available electrical energy.

Portions of this document appear to govern electrical design practices (e.g. [Clauses 9, 11, 12](#), and [17](#)). Their requirements are necessary because certain aspects of design cannot be separated from electrical safety.

Some of the content of this document is based on IEC 60204-1 and IEC 60204-11, adapted to the needs of earth-moving machinery. Non-electrical hazards are addressed in the ISO 20474 series.

Sample Document

get full document from standards.iteh.ai

Earth-moving machinery — Electrical safety of machines utilizing electric drives and related components and systems —

Part 1: General requirements

1 Scope

This document specifies general safety requirements for the electrical equipment and its components incorporated into earth-moving machines (EMMs) as defined in ISO 6165, and addresses the safety of operators, technicians, service/maintenance personnel and bystanders.

It is applicable to those machines using on-board voltages in the ranges of 50 V–36 kV AC r.m.s. at any frequency and 75 V–36 kV DC — including any repetition rate of pulsating DC — intended for outdoor use. It is applicable to both low and high voltages, except where its applicability to high- or low-voltage equipment only is indicated. Voltages occurring within devices are not considered to be on-board voltages and are thus not within its scope.

NOTE 1 Special considerations typically apply at frequencies greater than 30 kHz. Where reference standards are limited to frequencies below those used on the EMM, it is the responsibility of the user to assess the risks and address them appropriately.

This document covers all significant hazards, hazardous situations, and hazardous events relevant to the voltage range for earth-moving machinery within its scope when the machinery is used as intended or under conditions of misuse reasonably foreseeable by the manufacturer. It specifies appropriate technical measures for eliminating or reducing risks arising from significant hazards, hazardous situations, or hazardous events during commissioning, operation, and maintenance. It is not applicable to machines manufactured before the date of its publication.

It is intended to be used in conjunction with ISO 14990-2 and ISO 14990-3, which give provisions specific to the machine's power source that take precedence over the requirements of this document for the machines covered. For multipurpose machinery, all those parts of ISO 14990 are applicable whose requirements cover the functions and applications of the machine.

Even though this document addresses most hazards associated with the use of low- or high-voltage electrical systems in earth-moving machines, owing to the possible presence of additional electrical hazards, conformance with it cannot be taken as an absolute guarantee of electrical safety. Areas of concern are included in the list of significant hazards found in [Annex A](#).

This document specifies requirements for on-board generators, electrically isolated from other low-voltage systems and provided as power sources for general-purpose socket outlets installed on EMMs, and transformer or inverter power sources for general-purpose socket outlets.

NOTE 2 Local or regional requirements may also apply to general-purpose socket outlet arrangements.

Although nominal 12 V and 24 V (alternator/battery) systems are not addressed, the meeting of some of the requirements, including those of PELV, will ensure that the low-voltage system is sufficiently isolated from 12 V and 24 V systems.

This document does not address risks associated with explosive atmospheres, which are sometimes found in mining and other EMM applications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 2860, *Earth-moving machinery — Minimum access dimensions*

ISO 2867:2011, *Earth-moving machinery — Access systems*

ISO 3457:2003, *Earth-moving machinery — Guards — Definitions and requirements*

ISO 9244:2008, *Earth-moving machinery — Machine safety labels — General principles*. Amended by ISO 9244:2008/Amd. 1:2016

ISO 14990-2:2016, *Earth-moving machinery — Electrical safety of machines utilising electric drives and related components and systems — Part 2: Particular requirements for externally-powered machines*

ISO 14990-3, *Earth-moving machinery — Electrical safety of machines utilising electric drives and related components and systems — Part 3: Particular requirements for self-powered machines*

ISO 15817, *Earth-moving machinery — Safety requirements for remote operator control systems*

IEC 60071-1:2006, *Insulation Coordination — Part 1: Definitions, principles and rules*. Amended by IEC 60071-1:2006/Amd. 1:2010

IEC 60071-2:1996, *Insulation co-ordination — Part 2: Application guide*

IEC 60204-1:2005, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*. Amended by IEC 60204-1:2005/Amd. 1:2008

IEC 60364-1, *Low-voltage electrical installations — Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60364-4-41:2005, *Electrical installations of buildings Part 4-41: Protection for safety Protection against electric shock*

IEC 60364-5-54:2011, *Low-voltage electrical installations — Part 5-54: Selection and erection of electrical equipment — Earthing arrangements, protective conductors and protective bonding conductors*

IEC 60417-DB, *Graphical symbols for use on equipment*¹⁾

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

IEC 60617-DB, *Graphical symbols for diagrams*²⁾

IEC 60664-1, *Insulation coordination for equipment within low-voltage systems Part 1: Principles, requirements and tests*

IEC 60871-1: 2014, *Shunt capacitors for AC power systems having a rated voltage above 1 000 V — Part 1: General*

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

IEC 61230, *Live working — Portable equipment for earthing or earthing and short-circuiting*

IEC 61439-1, *Low-voltage switchgear and controlgear assemblies — Part 1: General rules*

IEC 61557 (all parts), *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. — Equipment for testing, measuring or monitoring of protective measures*

1) Online database: available at <http://www.graphical-symbols.info/>

2) Online database: available at <http://std.iec.ch/iec60617>

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

IEC 61558-2-6, *Safety of power transformers, power supply units and similar — Part 2-6: Particular requirements for safety isolating transformers for general use*

IEC 61984, *Connectors — Safety requirements and tests*

IEC 62271-102, *High-voltage switchgear and controlgear — Part 102: Alternating current disconnectors and earthing switches*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms, definitions and abbreviated terms given in ISO 12100 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Electric shock protection-related terms and definitions

3.1.1

electrically protective barrier barrier

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

[SOURCE: IEC 826-12-23]

3.1.2

direct contact

electric contact of persons with live parts

[SOURCE: IEC 826-12-03, modified]

3.1.3

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* (3.1.1) without the use of a key or tool, and which is clearly marked by appropriate warning signs

[SOURCE: IEC 60204-1: 2005, 3.15]

3.1.4

electrically protective enclosure protective enclosure enclosure

electrical enclosure (3.1.5) surrounding internal parts of equipment to prevent access to hazardous-live-parts from any direction

[SOURCE: IEC 826-12-22]

3.1.5

electrical enclosure

enclosure (3.1.4) providing protection against the foreseen dangers created by electricity

[SOURCE: IEC 826-12-21, modified]

Note 1 to entry: Some electrical enclosures also provide protection for equipment. It can be either of discrete construction or an enclosed space within the *machine* (3.5.2).

3.1.6

equipotential bonding

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

[SOURCE: IEC 195-1-10]

3.1.7

protective equipotential bonding

equipotential bonding (3.1.6) for the purposes of safety

[SOURCE: IEC 195-01-15]

3.1.8

exposed conductive part

conductive part of equipment which can be touched and which is not normally live, but which can become live when basic insulation fails

[SOURCE: IEC 826-12-10]

3.1.9

extra-low voltage ELV

voltage supplied from a source within the device that does not exceed 50 V between conductors and between conductors and earth (or chassis in the case of self-powered machines) when the device is supplied at rated voltage

[SOURCE: IEC 60335-1, 3.4.1, modified]

3.1.10

extraneous conductive part

conductive part not forming part of the electrical equipment and liable to introduce a potential, generally the ground (or chassis in the case of self-powered machines) potential

[SOURCE: IEC 826-12-11, modified]

3.1.11

indirect contact

contact of persons with *exposed conductive parts* (3.1.8) which have become live due to fault conditions

[SOURCE: IEC 826-12-04, modified]

3.1.12

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 1 to entry: This term does not necessarily imply a risk of electric shock.

[SOURCE: IEC 60204-1: 2005, 3.33]

3.1.13**obstacle**

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

[SOURCE: IEC 60204-1: 2005, 3.38]

3.1.14**protective conductor**

conductor provided for purposes of safety, e.g. protection against electric shock

[SOURCE: IEC 826-13-22, modified]

Note 1 to entry: A protective conductor is typically used to connect any of the following:

- exposed conductive parts;
- extraneous conductive parts;
- PE (or chassis ground in the case of self-powered machines) terminal.

3.1.15**protective extra-low voltage****PELV**

earthed (or chassis-bonded in the case of self-powered machines) circuit operating at safety extra-low voltage which is separated from other circuits by basic insulation and protective screening, double insulation or reinforced insulation

[SOURCE: IEC 60335-1, 3.4.4, modified]

Note 1 to entry: Protective screening is the separation of circuits from live parts by means of an earthed (or chassis-bonded in the case of self-powered machines) screen.

3.1.16**safety extra-low voltage****SELV**

voltage not exceeding 42 V between conductors and between conductors and earth (or chassis in the case of self-powered machines), the no-load voltage not exceeding 50 V

[SOURCE: IEC 60335-1, 3.4.2, modified]

Note 1 to entry: When safety extra-low voltage is obtained from the source mains, it is through a safety isolating transformer or a converter with separate windings, the insulation of which complies with double insulation or reinforced insulation requirements.

3.1.17**touch voltage**

voltage between conductive parts when touched simultaneously by a person or animal

[SOURCE: IEC 195-05-11]

Note 1 to entry: The value of the effective touch voltage may be appreciably influenced by the impedance of the person or the animal in electric contact with these conductive parts.

3.2 Control-related terms and definitions**3.2.1****actuator**

part of the actuating system to which an external actuating force is applied

Note 1 to entry: An actuator typically takes the form of a handle, knob, push-button, roller, plunger, etc.

Note 2 to entry: Cf. [3.2.5](#).

[SOURCE: IEC 60204-1: 2005, 3.1, modified]

3.2.2

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* (3.1.4) and supporting structures, intended in principle for the control of electric energy consuming equipment

[SOURCE: IEC 441-11-03]

3.2.3

emergency switching-off device

manually actuated control device used to switch off the source of electrical energy to all or a part of the electrical equipment of a *machine* (3.5.2) where a risk of electric shock or another risk of electrical origin is involved

[SOURCE: IEC 60204-1: 2005, 3.18, modified]

3.2.4

emergency stop device

manually actuated control device used to initiate an emergency stop function

[SOURCE: ISO 13850, 3.2]

3.2.5

machine actuator

electromechanical or electronic power mechanism used to effect a function of the *machine* (3.5.2)

[SOURCE: IEC 60204-1: 2005, 3.34, modified]

3.3 Electrical infrastructure-related terms and definitions

3.3.1

ampacity

maximum current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating

3.3.2

cable trunking system

system of enclosures, each consisting of a base with a removable cover, intended to completely enclose insulated conductors, cables, cords and for the accommodation of other electrical devices

[SOURCE: IEC 442-02-34, modified]

3.3.3

direct opening action

<of a contact element> achievement of contact separation as the direct result of a specified movement of the switch *actuator* (3.2.1) through non-resilient members (e.g. not dependent upon springs)

[SOURCE: IEC 60947-5-1: 2009, K.2.2]

3.3.4

duct

enclosed channel designed specifically to hold and protect electrical conductors, cables, and busbars

Note 1 to entry: Conduits and cable trunking systems are types of duct.

[SOURCE: IEC 60204-1: 2005, 3.14, modified]

3.3.5**functional equipotential bonding**

equipotential bonding for operational reasons other than safety

[SOURCE: IEC 195-01-16]

3.3.6**high voltage****HV**

voltage greater than 1 000 V AC and not exceeding 36 kV AC r.m.s or greater than 1500 V DC and not exceeding 36 kV DC

3.3.7**low voltage**

voltage greater than 50 V AC and not greater than 1000 V AC r.m.s or greater than 75 V DC and not greater than 1500 V DC

3.4 Risk-related terms and definitions**3.4.1****failure**

termination of the ability of a device to perform a required function

Note 1 to entry: After failure, the item has a *fault* (3.4.2).

Note 2 to entry: “Failure” is an event, as distinguished from “fault”, which is a state.

Note 3 to entry: This concept as defined does not apply to items consisting of software only.

[SOURCE: IEC 191-04-01, modified]

3.4.2**fault**

state of a device characterized by its inability to perform a required function

Note 1 to entry: A fault is often the result of a *failure* (3.4.1) of the item itself, but in some instances exists without prior failure.

[SOURCE: IEC 60204-1: 2005, 3.26, modified]

3.4.3**hazard**

potential source of physical injury or damage to health

Note 1 to entry: The term hazard can be qualified in order to define its origin (e.g. mechanical hazard, electrical hazard) or the nature of the potential harm (e.g. electric shock hazard, cutting hazard, toxic hazard, and fire hazard).

Note 2 to entry: The hazard envisaged in this definition is either

- permanently present during the intended use of the *machine* (3.5.2) (e.g. motion of hazardous moving elements, electric arc during a welding phase, unhealthy posture, noise emission, high temperature), or
- can appear unexpectedly (e.g.: 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).

[SOURCE: ISO 12100:2010, 3.6, modified]